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Hybrid Hydroelectric Power Plant : The Ultimate Technology For Electricity Generation

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Abstract

Power generation in India has grown in size to around 1.0 lakh MW which is distributed through a vast network of transmission, sub-transmission and distribution lines that reach all villages even in remote areas. The demand for power is growing rapidly. The problem will be compounded due to fast depletion of fossil fuel deposits, quality of fuels, heavy price to be paid for basic materials plus their transportation cost and above all the environmental degradation caused by the use of conventional energy sources. Under such conditions, environment friendly and pollution-free, non-conventional and renewable energy sources known as 'clean and green energy' have emerged as an important alternative to conventional energy sources. The renewable energy sources are clean and inexhaustible as they rely on sun, wind, biomass, etc., as primary sources of energy.

Our country is endowed with large amount of sustainable resource base and non-conventional energy sources. The dependence on coal and oil has soared at a phenomenal rate over the years. The burnt fuels result in the release of carbon dioxide and other gases into the atmosphere causing environmental damage. It has become imperative to look at energy technology with a new perspective. Therefore we have to think in the direction of exploration of these sources. In the paper we are focusing on the power generation through the Hybrid Hydroelectric Power Plants.

The Hybrid Hydroelectric Power Plant is the new concept, the experts are thinking in. In this concept the operation of the whole plant is as it is; the only difference is that in a existing hydroelectric power plant, the water after passing over the turbine, released into the further river line whereas in case of hybrid hydroelectric power plant, the water after passing over the turbine in a power house, released into the further river line & taken back into the inlet reservoir with the help of big pumps so that it can be again utilized for the power generation. This system is brought into existence whenever there is a scarcity of water & the rivers on which it is to be built is not flowing for throughout the year.

Keywords: *Hybrid Power Plant, Francis Turbine, Generator, Alternator, Potential Energy, Dam, Kinetic Energy, Penstock, Surge Tank, Seismicity.*

Introduction

The Industrial Revolution of the 19th century ushered in new technologies. The spurt in inventions in that century was unprecedented in many ways. Some of these inventions involved use of natural resources like coal and oil. The thought of exhaustible nature of these resources and the environmental damage from the use of these resources never occurred either to the inventors or the subsequent generations. In the quest to sustain galloping economic activity, the dependence on coal and oil has soared at a phenomenal rate over the years. The burnt fuels result in the release of carbon dioxide and other gases into the atmosphere causing environmental damage. It has become imperative to look at energy technology with a new perspective. There are abundant renewable sources of energy such as wind, sun, water, sea, biomass apart from even daily wastes. These sources are pollution free and hence clean energy apart from being unlimited/ inexhaustible.

Power generation in India has grown in size to around 1.0 lakh MW which is distributed through a vast network of transmission, sub-transmission and distribution lines that reach all villages even in remote areas. The demand for power is growing rapidly. The problem will be compounded due to fast depletion of fossil fuel deposits, quality of fuels, heavy price to be paid for basic materials plus their transportation cost and above all the environmental degradation caused by the use of conventional energy sources. Under such conditions, environment friendly and pollution-free, non-conventional and renewable energy sources known as 'clean and green energy' have

emerged as an important alternative to conventional energy sources. The renewable energy sources are clean and inexhaustible as they rely on sun, wind, biomass, etc., as primary sources of energy.

The country is endowed with large amount of sustainable resource base and non-conventional energy technologies which are well-suited for grid connected power generation, energy supplies in remote areas which are not / could not be connected to the grid and for captive consumption. Nonconventional energy sources like wind energy, solar energy through thermal as well as photovoltaic system, biomass and hybrid sources will help to a great extent in enhancing power generation capacity. Hence appropriate policies and programs that optimize the use of available energy resources with new technologies have to be propagated, promoted and adopted.

Our nation is bestowed with the lot of non conventional sources of energies. Only we have to think in the direction of exploration of these sources. In the paper we are focusing on the power generation through the Hydroelectric Power Plants.

Hydroelectric Power Plant

Basic Terminology

In hydroelectric power plants the potential energy of water due to its high location is converted into electrical energy. The total power generation capacity of the hydroelectric power plants depends on the head of water and volume of water flowing towards the water turbine. Hydroelectric power plants convert the hydraulic potential energy from water into electrical energy. Such plants are suitable where water with suitable head is available.

Working Principle of Hydroelectric Power plant

The water flowing in the river possesses two type of energy:

1. Kinetic Energy due to flow of water
2. Potential Energy due to the height of water.

In hydroelectric power and potential energy of water is utilized to generate electricity. The formula for total power that can be generated from water in hydroelectric power plant due to its height is given

$$P = r\ h\ g$$

Where: P - Power produced [w]
r - Rate of flow of water which [m^3/s]
h - Height of water [m] it's also known as a head of water. The difference between source of water (from where water is taken) and the water's outflow (where the water is used to generate electricity, it is the place near the turbines).
g - Gravitational Acceleration Constant 9.81 [m/s^2]

The formula clearly shows that the total power that can be generated from the hydroelectric power plants depends on two major factors:

1. The flow rate of water or volume of flow of water
2. Height or head of water.

More the volume of water and more the head of water more is the power produced in the hydroelectric power plant. To obtain the high head of water the reservoir of water should as high as possible and power generation unit should be as low as possible. The maximum height of reservoir of water is fixed by natural factors like the height of river bed, the amount of water and other environmental factors. The location of the power generation unit can be adjusted as per the total amount of power that is to be generated. Usually the power generation unit is constructed at levels lower than ground level so as to get the maximum head of water. The total flow rate of water can be adjusted through the pen stock as per the requirements. If more power is to be generated more water can be allowed to flow through it.

Layout of Hydroelectric Power Plant

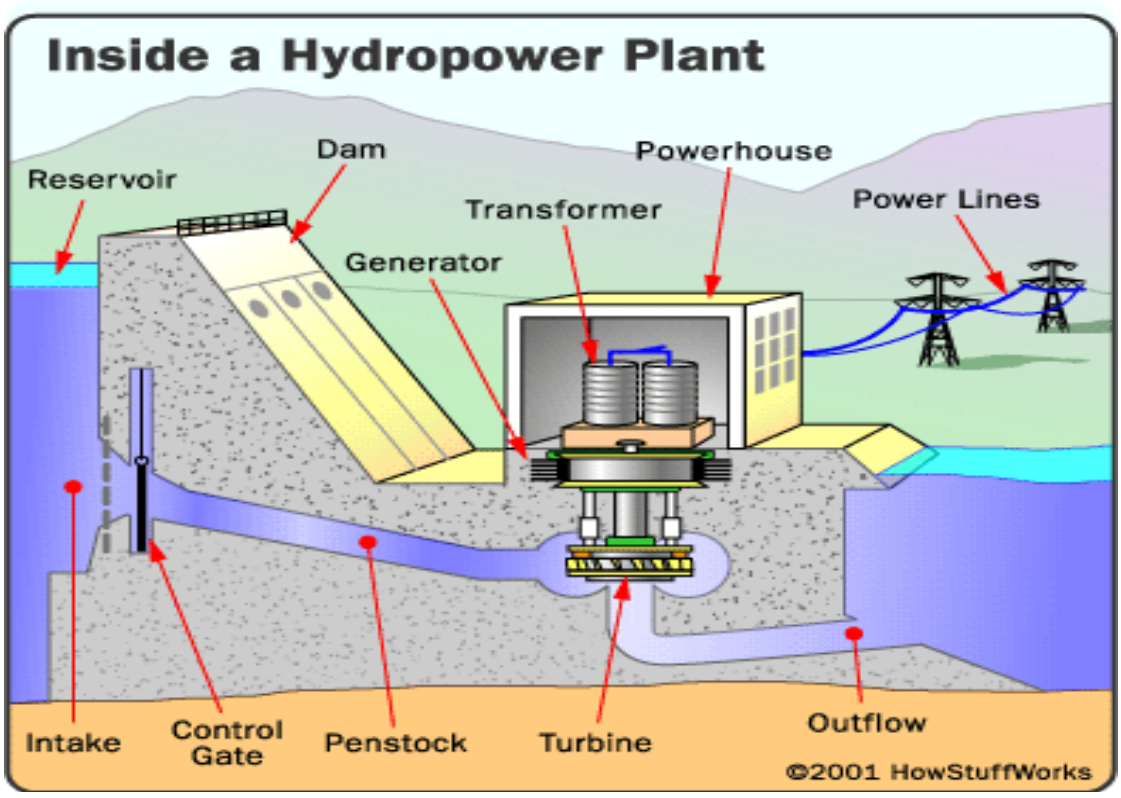

Figure.1: Layout of Hydroelectric Power Plant

The layout covered in this article is just a simple one and only cover the important parts of hydroelectric plant. The different parts of a hydroelectric power plant are

Dam

Dams are structures built over rivers to stop the water flow and form a reservoir. The reservoir stores the water flowing down the river. This water is diverted to turbines in power stations. The dams collect water during the rainy season and store it, thus allowing for a steady flow through the turbines throughout the year. Dams are also used for controlling floods and irrigation. The dams should be water-tight and should be able to withstand the pressure exerted by the water on it. There are different types of dams such as arch dams, gravity dams and buttress dams. The height of water in the dam is called *head race*.

Spillway

A spillway as the name suggests could be called as a way for spilling of water from dams. It is used to provide for the release of flood water from a dam. It is used to prevent over toping of the dams which could result in damage or failure of dams. Spillways could be controlled type or uncontrolled type. The uncontrolled types start releasing water upon water rising above a particular level. But in case of the controlled type, regulation of flow is possible.

Penstock and Tunnel

Penstocks are pipes which carry water from the reservoir to the turbines inside power station. They are usually made of steel and are equipped with gate systems. Water under high pressure flows through the penstock. A tunnel serves the same purpose as a penstock. It is used when an obstruction is present between the dam and power station such as a mountain.

Surge Tank

Surge tanks are tanks connected to the water conductor system. It serves the purpose of reducing water hammering in pipes which can cause damage to pipes. The sudden surge of water in penstock is taken by the surge tank, and when the water requirements increase, it supplies the

collected water thereby regulating water flow and pressure inside the penstock.

Power Station

Power station contains a turbine coupled to a generator. The water brought to the power station rotates the vanes of the turbine producing torque and rotation of turbine shaft. This rotational torque is transferred to the generator and is converted into electricity. The used water is released through the *tail race*. The elevation difference between head race and tail race is called gross head and by subtracting the frictional losses we get the net head available to the turbine for generation of electricity.

Hydroelectric Power Generation

Low Head Power Generation

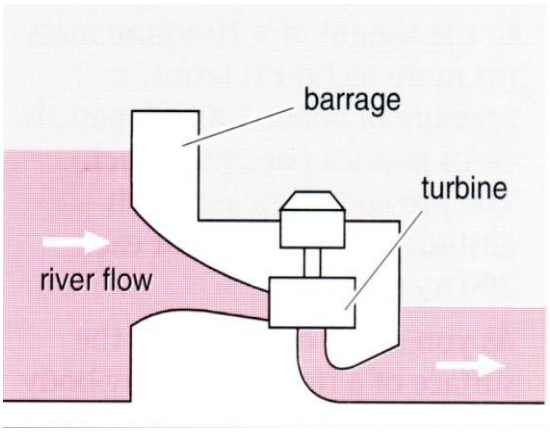

Figure.2: Low Head Hydroelectric Generators

Propeller type turbines are used for the hydroelectric power generation where the head available is as lower as it may be at ground level. I.e. the elevation of the reservoir & the elevation of the outlet river are at same level. In such cases only the flow of the water in the river is driving force for the turbine. These turbines are used for low head applications. These turbines are reaction turbines.

Medium Head Power Generation

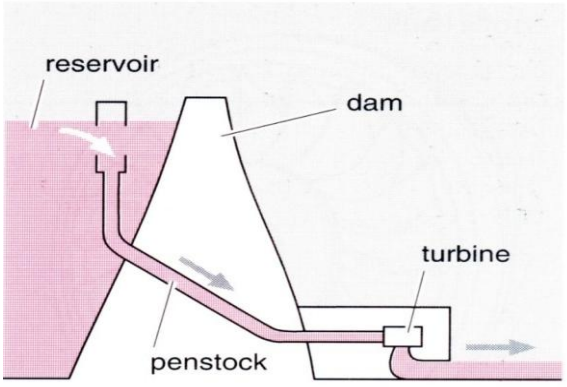

Figure.3: Medium Head Hydroelectric Generators

Francis turbines are used for the medium head hydroelectric power generation. I.e. the elevation of the reservoir & the elevation of the outlet river are at different level. In such cases potential energy of water is the driving force for the turbine. These turbines are used for moderate head applications. These turbines are reaction turbines.

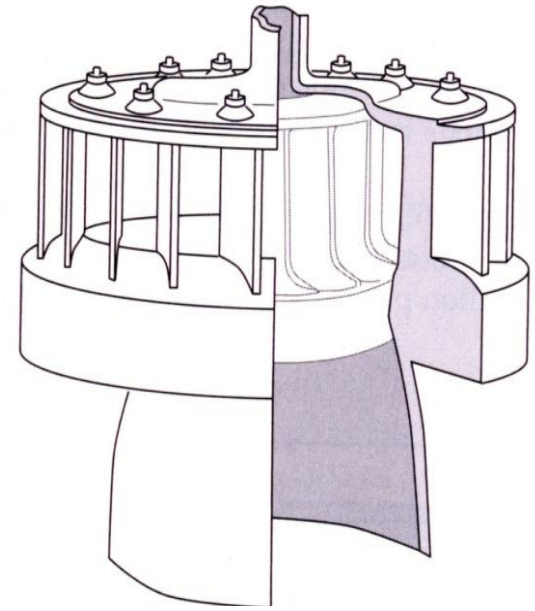

Figure.4: Geometry of the Francis Turbine

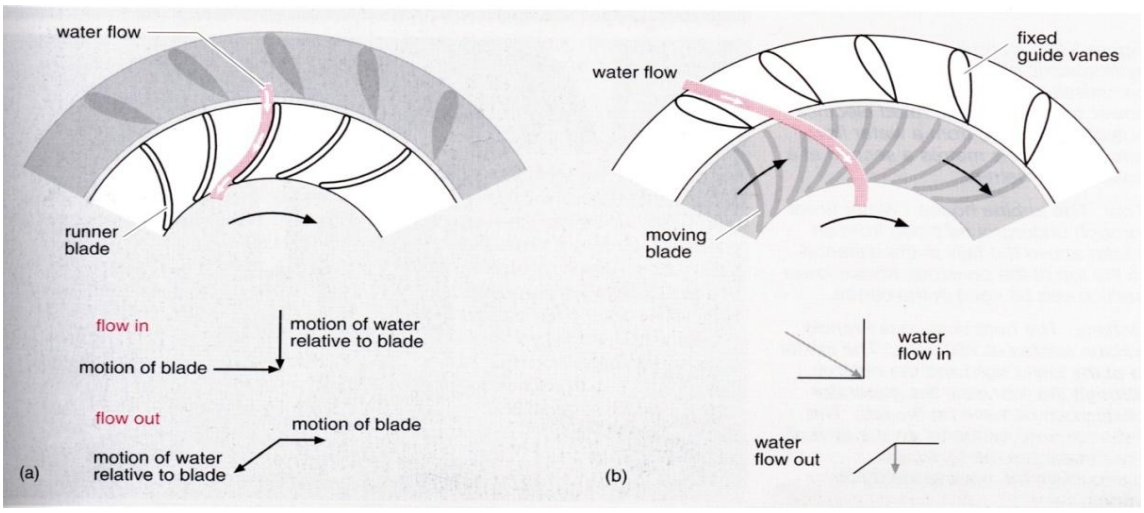

Figure.5: Geometry of the Francis Turbine with Water Flow

High Head Power Generation

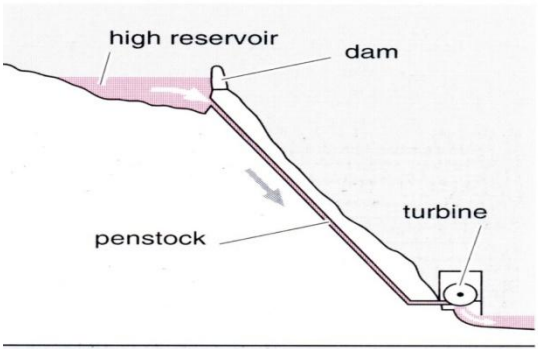

Figure.6: High Head Hydroelectric Generators

Pelton Water Wheel turbines are used for the high head hydroelectric power generation. I.e. the elevation of the reservoir & the elevation of the outlet river are at different level & the elevation difference is more than 250 meters. In such cases potential energy of water is the driving force for turbine. These turbines are used for high head applications. These turbines are impulse turbines.

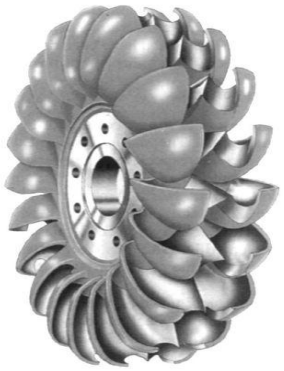

Figure.7: Geometry of Pelton Turbine

Jets of water are directed through a nozzle onto Pelton wheel. Cups on the wheel transfer kinetic energy from water to wheel.

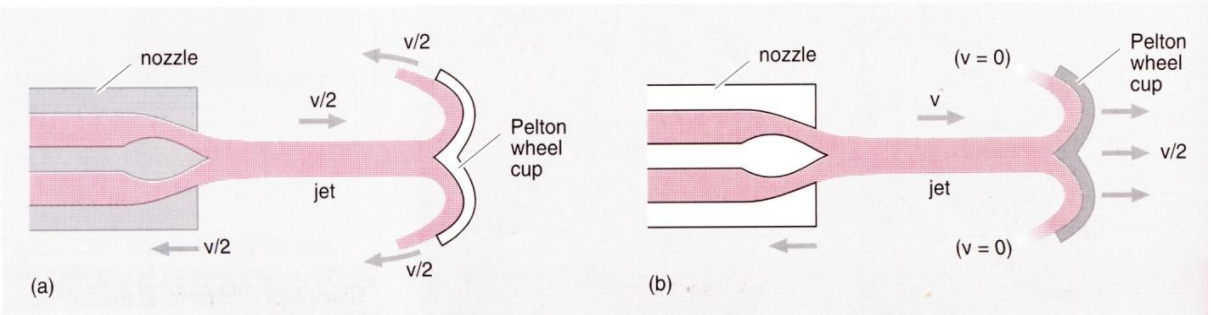

Figure.8: Water Jet hitting Pelton Turbine

Optimization of Hydroelectric Turbine

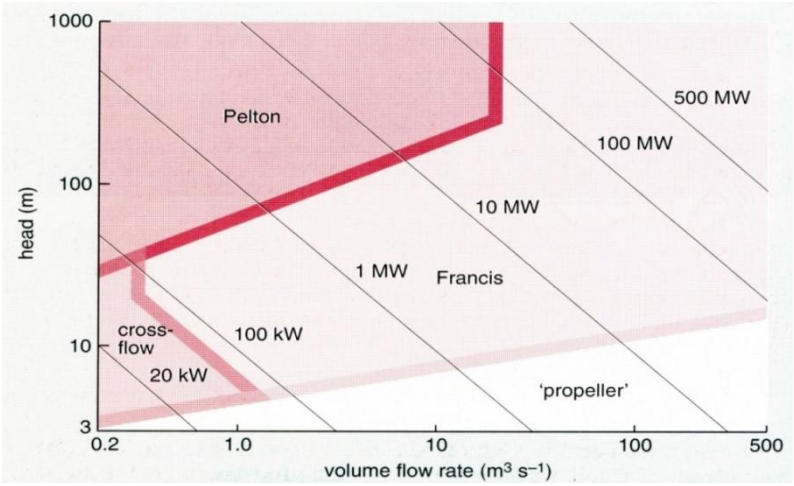

Figure.9: Graph of Head Vs Volumetric Flow Rate

Hybrid Hydroelectric Power Plant

The Hybrid Hydroelectric Power Plant is the new concept, the experts are thinking in. In this concept the operation of the whole plant is as it is; the only difference is that in a existing hydroelectric power plant, the water after passing over the turbine, released into the further river line whereas in case of hybrid hydroelectric power plant, the water after passing over the turbine in a power house, released into the further river line & taken back into the inlet reservoir with the help of big pumps so that it can be again utilized for the power generation. In this way the water is recycled back into the system. This system is brought into existence whenever there is a scarcity of water & the rivers on which it is to be built is not flowing for throughout the year.

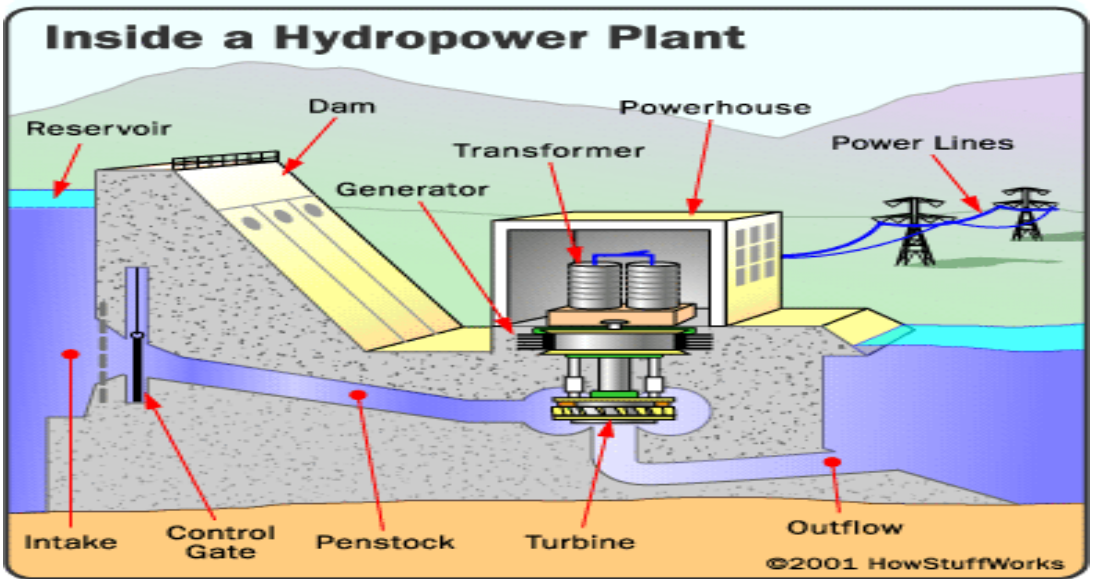

Figure.10: Layout of Hybrid Hydroelectric Power Plant

Environmental Impacts of Hydroelectric Power Plant

1. Silt buildup fills reservoir
2. Fish migration disrupted
3. Water temperature decreases
4. Water gets more saline
5. Water loses oxygen
6. Water slows down, increases disease
7. Water traps pollution, slows pollution flushing

8. Induced seismicity may occur

Conclusion

It is concluded that the hybrid power generation power plants are boon to the society especially in India if come into existence because there is a scarcity of the water in the most parts of the country. Also the rivers flowing throughout the year are very few in India, in these situations these plants will prove to be of great importance to mankind.

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Development of Mathematical Model for Stationary Compression Ignition Engine Performance Analysis

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ABSTRACT:
Internal combustion engine performance analysis is having common objectives of obtaining highest efficiency and minimum possible environmental degradation. In the present work, modeling is done for determining the relationship between operating variables of a stationary compression ignition engine performance enhancement. Load on engine, engine speed, gravitational acceleration or engine location, backpressure on engine and fuel consumption are taken as main operating variables. Dimensional analysis technique is used for reduction of variables, for the specific engine operating conditions. Backpressure is generated on a C.I. engine with the use of a specially designed diesel particulate filter. Value of correlation coefficient between observed data and computed data from the mathematical model is found satisfactory. The backpressure acting on engine is found to be most important controllable operating parameter of the engine. It is found to be a key factor which basically deteriorates the engine and emission control performance. The present work shows vital scope for improvement of operating performance of internal combustion engine by optimization of the model formed.

Keywords: Engine performance; Diesel particulate filter; Experimental data based model.

INTRODUCTION:

A need of comprehensive model development is always felt in every system performance analysis. The theory of experimentation is a good approach of representing the response in terms of proper interaction of various inputs involved in any phenomenon. In fact it is felt that such an approach is not yet seen towards research on I.C. engines. This approach finally establishes an experimental data based model for the phenomenon. Stationary class of internal combustion engine includes mainly diesel engines because of higher energy efficiency and output power. In this complete process three crucial steps viz. planning, operation and data analysis are adopted [1]. In experimental planning step study of instruments to be used for precision and accuracy errors is done. Due thought is given for replication of readings against constant inputs for better accuracy. Careful examination of the independent and dependent variables, using dimensional analysis for possible reduction in their number is also carried out. Selected independent variables are spaced and the proper sequence is followed in setting each point in turn. During the experimentation conventional plan of experimentation is followed by fixing the location at Nagpur in India. During experimentation due care is taken for extraneous variables. In the step of operation, it is necessary to evolve physical design of an experimental set up having provision of setting test points, adjusting test sequence, executing proposed experimental plan, provision for necessary experimentation for noting down the responses is done. Experimental set up is arranged as there is not much scope for design except putting engine systems together. The range for independent variables is selected properly within the test envelope as proposed in the experimental plan. Sufficient data have been collected and this data is converted in the usable form for analysis purpose by observing complete data set. In the final step of data analysis qualitative as well as quantitative approach is used.

1. REDUCTION OF VARIABLES:

There are several quite simple ways to make a given test compact in operating plan without losing generality or control. The best known as well as most powerful tool is dimensional analysis. In the past dimensional analysis was primarily used as an experimental tool whereby several experimental variables could be combined to form one. Using this principle modern experiments can substantially improve their working techniques and be made shorter requiring less time without loss of

control. Deducing the dimensional equation for a phenomenon reduces the number of variables in the experiments. The exact mathematical form of this dimensional equation is the targeted model. Experimental data based modelling of operating variables for determination of dimensionally homogeneous equations is achieved by applying Buckingham's Pi theorem. In this work for internal combustion engine performance analysis almost all the possible variables are considered.

After critical study of different variables only operating variables for specific C.I. engine are selected for performance analysis. Engine performance is basically dependent on fuel consumption rate, which bears direct influence on efficiency and engine out emissions. Fuel consumption rate is a basic dependent variable. It is an important parameter of an engine. It depends on all the engine variables such as engine design, its operating conditions, fuel composition and after treatment system used.

More efforts are required on the development of the after treatment system by further study of the theory of operation in each component used in exhaust system of I.C. engines. Future modifications must be done in such a way that each alternation should not cause backpressure rise. Finally, careful analysis of application environment and more stress is required for the fulfilment of durability requirements that is mainly on catalyst reactivation or replacement techniques development [14, 15, 16, and 17].

Gravitational acceleration (g) is also an independent variable. The gravity of earth refers to the acceleration that the earth imparts to objects on or near its surface. Earth's gravitational force is often modelled as though the earth is an inert sphere of uniform density. Such a body would produce a field of uniform magnitude and direction at all points on its surface. In reality, there are slight deviations in both the magnitude and direction of gravity across the surface of the earth. The net force exerted on an object due to the earth called apparent gravity or effective gravity varies due to the presence of other forces. A scale or plumb bob measures only this effective gravity. The strength of earth's apparent gravity varies with latitude, altitude, local topography and geology.

Finally in this analysis the fuel consumption (F_c) of four stroke single cylinder C.I. engine during a test run is considered as dependent upon load (l_d), speed (N), back pressure (p_b) on the engine and gravitational acceleration (g). Using Buckingham`s Pi theorem.

The fuel consumption (F_c) depends upon (I) l_d, (II) N (III) p_b and (IV) g, hence F_c is a function of l_d, N, P_b and g.

Mathematically,

$$F_c = f(l_d, N, P_b, g) \quad \text{---------- (I)}$$

Or it can be written as

$$f(F_c, l_d, N, p_b, g) = 0 \quad \text{----------(II)}$$

Therefore, total no of variables, n = 5, number of fundamental dimensions, m = 3

(m is obtained by writing dimensions of each variables as $F_c = MT^{-1}$, $l_d = MLT^{-2}$, N=T^{-1}, $P_b = ML^{-1}T^{-2}$& g = LT^{-2}. Thus the fundamental dimensions in the problems are M, L, and T hence m = 3).

Therefore the number of dimensionless Pi terms = n - m = 5 – 3 = 2

Thus, two Pi terms say π_1, π_2 are formed, hence equation (II) is written as

$$f(.\pi_1, \pi_2) = 0 \quad \text{---------- (III)}$$

Here m is equal to 3 and also called repeating variables. Out of five variables F_c, l_d, N, P_b and g, three variables are to be selected as repeating variables F_c is a dependent variables and should not be selected as repeating variables. Out of 4 remaining variables the variables l_d, N, and P_b are selected as repeating variables. The variables themselves should not form a dimensionless term and should have themselves fundamental dimensions equal to m = 3 here. Dimensions of l_d, N, and P_b are MLT^{-2}, T^{-1}, and $ML^{-1}T^{-2}$,, hence the 3 fundamental dimensions exist in l_d, N, and P_b and also they themselves do not form dimensionless group.

Each π- term is written as according to the equation,

$$\pi_1 = {l_d}^{a_1} * N^{b_1} * {P_b}^{c_1} * F_c$$

$$\pi_2 = {l_d}^{a_2} * N^{b_2} * {P_b}^{2} * g \quad \text{---------- (IV)}$$

Each л - term is solved by the principle of dimensional homogeneity.

For the π – term π_1, we have,

$$\pi_1 = M^0 L^0 T^0$$
$$= (MLT^{-2})^{a_1} (T^{-1})^{b_1} (ML^{-1}T^{-2})^{c_1} MT^{-1}$$

Equating the powers of M, L and T on both sides, we get

Power of M, $0 = a_1+c_1+1$, $a_1+c_1 = -1$ ---------- (i)

Power of L, $0 = a_1 - c_1$ ---------- (ii)

Subtracting equation (ii) from (i),

$c_1 = -\frac{1}{2}$ By putting this value in equation (i), $a_1 = -\frac{1}{2}$

Powers of T, $0 = -2\,a_1 - b_1 - 2\,c_1 - 1$, $-1 = 2\,a_1 + b_1 + 2\,c_1$ ----------(iii)

Putting values of a_1 & c_1, we get, $2\,(-1/2) + b_1 + 2\,(-1/2) = -1$

$-1 + b_1 - 1 = -1$,

$b_1 = -1 + 2 = 1$ ----------(iv)

Substituting the values of a_1, b_1, and c_1 in equation (IV),

$$\pi_1 = \frac{N * F_c}{\sqrt{P_b * l_d}}$$

$$\pi_1 = {l_d}^{\frac{-1}{2}} * N^1 * {P_b}^{\frac{-1}{2}} * F_c$$

$$n_2 = {l_d}^{a_2} * N^{b_2} * {P_b}^{c_2} * g = M^0\,L^0\,T^0 = (MLT^{-2})^{a_2}\,(T^{-1})^{b_2}\,(ML^{-1}T^{-2})^{c_2}\,LT^{-2}$$

Equating the powers of M, L, and T on both sides, we get

Power of L, $0 = a_2 + c_2$

Power of M, $0 = a_2 - c_2 + 1$, $c_2 = \frac{1}{2}$ $a_2 = -\frac{1}{2}$

Power of T,

$0 = -2a_2 - b_2 - 2c_2$,

$0 = 1 - b_2 - 1$, $b_2 = 0$

Substituting the values of a_2, b_2 and c_2 in equation (IV),

$$\pi_2 = {l_d}^{\frac{-1}{2}}\,N^0\,{p_b}^{\frac{1}{2}}\,g \qquad \pi_2 = \frac{g*\sqrt{P_b}}{\sqrt{l_d}}$$

Substituting the value of л- terms in equation (III),

$$f\left(\frac{N * F_c}{\sqrt{P_b * l_d}}, \frac{g * \sqrt{P_b}}{\sqrt{l_d}}, \right) = 0 \quad or \quad \left(\frac{N * F_c}{\sqrt{P_b * l_d}}\right) = f\left(\frac{g * \sqrt{P_b}}{\sqrt{l_d}}\right)$$

2. EXPERIMENTATION

The adopted procedure during experimentation is briefly discussed here. Single cylinder, four stroke stationary, naturally aspirated C.I. engine and tested diesel particulate filter are selected for the experimental task. A naturally aspirated C.I. engine, that is, intake pressure remains constant. In stationary engine operating parameters like load factor can be easily controlled since other factors air resistance, road resistance and vehicle weight are absent. Also value of gravitational acceleration (g) is assumed to be constant because of fixed engine location. Throughout the complete trials conducted, engine jacket cooling water and speed is kept constant at 0.1666×10^{-3} m^3/sec and 1500 rpm respectively. Backpressure on engine is controlled for the analysis of this factor on engine performance. Perforated circular copper plates arrangement in diesel particulate filter is used as a test piece for backpressure variations. During the trials on DPF each times the fresh perforated plates and rings are used. The different parameters are kept at the planned level for the different engine output conditions. Five numbers of load variations and 100 numbers of backpressure variations are observed. Thus total 100 numbers of fuel consumption rates as response variable are obtained keeping other parameters constant each time. Causes of errors or the deviations in tests may be a result of the lack of control in holding the variables at their planned levels or simple lack of precision in the measurements. Each observation is taken when the engine setup reaches at steady state condition to minimize the error.

Engine specifications:

1) Make: Kirloskar, single cylinder four stroke Naturally aspirated C. I. engine
2) Rated power output: 5 H.P
3) Stroke length: 110 mm
4) Bore diameter: 80mm
5) Loading type: Water resistance type load, with copper element and load changing arrangement
6) Moment arm: 0.2 meter
7) Orifice diameter (for air box): 25mm
8) Co-efficient of discharge of orifice: 0.64

Tested diesel particulate filter specifications:

1) Space velocity: 50,000 hr^{-1}
2) Catalyst used: copper based catalyst system
3) Circular perforated copper plates with 256 numbers of holes per square cm and copper rings made up of 5 mm diameter rod.
4) Flange arrangement for dismantling and varying number of perforated plates and number of rings (see appendix figure: 1).

4. DEVELOPMENT OF EXPERIMENTAL DATA BASED MODEL

One independent Pi term (viz. π_2) and one dependent Pi term (viz. π_1) have been identified in the design of experimentation. These Pi terms are available for the model formulation. Dependent Pi term is assumed to be the function of the available independent Pi term. The data of the independent and dependent parameters of the system has been gathered during the experimentation. It is necessary to correlate quantitatively independent and dependent Pi term involved in this man-machine system. This correlation is nothing but a mathematical model as a design tool for engine system performance analysis. The optimum values of the independent Pi terms can be further decided for optimization of this model for maximum efficiency with due considerations for the constraints in each engine application.

4.1. Development of model for dependent Pi term (π_1) :

From the analysis of Pi terms, π_1= f (π_2)

Where f stands for "function of"

A probable exact mathematical form for this phenomenon could be

$$\pi_1 = K_1 * (\pi_2)^{a_1} \qquad 1.1$$

Equation (1.1) is one of the most important and general relations assumed in scientific work and common functional relationship obtained as a result after applying dimensional analysis technique.

There are two unknown terms in the equation 1.1, viz. constant of proportionality K_1 and index a_1. To get the values of these unknowns minimum two sets of values of π_2. As per the experimental plan in design of experimentation, 20 set of these values are obtained. If any arbitrary one set from this data is selected and the values of unknowns K_1 and a_1 are computed. Then it may not result in one best unique solution representing a best-fit unique curve for the remaining set of the values. To be very specific to find out ${}^{n}C_{r}$ combinations of r sets taken together out of the available n set of the values. Solving these many sets and finding their solutions will be a herculean task. Hence it was decided to solve this problem by curve fitting technique. To follow this method it is necessary to have the equations in the form as given below.

$$Z = a + b * x + c * y + d * z \qquad 1.2$$

The equation 1.1 can be brought in the form of equation 1.2, by taking the log of both sides of this equation,

$$\text{Log } (\pi_1) = \log K_1 + a_1 * \log (\pi_2) \qquad 1.3$$

Let, log (π_1) =Z_1, logK_1 = K_1', log (π_2) = A,

Then the equation 1.3 can be written as

$$Z_1 = K_1' + a_1 * A \qquad 1.4$$

Equation 1.4 is a regression equation of Z on A, an n-dimensional co-ordinate system this represents a regression hyper-plane.

$$\Sigma Z_1 = nK_1' + a_1 * \Sigma A$$

$$\Sigma Z_1 * A = K_1' \Sigma A + a_1 * \Sigma A * A \qquad 1.5$$

Where n is the number of runs or the number of sets of these values.

These equations are called normal equations corresponding to the equation 1.4 and are obtained as per the definition. In the above sets of equation the values of the multipliers of K_1'and a_1 are substituted to compute the values of the unknowns (viz. K_1'and a_1). The values of the terms on L.H.S. and the multipliers of K_1'and a_1 in the sets of equation 1.5 are calculated. After substituting these values in the equation 1.5, one set of equation to be solved simultaneously, to get the values of K_1'and a_1 are obtained.

The matrix method of solving these equations using 'MATLAB' is given below.

Let, A = 2x2 matrix of the multipliers of K_1'and a_1

B = 2x1 matrix of the terms on L.H.S. and

C = 1x2 matrix of solutions or values of K_1'and a_1

Then, C=INV (A)*B 1.6

It gives the unique values of K_1'= - 0.0713 and a_1= - 2.2906, from K_1' the value of K_1 = 0.931182, is calculated.

Therefore, model of experimental data based modelling for I.C. engine operating performance analysis is formed as given below

$$\pi_1 = 0.931182 * (\pi_2)^{-2.2906}$$

Observed values and computed values with the help of this model formed are calculated.

5. COMPUTATION OF THE PREDICTED VALUES BY ANN

One of the main issues in research is prediction of future results. The experimental data based modelling achieved this through mathematical model for the dependent Pi term. In such complex phenomenon involving non-linear systems it is also planned to develop model using artificial neural network (ANN). The output of this network can be evaluated by comparing it with observed data and the data calculated from the mathematical model. For development of ANN the designer has to recognize the inherent patterns. Once this is accomplished training the network is mostly a fine-tuning process.

6. RESULTS AND DISCUSSIONS

The experimental data has been converted into the interpretable form. It is now necessary to analyze this data to draw some logical results.

6.1. Qualitative analysis of the data: In order to justify how the real phenomenon always results on account of appropriate interaction of independent Pi term, an attempt is made here as discussed below.

It is possible qualitatively to evaluate the behavior of any model through graphical representation. This method is adopted here for qualitative analysis of C.I. engine operating performance analysis.

After the model is formed for the dependent Pi term the values of the dependent Pi term are computed. Looking at the small variation in the values of these terms for plotting the variation of the dependent Pi term with the independent Pi term the values are calculated. Thus, for the engine test there are 20 set of readings of independent Pi term and computed values of dependent Pi term. Graphic plot as shown in appendix graph: 1 represents the variation of a dependent Pi term with the independent Pi term. In the graph: 1, the variation obtained is of certain complexity. In view of logic stated by J. P. Modak, it can be said that this activity involves different mechanisms which are equal to twice the number of observed peaks [18]. In the graph: 1, about twenty major peaks are observed meaning that about forty mechanisms are involved in this activity. Since a dependent Pi term is plotted against the independent Pi term (π_2), which is in turn products of the second, fourth and fifth variables. It is very difficult to put forth the basic physics of this phenomenon. This can be one possible offshoot for the future research. It is therefore recommended that the subsequent investigators should study this phenomenon between each of these peaks (nodal points) so that the exact variation between these various parts can be understood. It can be seen from the graph:2, that there is a similar trend of variation of engine performance parameters fuel consumption rate, brake thermal efficiency, air-fuel ratio and filtration efficiencies corresponding to the variation of the independent variables (viz. backpressure on engine). Thus qualitatively it is observed that the behavior of the model is very complex.

6.2. Quantitative analysis of the data: Data analysis from the indices of the model is the indicator of how the phenomenon is getting affected because of the interaction of various independent variables in the model. Here, the influence of index of the independent Pi term on dependent Pi term (computed from the model) for the experimental data based model is given below.

$\pi_1 = 0.931182 * (\pi_2)^{-2.2906}$ ---------- (1.7)

The deduced equation for this Pi term is given by $\pi_1 = \frac{N * F_c}{\sqrt{P_b * l_d}}$ ---------- (1.8)

It can be seen from the equation (1.8) that this is a model of a Pi term containing fuel consumption rate as a response variable. The following primary conclusions appear to be justified from the above model.

i) The absolute index of Pi_2 is 2.2906. The actual value is negative indicating Pi_1 is inversely varying with respect toPi_2, thus this value of index shows the exact influence of Pi term in this model.

ii) The constant of this model is approximately equals to one (viz. 0.931182). This means the overall effect of this constant is almost the same as

that of the actual value computed with the help of model.

iii) It is observed that the value of numerator (viz. product of N and F_c,) of equation (1.8) varies between 0.005571 and 0.010617 and the value of denominator (viz. square root of the product of l_d and P_b) of equation (1.8) varies between 128.132270 and 340.044445. These values after calculation are less than one and again bring the compression effect in the model, observing the behavior of fuel consumption with respect to independent variables.

This model is developed from the sample of only 20 set of the independent Pi term. Further in this case the values of four independent variable can be varied (viz. l_d, N, P_b, g), out of these four only two independent variables is varied, as the other two values of the independent variables are kept unchanged during experimentation. Qualitatively the computed values differ from the actual observed values of the dependent Pi term. Thus, the real behavior of the formulated model is clear from the available set of the data, but for specific engine setup and observed data range only.

6.3. Justification of the behavior of the model: The influence analysis has demonstrated certain trend for the behavior of the model this trend has to be justified through some possible physics of the phenomenon is attempted here. Equation for the independent Pi term is given below.

$$\pi_2 = \frac{g*\sqrt{p_b}}{\sqrt{l_d}} \qquad \text{---------- (1.9)}$$

The above independent Pi term has been considered in the model formed. To understand the behavior of the model the equation is critically analysed here. The only one influencing Pi term is Pi_2 . If the numerator of equation (1.9) is examined, from this some functional parameter ($g * \sqrt{p_b}$) is observed. Also if the denominator of equation (1.9) is examined, from this some functional parameter ($\sqrt{l_d}$) is observed. Backpressure and load on engine are the parameters varied during the experimentation. Gravitational acceleration (g) is a term relating to engine location, is constant. The model under consideration has a constant (viz.k_1) known as the curve fitting constant. This constant collectively in an integrated way represent the influence of some of the variables which do influence the phenomenon but which were not actually varied during the experimentation or which could not be varied in known way. Such independent variables are known as extraneous variables in the theory of experimentation [1]. If it is the case, in fact in future work either such independent variables should be identified and measured, so that the model which would then be formed, will have different values of these curve fitting constants. These constants will then be representing in an integrated way the effect of less number of uncontrolled or extraneous variables. In this case of experimental data based model for I.C. engine operating performance the value of k_1 is almost unity, so extraneous variables effect is almost negligible.

6.4. Analysis of performance of the model: The model has been formulated mathematically as well as using the ANN. The values computed by the mathematical model for the independent Pi term match very well with the observed values. In this model of I.C. engine operating performance analysis for the dependent Pi term (Pi_1) the computed value of the correlation coefficient is -0.8874. This value is calculated by using the MS excel. The correlation coefficient can further be improved by increasing the sets of the observations. The network developed for this model using the MATLAB has been successfully used for computation of the dependent Pi term for a given set of the independent Pi terms. The value of the R squared error is 0.098, which is well within the acceptable limits. The performance is stabilized only after the 9 iterations as shown in the graph: 7a. The value of the regression coefficient for the dependent Pi term (Pi_1) is 0.937 as shown in the graph: 3c.

7. CONCLUSION

From the above said work on I.C. engine operating performance analysis and model of the same, the following conclusions appear to be justified.

a) Only one model developed for I.C. engine operating performance analysis containing the response variable 'fuel consumption' is found to be effective from engine as a system consideration.

b) Model of I.C. engine operating performance analysis the value of regression coefficient for the observed data and the response predicted or computed from the ANN model seems to be fairly high. The response data generated by the ANN model is found to be similar to the one developed by the mathematical model. This gives the authenticity to the response predicted.

c) In this model (equation 1.7) when, a total range of the average change of 0.73 % is introduced in the value of independent variable backpressure on engine a change of about 0.24 % occurs in

dependent Pi term Pi_1 (value computed from the model). Also when a total range of the average change of 80 % is introduced in the value of independent variable load on engine a change about 2.34 % occurs in Pi_1(value computed from the model). It can be seen that highest change takes place because of change in the independent variable backpressure on engine, whereas the least change takes place due to the value of independent variable load on engine. Backpressure on engine is the most sensitive independent variable and load on engine is the least sensitive independent variable. Thus, from the study on model of 'fuel consumption' it is found that the influence of term relating to engine operating variables effect of controllable variable backpressure (viz. P_b) is predominant over load factor (viz. l_d). In old as well as modern internal combustion engines for optimum use of after treatment strategies, minimum possible backpressure on the engine is the key factor for effective emission control and waste energy recovery.

d) The model for the phenomenon truly represents the degree of interaction of various independent variables. This is only made possible by the approach adopted in this investigation.

Limitations of the present work: The adopted model of this study model is formulated for the single cylinder, four stroke C.I. engine, the engine is stationary so location and hence operated in controlled environment. Hence whether the adopted model can be applied directly to other environmental conditions and other type of engine applications is doubtful unless it is tested. As the working environment can be controlled in the laboratory setup whether the observed response is on the lower or the higher side could not be predicted. The ANN performance depends on the training. The ANN is unable to predict beyond the range for which it has been trained.

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APPENDIX

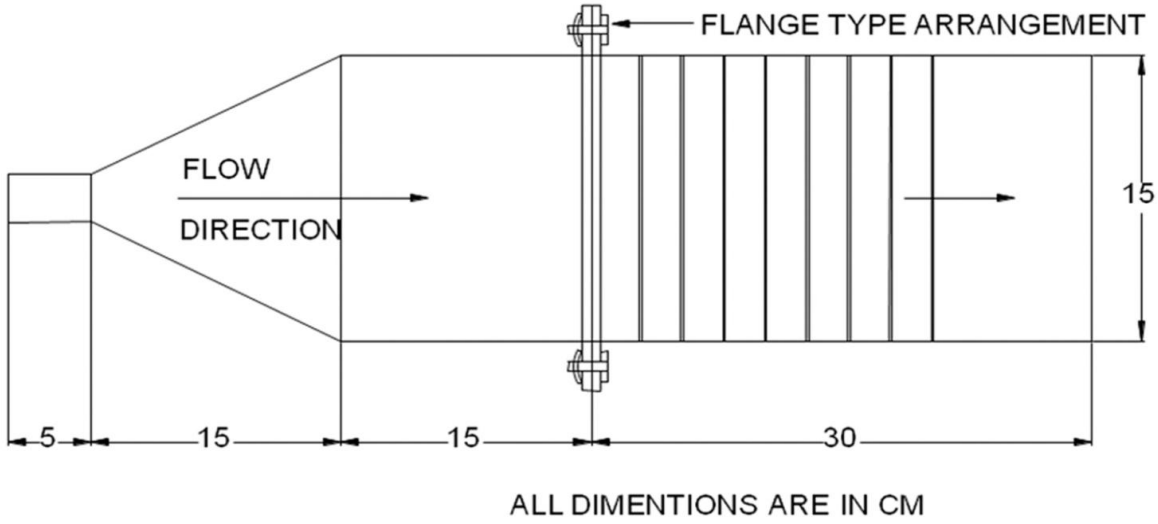
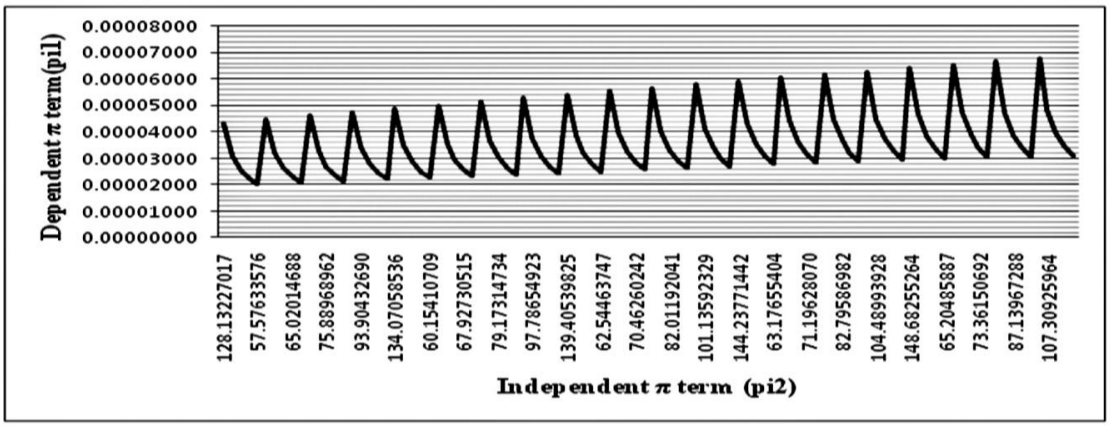
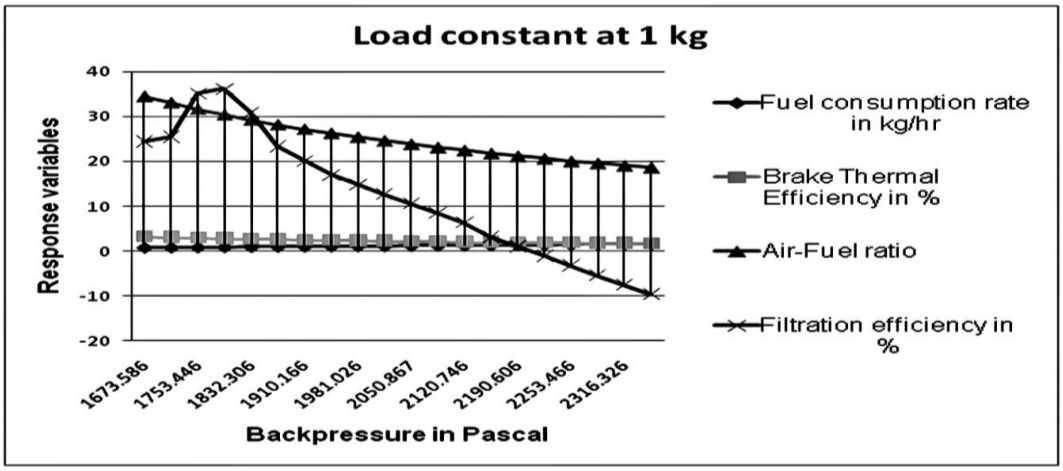


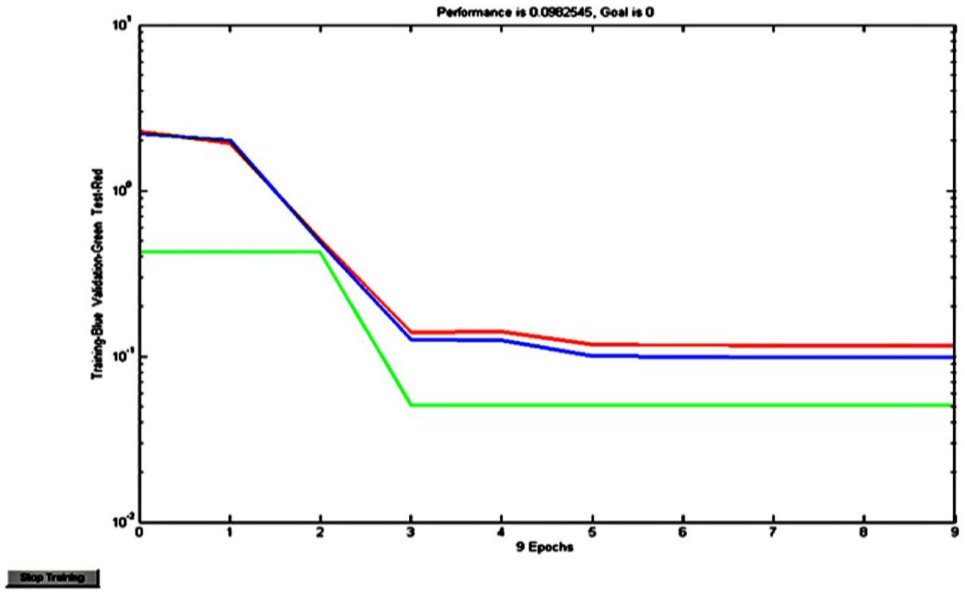
Figure 1: Tested Diesel Particulate Filter



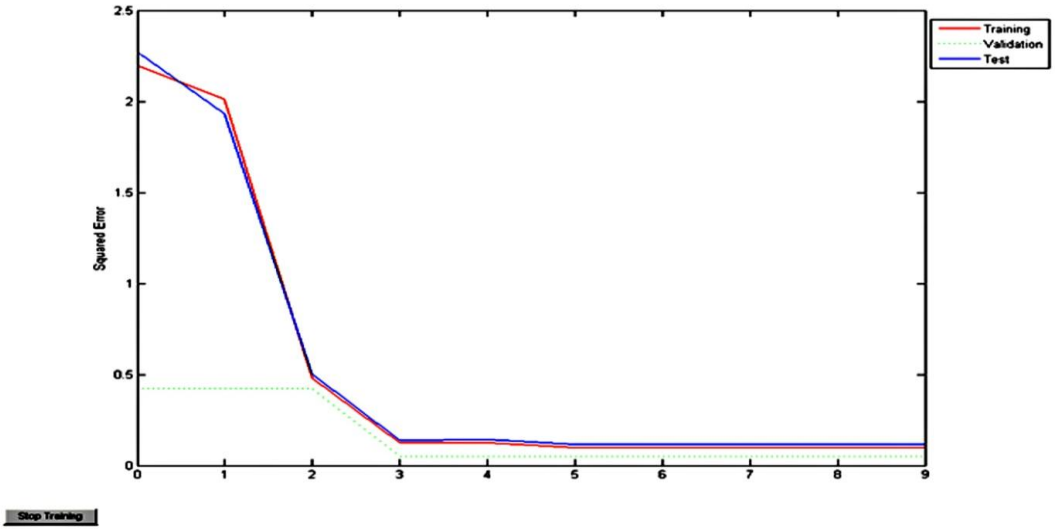
Graph :1 :Variation of dependent Pi term (π_1) versus independent Pi term (π_2)



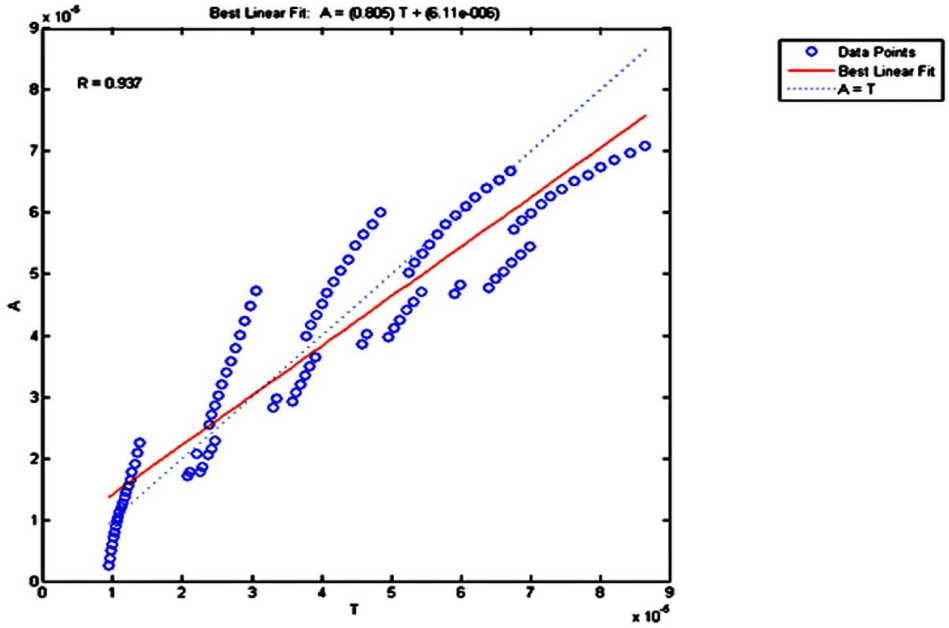
Graph 2: Variation in fuel consumption rate, brake thermal efficiencies, air-fuel ratio and filtration efficiency Vs back pressure, with tested diesel particulate filter using different number of plate arrangement.



Graph 3a: Performance analysis of ANN for dependent Pi term Pi_1.



Graph 3b: Comparison of actual and computed data by ANN for dependent Pi term Pi_1.



Graph 3c: Performance analysis of ANN for dependent Pi term Pi_1.

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Perspectives and Challenges of Hydrogen Storage by Metal-Organic Frameworks

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Abstract:
A potential solution to develop clean and low-carbon future, replacing fossil fuels with zero-carbon energy systems, such as hydrogen energy systems which uses sunlight, wind, geothermal & heat. Mostly these sources are environmentally favorable, but they are not supplemental enough on their own. It is strongly believed that as alternative renewable energy source, hydrogen energy can help to address the growing demand for energy and slow down global climate because it is environmentally clean, abundant in nature and shows higher gravimetric energy capacity compare to other energy sources.
Although the field of high surface area materials is considered very mature, the need for improved materials for alternative energy applications remains challenging. Currently zeolites, metal oxides, and activated carbons dominates the market, but more advanced materials required for a variety of applications.
Metal organic frameworks (MOFs) are a relatively new class of nanoporous materials that show promise for several energy and chemical engineering applications. At this point Metal-organic frameworks (MOFs), are currently emerging as ideal candidates for hydrogen storage due to their goal directed structures, high thermal stabilities, adjustable chemical functionalities and ultrahigh surface areas. They are basically built with rigid organic legends linked to metal or metal containing clusters.
In this review, a brief summary of the current status of porous MOFs for hydrogen storage, its perspectives and challenges for future energy sources, storage and other gas separation applications were studied.

Key Words: Metal organic framework, Hydrogen, Porosity, Energy storage, Physisorption

1. Introduction:

With the continuous growth of economies and increasing demand for replacing fossil fuels, clean energy has become one of the main challenge. Hydrogen is an ideal clean energy carrier because of its abundant availability, clean burning qualities, and its potential for domestic production from e.g. renewably produced electricity and water. Moreover, its high energy density (at STP, hydrogen is a gas with density of 0.089 gm/lit.), which is nearly triple that of gasoline per unit mass, makes it an attractive energy carrier. However, the extremely low volumetric storage density of hydrogen presents a barrier that limits its practical usage as a fuel for vehicles [1, 2].
For board use, hydrogen can be compressed to very high pressures or stored cryogenically. The storage of hydrogen in liquid or gaseous form is an important safety concerns for board transport applications. Therefore, it is desirable to design safe, light-weight and low-cost materials that can reversibly and rapidly store hydrogen near ambient conditions at a density equal to or greater than that of liquid hydrogen. Table- 1 shows the properties of hydrogen compared with those of some common fuels [3]:

Properties	Hydrogen	Petroleum (Gasoline)	Methane	Methanol
Boiling point (^{0}K)	20.3	350–400	111.7	337
Liquid density at B.P. (kg/m^3)	70.8	~ 700	425	797
Gas density at STP (kg/m^3)	0.08	~ 4.7	0.66	---
Vaporization heat (kJ/kg)	444	~ 300	577	1168
Combustion heat (MJ/ kg)	120	44.5	50.0	20.1
Combustion heat (liquid fuel) (MJ/ m$^{3)}$	8960	31170	21250	16020
Ignition temperature (in Air) (^{0}K)	858	495	807	658

Table- 1: Properties of hydrogen compared with those of some common fuels

Metal-organic frameworks (MOFs) can store nano scaled objects and make them available for various applications. For this reason, they are of particular interest in many research areas, including materials science, biology, and medicine. MOFs are highly ordered molecular systems, consisting of metal nodes and organic rods. The pores in these frameworks are freely accessible. MOFs are used in powder form to store hydrogen and other small molecules, such as carbon dioxide or methane. Metal organic frameworks (MOFs) are a unique class of crystalline porous solids that have been studied extensively for a number of applications, including gas storage, gas separation, heterogeneous catalysis, and so on. Generally, metal-organic frameworks are constructed by assembling metal atoms or small metal-containing clusters, referred to as the secondary building unit or SBU, with multi dentate organic legends via coordination bonds [1, 4, 5, 6].

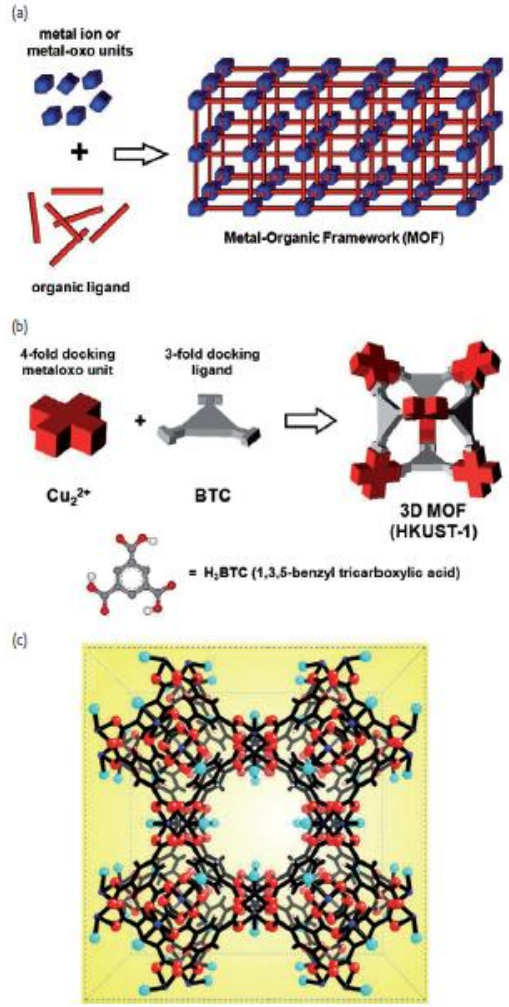
2. Fundamental study of hydrogen storage by physisorption

Besides metal hydrides, highly porous solids that can retain hydrogen by physical adsorption (Physisorption) are under active research as hydrogen storage materials. Since physisorption is a non-activated process, fast kinetics of adsorption and desorption, low heat of adsorption and being completely reversible. These are the main favorable characteristics of physical adsorbents. The major drawback is that physisorption is brought about by (weak) Vander Waals forces comprising dispersion, orientation and induction energy. In the absence of relatively strong polarizing centers, interaction between the adsorbent and the non-polar hydrogen molecules relies on dispersion forces, which are weak; typically of the order of 3-6 kJ /mol. Hence, significant hydrogen adsorption often takes place only at a cryogenic temperature [3, 7, 8].

Outstanding surface area and pore volume confers considerable potential to MOFs as prospective materials for hydrogen storage. And, in contrast to activated carbons, metal-organic frameworks have well-defined crystal structures; which results in a system of pores of uniform size (about 0.5 to 2 nm in diameter) for each particular material [3,9].

3. Synthesis of MOFs:

Different types of synthesis methods were applied in the literature for MOF materials. Among them are classical hydro (Solvo) thermal synthesis, microwave method, electrochemical synthesis, diffusion method, and ultrasonic method [9].
MOFs are synthesized under Solvo-or hydrothermal conditions in the presence of a base. The formation of MOFs is schematically shown in Fig 1 [a] and in more detail for the example of the MOF HKUST-1, in Fig. [b]. The fig. (c) shows the unit cell of the HKUST-1 MOF. The sizes of the largest pores in this particular MOF are 1.2 nm. Many MOFs are prepared in pure N,N-diethylformamide (DEF) or N,N-dimethylformamide (DMF), which are well known to undergo decomposition at elevated temperatures to slowly generate an amine base that deprotonates the organic functionalities of the linker and generates the metal-organic clusters [8,9,10].



Ref. [11]: Hartmut Gliemann et.al., Materials Today,Vol.15(3), March 2012
(Blue: copper; Red: oxygen; Black: carbon; Light blue: Oxygen of the associated water).

Figure-1: Synthesis scheme MOF
a)The scheme of the formation of a three-dimensional connection of a metal-oxo unit with organic legends to a MOF. b) Formation of the MOF HKUST-1 as an example c) The structure of a unit cell of HKUST-1.

The reactions are carried out either in glass in glass jars (1-10 g) sealed with Teflon lined caps to prevent solvent escape and corrosion of the caps. The reaction solutions are then heated to 50-250 ºC & crystalline materials are thus formed. Subsequently, the solvent is removed from the crystals. The crystals are submerged in a variety of low boiling, non- or weakly coordinating solvents (such as $CHCl_3$, CH_2Cl_2, methanol, ether) to extract DEF, DMF, and water from the pores of the material. Finally, the crystals are filtered from the solution and dried under vacuum at elevated temperature to completely evacuate the pores. Once the MOF is evacuated, it is likely to become air and moisture-sensitive, i.e. it may decompose or re-hydrate irreversibly in air. Some tips for maximizing the surface area of a MOF include using fresh DEF or DMF (which tend to degrade over time or upon exposure to air), filtration and sonication of the reaction mixture prior to heating, degassing of the reaction solvent with N_2, and certainly the proper activation (evacuation) procedure described above. Each of these steps can reduce crystal defects and enhance the surface area of the material [12,13,14].

The most important analytical techniques used in the characterization of new materials include surface area analysis by gas sorption, X-ray diffraction (XRD powder or single crystal), elemental microanalysis, IR, and thermo-gravimetric analysis (TGA) [8, 15].

4. Porosity of MOFs:

The porosity of MOFs is greater than that of any other porous material, double the record for porous carbon. The surface area of MOF-5 was initially reported at 2,900 m^2/g , but now MOF-5 can be activated to obtain 3,800 m^2/g. In such a material, 60% is open space, into which gases and organic molecules can be introduced [16].

Unlike other porous materials, MOFs have pores without walls; they are made entirely of struts and intersections. They are open scaffolds, where the struts or the intersections are sites for gas molecules to enter. That is the reason they have very high surface area, and this is the optimal way to create high surface area materials. MOF-177 had a surface area of 5500 m^2/g [16] by evacuating the pores completely. The surface areas of Zeolite is approximately 500 m^2/g, mesoporous materials of 1,000 m^2/g, and porous carbon, which is amorphous with 1,500 m^2/g surface area (2,000 m^2/g with some expensive processing). Now, using simple chemistry, we can obtain 5,500 m^2/g. MOFs can be shaped for various applications, including catalysis and gas separation [1, 9, 16, 17].

5. Hydrogen storage in porous MOFs:

Hydrogen storage is of great interest because hydrogen as a possible substitute for fossil fuels for zero-emission energy technology [16]. There are currently several storage systems for hydrogen including liquid or high-pressure H_2 gas like reversible metal hydrides, chemical hydrides, and porous adsorbents. The table-2 shows the few of them with their benefits and barriers for hydrogen storage. However, up to date none is capable of satisfying the criteria of size, recharge, kinetics, cost, and safety required for use in transportation.

H_2 storage Technology	Benefits	Barriers
Liquids Tanks	Well understood technology Good storage density possible	Very low temperature require super insulation; Cost can be high; Some hydrogen is lost through evaporation; Energy intensity of liquid hydrogen production; Energy stored still not comparable to liquid fossil fuels.
Compressed Gas Cylinders	Well understood up to pressure of 200 bar ;Generally available Can be low cost	Only relatively small amounts of H_2 are stored at 200 bar; Fuel and storage energy densities at high pressure (700 bar) are comparable to liquid hydrogen but still lower than gasoline and diesel; High pressure storage still under development.
Metal hydrides	Technology available; Solid-state storage; made into different shapes; Thermal effects can be used in subsystems; Very safe	Heavy; Can degrade with time; Currently expensive; Filling requires cooling circuit.
Carbon structures	May allow high storage density; Light & cheap	Not fully understood or developed

Table: 2- Benefits and barriers of hydrogen storage

Hydrogen storage is a problem that has been a focus of scientific research for decades. Each of these methods has its advantages and disadvantages, but all on-board storage technologies have to meet the requirements like safety, performance, cost, and technical adaptation for the infrastructure, scalability small and large vehicles [18].

The variety of methods have been investigated, although, none of these have accomplished the required performance level so far. Current methods for hydrogen storage can be broadly separated into: mechanical storage (storage in a tank of compressed gas or liquid hydrogen); Physisorption [19] (storage in a solid material) includes, Graphene and other carbon structures, metals and metallic nano-crystals and composites, metal-organic frameworks, zeolites; hydrogen: storage in solid or liquid material of chemically bound hydrogen that is released on decomposition, includes, light metal hydrides (alkaline hydrides), boro-hydrides, amines and imides [19,20].

Metal organic frameworks (MOFs) are a new class of porous materials with low density and high surface area. They are crystalline, infinite networks assembled by linking metal ions with various organic linkers through strong bonds. More recently, it was realized that some of them could be promising candidates for hydrogen storage. Table-2 shows the relevant data of some of the selected MOF at different pressure, surface area and H_2 uptake capacities of MOFs [3, 20].

Material	Surface Area (m^2/gm)	Pore volume (cm^3/gm)	H_2 uptake capacity (wt%)		ΔH^0 (kJ/ mol)
			77^0K	298^0K	
$Cu^2(*L^2)(H_2O)_2$	2247	1.08	6.1 (20 bar)	--	--
HKUST-1	2175	0.75	3.6 (10 bar)	0.35 (65 bar)	6.8
IRMOF-11	2180	--	3.5 (34 bar)	--	--
IRMOF-20	4580	--	6.7 (70 bar)	--	--
MIL-100	2800	1.0	3.28 (26 bar)	0.15 (73 bar)	6.3
MOF-5	4170	--	5.2 (48bar)	0.45(60 bar)	4.8
MOF-74	1132	0.39	2.3(26 bar)	--	8.3
MOF-177	5640	--	7.5(70 bar)	--	--
ZIF-8	1810	0.66	3.1 (55 BAR)	--	--

($*L_2$ = Terphenyl-tetracarboxylate).
Table-3 : Relevant data for some selected MOFs

6. Hydrogen- towards a sustainable energy future:

A major challenge facing our planet today related to the problem of anthropogenic driven climate change and the need of future energy. The technology of hydrogen energy will contribute significantly to a reduction in environmental impact, enhanced energy security and diversity and the creation of new energy industries [21]. However, the transition from a carbon-based (fossil fuel) energy system to a hydrogen-based economy involves significant scientific, technological and socioeconomic barriers to the implementation of hydrogen as the clean energy technologies [16,18, 22] of the future. Global drivers for sustainable energy vision of our future need to:

i) Reduce CO_2 emissions and improve air quality.
ii) Ensure security of energy supply.
iii) Create a new industrial and technological energy base, crucial for our economic prosperity.

7. Applications:

i) The vision of an integrated energy system of the future would combine large and small fuel cells for domestic and decentralized heat and electricity power generation with local hydrogen supply networks that would also be used to fuel conventional (internal combustion) or fuel-cell vehicles.
ii) Unlike coal, gas or oil, hydrogen is not a primary energy source. Its role more closely to that of electricity as an 'energy carrier', which first is produced using energy from another source and then transported for future use, where its stored chemical energy can be utilized. Hydrogen can be stored as a fuel and utilized in transportation and distributed heat and power generation using fuel cells, internal combustion engines or turbines, and, importantly, a hydrogen fuel cell produces only water and no CO_2 [2,16,23].
iii) Hydrogen can also be used as storage medium for electricity generated from intermittent, renewable resources such as solar, wind, wave and tidal power. It therefore provides the solution to one of the major issues of sustainable energy, namely the vexing problem of intermittency of supply. As long as the hydrogen is produced from non-fossil-fuel feed stock, it is a genuinely green fuel. Moreover, locally produced hydrogen allows the introduction of renewable energy to the transport sector, provides potentially large economic and energy security advantages and the benefits of an infrastructure based on distributed generation. It is this key element of the energy storage capacity of hydrogen that provides the link between sustainable energy technologies and a sustainable energy economy, generally placed under the umbrella term of 'hydrogen economy'[16].

8. Challenges:

In order to achieve the hydrogen economy, there are some obstacles that need to be overcome to make hydrogen a viable energy carrier. They are characterized by four main aspects of hydrogen use and some of these will be addressed here [18]:

i) **Production:** Since hydrogen needs to be produced, ideally from water, it is necessary to develop production methods that would consume the least amount of energy and provide ability to produce hydrogen renewably on a large scale.

ii) **Storage:** Fuel needs to be easily stored for use and transport, where one of the main requirements is that it is readily available, which requires not just short charge/discharge times, but also excellent control of charge/discharge process coupled with sufficient energy and gravimetric/volumetric density.

iii) **Power generation:** Once hydrogen is ready to be consumed, it is necessary to do so in the most effective way: the power generation system that uses hydrogen needs to be both efficient and, for mobile application, light weight.

iv) **Safety:** Hydrogen use and storage comes with some risks (flammability) which necessitate certain precautions and safety measures; another aspect related to this is environmental impact of the hydrogen cycle, which depends on the methods used to produce, store and use it.

Since hydrogen is thought to be a renewable fuel for the future, it is only appropriate that, when we consider all the challenges associated with its production, storage and use, we keep in mind that when we consider proposed systems, efficiency is only one of the factors that will determine the success of these systems. Other important aspects are production cost, durability, stability of

operation and safety, and these can, more than efficiency, determine the success or failure of any of the proposed solutions for a part of the hydrogen cycle.

For practical applications of hydrogen storage, the storage material should be rechargeable. H_2O is very difficult to be fully removed from commercial hydrogen sources. For practical applications, it is not economical to use super-high purity hydrogen for transportation because of the additional cost for purifying hydrogen. Thus, the H_2O adsorption characteristics and the structure stability upon H_2O adsorption are very important issues for a promising hydrogen storage material for practical applications. This is even more problematic for MOFs because MOFs decompose easily at elevated temperatures, indicating the instability of this type of material [14, 23]

9. Conclusion:

As a new class of functional materials, porous MOFs have exhibited great potential for energy-relatedapplications, ranging from gas storage to catalysis and from gas separation to fuel cell. Many MOFs can be synthesized easily and quickly at low cost; moreover, variations of MOF compositions and structures, including high aspect ratio MOFs, may be practically unlimited and the organic linkages provide a useful platform for chemistries that may improve adhesion to polymer matrices.

In the current state-of-the-art in hydrogen storage, no single technology satisfies all of the criteria required by manufacturers and end-users, and a large number of obstacles have to be overcome. At the present time, there are three major technological barriers that must be overcome for a transition from a carbon-based (fossil fuel) energy system to a hydrogen-based economy. i) First, the cost of efficient and sustainable hydrogen production and delivery must be significantly reduced. ii) Second, new generations of hydrogen storage systems for both vehicular and stationary applications must be developed. iii) Finally, the cost of fuel-cell [18] and other hydrogen-based systems must be reduced. Storage and transport of hydrogen constitutes a key enabling technology for the advent of a hydrogen-based energy transition. Main research trends on hydrogen storage materials, including metal hydrides, porous adsorbents and hydrogen clathrates, were reviewed with a focus on recent developments. There is a plenty of scope of this present work. It is of paramount importance to actually find the surface area, pore volume and pore size distribution of all the synthesized products. Additionally, newer mechanisms are required to be invented to improve the thermal and chemical stability of synthesized materials.

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STUDY OF SUSTAINABLE PRACTICES IN BRICK MANUFACTURING PROCESSES

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1. ABSTRACT:

The construction sector is an important part of the Indian economy. Clay fired bricks are the backbone of this sector. The Indian brick industry is the second largest producer of bricks in the world after China. India is estimated to produce more than 14000 crores of bricks annually, mainly by adopting age-old manual traditional processes. The brick sector consumes more than 24 million tonnes of coals annual along with huge quantity of biomass fuels. The per annum CO_2 emissions from Indian brick industry are estimated to be 42 million tonnes. Due to large scale construction activities in major towns and cities, a number of brick plants have been set up on the outskirts of these cities. These clusters are the source of local air pollution affecting local population, agriculture and vegetation. For the production of clay bricks, top soil to the extent of 350 million tonnes is used every year, which is a reason for concern.

Pulverized fuel ash commonly known as fly ash is a useful by-product from thermal power stations using pulverized coal as fuel and has considerable pozzolonic activity. This national resource has been gainfully utilized for manufacture of pulverized fuel ash-lime bricks as a supplement to common burnt clay buildings bricks leading to conservation of natural resources and improvement in environment quality. Various test are taken on different types of bricks available in market.flyash bricks can replace the conventional burnt clay bricks. The results obtained are very encouraging.

2. INTRODUCTION:

2.1What is sustainability?

Sustainability is defined as "*meeting the needs of the present without compromising the ability of future generations to meet their own needs*". Sustainable buildings are designed in a way that uses available resources efficiently and in a responsible manner, balancing environmental, societal and economic impacts to meet the design intents of today while considering future effects. Sustainably designed buildings are energy-efficient, water-efficient and resource-efficient. They address the well-being of the occupants by considering thermal comfort, acoustics, indoor air quality and visual comfort in the design. They also consider the impact of a building's construction, operation and maintenance on the environment, and the environmental impact of the building's constituent materials. A sustainably designed building considers all of these aspects through the entire life cycle of the building, including its operation and maintenance.

2.2 Efficient Use of Materials

How a building material is used also should be considered when examining the sustainability of a material. Brick masonry walls are able to perform multiple functions that often require several components in other wall systems. By designing walls that serve multiple functions, materials are used efficiently. This translates into reduced environmental impacts for the building. A single brick can do all of the following:

- Serve as a load-bearing structural element.
- Provide an interior or exterior finish without the need for paints or coatings.
- Provide acoustic comfort with a sound transmission class (STC) rating of 45 or greater.
- Regulate indoor temperatures as a result of thermal mass.
- Provide fire resistance (a nominal 4-in. (100 mm) brick wall has a one-hour fire rating).
- Provide impact resistance from wind-borne debris or projectiles.

• Improve indoor air quality by eliminating the need for paint and coatings.
• Provide a non-combustible material which does not emit toxic fumes in fires.
• Provide an inorganic wall that is not a food source for mold.
• Serve as a heat-storing element in a passive solar design.
• Last for generations.

In addition, other innovations in brick masonry design can further decrease the raw materials used. The use of prestressed brick walls capitalizes on the inherent compressive strength of brickwork, resulting in typically thinner, taller walls.

2.3 Sustainable design with brick

Every sustainable building is unique, designed specifically for its site and the programming requirements of the user. However, all high-performance, sustainable buildings should consider the following components of design. The versatility and durability of brick facilitate its use as part of many elements of sustainable design.

• Environmentally responsive site planning
• Energy-efficient building shell
• Thermal comfort
• Energy analysis
• Renewable energy
• Water efficiency
• Safety and security
• Daylighting
• Commissioning
• Environmentally preferable materials and products
• Durability
• Efficient use of materials
• High-performance HVAC
• High-performance electric lighting
• Life cycle cost analysis
• Acoustic comfort
• Superior indoor air quality
• Visual comfort

2.4 Flyash bricks

Pulverized fuel ash-lime bricks are obtained from materials consisting of pulverized fuel ash in major quantity, lime and an accelerator acting as a catalyst. Pulverized fuel ash-lime bricks are generally manufactured by intergrading blending various raw materials are then moulded into bricks and subjected to curing cycles at different temperatures and pressures. On occasion as and when required, crushed bottom fuel ash or sand is also used in the composition of the raw material. Crushed bottom fuel ash or sand is also used in the composition as a coarser material to control water absorption in the final product. Pulverized fuel ash reacts with lime in presence of moisture from a calcium hydrate which is a binder material. Thus pulverized fuel ash – lime in presence of moisture form calcium – silicate hydrate which is binder material. Thus pulverized fuel ash – lime brick is a chemically ended bricks.

These bricks are suitable for use in masonry construction just like common burnt clay bricks. Production of pulverized fuel ash-lime bricks has already started in the country and it is expected that this standard would encourage production and use on mass scale. This stand lays down the essential requirements of pulverized fuel ash bricks so as to achieve uniformity in the manufacture of such bricks.

3. BRICK MANUFACTURING AND SUSTAINABILITY

In order to understand how brick can contribute to sustainable building design, it is important to consider how brick is made, as well as how it is used. Brick manufacturing is a highly efficient process incorporating many sustainable practices as described below.

Fly Ash s the inorganic mineral residue obtained after burning of coal/lignite in the boilers. Fly Ash is that portion of ash which is collected from the hoppers of ESP's and pond ash is collected from the ash ponds. Bottom ash is that portion of ash which can be collected fro the bottom portion of the boilers. The characteristics of fly ash depend upon the quality of lignite/coal and the efficiency of boilers.

India depends upon primarily on coal for the requirement of power.The generation of fly ash is also likely to increase. The disposal of fly ash in the present method will be a big challenge to environment, especially when the quantum increases from the present level.

4. MATERIALS AND METHODS

4.1 Flyash

The physical and chemical properties of Fly Ash used are as shown below.

a. Physical Properties

Specific Gravity	2.54 to 2.65 gm/cc
Bulk Density	1.12 gm/cc
Fineness	350 to 450 M2/Kg

b. Chemical Properties

particulars	Silica	Alumina	Calcium Oxide	Loss on ignition	Sulphur	Iron
%	35-59	23-33	10-16	1-2	0.5- 1.5	0.5- 2.0

It may be seen that lignite fly ash is characterized primarily by the presence of silica, alumina, calcium etc.Presence of silica in fine form makes it excellent pozzolanic material. Its abundant availability at practically nil cost gives a very good opportunity for the construction agencies.

4.2 Sand or stone dust.
Stone dust about 40to 50 % is used.

4.3 Water
Drinkable water is used for the test.

5. MANUFACTURING PROCESS:

Fly ash (50%) and stone dust (50%) are manually feed into a pan mixer where water is added to the required proportion for homogeneous mixing. The proportion of raw material may vary depending upon quality of raw materials. After mixing, the mixture are allowed to belt conveyor through feed in to automatic brick making machine were the bricks are pressed automatically. Than the bricks are placed on wooden pallets and kept as it is for two days there after transported to open area where they are water cured for 10 -15 days. The bricks are sorted and tested before dispatch.

6. COMPRESSION TEST

Conventional burnt clay brick and flyash bricks are tested in laboratory for compression on Universal testing machine.

7. RESULTS AND DISCUSSION

7.1 INSPECTION AND QUALITY

CONTROL:

The Bureau of Indian Standards has formulated and published the specifications for maintaining quality of product and testing purpose. IS: 12894:2002. Compressive strength achievable: 60-250 Kg/Cm.Sq. Water absorption: 5 – 12 %; Density: 1.5 gm/cc Co-efficient of softening (depending upon water consistency factor) Unlike conventional clay bricks fly ash bricks have high affinity to cement mortar though it has smooth surface, due to the crystal growth between brick and the cement mortar the joint will become stronger and in due course of time it will become monolithic and the strength will be consistent.

7.2 ENERGY CONSERVATION:

These products are low energy consumption since no need of fire operation in the production unlike conventional bricks. Thus considerable energy could be saved not only in manufacturing activities but also during the construction.

7.3. COMPRESSIVE STRENGTH:
The compression test was carried out in accordance with IS 456-2000; on different samples of flyash bricks & conventional burnt clay bricks. The average compressive strength of flyash brick is 66 kg/cm^2 while that for conventional burnt clay brick is 44 kg/cm^2.

8. CONCLUSIONS

1. The results are indicative of the satisfactory performance of flyash bricks as load bearing elements. This type of bricks uses 100 % flyash without mixing with clay and shale. It, therefore provides a large disposal of flyash in a very efficient, useful and profitable way.
2. The mechanical properties of flyash bricks have exceeded those of the standard load bearing clay bricks. Notable among these properties are the compressive strength .Compressive strength is 20 % better than good quality clay bricks.
3. There is evidence that the micro structural feature of the surface of flyash bricks is characterised by a rougher texture then that of clay briks.The characteristics is belived tobe responsible for the increased bond strength with mortar.
4. The density of flyash bricks is 28% less than that of standard clay bricks. This reduction in the weight of bricks results in a greater deal of saving amount which are saving in the raw material and transportation cost and saving to consumer, that result from increased number of units and reduction in the structural elements.
5. The process of manufacture of flyash bricks indicate clearly that there is much saving tobe done during the making of the bricks. These savings arise mainly from the uniformity of the

raw material as well as from doing away with whole process of mining, transporting, mixing and grinding that are necessary in the case of the clay bricks.

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GENERATION OF ENERGY FROM DISTILLERY WASTE WATER

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Abstract: One of the most important environmental problems faced by the world is management of wastes. Industrial processes create a variety of wastewater pollutants; which are difficult and costly to treat. Wastewater characteristics and levels of pollutants vary significantly from industry to industry. Now-a-days emphasis is laid on waste minimization and revenue generation through byproduct recovery. Pollution prevention focuses on preventing the generation of wastes, while waste minimization refers to reducing the volume or toxicity of hazardous wastes by water recycling and reuse, and process modifications and the byproduct recovery as a fall out of manufacturing process creates ample scope for revenue generation thereby offsetting the costs substantially.

Production of ethyl alcohol in distilleries based on cane sugar molasses constitutes a major industry in Asia and South America. The world's total production of alcohol from cane molasses is more than13 million m^3/annum. The aqueous distillery effluent stream known as spent wash is a dark brown highly organic effluent and is approximately 12-15 times by volume of the product alcohol. It is one of the most complex, troublesome and strongest organic industrial effluents, having extremely high COD and BOD values. Because of the high concentration of organic load, distillery spent wash is a potential source of renewable energy. The project of the status and appropriate treatment alternatives for disposal of the distillery wastewater.

Keywords: *CPCB, DO, BOD, COD, TSS,TDS,MLVSS,ASP,RBC,F/M, HRT, SRT,AGSS*

The Indian distillery units use sugarcane molasses as a preferred raw material because of its easy and large scale availability for alcohol production. There are about 579 sugar mills and 325 distilleries in India. Currently, about 45.72 million m3 of spent wash is generated annually from distilleries alone in India The production and characteristics of spent wash are highly variable and dependent on feed stocks and various aspects of the ethanol production process. The spent wash is acidic (pH 3.94 - 4.30) dark brown liquid with high BOD (45000–100000 mg /Lit) and COD (90000–210000 mg/lit), and emits obnoxious odor. Although it does not contain toxic substances, its discharge without any treatment brings about immediate discoloration and depletion of dissolved oxygen in the receiving water streams, posing serious threat to the aquatic flora and fauna. Membrane based separation processes like Ultra filtration (UF), Nanofiltration (NF), Reverse osmosis (RO) and membrane Bioreactor (MBR) have been applied for treating distillery effluent. Distilleries are one of the 17 most polluting industries listed by the Central Pollution Control Board (CPCB) of India (CPCB, 2003). Indian distilleries employ various forms of primary, secondary and tertiary treatments of wastewater. The typical treatment sequence is screening and equalization, followed by biomethanation; ferti-irrigation and biocomposting with sugarcane press mud are the most widely used options for effluent disposal. However, these methods are highly energy intensive and hence quite expensive. These disadvantages emphasized the need for further research using novel separation methods.

1.0 Effect of Distillery Waste Water on Environment

To characterize distillery wastewater in detail, so that proper attempt to treat the waste to reduce the pollution hazards. In a distillery, sources of wastewater are stillage, fermenter and condenser Cooling water and fermented wastewater. The liquid residues during the industrial phase of the production of alcohol are liquor, sugar cane washing water, and from the

cleaning of the equipment, apart from other residual water. This extract is extremely polluting as it contains approximately 5% organic material and fertilizers such as potassium, phosphorus and nitrogen. The amount of water used in this process is large, generating a high level of liquid residues. The effluents from molasses based distilleries contain large amounts of dark brown colored molasses spent wash (MSW). The molasses spent wash (MSW) is a potential water pollutant in two ways. First, the highly colored nature of MSW can block out sunlight from rivers and streams, thus reducing oxygenation of the water by photosynthesis and hence becomes Problem to aquatic life. Secondly, it has a high pollution load which would result in eutrophication of contaminated water sources. Due to the presence of putriciable organics like skatole, indole and other sulfur compounds, the MSW that is disposed in canals or rivers produces obnoxious smell.

2.0 Need for Industrial Waste Water Treatment: -

a) Water Pollution

1. Agrochemicals and sediments can pollute nearby water sources.
2. Most of the time it is observed that the sugar industries discharge their wastewater i.e. spent wash during the rainy season in the nearby rivers and other surface water bodies resulting in severe contamination of the surface water resources.
3. Siltation and eutrophication of nearby surface water bodies due to soil erosion due to flood irrigation and over irrigation.

b) Water Scarcity

1. Sugarcane is a deep-rooted crop and can have a great impact on river flow as it reduces run-off from the catchment into rivers and draws heavily on ground water resources

c) Air Pollution

1. Burning of cane to speed harvest causes air pollution and increases erosion.
2. Bagasse, which is commonly used as fuel in boilers, produces fly ash, which escapes to the atmosphere and can affect the population with irritation in eyes, nose, throat and lungs, and can damage crops

d) Degraded Soils

e) Field level impact

1. Erosion is a significant issue in areas under sugar cane or beet cultivation, since erosion rates in tropical agro-ecosystems are usually greater than the rate of soil formation.
2. Cane harvesting can cause a significant removal of soil with the roots. Declining soil quality is associated with cane and beet production, due to soil compaction, loss of organic matter, salinization and acidification. 10-30 percent of the total beet harvest weight is soil

f) Impact on soil health

1. Heavy infield transport machinery is most commonly associated with soil compaction problems. Soil compaction decreases porosity and water infiltration rate, restricting the rooting ability of the crop
2. Conventional tillage commonly promotes erosion by exposing soil aggregates to rainfall. Conventional tillage i.e. deep ploughing, also drastically changes soil structure
3. Acidification is also more prevalent in cane than beet growing areas, largely due to the use of inorganic nitrogenous fertilizers such as urea and ammonium sulphate.
4. Most of the farmers still use the flood irrigation pattern which results in huge wastage of water, electricity and results in salinization of the soil which is another important cause of lower productivity.
5. Productivity of the sugarcane in the region is going down owing to excessive use of chemical fertilizers/herbicides

g) Solid Waste Management.

Also, the bagasse when used as fuel in boilers produces particulate matter, nitrogen oxide and sulphur. If pollution control equipment is not installed, fly ash escapes to the atmosphere and can affect the population with a number of health related problems.

3.0 Waste Characteristics Distillery Effluents

The distillery wastes – liquid, solid and gas- are heavily polluting and noxious. The distilleries generate about 6-15 m^3 of waste water (generally called spent wash) per m^3 of alcohol produced and a large amount of press mud. The spent wash poses a very serious pollution problem, as it has very high COD, BOD, inorganic load, low pH and dark brown color. They cannot be

discharged directly without reducing COD/ BOD values below State Pollution Control norms.

The treatment of distillery wastes is a priority area for environmental sustenance and its quality. The general treatment of spent wash involves its energy recovery through biomethanation. It is also used in the bio-composting of the press mud to produce good quality manure. It can be noted that the waste water can generate biogas through biomethanation and biogas can be further utilized for the production of electricity and thermal energy through a technology integration comprising a boiler/ steam turbine or 100% biogas engine. The distilleries can generate steam at desired pressure and temperature to meet their process requirements and produce electricity for captive use or for export. Several methods of waste treatment are in use; but a very few of them are able to meet the effluent quality standards.

The average characteristics of distillery spent wash total solids concentration of 7 -9 percent, spent wash is a strong process wastewater and consists mainly of biodegradable organic constituents as indicated by the ratio of COD:BOD values of 2.2 - 2.5. The concentration of biodegradable matter, represented by high BOD values (40,000 - 50,000 mg/L) indicates a significant source of biochemical energy potential of spent wash. This stock of energy is available in the residual sugar present in spent wash and can be recovered as methane (bio-methane/ biogas) by anaerobic fermentation reactions. The typical odor emanating from distilleries is a major nuisance.

The color of the spent wash interferes with its oxygenation and self purification.

4.0 Present Status of Treatment and Disposal:-

Spent wash treatment is proposed by three different routes currently are as follows,

(a) Concentration followed by incineration.

(b) Anaerobic digestion with biogas recovery followed by aerobic polishing.

(c) Direct wet oxidation of stillage by air at high temperature with generation of steam followed by aerobic polishing.

5.0 Scope of the Work: -

1. Developed countries can not only share technology better, including cost-effective waste water and water treatment systems but also in hydrological transport modeling. In developing countries to achieve primary wastewater treatment or to secure septic systems and carefully analyse wastewater outfall design to minimize impacts to drinking water and to ecosystems.
2. Various treatment technologies such as composting, incineration, biological treatment, Reverse osmosis, Ultrafilteration have been studied and evaluated performance for the treatment on spent wash.
3. To find out the biogas production rate.
4. To determine the performance of distillery spent wash treatment and compare to as per I.S code.
5. To Study the distillery waste water treatment methods.
6. To study of inlet and outlet Characteristics of waste water.
7. To evaluate the economical method for treatment of distillery waste water.

Table No.1:Annual Bio energy Potential of Distillery Effluent in Various States of India							
State	**Units**	**Capacity (M Ltr/Yr)**	**Effluent (M Ltr/Yr)**	**Biogas (M m^3)**	**Total N(tones)**	**Total Ka (tones)**	**Biomass (tones)**
A P	24	123	1852	50	566	11115	3704
Assam	1	2	24	0.7	7	144	48
Bihar	13	88	1323	35.7	397	7940	2646
Goa	6	15	218	6	65	1304	436
Gujarat	10	128	1919	51.8	576	11511	3838
Karnataka	28	187	2799	75.6	840	16794	5598
M P	21	469	7036	190	2111	42219	14072
Maharashtra	65	625	9367	253	2810	56217	18734
Punjab	8	88	1317	35.6	395	7902	2634
Tamilnadu	19	212	3178	86	953	1971	6356
U P	43	617	9252	250	2776	55512	18504
W B	6	24	371	10.1	111	22223	742
Rajasthan	7	14	202	3	61	1215	404
Kerala	8	23	343	9.3	103	2064	686
Pondicherry	3	11	165	4.5	50	990	330
Sikkim	1	7	98	5.5	29	585	196
Nagaland	1	2	24	0.7	7	144	48
J & K	7	24	366	11	110	2196	732
H P	2	3	39	1	12	234	78
Haryana	5	41	615	16.6	185	3690	1230
Total	285	2703	40,508	1096.1	12,154	263,070	81016

6.0 Measurement of water Pollution: -

Water pollution may be analyzed through several broad categories of methods:

1) Physical method. 2) Chemical method. 3) Biological method.

i) Physical Method –
a) Sedimentation b) Screening c) Aeration d) Filtration e) Floatation

ii) Chemical Method- The principal chemical unit processes used for waste water treatment includes:-
a) Chemical coagulation b) Chemical precipitation c) Chemical disinfection d) Chemical oxidation e) Advanced oxidation processes f) Ion exchange g) Chemical neutralization, scale control, and stabilization.

iii) Biological Method-
There are two major methods of biological treatment:-

a) Aerobic: a) Activated sludge treatment b) Lagoons c) Trickling Filtration d) Oxidation pond

b) Anaerobic Methods: -
i) Anaerobic digestion.
ii) Up flow anaerobic sludge blanket reactors (UASB Reactors)
iii) Anaerobic fixed film reactor iv) Anaerobic fluidized bed rectors.
v) Anaerobic batch reactors vi) Septic Tank.

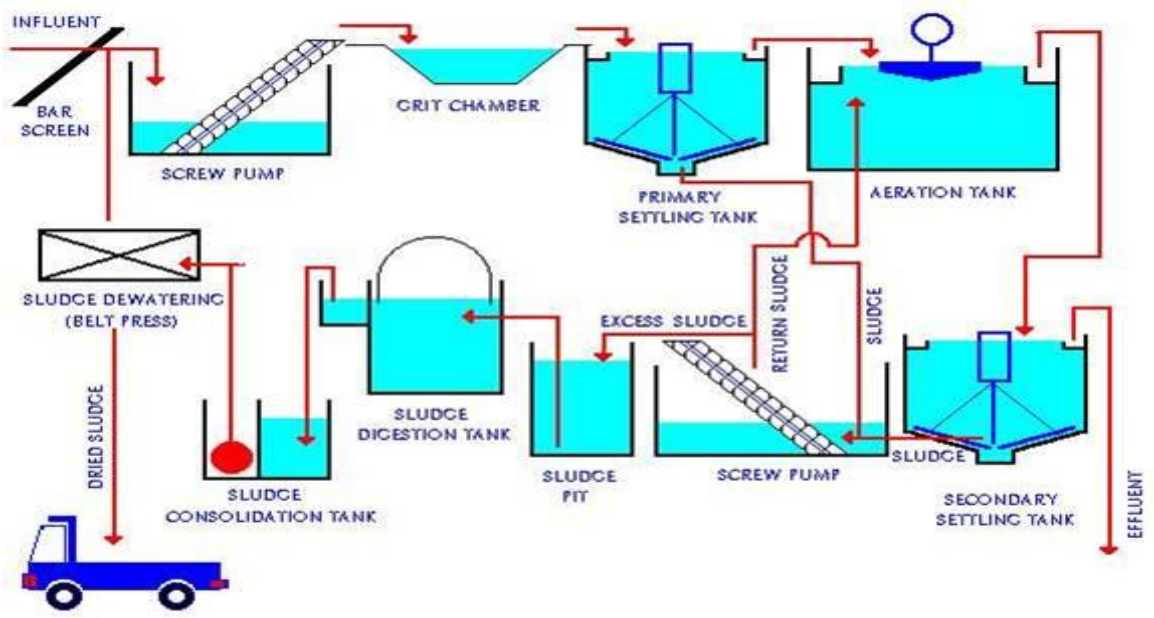

Fig. No.1Flow Diagram for Treatments on Distillery Spent Wash

7.0 Up flow Anaerobic Sludge Blanket Reactor (UASBR): -

Introduction: The UASB process is based on the slow upward movement of waste through a dense bed and blanket zones of biologically active sludge. The reactor consists of three distinct zones: the sludge bed, sludge blanket, and settling/biomass separation zones.

The sludge bed zone is responsible for 80 to 90% of the waste stabilization occurring in the reactor while occupying roughly 30% of the reactor volume. This main waste stabilization is due to high biomass concentration in the sludge bed. Under favorable conditions for sludge granulation, anaerobic granules with high microbial activities and excellent settling characteristics, up to 3-4 mm in diameter, are formed in the reactor.

The next zone encountered by the waste stream is the sludge blanket zone, which occupies about 50% of the total reactor volume and contains less sludge concentration than the sludge bed zone. The sludge in the blanket zone has almost uniform particle size and originates from the bed where it is whirled up by rising gas bubbles.

A third area is a zone in the settler where the sludge concentration decreases to a minimum. The fluid flow in the settling zone is laminar, which might be described as a plug-flow region. The

main function of the separator at the top of the reactor is to drive the rising gas and biomass particles in toward the gas collector, where a swirling action occurs, and the biomass settles back down into the reactor, thereby preventing most of the biomass rising with gas bubbles from leaving the reactor.

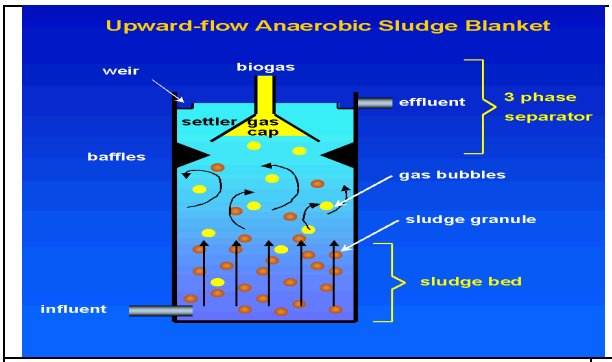

Fig. No.2: Upflow Anaerobic Sludge Blanket Reactor

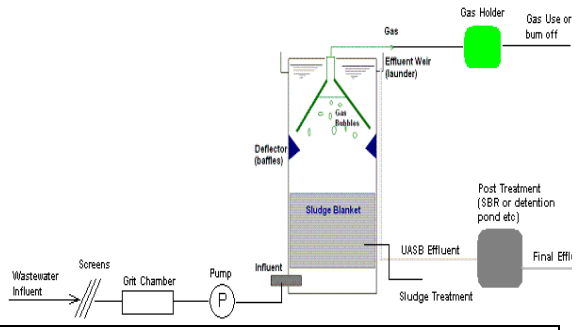

Fig. No.3: Upflow anaerobic sludge blanket (UASB) reactor process flow diagram

8.0 Factors Influencing Reactor Performance: -

1) pH 2) Temperature 3) Organic Loading Rate (OLR)
4) Hydraulic Retention Time and Up-Flow Velocity
5) Substrate 6) Sludge Inoculation

9.0 Design Criteria of UASB Reactors

a) Minimum average HRT = 4 Hrs. b) Height = 4-5 meter.
c) Feed inlet points = 1 inlet per 1 to 4 m^2
d) Feed distribution = Each inlet pipe from a separate compartment.
e) Static pressure in feed inlet box = Upto 50 cm.
f) Upflow velocity in aperture = Average daily 4m/hr during 2-4 hrs 8m/hr.
e) Upflow velocity = 0.5 m/hr.

10.0 Case Study: -

Detailed studies for Niphad Sahakari Sakhar Factory, Bhausaheb Nagar, Pimplas, Taluka-Niphad, District-Nashik, Maharashtra. Niphad Sahakari Sakhar Factory is located 30 km. from Nashik. The molasses produced during sugar manufacturing is taken to the production for alcohol.

A case study on Niphad Sahakari Sakhar Karkhana, daily crushing capacity is 3500 tones/day. Sugar content in the raw molasses is 45% or depends on the quality of molasses. The quantity of molasses produced 3.5% of the sugar cane crushed. Raw molasses is diluted with water 1:3 proportion (1part molasses: 3 part water). 12 numbers of fermented are provided. Capacity of yeast is 165000 lit.48 hours are required for fermentation process. Then fermented molasses then taken for separation of yeast sludge. Then fermented wash is taken for distillation where the alcohol is separated and only some liquid left are called as spent wash and they are proceed for further treatment. In sedimentation tank residence time is provided for 24hours. In fermentation process heat are generated these air are control by using cool water and to maintained the temperature is 38ºC. In Spent wash 64% - 66% methane are content in biogas.

To conduct the collection of waste water sample of distillery influent and effluent and following tests are conducted such as pH,Temperature, COD,BOD, Alkalinity etc.

11.0 Analysis of spent wash: -

Table No.2. Characteristics of Spent Wash From Biomethanation plant of Niphad Sugar Factory

Sr. No.	Parameters	Untreated spent Wash	After anaerobic treatment by UASB reactor
1	Total Solids (mg/ L)	85000	38900
2	Total Fixed Solids(mg/L)	25430	21400
3	Total Volatile Solids (mg/L)	59570	17500
4	Total Dissolved Solids (mg/L)	56630	7600
5	Total Suspended Solids (mg/L)	28370	31300
6	Chemical Oxygen Demand (mg/L)	96000	28000
7	Chlorides (mg/L as CL)	5100	2600
8	Sulphates (mg/L as SO_4)	6400	4000

Conclusion: -

- COD are influences the production of biogas.
- COD reduction goes on increasing the biogas production rate goes on increasing.
- COD plays an important in biogas production rate.
- When Sulphate (SO_4) reduction goes on increasing it is observed that biogas production goes on decreasing. Then it is necessary to reduce sulphate in the spent wash to get the maximum biogas production.
- UASB Reactor produced by- product are biogas and furnace oil.
- UASBR treatment saves the operational cost as no energy required for aeration.
- This treatment energy is produced in the form of methane gas which can be used for heating or electricity production.
- The technologies are simple in construction and operation.

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Magnetic Field Conditioning: An Energy Efficient Method for Crude Oil Transportation

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Abstract
Paraffin wax deposition causes severe operational problems in oil fields. The major problem is the blockage of flow passage of the transportation lines and increase in the apparent viscosity of crude oil. This leads to decreased production rates, equipment breakdown and production shutdown. Tremendous energy and labour is utilized in pumping this waxy crude and maintenance of the flowlines which further affects the economics of the process. Hence timely control and removal of wax deposition is of prime importance. A number of treatment methods are available that have their own relative advantages and disadvantages. Chemical methods are mostly used. But they have their own limitations like being highly crude specific and environmentally hazardous. Mechanical methods like pigging although used widely suffer the drawback of requiring a lot of downtime, thereby affecting the production. This paper discusses briefly the various treatment methods and focuses on the method of magnetic field conditioning. It reviews the work carried out till date by various workers in the field of magnetic treatment of crude oil. Literature suggests that magnetic field reduces the apparent viscosity and cloud point of crude oil thereby assuring smooth flow. Hence it is less energy intensive, more economical and environment friendly. An attempt is made to understand the mechanism, challenges and future scope of this method.

Keywords: *Crude oil, Wax Mitigation, Magnetic field, Viscosity, Cloud point*

1. Introduction

With rapid technological advancements, the demand for energy is ever increasing. In order to meet this demand, oil companies are compelled to exploit heavy oil reserves in hostile and inaccessible environments. Transportation of viscous crude offshore via deepwater pipelines is a critical job in oil industry. Further, deposition of paraffin wax due to low temperature environment increases the problems in transportation. As wax gets deposited along the flowlines and production tubing, it causes plugging of flowlines. Moreover it increases the apparent viscosity of the crude oil and the surface roughness of the walls. It leads to increased pumping costs and decreased production rates. Accumulation of wax in the process vessels and storage vessels causes system upsets and equipment breakdown. It interferes with valve operations and instrumentation. This ultimately leads to production shutdown. Pipeline transportation of crude oil thus becomes a highly energy intensive process. The economic loss due to wax deposition is estimated to be in the order of millions of dollars every year. A typical well work-over costs around USD 250,000 (Frenier, Zainuddin and Venkatesan, 2010). Hence control of wax deposition is of prime importance. A number of treatment methods are available that have their own relative advantages and disadvantages. Amongst them, the method of magnetic field conditioning is discussed in this paper.

2. Problem of Wax deposition

Wax may be defined as the combination of paraffinic hydrocarbons that are usually between C_{18} and C_{70} along with resins, gums, and asphaltic materials. Under normal reservoir conditions it is in equilibrium with other constituents. But when the temperature falls below a certain temperature called as the Wax Appearance Temperature (WAT) or the cloud point temperature, wax precipitation begins. The other factors responsible for altering the crude oil equilibrium that lead to wax precipitation are pressure changes, evaporation and loss of dissolved gases. (Sadeghazad, Christiansen, Sobhi and Edalat, 2000). A detailed description of the various mechanisms for wax deposition is provided by Aiyejina *et al*. (Aiyejina, Chakrabarti, Pilgrim and Sastry, 2011). These include molecular diffusion, Soret diffusion, Brownian diffusion, Gravity

settling mechanism, Shear dispersion mechanism, Shear stripping, Nucleation and gelation kinetics and deposition in two phase flow. A good understanding of the deposition mechanism and governing factors is necessary for control of wax deposition.

3. Treatment methods

Figure 1 gives a brief idea of the various methods available for treatment of wax deposition. Detailed review of the various methods is available in the literature. (Al-Yaari, 2011) (Aiyejina, Chakrabarti, Pilgrim and Sastry, 2011)(Frenier, Zainuddin and Venkatesan, 2010). Amongst these, chemical treatment and pigging are the favourites in the oil industry. But the major problem with chemicals is that they are crude specific and less environment friendly. Pigging requires specific downtime and suffers the disadvantage of being more energy intensive.

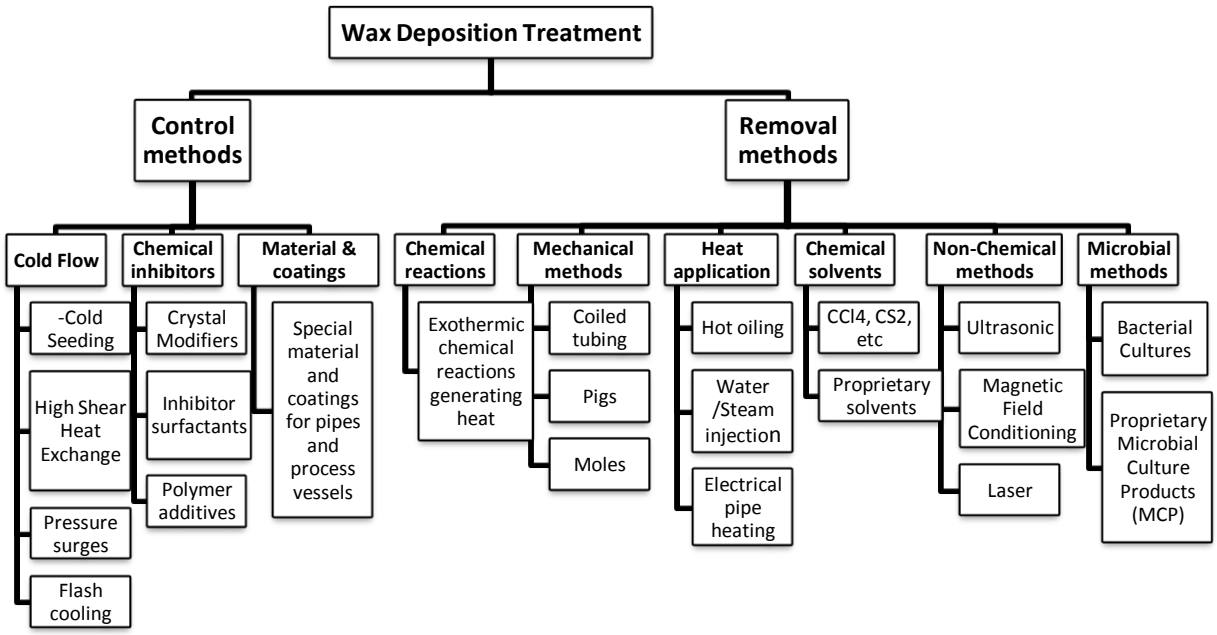

Figure 2: Methods for Treating Wax Deposition [Ref: Frenier, 2010 and Al-Yaari, 2011]

4. Magnetic Field Conditioning Method

The method of magnetic field conditioning has been widely used for different applications since long time. It has been used for treatment of waste water, boiler feed water, inorganic slurries and emulsions. It has also been used for improving fuel combustion efficiency and pollution control. Recently this method has been used for the control of wax deposition in crude oil. Quite a few companies manufacturing magnetic fluid conditioners are functional. (Algae X International Inc), (MundiMex Inc), (Mag Tek Inc), (Fuel Mag International Ltd.)

Magnetic field conditioning method is based on the claim that when crude is treated with magnetic field, the apparent viscosity and cloud point temperature decreases thereby making transportation of oil easy. Moreover, the original properties of crude oil remain unaltered as the apparent viscosity returns to the original value after a specific time interval. Early literature was mostly patented one which described the magnetic tools installed in the oil fields. (Corney, 1993)(Francis, 2000). Various mechanisms have been proposed by a number of workers in the literature.

Wax deposition is organic in nature. Magnetic field conditioning was mainly being used for the treatment of inorganic scales. The mechanism of scale or wax inhibition has been studied with respect to inorganic scale deposition and organic scale deposition by Marques *et al.* (Marques, Rocha, Machado, Neves, Vieira and Dittz, 1997). According to the authors, in case of inorganic scale formation, the Lorentz forces play an important

role in scale inhibition. The action of these forces cause a change in the charges of the polar species, thereby affecting both the particle to particle as well as particle to solvating liquid interactions. This results in changing the crystal habit. On the other hand diffusion is the key factor controlling the paraffin deposition in organic liquids like crude. When crude is flowed through a magnetic field, paraffin molecules tend to align their poles with the ones of the magnetic field. The applied magnetic field also changes both electron rotation and translation patterns. This changes the total orbital momentum. This leads to disturbance in the crystal agglomeration process. Under a given magnetic field weak dipoles are actually brought into being in the paraffin molecules. These dipoles generate a repulsion force between these molecules leading to changes in their rheological and morphological properties.This early literature was based on hypothesis without any experimental support. The mechanism of the effect of magnetic field on properties of crude oil was a mystery and also the results obtained were very much controversial.

One of the works claims that the viscosity of crude oil increases with the application of magnetic field (Chow, et al., 2000). Supported by experimentation and subsequent hypothesis, it states that the presence of a magnetic field can alter the kinetics of precipitation of wax crystals from crude oil. It is only precipitation kinetics that is involved and equilibrium thermodynamic properties such as the wax out temperature and the solubility of wax in the oil are not affected by the presence of a magnetic field. The hypothesis assumes that crude oil contains charged species. In order to have an effect on wax precipitation, the magnetic field must be applied while the crude oil is saturated or super-saturated with wax. Presence of magnetic field increases the potential nucleation sites for wax precipitation. Application of magnetic field favours the solvation process rather than association process. This increases wax precipitation and increases the viscosity of crude oil.

According to another hypothesis (Tung, Vuong, Long, Vinh and Hung, 2001), viscosity of oil decreases when subjected to magnetic field. It states that paraffin clogging is a result of combination of magnetic and electrostatic forces that develop from friction in the flowing of oil. The action of magnetic field on these molecules changes both electron rotation and translation patterns thus changing their orbital angular momentum. This leads to a disturbance in the crystal agglomeration processes. As the result, under a given magnetic field, weak dipoles are actually brought into being in the paraffin molecules. These dipoles generate a repulsion force between these molecules leading to changes in their rheological and morphological properties.

As experimentation continued further, efforts were made to establish the relation between the rheological properties of magnetically treated crude oil with the paraffin content and resin-asphaltene content (Loskutova and Yudina, 2003). The controversy as to whether the viscosity of oil increases or decreases with magnetic field has been clarified by Tao and Xu (Tao and Xu, 2006). They conclude that increase in viscosity is due to application of magnetic field for a long time whereas decrease is when the field is applied for a short time. Using the suspension theory of Einstein as the base, they claim that crude oil is a suspension of paraffin particles. The magnetic permeability of the particles is different from that of the base fluid. If a strong magnetic field is applied or a weak magnetic field is applied for a long time, the particles align in the direction of the field aggregate into macroscopic chains and restrict the fluid flow thereby increasing the viscosity. But if the field is applied for a short duration, the interaction aggregates the particles that are nearby and does not have time to assemble the ones which are at a distance. The assembled clusters are of limited size and are suspended in the fluid. This reduces the effective viscosity. This paper also proposes the relation between the intensity of magnetic field and the viscosity. It also states that magnetic field reduces the viscosity of crude with paraffinic base only. For asphaltic base or mixed base, electrical field is more suitable.

As the quest for understanding the mechanism continued, one mechanism claimed that tetravalent vanadium complexes concentrated in resinous asphaltenic components were responsible for paramagnetism in crude oil (Loskutova, Yudina and Pisareva, 2008). In another experiment, super paramagnetic colloid particles of iron oxides were discovered in oil samples from producing wells (Lesin, Koksharov and Khomutov, 2010). During magnetic treatment these aggregates get destroyed which results in the change in physiochemical behaviour.

Hot oiling method is extensively used to control wax deposition. This consumes a large amount of energy. The comparison with respect to energy saved by hot oiling method and magnetic treatment has been discussed by Zhang *et al.* (Zhang, Zhang and Huijuan, 2010). Continuous research is being done on the method of magnetic field conditioning which is seen from the recent patents obtained. (White, 2008)(Hale, 2009) Although considerable research is being carried out, there is no conclusive data available on the effect of magnetic field on the phase behaviour of paraffins.

From the above literature it is observed that following are some of the issues to be considered for effective implementation of magnetic field conditioning method.

- Most of the work done till date is on paraffinic crude oil. The effect needs to be studied for asphaltenic and mixed crude.
- No proper mathematical model is available that can explain the phenomena. This can be attributed to lack of authentic and sufficient data. Also a large number of parameters affecting the process make the formation of model difficult.
- Very few field case studies are available or have not been disclosed. So the industry currently has less confidence in this method and is reluctant to implement the method.
- Any new technology cannot be implemented as a standalone technology initially. Hence it would be economical and efficient to implement the magnetic method along with other conventional techniques like chemical treatment, hot oiling method, etc.

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Solution of Laplace Equation using Finite Element Method

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Abstract: In this paper finite element numerical technique has been used to solve two dimensional steady heat flow problem with Dirichlet boundary conditions in a rectangular domain and focuses on finite element solution using spreadsheets with triangular grid and Metlab command with rectangular grid. Finally the finite element numerical solutions are compared to check the accuracy of the developed scheme.

Keywords: *Dirichlet Conditions, Finite Element Method, Laplace Equation*

I.INTRODUCTION

The finite element methods are a fundamental numerical instrument in science and engineering to approximate partial differential equations.The finite element method (FEM) is a numerical technique for solving PDEs. FEM was originally applied to problems in structural mechanics. The finite element analysis involves four basic steps.

1. Divide the solution region into a finite number of elements. The most common elements have triangular or quadrilateral shapes. The collection of all elements should resemble the original region as closely as possible.
2. Derive governing equations for a typical element. This step will determine the element coefficient matrix.
3. Assemble all elements in the solution region to obtain the global coefficient matrix.
4. Solve the resulting system of equations.

This paper is organized as follows. Section 2 presents formulation of two dimensional Laplace equations with dirichlet boundary conditions. Section 3 presents the finite element method for solving Laplace equation by using spreadsheet. Section 4 presents the finite element method using Matlab command. Section 5 compares the results obtained by each method. Finally, Section 6 gives concluding remarks.

II.PROBLEM FORMULATION

A simple case of steady state heat conduction in a rectangular domain shown in Fig.1 may be defined by two dimensional Laplace equations:

$$\nabla^2 u = \frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0 \qquad (1)$$

For $x = [0, a]$, $y = [0, b]$, with $a = 4, b = 2$

Where $u(x, y)$ is the steady State temperature distribution in the domain.

The Dirichlet boundary conditions are

$$u(0, y) = 100\,, \quad u(a, y) = 250$$
$$u(x, 0) = 50\,, \quad u(x, b) = 200$$

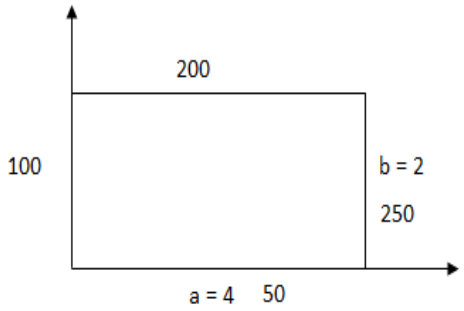


Fig. - 1: Rectangular region R with boundary conditions

III.USING SPREADSHEET

The region is divided into 16 equal triangular elements as indicated in Fig. 2. The elements are identified by encircled numbers 1 through 16. In this discretization there are 15 global nodes numbered 1 through 15 as indicated in the fig. 2.

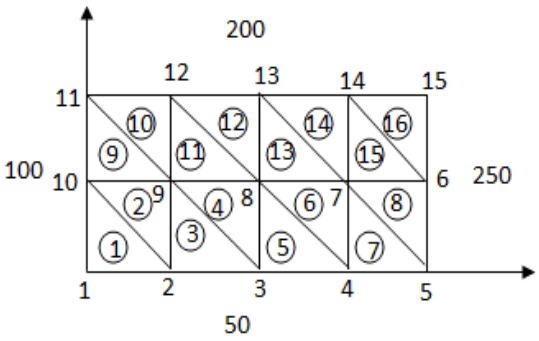


Fig.-2: The region R showing prescribed potentials at the boundaries and triangular grids

The creation of the assembled equations required element coefficient matrix and global coefficient matrix .The entries of the 3×3 element coefficient matrix are then given by the equation:

$$C_{ij}^{(e)} = \frac{1}{4A}\left[P_i P_j + Q_i Q_j\right] \qquad (2)$$

Where $i, j = 1,2,3$

$P_i, P_j and Q_i, Q_j for element ethat are computed.$

$$A = \frac{1}{2}[P_2 Q_3 - P_3 Q_2]$$

The element coefficient matrices computed according to equation (2) are, respectively as shown in Table 1.

Table 1: Computation of element coefficient matrices with respective element

Element	Element Coefficient Matrix			Element	Element Coefficient Matrix		
1	1	-0.5	-0.5	9	1	-0.5	-0.5
	-0.5	0.5	0		-0.5	0.5	0
	-0.5	0	0.5		-0.5	0	0.5
2	0.5	-0.5	0	10	0.5	-0.5	0
	-0.5	1	-0.5		-0.5	1	-0.5
	0	-0.5	0.5		0	-0.5	0.5
3	1	-0.5	-0.5	11	1	-0.5	-0.5
	-0.5	0.5	0		-0.5	0.5	0
	-0.5	0	0.5		-0.5	0	0.5
4	0.5	-0.5	0	12	0.5	-0.5	0
	-0.5	1	-0.5		-0.5	1	-0.5
	0	-0.5	0.5		0	-0.5	0.5
5	1	-0.5	-0.5	13	1	-0.5	-0.5
	-0.5	0.5	0		-0.5	0.5	0
	-0.5	0	0.5		-0.5	0	0.5
6	0.5	-0.5	0	14	0.5	-0.5	0
	-0.5	1	-0.5		-0.5	1	-0.5
	0	-0.5	0.5		0	-0.5	0.5
7	1	-0.5	-0.5	15	1	-0.5	-0.5
	-0.5	0.5	0		-0.5	0.5	0
	-0.5	0	0.5		-0.5	0	0.5
8	0.5	-0.5	0	16	0.5	-0.5	0
	-0.5	1	-0.5		-0.5	1	-0.5
	0	-0.5	0.5		0	-0.5	0.5

The global coefficient matrix is then assembled from the element coefficient matrices. Since there are 15 nodes, the global coefficient matrix will be a 15×15 matrix. The assembly of the global coefficient matrix is shown in Matrix Table 2.

Table 2: Showing global coefficient matrix C

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	-0.5	0	0	0	0	0	0	0	-0.5	0	0	0	0	0
2	-0.5	2	-0.5	0	0	0	0	0	-1	0	0	0	0	0	0
3	0	-0.5	2	-0.5	0	0	0	-1	0	0	0	0	0	0	0
4	0	0	-0.5	2	-0.5	0	-1	0	0	0	0	0	0	0	0
5	0	0	0	-0.5	1	-0.5	0	0	0	0	0	0	0	0	0
6	0	0	0	0	-0.5	2	-1	0	0	0	0	0	0	0	-0.5
7	0	0	0	-1	0	-1	4	-1	0	0	0	0	0	-1	0
8	0	0	-1	0	0	0	-1	4	-1	0	0	0	-1	0	0
9	0	-1	0	0	0	0	0	-1	4	-1	0	-1	0	0	0
10	-0.5	0	0	0	0	0	0	0	-1	2	-0.5	0	0	0	0
11	0	0	0	0	0	0	0	0	0	-0.5	1	-0.5	0	0	0
12	0	0	0	0	0	0	0	0	-1	0	-0.5	2	-0.5	0	0
13	0	0	0	0	0	0	0	-1	0	0	0	-0.5	2	-0.5	0
14	0	0	0	0	0	0	-1	0	0	0	0	0	-0.5	2	-0.5
15	0	0	0	0	0	-0.5	0	0	0	0	0	0	0	-0.5	1

Defining the vector of potentials $u_f$and u_p,where the subscripts f and p refer to nodes with free (unknown) potentials and prescribed potentials respectively, the global coefficient matrix is then partitioned accordingly and unknown potentials are obtained from

$$u_f = -C_{ff}^{-1} C_{fp} u_p \qquad (3)$$

The essential boundary conditions on the boundary of the domain, the vector of prescribed potentials u_p and the Matrices C_{ff}(Free Nodes Matrix), C_{fp}(Free and Prescribed Nodes Matrix) obtained from global coefficient matrix as shown in Table 3.

Table 3: Nodes in the finite element mesh having prescribed potentials

Node	Prescribed Potentials	Node	Prescribed Potentials
1	75	10	100
2	50	11	150
3	50	12	200
4	50	13	200
5	150	14	200
6	250	15	225

Table 4: Matrices C_{ff} and C_{fp} obtained from global coefficient matrix C.

	7	8	9
7	4	-1	0
8	-1	4	-1
9	0	-1	4

Matrix of free nodes C_{ff}

	1	2	3	4	5	6	10	11	12	13	14	15
7	0	0	0	-1	0	-1	0	0	0	0	-1	0
8	0	0	-1	0	0	0	0	0	0	-1	0	0
9	0	-1	0	0	0	0	-1	0	-1	0	0	0

Matrix of free and prescribed Nodes C_{fp}

The implementation of Equation (3) has been broken down into three parts.

1. Computation of the inverse of the C_{ff} matrix(this has been labelled $A^{-1} = C_{ff}^{-1}$)
2. Computation of an intermediate vector $b = -C_{fp}u_p$and
3. Computation of vector of potentials at free nodes $u_f = A^{-1}b$

This step is shown in below Table 5.

Node	Inverse		
7	0.2679	0.0714	0.0179
8	0.0714	0.2857	0.0714
9	0.0179	0.0714	0.2679

Node	Vector
7	500
8	250
9	350

Node	Vector
7	158.0357
8	132.1429
9	120.5357

Table 5: Final Calculation: (left) the inverse of the C_{ff} matrix, (middle) the intermediate vectorb,(right) the vector of potentials at free nodes u_f

IV.USING METLAB COMMANDS

The region is divided into 8 equal rectangular elements as indicated in Fig. 3. The elements are identified by encircled numbers 1 through 8. In this discretization there are 15 global nodes numbered 1 through 15 as indicated in the fig. 3.

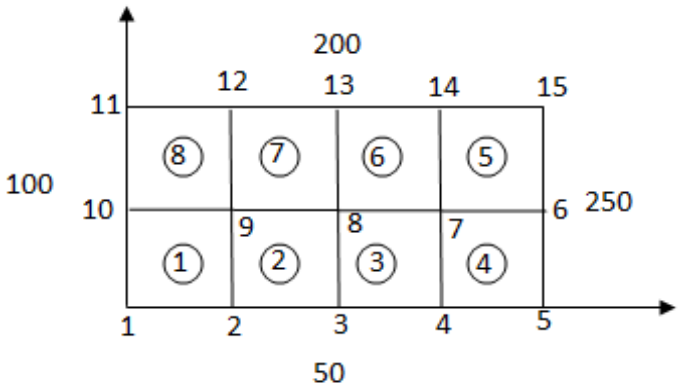


Fig.3: The region R showing prescribed potentials at the boundaries and rectangular grids

The creation of the assembled equations requires the definition of the element connectivity matrix, which defines the equivalence between local element node numbers and global node numbers. From the mesh given in Figure 1, the element connectivity matrix is

$$[B] = \begin{bmatrix} 1 & 2 & 9 & 10 \\ 2 & 3 & 8 & 9 \\ 3 & 4 & 7 & 8 \\ 4 & 5 & 6 & 7 \\ 7 & 6 & 15 & 14 \\ 8 & 7 & 14 & 13 \\ 9 & 8 & 13 & 12 \\ 10 & 9 & 12 & 11 \end{bmatrix}$$

There are 15 global nodes, therefore the assembled global coefficient matrix, [*K*], will be a *[15x15]* matrix, with one degree of freedom per node. There are no flux or source term vectors to be computed. From the

element connectivity matrix, it is clear that the mappings for the first two elements into the global stiffness matrix are obtained as follows.

ELEMENT #1

Local Indices of $[K^e]$

$$\begin{bmatrix} (1,1) & (1,2) & (1,3) & (1,4) \\ (2,1) & (2,2) & (2,3) & (2,4) \\ (3,1) & (3,2) & (3,3) & (3,4) \\ (4,1) & (4,2) & (4,3) & (4,4) \end{bmatrix} \xrightarrow{\text{map to}} \begin{bmatrix} (1,1) & (1,2) & (1,9) & (1,10) \\ (2,1) & (2,2) & (2,9) & (2,10) \\ (9,1) & (9,2) & (9,9) & (9,10) \\ (10,1) & (10,2) & (10,9) & (10,10) \end{bmatrix}$$

Global Indices of [K]

ELEMENT #2

Local Indices of $[K^e]$

$$\begin{bmatrix} (1,1) & (1,2) & (1,3) & (1,4) \\ (2,1) & (2,2) & (2,3) & (2,4) \\ (3,1) & (3,2) & (3,3) & (3,4) \\ (4,1) & (4,2) & (4,3) & (4,4) \end{bmatrix} \xrightarrow{\text{map to}} \begin{bmatrix} (2,2) & (2,3) & (2,8) & (2,9) \\ (3,2) & (3,3) & (3,8) & (3,9) \\ (8,2) & (8,3) & (8,8) & (8,9) \\ (9,2) & (9,3) & (9,8) & (9,9) \end{bmatrix}$$

Global Indices of [K]

The assembly procedure was performed by writing a short Matlab code, whose output is shown below: For a typical rectangular element,

$$[Ke] = \begin{bmatrix} 2/3 & -1/6 & -1/3 & -1/6 \\ -1/6 & 2/3 & -1/6 & -1/3 \\ -1/3 & -1/6 & 2/3 & -1/6 \\ -1/6 & -1/3 & -1/6 & 2/3 \end{bmatrix} \qquad \{Fe\} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

Assembly Global coefficient Matrix

$$[K] = \begin{bmatrix} 2/3 & -1/6 & 0 & 0 & 0 & 0 & 0 & 0 & -1/3 & -1/6 & 0 & 0 & 0 & 0 & 0 \\ -1/6 & 4/3 & -1/6 & 0 & 0 & 0 & 0 & -1/3 & -1/3 & -1/3 & 0 & 0 & 0 & 0 & 0 \\ 0 & -1/6 & 4/3 & -1/6 & 0 & 0 & -1/3 & -1/3 & -1/3 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & -1/6 & 4/3 & -1/6 & -1/3 & -1/3 & -1/3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1/6 & 2/3 & -1/6 & -1/3 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & -1/3 & -1/6 & 4/3 & -1/3 & 0 & 0 & 0 & 0 & 0 & 0 & -1/3 & -1/6 \\ 0 & 0 & -1/3 & -1/3 & -1/3 & -1/3 & 8/3 & -1/3 & 0 & 0 & 0 & 0 & -1/3 & -1/3 & -1/3 \\ 0 & -1/3 & -1/3 & -1/3 & 0 & 0 & -1/3 & 8/3 & -1/3 & 0 & 0 & -1/3 & -1/3 & -1/3 & 0 \\ -1/3 & -1/3 & -1/3 & 0 & 0 & 0 & 0 & -1/3 & 8/3 & -1/3 & -1/3 & -1/3 & -1/3 & 0 & 0 \\ -1/6 & -1/3 & 0 & 0 & 0 & 0 & 0 & 0 & -1/3 & 4/3 & -1/6 & -1/3 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1/3 & -1/6 & 2/3 & -1/6 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & -1/3 & -1/3 & -1/3 & -1/6 & 4/3 & -1/6 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & -1/3 & -1/3 & -1/3 & 0 & 0 & -1/6 & 4/3 & -1/6 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1/3 & -1/3 & -1/3 & 0 & 0 & 0 & 0 & -1/6 & 4/3 & -1/6 \\ 0 & 0 & 0 & 0 & 0 & -1/6 & -1/3 & 0 & 0 & 0 & 0 & 0 & 0 & -1/6 & 2/3 \end{bmatrix}$$

Assembly source and flux terms

$$\{F\} = [0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0\ 0]' \quad (15x1\ MATRIX)$$

The assembled equation is of the form

$$[K][U] = [F]$$

Because of Essential Boundary conditions on the boundary of the domain, the nodal solution vector should be of the form

$$\{U\}= [75\ 50\ 50\ 50\ 150\ 250\ U7\ U8\ U9\ 100\ 150\ 200\ 200\ 200\ 225]' \quad (15x1\ MATRIX)$$

So that the unknown values of [U] occur at global nodes 7, 8 and 9.At the singular points (global nodes 1,5,15 and 11), the specified nodal values are handled by averaging. Another option is to select the higher of the two specified values.

The condensed equations are obtained by eliminating rows (and columns) 1-6 and 10-15.All known quantities are moved from the left side of the matrix equation to the right side to obtain the condensed equations

$$\begin{bmatrix} 2.6667 & -0.3333 & 0 \\ -0.3333 & 2.6667 & -0.3333 \\ 0 & -0.3333 & 2.6667 \end{bmatrix} \begin{bmatrix} U7 \\ U8 \\ U9 \end{bmatrix} = \begin{bmatrix} 375.0000 \\ 250.0000 \\ 275.0000 \end{bmatrix}$$

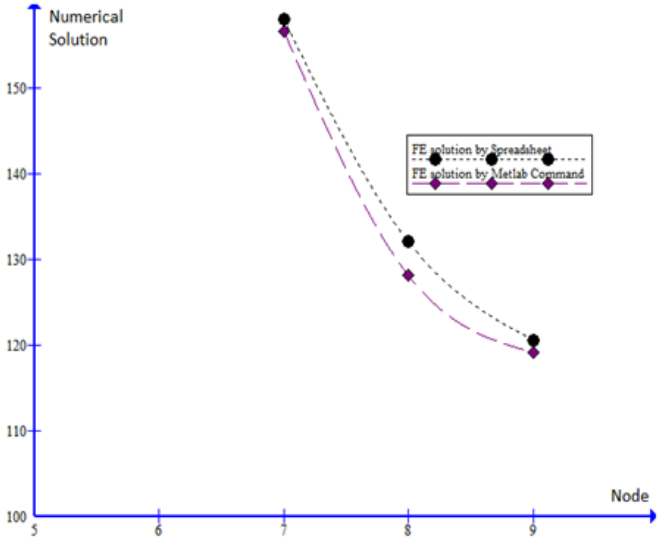
The solution of this equation yield

$$\begin{bmatrix} U7 \\ U8 \\ U9 \end{bmatrix} = \begin{bmatrix} 156.6532 \\ 128.2258 \\ 119.1532 \end{bmatrix}$$

V.COMPARISON BETWEEN FINITE ELEMENT NUMERICAL SOLUTIONS

As indicated in below table and graph, the potentials at the free nodes computed by using spreadsheet and Met lab Command numerical solutions compared fairly well. The better agreement should be obtained between the finite element numerical solution results by using spreadsheet with a triangular grid and Met lab command with a rectangular grid.

Node	Finite Element Numerical Solution	
	Spreadsheet	Met lab Command
7	158.0357	156.6532
8	132.1429	128.2258
9	120.5357	119.1532



VI.CONCLUSION

EXCEL provides a very good platform to take over the 'number crunching' process and focus on the understanding of the basic algorithm of the numerical method.The spreadsheet approach is ideal if the emphasis is on understanding of numerical techniques. It is observed that Finite element numerical solution using spreadsheet technique gives almost the same accuracy as that of Metlab technique.

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Field Sprouted Damaged Sorghum Grains for Sustainable Fuel Energy Production: A Critical Review

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Abstract: Germination, or sprouting, is a common problem for grain when weather is moist during harvest or the environment is humid during storage. The most important issues in industrial ethanol production are yield, efficiency, and energy consumption. Laboratory results in terms of ethanol yield and ethanol fermentation efficiency from artificially germinated high-tannin sorghum suggest that huge potential energy savings exist in production of ethanol from germinated sorghum grain. Using germination-damaged sorghum for industrial ethanol production might benefit the producer and end user by expanding market uses of what has been historically considered a low-value commodity. Germination not only causes compositional changes in the sorghum grain but also initiates a series of biochemical and physiological changes. Intrinsic enzymes such as amylases, proteases, lipases, fiber-degrading enzymes, and phytases are activated.

Current fuel ethanol research and development deals with process engineering trends for improving biotechnological production of ethanol. This paper gives a overview of the current ethanol production processes from cereal grains and effect of sorghum grain sprouting on fermentation for sustainable fuel energy production.

Keywords: *Energy, Bioethanol, Sorghum, Factors, Yield, Efficiency*

1. Introduction:

Ethanol (ethyl alcohol, C_2H_5OH, melting point -114^0C, boiling point 78.4^0C) is soluble in water and has a density of 789 g/l at 20^0C. Catalytic hydration of petroleum products (ethylene) produces a synthetic ethanol.

$$\underset{\text{Ethylene}}{C_2H_4} + \underset{\text{steam}}{H_2O} \longrightarrow \underset{\text{Ethanol}}{CH_3CH_2OH}$$

Many traditional chemical processes based on acidic - or base catalysed reactions for processing of agricultural products have inherent drawbacks from a commercial and environmental point of view. Non-specific reactions may result in poor product yields. High temperatures and high pressures needed to drive reactions may lead tohigh costs and requirement of large volumes of cooling water downstream. Harsh and hazardous processes involving high temperatures, pressures, acidity or alkalinity need high capital investment, and specially designed equipment and control systems. Unwanted by-products may prove difficult or costly to dispose of. High chemical and energy consumption, and harmful by-products have a negative impact on the environment. The use of enzymes may virtually eliminate these drawbacks within the non-food as well as within the food area. Fermentation processes for brewing, baking and the production of alcohol have been used in ancient China and Japan. The production of fermented alcoholic drinks from crops rich in starch has been practiced for centuries.

2. Bioethanol:

Bioethanol is derived from alcoholic fermentation of sucrose or simple sugars. Absolute and 95% ethanols are good solvents and are used in many industrial products such as paints, perfumes and tinctures. Bio-ethanol captures the alcoholic beverage market and a small share of vehicle fuel market. Ethanol intended to nonfood uses is made unfit for human absorption by addition of small amount of toxic or unpleasant substances such as methanol or gasoline. Bioethanol has an increased attention over the last few years, mainly due to its potential as a substitute for fossil fuels and the need to reduce global economics dependence on fossil resources. Significant advances have been made towards the technology of ethanol fermentation [Lin and Tanaka[1], 2006]. Bioethanol is a form of renewable fuel that can be produced from agricultural feedstocks such as sugar cane [Mayuri[2] *et al.*, 2011], sorghum [Sheorain[3] *et al.*, 2000; Tahmina[4] *et al.*, 2011; Wu[5] *et al.*, 2007], organic and food waste (maize) [Akpan[6] *et al.*,

2008], banana peel waste [Manikandan[7] *et al.*, 2011], agro industrial byproducts [Sara Raposo[8] *et al.*, 2009], starch industy waste [Shah[9] *et al.*, 2010]. Actually Brazil and the USA are the world's largest producers of bioethanol, counting with approximately 62% of world production [Kim and Dale[10] 2004]. The major feedstocks used by these countries are sugar cane and corn, respectively. It is estimated that about 95% of the alcohol manufactured in India is from molasses and the rest comes from grains, and roots and tubers. Production of sorghum-based alcohol was not encouraged in the past keeping in mind food security, since it is the third most important food grain in India. However, with decreasing per capita consumption of sorghum and greater availability of rice and wheat, rainy-season sorghum is gaining popularity as a raw material for industrial uses. Rain-damaged or blackened sorghum could be a favorable raw material for alcohol production because of its lower market price. Maharashtra, the main producer of rainy season sorghum, regularly faces the problem of finding suitable users of blackened sorghum which constitutes 40-60% of its produce, depending on the rainfall pattern during grain maturity.

3. Sorghum Grain as Raw Material for Ethanol Fermentation: Sorghum on a world basis ranks fifth among the cereal grains. It is the third most important cereal crop in India after rice and wheat, grown on 16.11 million ha, with a total production of 10.68 million tonnes (Anonymous[11] 1983). The important states with sizable acreages are: Maharashtra, Andhra Pradesh, Madhya Pradesh, Karnataka, Tamil Nadu, Gujarat, Rajasthan, Uttar Pradesh, and Haryana. Grains are a rich and cheap source of starch. Although maize is the most commonly used grain for alcohol production especially in USA, sorghum has several advantages over maize. It has higher starch compared to maize (Table 1) (Lorenz and Kulp[12] 1991). Sorghum is grown in both kharif and rabi seasons and the kharif crop is mostly F1 hybrids, which have good fodder and grain yield.

Table 1

Comparison of composition of sorghum and maize

Component	Content (%)	
	Sorghum	Maize
Starch	63–68	60–64
Moisture	9–13	8–11
Proteins	9–11	9–11
Fats and oils	1–1.5	3–5
Crude fiber	1.5–2	1.5–2
Ash	1–2	1–2
Other organics	8–12	7–9

Grain-based alcohol is more expensive to produce than molasses-based alcohol, due to the high cost of raw material and additional processing costs (for coal/steam, and enzymes). During mid-1998 in eastern Maharashtra, the cost of producting extra neutral alcohol ENA from molasses varied from Rs 13 to 16 per liter, and that from grain from Rs 21 to 27 per litre depending on raw material cost and alcohol recovery. Maharashtra Government is in favor of promoting grain-based alcohol production to create a demand for rainy-season sorghum**.**

Sorghum grain is one of the most important sources of carbohydrates. Carbohydrates and fibers comprise approximately 72% of sorghum grains (Wu[5] *et al*., 2007). Its starch component has similar properties to corn starch, and can be used almost interchangeably. Since there are hundreds of sorghum hybrids available commercially, if these feedstocks are the option for bioethanol production, the large variations in their composition will surely affect the hydrolysis and fermentation performance (Wang[13] *et al*., 2008). Thus, it is important for the ethanol industry and sorghum producers to have appropriate methods that accurately predict sorghum ethanol yields and conversion efficiencies (Zhao[14] *et al*., 2009). In approximate terms, ethanol yield from sorghum grain is comparable to that from corn grain. However, in the past, factors impacting ethanol yield were less well studied for sorghum than for corn. Little research has been conducted on performance of sorghum varieties in ethanol fermentation. Zhan[15] *et al.* studied the effect of genotype and location on ethanol and lactic acid production of a limited number of sorghum genotypes. Several researchers have investigated the digestibility of sorghum starch [Rooney LW and PXugfelder RL[16] 1986,] and sorghum protein [Zhang G[17] 1998, Duodu KG[18] 2003] as related to its use in feed or food. Others have investigated the isolation of sorghum starch [Yang p and Seib PA[19] 1995, Yang P and Seib PA[20] 1996] and its properties [Beta T[21] *et al*., 2001, Beta T[22] *et al*., 2001]. The economic viability of an ethanol production facility depends on several factors, including ethanol yield, efficiency of conversion, and quality of the "distiller's grain" (grain residue and yeast mass remaining after the fermentation process). Recently, however, sorghum cultivars with high protein digestibility and improved starch digestibility have been reported (Weaver[23] *et al* 1998). By analyzing the relationship of genetics, grain component structure, molecular structure/function, and starch conversion to ethanol, factors affecting the bioprocessing of sorghum into ethanol can be studied in a better way.

4. Current Technology for Ethanol Production using starch based raw material:

Ethanol production from grain involves milling of grain, hydrolysis of starch to release fermentable sugars, followed by inoculation with yeast. Chemically starch is a polymer of glucose. Yeast cannot use starch directly for ethanol production. Therefore, grain starch has to be completely broken down to glucose by a combination of two enzymes, viz., amylase and amyloglucosidase, before it is fermented by yeast to produce ethanol. Alcohol so produced is distilled from fermented broth. The remaining stillage is processed to produce Distillers Dried Grains DDG or DDGS. Fuel ethanol is produced from corn by either dry grind (82%) or wet mill (18%) process and majority of these biorefineries being constructed are dry grind plants (Renewable Fuel association24 2007). A schematic overview of the process from grain to fuel alcohol is shown in Figure 1.

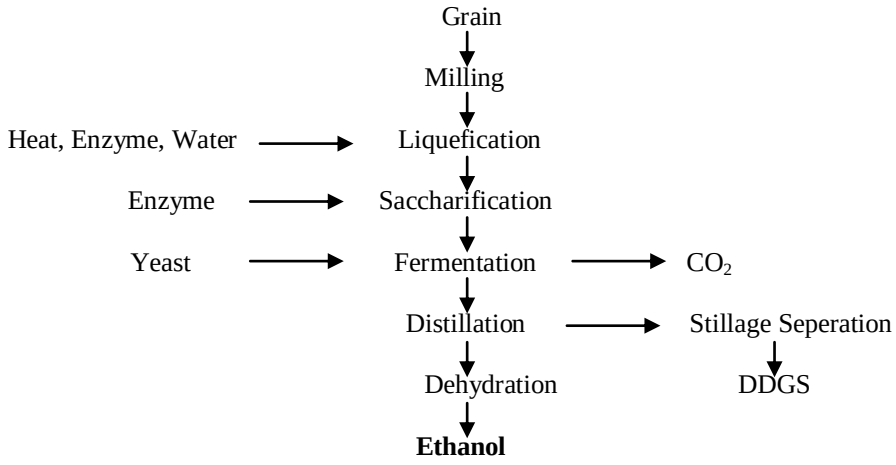

Figure 1: *Overview of the basic "dry grind" process of fuel alcohol production*

5. Effect of Grain Sprouting on Fermentation Performance:

Germination promotes the development of cytolytic, proteolytic, and amylolytic enzymes that are not active in dry kernels. Yan25 et al. (2009) studied the effect of germinated sorghum on ethanol fermentation and fermentation efficiency. Results from laboratory-germinated, tannin-containing grain sorghum (i.e., sorghum with a pigmented testa) showed that germination decreased tannin content, improved sorghum fermentation performance, shortened fermentation time. To a certain degree, germination of feedstocks may not be negative for ethanol fermentation. Germination causes compositional changes in the sorghum grain and also initiates a series of biochemical and physiological changes. Intrinsic enzymes such as amylases, proteases, lipases, fiber-degrading enzymes, and phytases are activated; this disrupts protein bodies and degrades proteins, carbohydrates, and lipids to simpler molecules, which increases digestibility of proteins and carbohydrates in the kernel and makes nutrients available and accessible for enzymes. Free amino nitrogen (FAN) is an essential nutrient for yeast growth during fermentation. Protein is the second major component in grain sorghum. Protein degradation could provide nitrogen for yeast growth during fermentation. Recent research has found that ethanol yield and conversion efficiency significantly increased as FAN increased in laboratory-germinated and field-sprouted grain sorghum. Yeast can only utilize FAN and short peptides, not large intact proteins. Table 2 shows chemical composition of the five field-sprouted samples and the control (non-sprouted). Field sprouting damaged starch granules, protein matrices, and cell walls in sorghum kernels, consequently decreasing kernel hardness, kernel weight, and kernel size. Field sprouting also changed the chemical composition and pasting properties of field-sprouted grain sorghum, which could shorten fermentation time without decreasing ethanol yield. Field-sprouted grain sorghum had relatively high FAN content. The FAN provided efficient buffering capacity and optimal yeast performance, and field sprouted sorghum had a more rapid fermentation rate than non sprouted sorghum. The FAN in the non-sprouted sample was lower than that in the sprouted samples even though the non-sprouted sorghum sample had the highest protein content. Enzymatic degradation of protein by activated intrinsic proteases during sprouting resulted in an increase in FAN contents and short peptides, which accounted forthe significant increase in FAN levels of field-sprouted sorghumsamples.

FAN contents in the mashes of sprouted sorghum samples will further increase during the slurry and liquefaction process. Also, α-amylase activity in the non-sprouted control was lower than that in sprouted grainsorghum. The diverse values of FAN and α-amylase activity also revealed that samples had experienced different degrees or durations of field sprouting. All field-sprouted samples had high starch content.

Table 2: Physiochemical characteristics of sorghum grains

Sorghum samples	Chemical composition (%wb)					FAN (mg/l)	α-amylase activity	Kernel weight (mg)
	MC	Ash	Protein	Fiber	Starch			
Control	10.38	1.62	11.59	1.15	64.50	162	5.6	30.00
Variety1	12.28	1.18	6.66	2.12	67.30	221.9	12.03	24.76
Variety2	12.97	1.19	7.02	2.24	66.78	234.8	12.6	25.42
Variety3	11.92	1.26	7.60	2.07	67.80	284.3	15.79	25.53
Variety4	12.71	1.10	7.27	1.95	69.28	189.5	13.35	25.12
Variety5	12.52	1.15	6.96	1.91	69.65	258.4	13.18	26

6. Conclusion: This review concludes that there is vast scope of ethanol production from biodegradable food grains in this era of energy crises. In ethanol production industries hundreds of sorghum hybrids are used, there is variation in fermentation quality among these hybrids. This shows the importance for ethanol industries and sorghum producers to have proper methods to predict their ethanol yield as well as conversion efficiencies. Review of scholars work indicates that genetically improving the quality of grain sorghum for ethanol production increases the utilization of sorghum for ethanol production. Sprouted sorghum had a more rapid fermentation rate than non sprouted sorghum. Sprouted grain sorghum had relatively high free amino nitrogen content. Grain damaged by sprouting may lose value for food applications but may not affect ethanol production and final ethanol yield. Thus, using weathered and/or sprouted sorghum from regions affected by unusually high moisture events during grain fill and harvest may provide an opportunity for ethanol producers to maintain ethanol production efficiency, while shortening processing time. This could offer sorghum producers an opportunity to receive a premium, or at least a fair market value for sorghum when such environmental events occur. Hence from the above review of literature it is evident that there is a vast scope of ethanol fermentation using damaged food grains. After the study of factors affecting ethanol fermentation using food grains it is possible to control the operating variables like processing temperature, enzyme concentration and time. These governing parameters would definitely enhance the bioethanol production rate as well as utilization of germinated damaged food grains.

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Treatment of Dairy waste water using UASB Reactor and generation of energy

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ABSTRACT

In recent years we have been moving towards more and more industrial development. As a result we are facing many environmental pollution problems. The waste water emanating from this highly processed industrial processes which are putrescible in nature. Hence treatment of such waste water is essential before disposal of river, stream etc.

The quality of wastewater decides the line of treatment. The study undertaken involved the characterization of wastewater and the dairy waste is selected for this purpose. The model study gives the approximate idea about the usability and function of the treatment of the waste water of industry by UASB method.

UASB being the anaerobic treatment many other processes also exists but with comparison to UASB it has certain advantages which are also made here. Thus trying to bring out the best and foremost means to use the UASB against others.

The anaerobic treatment results in formation of methane (CH_4) which can be used as an energy source. Therefore anaerobic process followed by aerobic process has proved to be economical in waste treatment.

The degree of removal of organic matter is in direct proportion to the amount of methane produced. If gas production trend is downward continually the digestion process is failing.

Gas produced after degradation of organic matter contains about nearly 75-80% CH_4 by volume, 15 to 25% CO_2& small of N_2, H_2other gases. Since methane gas has high calorific value. This gas is collected & can be used as an alternative source of energy. Thus, this process becomes economical and effective for high BOD wastes.

1. INTRODUCTION

India is one of the fast developing countries with growing number of industries. The situation is similar to that prevailing in most of the developing countries, which have not been able to develop adequate civic infrastructure even when their number of citizens and industries have increased rapidly. As a result many of cities have grown into overcrowded and ill-equipped settlements with a highly polluted environment prone to frequent epidemics and hardships. Dairy industry has become one of the major food processing industries of the world in current century after the inversion of milk preservation techniques and pasteurization and powderisation technique.

In India near about in 273 dairy industries processing and supplying 18.33 million liters milk soled per day through arranged sales. But in whole process large amount of waste water generates, that's why it is necessary to treat that water by using sustainable method like UASB reactor (i.e. Upflow Anaerobic Sludge Blanket reactor).

The Upflow Anaerobic Sludge Blanket (UASB) process is one of the recent developments in field of anaerobic treatment. In this process the use of primary treatment and the filter bed is completely eliminated. The UASB process is seen as one of the most cost effective & efficient anaerobic treatment. The anaerobic treatment results in formation of methane (CH4) which can be used as an energy source. Therefore anaerobic process followed by aerobic process has proved to be economical in waste treatment.

2. LITERATURE REVIEW

In any dairy plant, the quantity and characteristics of effluent is depending upon the extent of production activities, pasteurization of several milk products. The anaerobic digesters are used in the first phase of treatment, which is followed by high rate aerobic treatment.

Upflow Anaerobic Sludge Blanket reactors are designed. UASB is a hybrid type of reactor, involving both suspended and attached growth

process. This study involves the treatment of dairy industry wastewater by UASB reactor by varying the retention times in days for a particular organic loading rate . This has effectively removed BOD, COD and other parameters because of the combined suspended and attached growth processes. [1]

Anaerobic wastewater treatment differs from conventional aerobic treatment. The absence of oxygen leads to controlled conversion of complex organic pollutions, mainly to carbon dioxide and methane.Anaerobic treatment has favourable effects like removal of higher organic loading, low sludge production, high pathogen removal, biogas gas production and low energy consumption.Application of anaerobic systems for municipal sewage treatment is so far very limited. The predominant reason given for is, that municipal sewage are to weak (to low BOD or COD) to maintain high biomass (in the form of granules – suspended solids or fixed film) content in reactor.[2]

3. CHARACTERISTICS OF WASTE WATER

3.1 Physical characteristics :

a) Colour b) Odour c) Temperature d) Solids:

3.2 Chemical characteristics:

a) Chloride b) Alkalinity c) Acidity
d) Hydrogen Concentration
e)Biochemical Oxygen Demand (BOD)
f) Chemical Oxygen Demand (COD)

3.3 COMPOSITION OF TYPICAL DAIRY WASTEWATER:

Sr. No.	Parameters	Value
1	pH	7.2
2	Alkalinity	600
3	Total Dissolved Solids	1060 mg/lit
4	Suspended solids	760 mg/lit
5	BOD	1240 mg/lit
6	COD	2580 mg/lit
7	Total Nitrogen	84
8	Phosphorous	11.7
9	Oil and Greases	290
10	Chlorides	105

4. ANAEROBIC SUSPENDED GROWTH TREATMENT PROCESSES

In the post ten years a number of different anaerobic processes have been developed for the treatment of sledges and high-strength organic wastes. Some commonly use anaerobic suspended growth treatment processes are given as follows:
A) Anaerobic digestion, B) Anaerobic contact process, C) UASB blanket.

- Up-flow anaerobic sludge-Blanket process

In the up flow anaerobic sludge-blanket (UASB) process, the wastewater flows upward through a sludge blanket composed of biologically formed granules or particles. Treatment produced under anaerobic conditions (principally Methane and carbon dioxide) cause internal circulation, which helps in the formation and maintenance of the biological granules. Some of the gas produced within the sludge blanket becomes attached to the biological granules. The free gas and the particles with the attached gas rise to the top of the reactor.

4.1 Factors Affecting Anaerobic Digestion

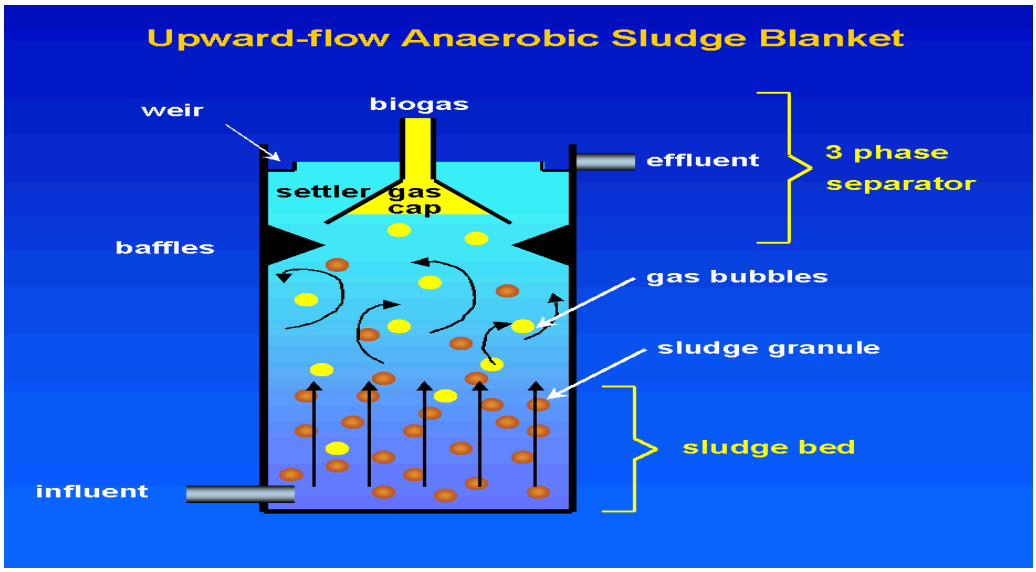
A. Environmental factors:
1) PH & Alkalinity 2) Volatile acid concentration 3) Temperature 4) Nutrient Availability 5) Toxic materials

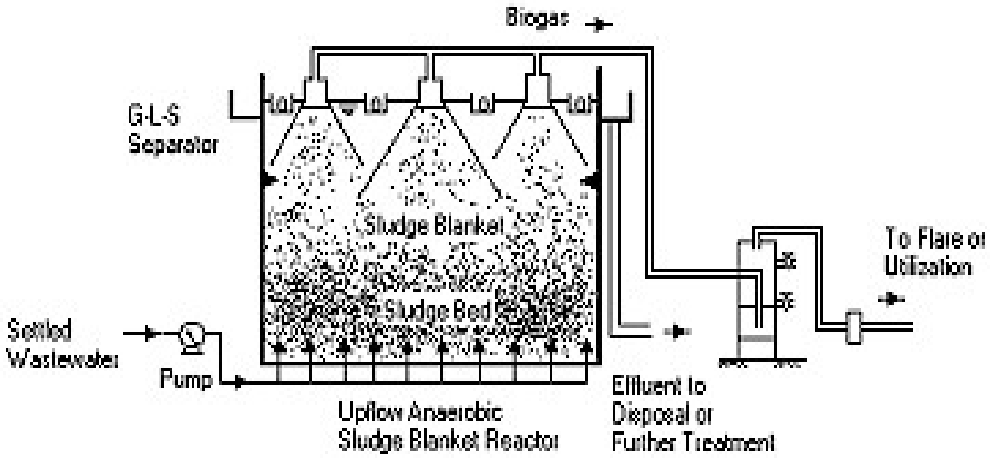
B.Basic Factors:
1) Bacteria 2) Food 3) Contact 4) Time.

5. UASB PROCESS AND EXPERIMENTAL SETUP

- **Brief History UASB:**

The UASB process was developed by Dr. Gatze Lettinga (and colleagues in the late 1970's at the Wageningen University. Inspired by publications of Dr. Perry McCarty, Lettinga's team was experimenting with an anaerobic filter concept. The anaerobic filter (AF) is a high rate anaerobic reactor in which biomass is immobilized on an inert porous support material. During experiments with the AF, Lettinga had observed that in addition to biomass attached on the support material, a large proportion of the biomass developed into free granular aggregates. The UASB concept crystallized during a trip Gatze Lettinga made to South Africa, where he observed at an anaerobic plant treating wine vinasse, that sludge was developing into compact granules. The reactor design of the plant he was visiting was a "clarigestor", which can be viewed as an ancestor to the UASB. The upper part of the "clarigestor" reactor design has a clarifier but no gas cap.





Schematic diagram of UASB reactor

Internal three-phase GSL device:

Installed at the top of the tank, the GSL device constitutes an essential part of an UASB reactor with following functions:

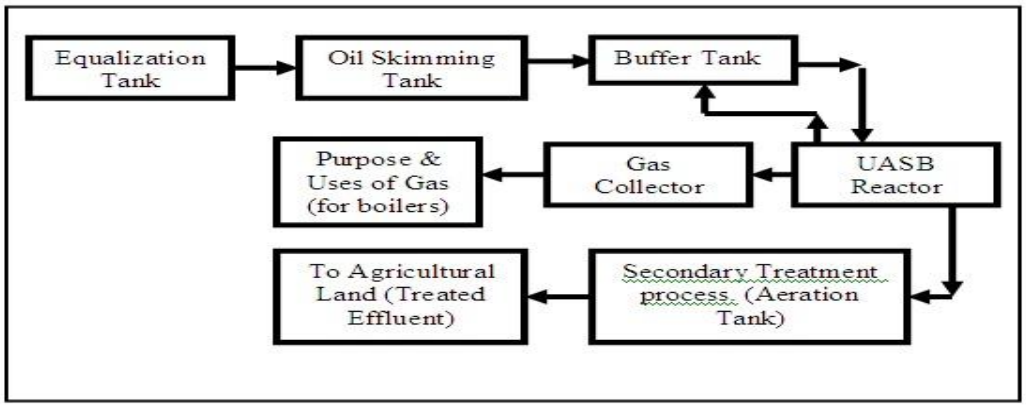
1) To collect, separate and discharge the biogas formed.
2) To reduce liquid turbulences, resulting from the gas production, in the settling compartment.
3) To allow sludge particles to separate by sedimentation, flocculation or entrapment in the sludge blanket.
4) To limit expansion of the sludge bed in the digester compartment.
5) To reduce or prevent the carry-over of sludge particles from the system.

6. CASE STUDIES

Thorat Milk Production: Sangamner

Dairy has set up on UASB reactor by March 1998, the reactor was the first UASB treatment for dairy in the state of Maharashtra. The reactor was designed by Netherlands technology. This reactor made the table of waste water treatment much easier effective and also was much economical giving good end-result.

Dimensions: Ht – 6.5 m.



a) Equalization tank:

At first the waste water gets collected so that the waste substrate can be equalized and the pH is maintained strictly processing to the UASB reactor.

b) Oil skimming tank:

The waste water after being neutralized is passed through the oil skimming tank in order to remove the oils fats, grease remained in the waste; because if this goes without skimming then if chock up the UASB and proper working will not be done.

c) Buffer tank:

It is a storage tank where the waste water from oil skimming tank comes and from the here is supplied is the UASB reactor. Also the excess of waste-waste that is present in UASB is again brought to the buffer tank.

d) UASB Reactor: It is a reactor where sludge from and waste is treated at the bottom of reactor. The wastewater blows up through a sludge blanket composed of biologically formed granules. Thus treating under anaerobic condition gives out geese which are collected to the dome shaped structure and the waste water is collected in the side way hoods. The up flow velocity is in the range of 0.6-0.9 m/hr.

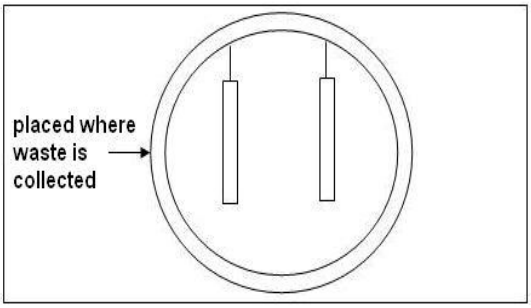


Figure 6.2: UASB Reactor (Plan)

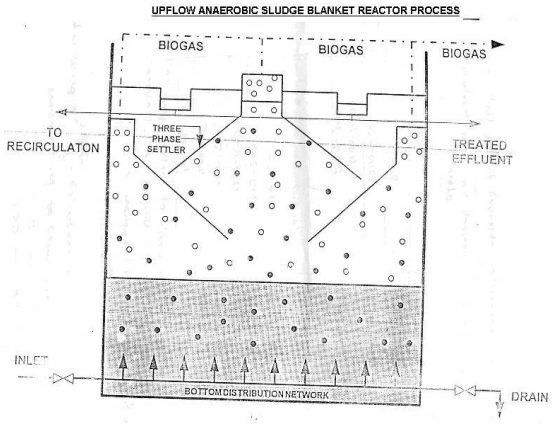


Figure 6.3: UASB Blanket Process

There is a small pipe attached through which is goes down in to the tank. The gas collected in transferred to the foam trap

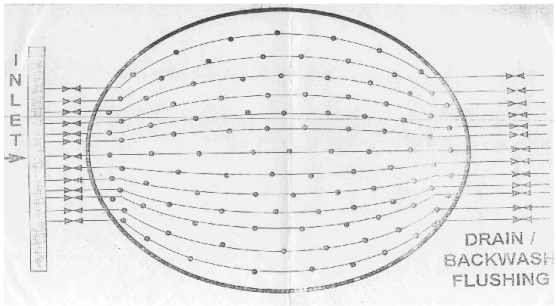


Figure 6.4: Bottom Distribution System

7. CONCLUSION

- This anaerobic system of digestion can be used in small scale for the treatment of domestic waste water.
- An arrangement can be made for the continuous loading of digesters and a better gas collection system.

- After the treatment Dairy waste water can be used for agriculture purpose and the formed methane (CH4) which can be used as an energy source.
- In this process the use of primary treatment and the filter bed is completely eliminated.
- The UASB process is seen as one of the most cost effective & efficient anaerobic treatment.

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Turbidity and Coagulation Effect in Salt Gradient Solar Pond: A Review

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Abstract
Solar ponds are thermal energy storage systems containing pool of salt water. The utilization of available solar energy is depending on efficient use of Thermal Energy Storage systems. This stored thermal energy, is use for various applications like process heating, power generation, and desalination. The effect of Turbidity on uses of salt gradient solar pond and method of Coagulation to control turbidity are discussed in this paper to create awareness and attract attention of energy researchers.

Keywords : *Turbidity; coagulation; gradient*

Introduction

Modern society is deeply influenced with the development of science and technology as well the industrialization. This has radically transformed the way we live toady. Yet all this has a darker side too. The civilization toady is facing two severe threats to its very existence: 1. Depletion of conventional energy resources 2. Rising level of pollution.
All over the world the scientists are searching for the solution to these crises. It is very interesting and important to be pursued that the problems of energy, environment and economics are intimately linked with each other and can be discussed individually. Use of alternative sources of energy is very important aspect of the solution to these problems. Amongst alternative energy sources, solar energy is the most viable, economical and environmental friendly. Earth receives solar energy in abundance in fact the solar energy is received in a very large quantity by our earth. It is significantly larger than the requirements of modern civilization. Salt Gradient Solar Pond (SGSP) is a device that converts solar energy into heat energy and stores it for long term and in large quantity. It is considered to be the most economical solar thermal conversion and storage device.

The SGSPs are being used all over the world for variety of applications. Israel has done a pioneer work in this direction. They have an ambitious plan to meets their entire electricity demand by solar ponds exclusively by the end of this decade. They are using the potential of dead-sea for this purpose. SGSPs use saline water in large quantity. Hence researchers have constructed them using marine water. India has a big coastal line. It has tremendous potential for providing saline water for ponds.

Turbidity and SGSP

SGSP is a system open to atmosphere.Air born dust etc continuously falls consequently the clarity of water gets reduced. This reduces radiation penetration in the pond and results in to loss of thermal efficiency. Many researchers have worked on the issue water clarity and its effect on thermal efficiency. Many have worked on control of water clarity.
Some researchers observed that water “clarity” has a significant effect on radiation penetration and hence thermal performance of the pond. Clarity as such is a qualitative work. For the sake of mathematical modeling and analysis quantitative definition is required. Since for duration of more than one and half decades, researchers worked for identifying a quantitative term (from 1980 to 1994). In fact in the field of solar engineering such a term was not obviously available. Yet in the field of water engineering such a term was existing, that is “turbidity”.Wang and Yagoobi first used this term to quantify the term “clarity” as “turbidity” of water. They developed a radiation transmission model based upon curve fitting of experimentally measured data. They observed that turbidity has such a profound effect on pond’s thermal performance that no realistic analysis of the pond can be done ignoring the turbidity. Recently Malik *et al* have reinvestigated the impact of turbidity on radiation transmissions in water. They have also investigated the turbidity accumulation and removal aspect in prototype ponds.

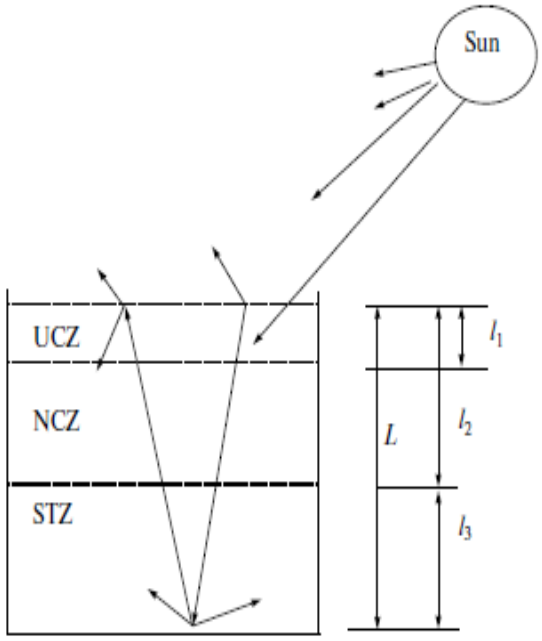

Fig. 1. Schematic diagram of a salt gradient solar pond showing the three zones and radiation pathway.

Turbidity and Particle effects

Turbidity is defined as an "expression of the optical property that causes light to be scattered and absorbed rather than transmitted". When the light beam passes through the sample of fluid, the suspended solids scatter the light in all directions (360°spherically). Reduction in the intensity of the light beam is primarily caused by the suspended solids scattering the light.

There is no absolute difference between dissolved and un-dissolved matter. The water treatment authority considers all particles of less than 0.45 microns in diameter as being dissolved. It is important to note that particles smaller than 0.45 microns will also scatter light. The amount of scattered light is not the same in all directions and the special distribution pattern varies with particle size. Figure 2 illustrates this fact in which large and small particles show different lines of equal light intensity.

Scattering distribution patterns show that when particles are equal to or larger than the wavelength of the incident light beam (1 micron), there is a higher amount of forward scattered light. As the particle size becomes smaller, the pattern becomes somewhat peanut-shaped (see Figure 2). However, particles smaller than 0.05 microns in diameter (colloids) are also scatter light equally in all directions.

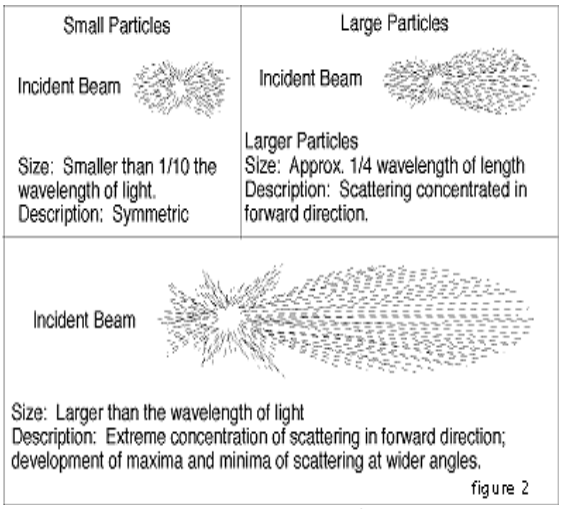

Figure 2: Scattering of Light

Other Factors Which Influence Light Scattering is:

1. Particle color-This determines the ability to absorb or reflect the incident light beam. For example, two different types of filter beds are typically used in water treatment: carbon and sand. The sand is light in color which reflects the incident beam very well. Conversely, the black carbon has a tendency to absorb the incident beam. Therefore, with all else being constant (particle size, shape, etc.), the fines from carbon filters have lower scattered light intensity.

2. Particle shape-This determines the ability of the suspended solids to provide a constant spatial distribution pattern. A smooth, spherical-shaped particle will provide predictable results, whereas an irregularly-shaped particle can produce widely varying responses depending on the side that the incident light beam strikes.

3. A difference between the refractive indexes of the particle and the sample fluid-This allows light scattering to occur. The intensity of the scattered light can be increases as the difference increases.

Coagulation

The turbidity can be reduced by coagulation. Coagulation is a process which involves gentle stirring (flocculation) of water so as to bring insoluble coagulant molecule and colloids together to attach them together by adhesion. But the stratified layers of SGSP do not permit stirring in the pond. Hence, coagulation for SGSP is typically an "unstirred" coagulation.

Water clarity is extremely desirable for efficient thermal performance of SGSP. Coagulation using alum (as well as other chemical) is a well established technique for turbidity removal from waters. Coagulation is a four stage phenomenon: *addition of coagulant→ rapid mixing→ slow mixing→ sedimentation.* Rapid mixing is done in order to dissolve the chemical. Slow mixing is done in order to bring insoluble coagulant molecule and colloids together. As such, the technique of coagulation can not be applied to solar ponds, because in solar ponds mixing is not allowed due to gradient layers. Hence coagulation can be done simply by sprinkling coagulant solution at the surface. This is typically termed as unstirred coagulation. Further, solar ponds contain water which is highly saline and is at high temperature. Under these circumstances, the required dose of coagulant, performance of coagulant and the frequency (duration) at which the coagulation should be done, needs to be investigated.

Flocculation is the physical process of bringing the destabilized particles in contact to form larger flocs that can be more easily removed from suspension. Flocculation is almost always used in conjunction with and preceded by coagulation. The process is generally accomplished by slow mixing of the destabilized suspension to provide an opportunity for the particles to come into contact with one another and bridge together. Therefore, flocculation enhances subsequent sedimentation or the performance of filtration systems by increasing particle size, resulting in increased settling and filter-capture rates.

Conclusion

SGSP has wide scope in India for process heat applications, power generation, etc. but its operational parameters especially turbidity phenomenon and different methods for control it needs to be investigated. This is the effort to give inside into these most important terms, which are extremely important for efficient performance of SGSP.

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Transient Overvoltages in Power System

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Abstract.
There are many reasons for over voltages in power system. The overvoltage causes number of effect in the power system. It may cause insulation failure of the equipments, malfunction of the equipments. Overvoltage can cause damage to components connected to the power supply and lead to insulation failure, damage to electronic components, heating, flashovers, etc. Over voltages occur in a system when the system voltage rises over 110% of the nominal rated voltage. Overvoltage can be caused by a number of reasons, sudden reduction in loads, switching of transient loads, lightning strikes, failure of control equipment such as voltage regulators, neutral displacement,. Overvoltage can cause damage to components connected to the power supply and lead to insulation failure, damage to electronic components, heating, flashovers, etc. The causes of power system overvoltages are numerous and the waveforms are complex. It is customary to classify the transients on the basis of frequency content of the waveforms. This paper presents causes and sources of overvoltage that may damage power system equipments. This also helps us to classify type of problems so that further analysis and protection can be accomplished in the system.

Index Terms:-*Power frequency over voltages, Switching over voltages, lightning over voltages, Sources of Transient Over voltages*

Power Frequency Overvoltages.

The magnitude of power frequency overvoltages is typically low compared to switching or lightning overvoltages. Specifically, for most causes of these types of overvoltage, the magnitude may be few percent to 50% above the nominal operating voltage. However, they play an important role in the application of overvoltage protection devices. The reason is that modern overvoltage protection devices are not capable of discharging high levels of energy associated with power frequency overvoltages. Thus, it is imperative that protective device ratings be selected in such a way that they do not operate under any foreseeable power frequency over voltages.

Table 1. Power-System Over voltages

Power frequency overvoltages	Description	Causes
Power frequency overvoltages	Temporary overvoltages dominated by the power frequency component	Electric faults Sudden changes of load Ferroresonance
Switching overvoltages	Temporary overvoltages resulting from a switching operation	Energization of lines Deenergization of capacitor banks Fault interruption/TRV High-speed reclosing Energization/deenergization of transformers Other
Lightning overvoltages	Temporary overvoltages resulting from a lightning stroke terminating at a phase conductor, shield conductor, any other part of a power system, or a nearby object (tree, etc.)	Lightning—cloud-to-ground flashes

The most common causes of power frequency over voltages are (1) electric faults, (2) sudden changes of load, and (3) ferroresonance. An electric fault results in voltage collapse for the faulted phase and in a possible overvoltage at the unfaulted phases. The magnitude of the overvoltage depends on the parameters of the circuit, such as positive, negative, and zero sequence impedance, as well as the grounding parameters of the system, such as ground impedance or single- or multiple-grounded system. Figure 2 illustrates a typical case of a single-phase-to-ground fault at the end of a 40-mi-long 115-kV transmission line. Because the electric power system is not completely symmetric, the magnitude of the overvoltage on the unfaulted phases may be different; that is, for the case of Fig. 2, the overvoltage on phase B is 28.3%, while for phase C the overvoltage is 31.9%. Many studies have been performed over the years to determine simple techniques for determining the power frequency overvoltages. As a first approximation, one can determine the power frequency overvoltage due to a fault from the sequence parameters (positive-, negative-, and zero-sequence impedances) at the fault location. Figure 3, taken from Johnson (1979), illustrates the power frequency overvoltage at the unfaulted phases due to a ground fault in one phase as a function of the ratios (X 0/X 1) and (R 0/X 1).

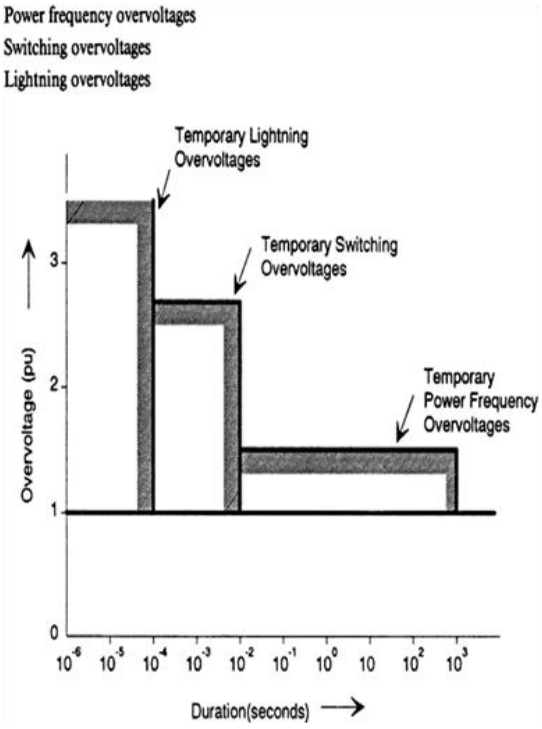

Figure (1):- Typical range of magnitude and duration of power system temporary overvoltages.

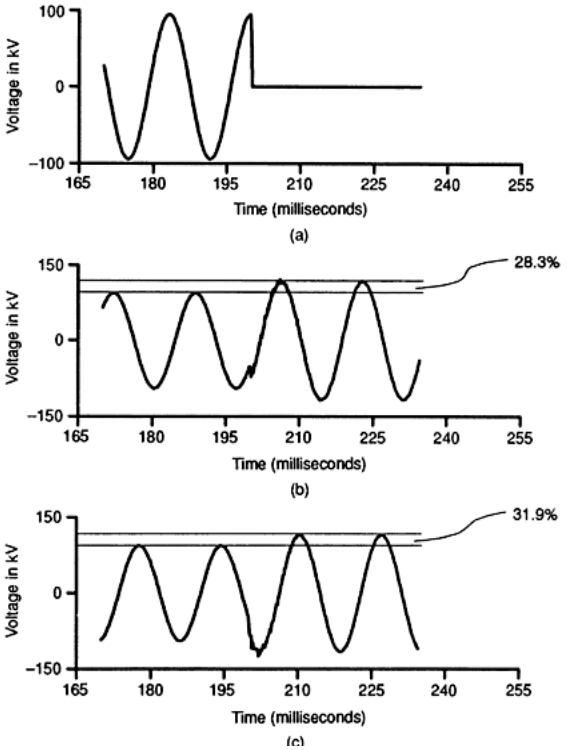

Figure (2). Overvoltage due to a single-phase-to-ground fault at the end of a 40-mi-long 115-kV line: (a) phase A voltage; (b) phase B voltage; (c) phase C voltage.

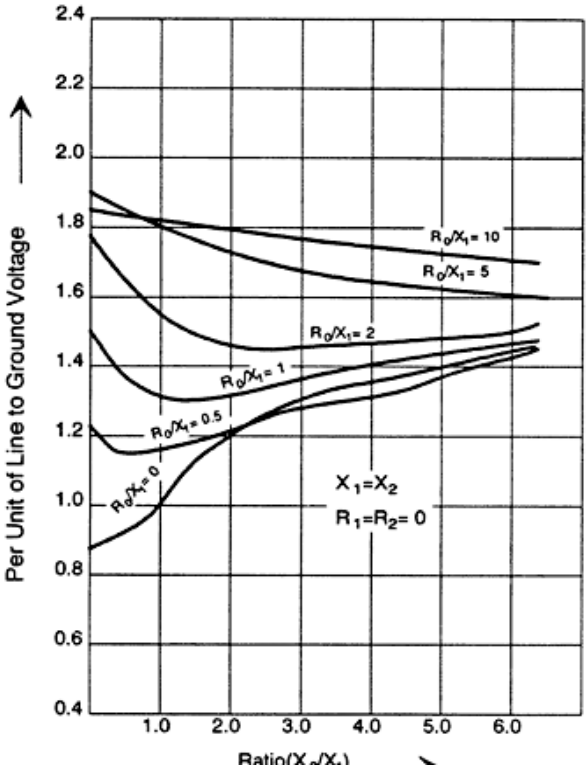

Figure (3). Overvoltage on unfaulted phase during single-line-to-ground fault.

Switching. Switchings in a power system occur frequently. A variety of switchings are performed for routine operations or automatically by control and protection systems. Typical switchings are as follows:

1. Lines (transmission or distribution)
2. Cables
3. Shunt/series capacitors
4. Shunt reactors
5. Transformers
6. Generators/motors

Another class of switching transients are those generated from insulation flashovers and breaker restrikes. These phenomena are equivalent to the closing of a switch and generate switching surges, which propagate in the system.

Sources of Transient Overvoltages

There are two main sources of transient overvoltages on utility systems: capacitor switching and lightning. These are also sources of transient overvoltages as well as a myriad of other switching phenomena within end-user facilities. Some power electronic devices generate significant transients when they switch. Transient overvoltages can be generated at high frequency (load switching and lightning), medium frequency (capacitor energizing), or low frequency.

Capacitor Switching

Capacitor switching is one of the most common switching events on utility systems. Capacitors are used to provide reactive power (in units of vars) to correct the power factor, which reduces losses and supports the voltage on the system. They are a very economical and generally trouble-free means of accomplishing these goals. Alternative methods such as the use of rotating machines and electronic var compensators are much more costly or have high maintenance costs. Thus, the use of capacitors on power systems is quite common and will continue to be.

One drawback to the use of capacitors is that they yield oscillatory transients when switched. Some capacitors are energized all the time (a fixed bank), while others are switched according to load levels. Various control means, including time, temperature, voltage, current, and reactive power, are used to determine when the capacitors are switched. It is common for controls to combine two or more of these functions, such as temperature with voltage override.

One of the common symptoms of power quality problems related to utility capacitor-switching overvoltages is that the problems appear at nearly the same time each day. On distribution feeders with industrial loads, capacitors are frequently switched by time clock in anticipation of an increase in load with the beginning of the working day. Common problems are adjustable-speed-drive trips and malfunctions of other electronically controlled load equipment that occur without a noticeable blinking of the lights or impact on other, more conventional loads.

Figure 4 shows the one-line diagram of a typical utility feeder capacitor-switching situation. When the switch is closed, a transient similar to the one in Fig. 5 may be observed upline from the capacitor at the monitor location. In this particular case, the capacitor switch contacts close at a point near the system voltage peak. This is a common occurrence for many types of switches because the insulation across the switch contacts tends to break down when the voltage across the switch is at a maximum value. The voltage across the capacitor at this instant is zero. Since the capacitor voltage cannot change instantaneously, the system voltage at the capacitor location is briefly pulled down to zero and rises as the capacitor begins to charge toward the system voltage. Because the power system source is inductive, the capacitor voltage overshoots and rings at the natural frequency of the system. At the monitoring location shown, the initial change in voltage will not go completely to zero because of the impedance between the observation point and the switched capacitor. However, the initial drop and subsequent ringing transient that is indicative of a capacitor-switching event will be observable to some degree.

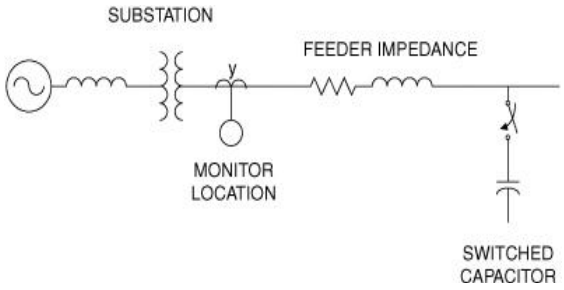

Figure 4 .One-line diagram of a capacitor-switching operation corresponding to the waveform in F. 5.

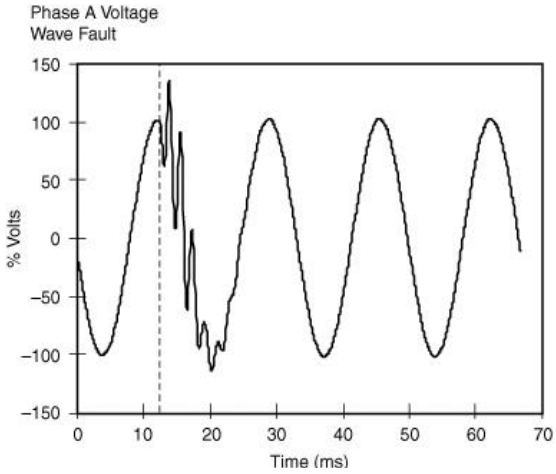

Figure 5. Typical utility capacitor-switching transient reaching 134 percent voltage, observed upline from the capacitor.

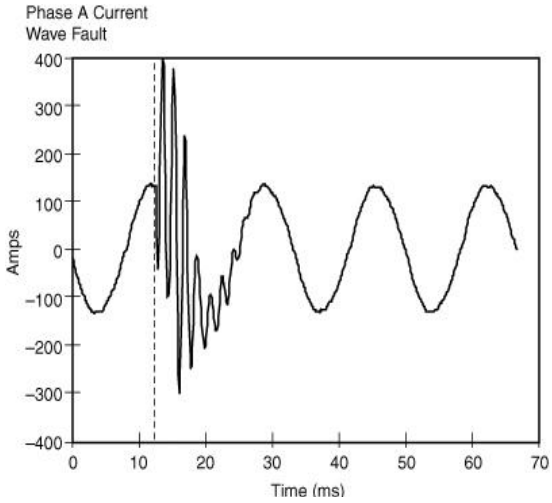

Figure 6. Feeder current associated with capacitor-switching event.

The overshoot will generate a transient between 1.0 and 2.0 per unit (pu) depending on system damping. In this case the transient observed at the monitoring location is about 1.34 pu. Utility capacitor-switching transients are commonly in the 1.3- to 1.4-pu range but have also been observed near the theoretical maximum.

The transient shown in the oscillogram propagates into the local power system and will generally pass through distribution transformers into customer load facilities by nearly the amount related to the turns ratio of the transformer. If there are capacitors on the secondary system, the voltage may actually be magnified on the load side of the transformer if the natural frequencies of the systems are properly aligned (see Sec. 4.1.2). While such brief transients up to 2.0 pu are not generally damaging to the system insulation, they can often cause misoperation of electronic power conversion devices. Controllers may interpret the high voltage as a sign that there is an impending dangerous situation and subsequently disconnect the load to be safe. The transient may also interfere with the gating of thyristors.

Switching of grounded-wye transformer banks may also result in unusual transient voltages in the local grounding system due to the current surge that accompanies the energization. Figure 6 shows the phase current observed for the capacitor-switching incident described in the preceding text. The transient current flowing in the feeder peaks at nearly 4 times the load current.

Transformer Energizing

Energizing a transformer produces inrush currents that are rich in harmonic components for a period lasting up to 1 s. If the system has a parallel resonance near one of the harmonic frequencies, a dynamic overvoltage condition results that can cause failure of arresters and problems with sensitive equipment. This problem can occur when large transformers are energized simultaneously with large power factor correction capacitor banks in industrial facilities. The equivalent circuit is shown in Fig. 7. A dynamic overvoltage waveform caused by a third-harmonic resonance in the circuit is shown in Fig. 8. After the expected initial transient, the voltage again swells to nearly 150 percent for many cycles until the losses and load damp out the oscillations. This can place severe stress on some arresters and has been known to significantly shorten the life of capacitors.

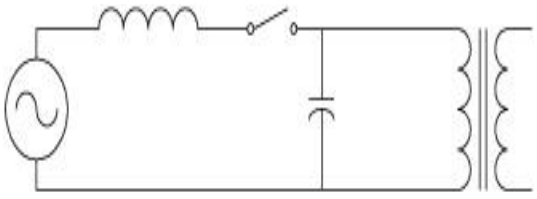

Figure 7. Energizing a capacitor and transformer simultaneously can lead to dynamic overvoltages.

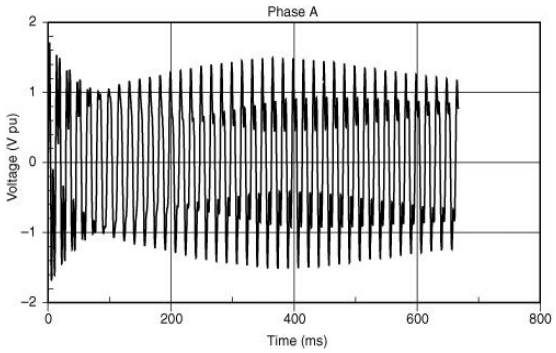

Figure 8. Dynamic overvoltages during transformer energizing.

This form of dynamic overvoltage problem can often be eliminated simply by not energizing the capacitor and transformer together. One plant solved the problem by energizing the transformer first and not energizing the capacitor until load was about to be connected to the transformer.

Conclusion

In this paper we can conclude that the causes of overvoltages in the system may be internal or external cause. If we design proper system having effectively grounded system the system can get rid of overvoltages in the system. We can use lighting arrester to prevent system from overvoltages.

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ANALYTICAL SOLUTION OF ADVECTION DIFFUSION EQUATION IN HOMOGENEOUS MEDIUM

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Abstract: Advection-diffusion equation with constant and variable coefficients has a wide range of practical and industrial applications. Due to the importance of advection-diffusion equation the present paper, solves and analyzes these problems using a new analytical scheme is based on amathematical combination between Variational Iteration Method and Homotopy Perturbation Method.The results are tabulated and are represented graphically.

Keywords: Advection-diffusion equation, Variational Iteration Method , Homotopy Perturbation Method.

INTRODUCTION

Advection Diffusion equations are used to stimulate a variety of different phenomenon and industrial applications .Advection Diffusion equation describes the transport occurring in fluid through the combination of advection and diffusion. Its analytical/numerical solutions along with an initial condition and two boundary conditions help to understand the contaminant or pollutant concentration distribution behaviour through an open medium like air, rivers, lakes and porous medium like aquifer, on the basis of which remedial processes to reduce or eliminate the damages may be enforced. In the initial works while obtaining the analytical solutions of dispersion problems in the ideal conditions, the basic approach was to reduce the advection-diffusion equation into a diffusion equation by eliminating the advection term(s). It was done either by introducing moving coordinates see, Ogata Banks 1961 [1]; Harleman and Rumer 1963 [2]; Bear 1972 [3]; Guvanasen and Volker 1983 [4]; Aral and Liao 1972 [5] and Marshal *et al.*, 1996 [6]. Another direction is to transform advection-diffusion to diffusion equation only was by introducing another dependent variable see Banks and Ali 1964 [7]; Ogata 1970 [8]; Lai and Jurinak 1971 [9] and Al-Niami and Rushton 1977 [10].Some one-dimensional analytical solutions have been given,see Tracy 1995 [11] by transforming the nonlinear advection-diffusion into linear one for specific forms of the moisture contents *vs* pressure head and relative hydraulic conductivity *vs* pressure head curves which allow both two dimensional and three-dimensional solutions to derived. The work of Yates[12] was extended (Logan and Zlotnik 1995 and Logan 1996)[13] by including the adsorption and decay effects and by studying their interaction with the inhomogeneity caused by scale-dependent dispersion along uniform flow for periodic input condition. One dimensional analytical solutions were presented for the advection–diffusion equation for solute dispersion, being proportional to the square of velocity and velocity proportional to the position variable (Zoppou and Knight 1997) [14]. Analytical solutions were presented for solute transport in rivers including the effects of transient storage and first order decay (Smedt 2006)[15]. Tian and Dai (2007) have given a class of High-Order Compact (HOC) Exponential Finite Difference (FD) methods for solving one and two-dimensional steady-state convection diffusion problems. Schlegel *et al.* (2008) [16] have introduced a generic recursive multirate Runge-Kutta scheme that can be easily adapted to an arbitrary number of refinement levels. Finite element computations for singularly perturbed convection-diffusion equations have long been an attractive theme for numerical analysis. In Roop (2008) [17], the singularly perturbed Fractional Advection-Dispersion Equation (FADE) with boundary layer behaviour was examined. In Temsah (2009) [18] article, El-Gendi method was presented with interface points to deal with linear and non-linear convection diffusion equations. Analytical Solutions of one dimensional advection-diffusion equation with variable coefficients in a finite domain is presented by Atul Kumar et al (2009) [19] **.**Solution of the Advection-Diffusion Equation Using the Differential Quadrature Method was done by Kaya (2009) [20],In 2012 A numerical algorithm based on a mathematical combination between Siemieniuch and Gradwell

approximation for time and Dehghan's approximation for spatial variable was given by S.G.Ahmed [21].

VARIATIONAL HOMOTOPY PERTURBATION METHOD

To convey the basic idea of the Variational homotopy perturbation method[23], we consider the following general differential equation

$$Lu + Nu = g(x) \tag{1}$$

where L is a linear operator, N is a nonlinear operator, and g(x) is the forcing term. According to variational iteration method [22], we can construct a correct functional as follows:

$$u_{n+1}(x) = u_{n(x)} + \int_0^t \lambda(\tau)\ Lu_n\ \tau\ + Nu_n\ \tau\ - g\ \tau\ \ d\tau \tag{2}$$

Where λ is a general Lagrange multiplier[22], which can be identified optimally via variational theory. We apply restricted variations to nonlinear term Nu so that we can determine the multiplier. Making the above functional stationary, noticing that $\delta\tilde{u}_k = 0$,

In the homotopy perturbation method, the basic assumption is that the solutions can be written asa power series in *p*.Now, we apply the homotopy perturbation method,

The variational homotopy perturbation method is obtained by the elegant coupling of correction functional of variational iteration method with He's polynomials and is given by

$$\sum_{n=0}^{\infty} p^{(n)} u_n = u_{0(x)} + p\int_0^t \lambda(\tau)\left(\sum_{n=0}^{\infty} p^{(n)} L(u_n\ \tau\ ) + N\sum_{n=0}^{\infty} p^{(n)} u_n\ \tau\ \right) d\tau - \int_0^t \lambda(\tau) g\ \tau\ d\tau \tag{3}$$

A comparison of like powers of p gives solutions of various orders.

VHPM SOLUTION FOR UNIFORM FLOW

One-dimensional advection diffusion equation can be expressed as;

$$\frac{\partial C}{\partial t} + u\frac{\partial C}{\partial x} = \frac{\partial}{\partial x}\left(D\frac{\partial C}{\partial x}\right) \tag{4}$$

where *u*is advection velocity, *D* is diffusion coefficient, and *C* is dependent variable that change according to physical problem

For this both advection diffusion coefficients are taken as constants [19,21]
D = α and u=β

We consider the initial approximation as

$$C(x,0) = f(x) = ae^{-cx} \tag{5}$$

Thus applying Variational Homotopy Perturbation Method

$$\sum_{n=0}^{\infty} p^{(n)} C_n = C_{0(x)} - p\int_0^t \left[\ C_{nt}\ _{\tau} + \beta\left[\left(\sum_{n=0}^{\infty} p^{(n)} C_n\right)_x\right] - \alpha\left[\left(\sum_{n=0}^{\infty} p^{(n)} C_n\right)_{xx}\right]\right] d\tau \tag{6}$$

Thus comparing the like powers of p we get

$$p^0 : C_0(x,t) = ae^{cx}$$

$$p^1 : C_1(x,t) = ace^{cx}t(c\alpha - \beta)$$

$$p^2 : C_2(x,t) = \frac{1}{2}ac^2e^{cx}t^2(-c\alpha + \beta)^2$$

$$p^3 : C_3(x,t) = \frac{1}{6}ac^5e^{cx}t^3(c\alpha - \beta)^3$$

$$p^4 : C_4(x,t) = \frac{1}{24}ac^4e^{cx}t^4(-c\alpha + \beta)^4$$

and so on thus to obtain the solution

$$C(x,t)=ae^{cx} + ace^{cx}t(c\alpha - \beta) + \frac{1}{2}ac^2e^{cx}t^2(-c\alpha + \beta)^2 + \frac{1}{6}ac^5e^{cx}t^3(c\alpha - \beta)^3 + \frac{1}{24}ac^4e^{cx}t^4(-c\alpha + \beta)^4 \quad (7)$$

RESULTS AND DISCUSSIONS

The solution in Equation (7) describes the solute uniform dispersion of uniform flow . The coefficients of advection and dispersion are taken as constant.. The concentration values C/C_0 are evaluated from the solution in Equation (7) where the values of β is 0.22 respectively and is illustrated in Figure (1). The different combinations for which the curves in these figures are drawn are given in Table 1. It can be easily observed that when the value of β=0 the result resembles to that of diffusion process, On increasing the value of velocity β=0.11 still the Peclet's Number is less than one so still the diffusion dominates. But as soon as the value of velocity β=0.22 ,the Peclet number turns out to be 1.04 which is greater than one so Advection dominates over diffusion . Thus on increasing the value of velocity β greater than 0.22 the advection Diffusion process will take place. . The pattern is on the expected lines, *i.e.*, in the presence of uniform point source of pollution the concentration level decreases with position at a time and increases with time at a particular position.

Table1
Numerical Values of Concentration for Uniform Dispersion along Uniform Flow where α=0.21andβ=0.22

x	t=0.01	t=0.04	t=0.07	t=0.1
0	1.004	1.0173	1.0305	1.0439
0.2	0.8222	0.8329	0.8437	0.8547
0.4	0.6732	0.6819	0.6908	0.69977
0.6	0.5511	0.55833	0.56558	0.5729
0.8	0.4512	0.45712	0.463	0.46907
1	0.3694	0.3742	0.3791	0.384

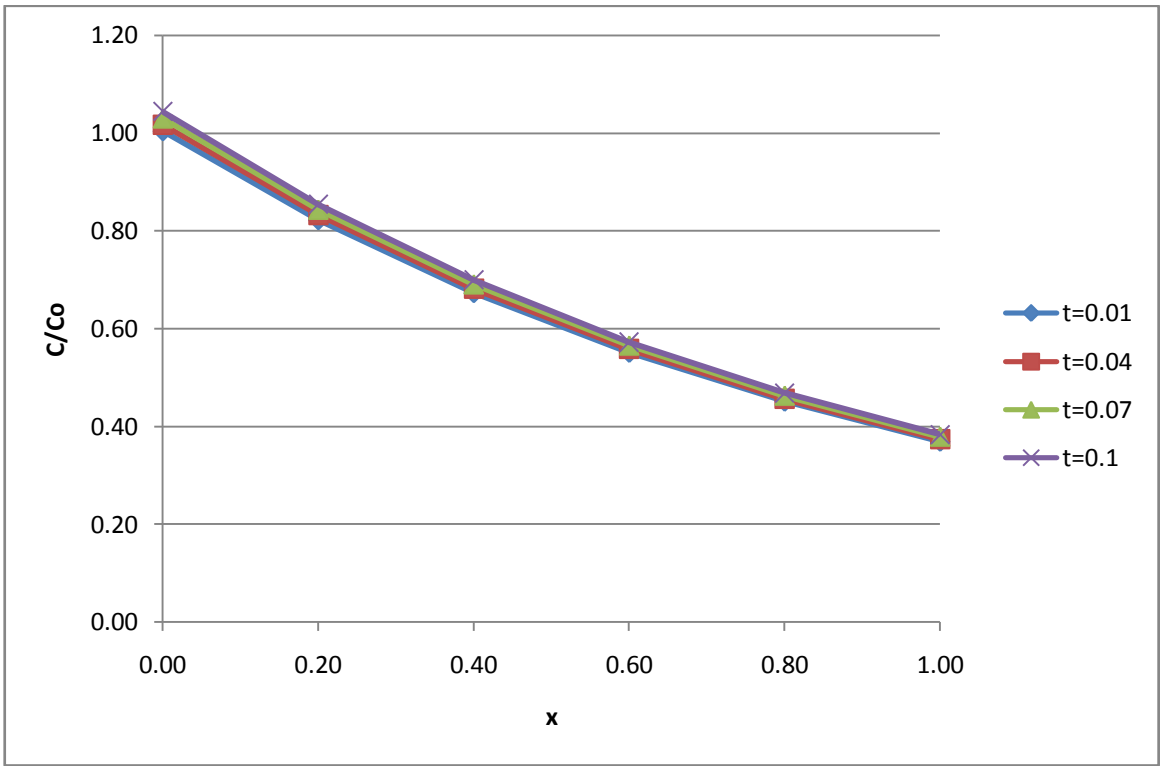

Figure 1: Curves refers to uniform dispersion in uniform flow at different times where α=0.21 and β=0.22 Concentration values are evaluated from solution in Equation (7)

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Venturi Design- An Agriculture Based Case Study

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Abstract

Day by day the reqirements in agriculture are increasing for higher productivity of crops due to increasing population. In the agricultural field, for proper growth of the crop, it is neccesary to provide it require nutrients & this nutrients are made available by the fertilizers. If we use Liquid fertilization it is better for plant growth &it's productivity. So our aim is to maintain constant amount of flow for each & every crop or plant. In this perticular design case study fertilizer reqirement of each Banana crop is 9 kg. & to dissolve this fertilizer in liquid form we require water in the ratio of 1:4. In the farm of Three acres, there are 5500 crops of Banana, then total reqirement of fertilizer is 45 kg. Therefore total fertilizer reqirement in liquid form is 200 Lt. If time require to flow this liquide fertilizer is 360 seconds. The flow of fertilizer is 0.556 Lt/sec. So this much amount of flow is to be kept constant to fulfill the requirement of fertilizer of each crop. To do this job we have to use a Venturimeter. Means to maintain the flow of 0.556 Lt/sec., we have to design the Venturimeter as per our requirement of flow. Our design is aim to decide that area or diameter of the Throat of the venturimeter,by considering all occuring conditions in particular farm.

Keywords: Venturimeter, liquid fertilization, Throat area.

I. Introduction

In the agricultural field, for proper growth of the crop, it is neccesary to provide it require nutrients & this nutrients are made available by the fertilizers. If we use Liquid fertilization it is better for plant growth &it's productivity. For this purpose liquid fertilizer must be provided in adiquate amount.

So our aim is to maintain constant amount of flow for each & every crop or plant. In this perticular design case study fertilizer reqirement of each Banana crop is 9 kg. & to dissolve this fertilizer in liquid form we require water in the ratio of 1:4. In the farm of Three acres, there are 5500 crops of Banana, then total reqirement of fertilizer is 45 kg. Therefore total fertilizer reqirement in liquid form is 200 Lt. If time require to flow this liquide fertilizer is 360 seconds,the flow of fertilizer is 0.556 Lt/sec. So this much amount of flow is to be kept constant to fulfill the requirement of fertilizer of each crop.

We have to estimate the diameter of Venturimeter, so that to maintain the flow of 0.556 Lt/sec. For designing the venturimeter Section (1) is taken at the pipe to which Venturimeter is connected. & section (2) is taken at the point of minimun area of the device i.e. Throat area. Our design is aim to decide that area or diameter of the Throat of the venturimeter,by considering all occuring conditions & taking usual references.

A. Venturimeter in Agriculture

The measurement of flow rate is a fundamental topic to which a considerable degree of attention has been paid with the result that there are flow meters available using a wide variety of principles [1]. Flow measurement is the quantification of bulk fluid movement. Flow can be measured in a variety of ways. Positive-displacement flow meters accumulate a fixed volume of fluid and then count the number of times the volume is filled to measure flow. Other flow measurement methods rely on forces produced by the flowing stream as it overcomes a known constriction, to indirectly calculate flow. Flow may be measured by measuring the velocity of fluid over a known area Venturi flow meters have been used for many years to measure the pipe discharge. The fluid flowing through a pipe is led through a contraction section to a throat with a smaller cross section. Thus, the velocity in the throat is higher, leading to a reduction in pressure. The discharge from the pipe can be determined based on the pressure drop between the inlet and throat sections of the Venturimeter.

B. Liquid Fertilization

For efficient fertilization of nutrient elements which plants require at each stage of their growth, this liquid fertilization is used. For healthy growth of any plants, a balanced supply of trace elements such as Iron, Boron or Molybdenum is necessary in the water. Furthermore, Nitrogen, Phosphorus

and Potassium which are often called the three major (or macro) nutrients for plants, are also often found lacking in many plants which cannot give it's usual productivity. It enables efficient supplement of nutrient elements to meet the requirements of all your aquatic plants which change in time. A full line of specially formulated supplements were developed also to target specific issues such as color loss, stress after trimming, and algae resistance[2]. For liquids, various units are used depending upon the application and industry, but might include gallons (U.S. liquid or imperial) per minute, liters per second, bushels per minute or, when describing river flows, cumecs (cubic metres per second) or acre-feet per day.

This liquid fertilization proves better than ordinary one. Because all require nutrients of the plant are made available to it in terms, to dissolve in the farm & that are reaches to the stem of plant with the help of roots. Means for ordinary powder fertilizer, first it has to dissolve in the farm & then it will reach to the plant with the help of roots. Due to this productivity increases.

II. Scope of Design

In the agricultural field, for proper growth of the crop, it is neccesary to provide it require nutrients & this nutrients are made available by the fertilizers. If we use Liquid fertilization it is better for plant growth &it's productivity also. For this purpose liquid fertilizer must be provided in adequate amount.

So our aim is to maintain constant amount of flow for each & every crop or plant. In this perticular design case study fertilizer requirement of each Banana crop is 9 gm. & to dissolve this fertilizer in liquid form we require water in the ratio of 1:4. In the farm of Three acres, there are 5500 crops of Banana, then total requirement of fertilizer is 45 kg. Therefore total fertilizer reqirement in liquid form is 200 Lt. If time require to flow this liquid fertilizer is 360 seconds,the flow of fertilizer is 0.556 Lt/sec. So this much amount of flow is to be kept constant to fulfill the requirement of fertilizer of each crop.

To do this job we have to use a Venturimeter. Means to maintain the flow of 0.556 Lt/sec., we have to design the Venturimeter as per our requirement of flow. For designing the venturimeter Section (1) is taken at the pipe to which Venturimeter is connected. & section (2) is taken at the point of minimum area of the device i.e. Throat area. Our design is aim to decide that area or diameter of the Throat of the venturimeter, by considering all occurring conditions & taking usual references. In a conventional way we just use same venturi for all types & requirement of crop. But if we do this design for every crop & it's every requirement of fertilizer, then adequate amount of fertilizer is given to the crop. There is also saving in the quantity of fertilizer.

III. VENTURI DESIGN- A Case Study

For liquid fertilization of any crop, in agricultural field, the flow rate of liquid fertilizer should be maintained at constant value for proper fertilizer requirement of every crop. Generally Venturimeter(Venturi flow-meter) is to maintain the flow rate of fertilizer[3]. It also indicate what is the value of flow of fertilizer or what amount of fertilizer is given to the particular crop.

In the banana crop, which is consider for this case study, this liquid fertilization becomes an act to increase the production of banana. Three acre farm of this banana crop is considered for this case study. Requirement of potash per crop of banana is near about 9 gm. For proper growth of bananas(fruit). In a Three acre farm, 5500 crops of banana are planted. So total requirement of potash for this farm is = 5500x9 =49500 gm. i.e. 49.5 kg. We just consider this total requirement as 50 kg.

To dissolve this potash (To convert it into liquid form), generally 1:4 ratio of water is used. Means for 1 kg of potash 4 Lt.of water is to be used. So, total liquid which is of potash is 200 Lt. After conducting the whole process of fertilization, for 3 acre of banana, we observe that, it requires 360 seconds to emptying this fertilizer of 200 Lt. Therefore flow of liquid potash becomes,

$Q_{fertilizer}$= 200/ 360 Lt./sec.

i.e. $Q_{fertilizer}$= 0.556 Lt./sec.

i.e. $Q_{fertilizer}$= 0.556×10^{-3} m^3/sec

Fig. No. 1: A view of connections of Venturimeter in three acre banana farm

But as shown in fig. the total flow is the addition of Two flows. First is of fertilizer, i.e. flow of fertilizer & Second one is the flow of water from submersible pump. Therefore,

$$Q_{total} = Q_{fertilizer} + Q_{pump}$$

For this case study the submersible pump used is of 8 HP power, whose rated capacity of output flow rate is 48 GPM (Gallons per minute). We know that 1 Gallon= 0.004546 m^3,

$$Q_{pump} = 0.00364 \ m^3/sec$$

Adding we get,

$$Q_{total} = 0.556 \times 10^{-3} + 0.364 \times 10^{-2}$$
$$Q_{total} = 0.0042 \ m^3/sec$$

Calculations

Now, from the reference of Fluid Mechanics, the flow rate of liquid from the Venturimeter is given by [5],

$$\frac{Cd \times A1 \times A2 \times \sqrt{2 \times g \times H}}{\sqrt{A1^2 - \sqrt{A2^2}}}$$

Where,

A_1= Cross sectional area at section of pipe, i.e. area of pipe to which venturimeter is connected, d_1= 5cm or 0.05 m

A_1= $(\pi/4)\times(0.005)^2$=0.03925 m^2

A_2= Cross sectional area at section throat, i.e. area at Throat of the Venturimeter, which is to be design or determine.

C_d= Coefficient of Discharge or Coefficient of Venturimeter, whose value varies from 0.95 to 0.98. We take the value of it as 0.98.

H= Differential pressure head between section (1) & section (2),

For this case,

H= Height of liquid fertilizer (Potash) in the 200 Lt. drum + Atmospheric pressure head[6]

H=0.9144 m + 10.3 m

H=11.2144 m.

Adding all this values in above equation,

$$0.0042 = \frac{0.98 \times 0.03928 \times A2 \times \sqrt{2 \times 9.81 \times 11.21}}{0.03925^2 - A2^2}$$

$$A_2 = 2.889 \times 10^{-4} \ m^2$$

But, We know that,

$$A_2 = (\pi/4) \times d_2^2$$

Therefore, d_2=0.0192 m

Therefore diameter of 0.0192 m or 1.92 cm at section (2) i.e. Throat, is to be required for proper liquid fertilization of banana crop.

IV. Results

From the whole analysis & Design of the Venturimeter, for fertilization of three acre Banana crop, for 9 kg fertilizer requirement of each crop of Banana, the diameter of Venturimeter at throat area should be 1.92 cm.

This is only for Three acre crop of Banana. But if the crop is another one &it's requirement is also not same to this case, so the diameter will be change. In a conventional way we just use same venturimeter for all types & requirement of crop [4]. But if we do this design for every crop & it's every requirement of fertilizer, then adequate amount of fertilizer is given to the crop. There is also saving in the quantity of fertilizer.

Table.1:Diameter of Throat for different readings of Discharge

Sr. No.	Time (sec)	Discharge Q $(m^3/s)^{x10-3}$	Diameter of Throat(cm)
1	365	4.202	1.917
2	352	4.208	1.919
3	363	4.191	1.915
4	367	4.185	1.914
5	361	4.194	1.916
6	359	4.197	1.9172

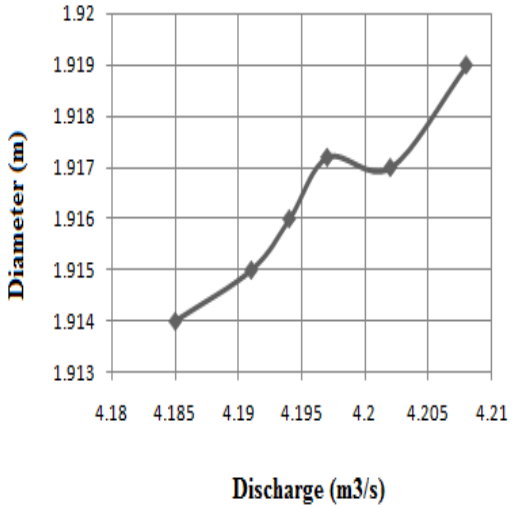
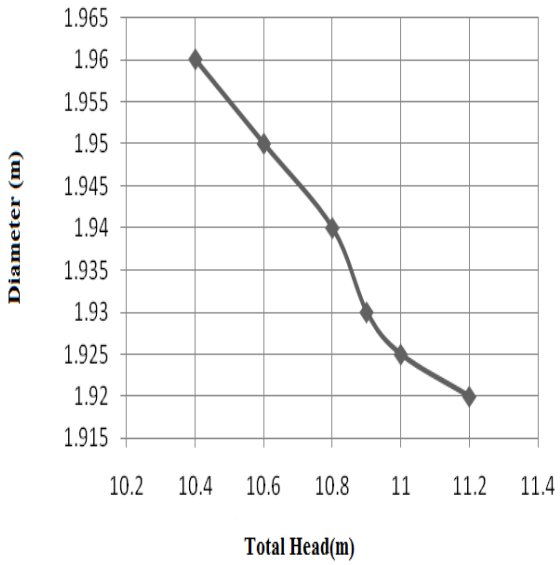


Table.2: Diameter of Throat for different readings of Total Head

Sr. No.	No. of plants	Total Head available(m)	Diameter of Throat(cm)
1	5500	11.2	1.92
2	5000	11	1.925
3	4800	10.9	1.93
4	4500	10.8	1.94
5	4200	10.6	1.95
6	4000	10.4	1.96



V. Conclusion

It is concluded that liquid fertilization proves best for the nutrients requirement of a crop. To provide adequate amount of fertilizer for each crop, the flow must be remain constant at certain level, which depends on the fertilizer requirement of each crop. Venturimeter is one of the important device for doing this work, which also indicate what amount of flow is occurring in the pipeline. Diameter of throat portion can be design for this constant flow rate of fertilizer. Here this work is presented for Three acre banana crop for which diameter of throat portion is 1.98 cm. But this work can be applied to any type of crop & Venturi can be design for that crop, which also depend on the fertilizer requirement of that crop. After doing this job we experience that, adequate amount of fertilizer is given to the crop. So it's all requirement of nutrients are get fulfill & it gives more production than the conventionally fertilized crop. As amount of fertilizer is getting optimized, the cost of fertilizer also reduces.

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Constraints in Banana Marketing and Scope of improvement: A case study for Jalgaon Region

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Abstract:

India owes the credit of being leader in global banana production. Maharshtra state enjoys the status of being the leader in the country for banana production and marketing. In Maharashtra, Jalgaon District is at the top in banana production, marketing research and technology generation. However the other side of the coin is dark. At global scale India has not secured any status in banana trading. Its contribution in international banana export is negligible.

In the era of globalization when India has joined the global economy open-mindedly there is a great necessity to investigate and identify the specific constraints in overall banana marketing. This paper defines the banana marketing network, identifies the role of various agencies involved and addresses their explicit problems. An extensive survey is done to study the problem and based upon the data generated, suggestions and recommendations are given here to improve the banana trade in Jalgaon region.

Key words: *Banana, Marketing constraints, marketing strategic planning.*

Introduction:

Banana is a fruit with marvelous properties. The banana plant has versatile uses. The plants are used for decorative purposes, preparation of fiber and the leaves for storing and packaging food items. Globally Banana is fourth most important commodity after Rice, Wheat and Corn (Dan Koepple 2008). Bananas have universal appeal as a fresh food while plantains for wholesome food to millions of people in the world in the countries like Puerto Rico and Tanzania (Valsalakumari 2005).

Banana is cultivated in nearly 120 countries in the world. The Global production of Banana is roughly 86 million tones (Ramesh Chand 2006). India ranks 1st in Banana production (UNCTAD). Fig 1 shows the global banana production distribution (UNCTAD):

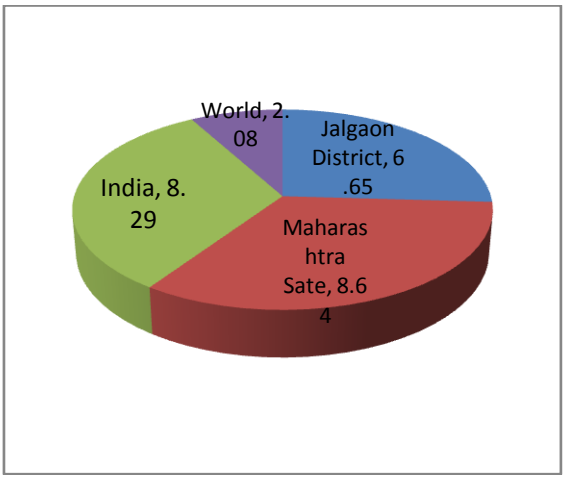

Fig 1: Compound growth rate of banana production.

India has remarkably high productivity of banana measured in terms of MT/ha. Particularly in India, State of Maharashtra has the highest productivity. This is shown in fig 2:

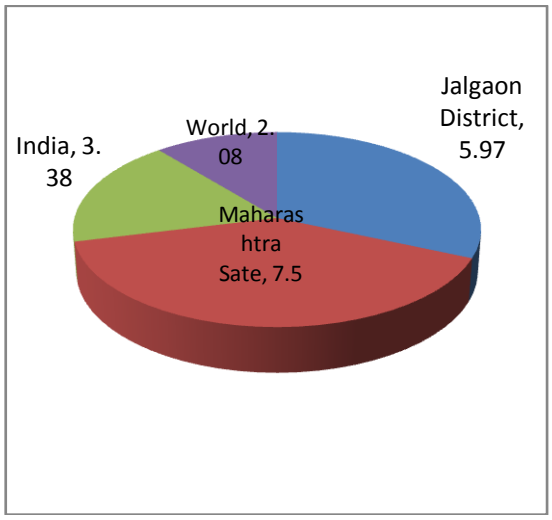

Fig 2: Global banana productivity as compared to India and the study region, in MT/ha

In India also the production of banana has steeply increased in the globalization. In India, Maharashtra has shown very good performance in banana production. Fig 3 shows the growth trend of banana in India and in Maharashtra:

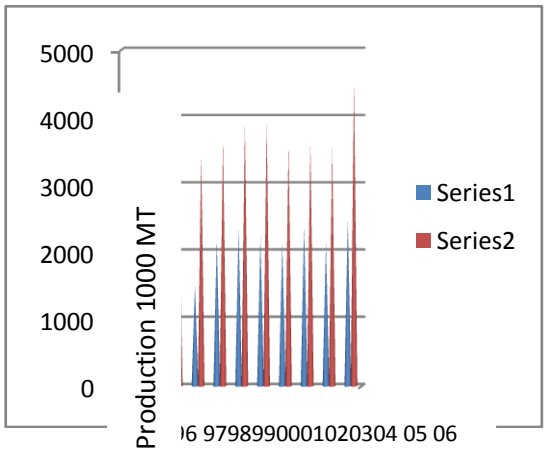

Fig 3: Increasing production of banana in Jalgaon and MS. Series 1 & 2 represent banana production in 1000 MT.

The fig 2 shows that the banana production has increased by more than two folds in past decade.

Out of the total area under horticulture in India Banana occupies only 20% of it. India is having more than 4.4 Lakhs ha. Of land under banana cultivation and nearly 103 lakh tones of production available. The National average production is 25.4 tons per ha (www.ikisan.com). Maharashtra State is a leader in the production and marketing of Banana, Onion, Grapes, Pomegranate and Papaya in the country. Maharashtra ranks second in total area under Banana in the country. But Maharashtra is having highest productivity per ha. that is 62 tons per ha (Singh 2007).. In Maharashtra Jalgaon District has the maximum area accounting for 71.64% and 61% of production in the state with an estimated turnover of Rs. 150 crores. Jalgaon District has nearly 45000 ha of land under Banana cultivation and approximately 23 lakhs tones of production takes place in the District. Production and most of the quality is sold in the domestic marketing (Agri-Information 2001; Kalamkar 2007).

The term 'market' has originated from the Latin word 'Marcatus', means a *place* where buyers and sellers meet together (Sherlekar 2008). Market consists of - unmet demand, products to meet the demand, and means of interaction. The deep impact of IT has radically transformed this definition (Market Wikipedia). Today, market can be more accurately defined as a *forum* for meeting of buyers and seller (Philip Kotler 2008) and do interactions/transactions on digital chips! Radical changes have taken place due to the globalization in banana marketing.

Banana marketing a complex chain having several links in it. All the links in the chain are not getting equally benefitted. Particularly the producer (farmer) and retailer both are the underprivileged components of the banana marketing network. The whole world has under gone the impact of globalization in last two decades and food and agricultural sector also had not been impervious of this (Tim Jostting 1997). This has obviously affected banana marketing also. Banana marketing is schematically shown in fig 4.

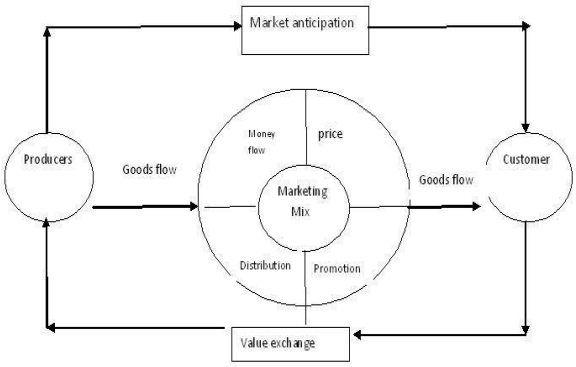

Fig 4: Modern marketing concept

Obviously, there is a need for examining in detail the complete marketing chain of banana in India and especially in Jalgaon area of Maharashtra. The present paper is an humble yet firm attempt in this direction. Authors have taken up this task as a doctorial research problem and a summary of their regressive analysis and findings is presented here.

The various stake holders of banana marketing chain have been interviewed through questionnaires. The information thus collected is analyzed and summary of observations is presented herein.

Results and discussions:

In gist form, banana marketing in Jalgaon region and in the Maharashtra State is synonym of co-operative societies. They have completely dominated the market and have performed much superior also. Societies have emerged as icon of agro-economy as well as politics in Maharashtra. The fig 5 describes growth of banana societies in Maharashtra State:

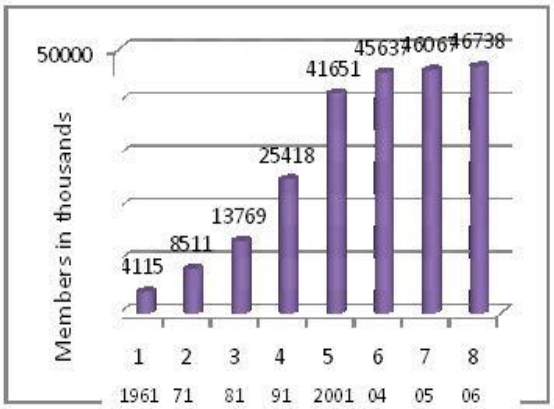

Fig 5 Increasing number of members in cooperative societies in Maharashtra.

The present work is based upon response analysis of banana marketing chain stake holders. The response given by various stake holders of banana marketing chain are analyzed. The results are presented with the help of diagrams. In case of multiple option questions, the variation in responses is calculated by standard deviation also. Some important results are highlighted here in:

1. The literacy standard of farmers is appreciably high.
2. Banana farmers belong to middle income group only.
3. The majority of banana farmers are having small fields of size below 20 acres.
4. In last 10 to 20 years of duration more number of farmers is attracted towards banana.
5. Majority of banana farmers are using hybrid species due to better yield are market value.
6. Modern irrigation techniques are preferred by the banana farmers.
7. Banana farmers are associated with the societies and also express satisfaction with their functioning.
8. Banana farmers have preferred societies as their sell outlets.
9. Banana societies are the first preference for taking loan by the farmers.
10. Farmers have expressed their dissatisfaction with the Government initiatives regarding banana farming promotion.
11. Banana by-product making has lot of hidden potential which has not been utilized at the fullest extent yet now.
12. The wine production from banana is emerging up as a new concept.
13. Government has initiated insurance facility for the farmers. Still awareness in this regard is very poor.
14. The by-product producers' are good in educational awareness.
15. By-product producers prefer to sell their products to the shops. However some have preferred to sell door to door by their salesmen too.
16. Banana by product makers have expressed their concerns with the low profit margin of their products.
17. Banana by product producers have expressed worry due to introduction of fancy products in the market.
18. Banana transporters do not have fixed rates of banana transport. They depend largely on negotiations. This creates a confusion and sometimes lack of confidence in the market.
19. Cooling containers are very much important to prevent perishing of banana. Only 10% of the transporters are using this facility.
20. Government is going ahead for use of carriage trains with cooling containers. This will revolutionalize the banana transport.
21. Airport is soon going to be functional at Jalgaon city. This is also going to radically influence the banana trade.
22. Banana commissioners are integral part of the banana marketing. However they are always suspicious link in the entire chain.
23. Modern trading techniques including IT based trading has minimized the role of commission agents.
24. More number of persons are attracted towards the business of banana retailing in last two decades. This observation has

some link with the globalization process going on.

25. Banana retailers have preferred to purchase banana from societies.
26. Banana stalls have been the most preferred mode of sell from banana retailers.
27. Seasonal nature of banana market has impact on the retailers also. They have to search for alternative employments during off seasons.
28. Consumers have awareness regarding health benefits of banana due to traditional wisdom as well as due to education. However this awareness needs to be enhanced greatly.
29. Consumers prefer to purchase banana from stalls or from door to door sellers. Though malls have also started selling banana, but they have not been much preferred by the consumers.
30. Consumers use a variety of banana by products, but their preference is wafers.
31. Consumers have expressed their preference of banana for partially ripped type due to perishing nature of fruit.
32. Consumers have given preference to the number based selling of banana over the weight based selling.
33. Wine production by banana is a very controversial issue that will affect the banana marketing in radical sense in coming time.

Conclusions:

The present study has revealed that banana marketing is a very important aspect of Indian agro-economics. It is gigantic in magnitude. Yet it has tremendous potential to grow up. India has an ability to emerge as a global banana leader in export. In the marketing chain of the banana also some improvements are required. Based upon the present study, some suggestions are recommended.

A summary of these suggestions and recommendations is as follows.

1. Government must initiate awareness and training programs for the banana farmers and should reach to them through electronic media.
2. Government must take advantage of high literacy rate of farmers.
3. Low cost modern biotechnology must be promoted for banana farmers.
4. Government must subsidize for using modern irrigation techniques for banana farming.
5. There is need to encourage research in banana hybrid species as it is getting more popularity amongst growers as well as consumers too.
6. Societies are playing pivotal role in the banana marketing chain. They must be given statutory protection so that they can better do their jobs.
7. Loan is a very important factor in the banana marketing chain. Government authorities must make necessary arrangements for giving loans and nominal interest for banana farming.
8. Banana farmers barely need a system of insurance for their agriculture.
9. Banana by-product making has scope to emerge as a small scale enterprises in Jalgaon region. Government incentives can promote growth of this sector.
10. Wine production from banana is a very crucial issue. It has pros and cons both. There is a need to carefully watch the impact of this new concept on the established market of banana.
11. The present study has revealed that most of the transporters do not have cooling containers. Banana is highly perishable if not stored in coolers. It his highly recommended to enhance cooling facilities for transportation by roads and even by railways.
12. The road conditions have significant impact on banana damage. When banana is transported from rough roads shocks create damage to the fruit. It is necessary to improve the road conditions for smooth transportation of banana.
13. In the container itself some special arrangement can be made to absorb shocks due to road conditions. This requires research and investigations in this particular direction.
14. The transportation rates are solely based upon mutual negotiations. This is a very poor scenario. There must be well defined rates so that a confidence is developed and there is no scope for cheating.
15. Government must look into for developing cooler based storage facilities in the rural areas. The societies may be given loan and other facilities for creating cooling facilities in their stores.
16. Electricity itself is a major problem in rural areas. When electricity fails for prolonged durations, banana gets perished even in the stores having cooling facilities. Government must have provision to supply electricity separately for such store houses.
17. The role of commission agent cannot be eliminated totally. But it needs to be minimized.
18. IT Technology has penetrated the banana trading also. The societies are supplying

banana to their customers using internet facilities also. Even the payment is being done digitally. This can be used to minimize the role of middleman.

19. Banana retailing is done mostly by small scale stall-keepers or door to door suppliers. These low waged workers play a very important role in the overall economics of the banana marketing. It is recommended that in order to improve their livings, some measures must be taken by the government.
20. The seasonal nature of banana makes the retailers and small stake holders unemployed for certain part of the year. However the hybrid species of banana can be harvested throughout the year. Under such circumstances it is recommended that government must encourage the use of hybrid species so that the "blank period" gets minimized.
21. Considering the high nutritious value and reasonable cost of banana government has launched few schemes to use banana and it's by products to give nutritious food to school children. It includes supply of banana biscuits and other banana products. Such activities must be encouraged and they must cover a larger section of the society.
22. The minimum support cost of banana must be well published in news papers and must be promulgated via electronic media.
23. Installation of public weighing machine in every village is also an important suggestion for the government authorities.
24. There is a tremendous scope of using organic fertilizers and biotechnological approaches to enhance the quantity and quality of banana production. Farmers need to be made aware of this through extensive awareness programs.
25. Indian railways should consider banana as B grade fruit. It must be transported on priority basis so that the transportation losses are minimized and the profit margin is maintained.
26. Banana Export Facility Centre is presently functioning only at one place that is Sawda in Raver Taluka. It is recommended that such centers must be increased in numbers.
27. There is provision of establishment of Special Commodity Market in the Maharashtra Agriculture Produce Marketing (Development and Regulation) Act, 1963. State Govt. has to establish Special Commodity Markets. Such Special Commodity Market with all infrastructure facilities to handle huge Banana quantum should be established in Jalgaon District.
28. Many farmers toady are using conventional methods of banana ripening. This has the problem of non-uniform ripening. It is recommended that the ripening should be done by advanced techniques so that uniform good quality ripening takes place.
29. Updating of marketing information and intelligent network. Government should evolve a mechanism for rapid dissipation of marketing information using electronic systems. This will make the producers aware of marketing trends and they will be able to get a proper profit of their product.

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Simulative Analysis of Single Cylinder Four Stroke C.I. Engine Exhaust System

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Abstract
In internal combustion engines, exhaust system plays a vital role in theimprovement of the combustion efficiency. A good conditioned exhaustsystem increase the performance of the engine. To analyse the exhaust energies available at different engine operating conditions and to develop an exhaust system for maximum utilization of available energy at the exhaust of engine cylinder is studied. Design of each device should offer minimum pressure drop across the device, so that it should not adversely affect the engine performance. Backpressure acting on engine is most important controllable factor which basically deteriorates the engine and emission control performance. The work is focused onreducing the backpressure in the exhaust system to increase the combustion efficiency using CFD FLUENT.

In CFD analysis, various diffuser models with different angels were simulated using the appropriate boundary conditions and fluid properties specified to the system with suitable assumptions. The back pressure variations in various models are discussed in this paper.

Keywords*: Computational Fluid Dynamics (CFD), Back pressure***,** *Compression ignition engine, pressure Drop, Diffuser.*

1. Introduction

Energy efficient exhaust system development requires minimum fuel consumption and maximum utilization of exhaust energy for reduction of the exhaust emissions and also for effective waste energy recovery system such as in turbocharger, heat pipe etc. from C.I. engine. To analyse the exhaust energies available at different engine operating conditions and to develop an exhaust system for maximum utilization of available energy at the exhaust of engine cylinder is studied.

Design of each device should offer minimum pressure drop across the device, so that it should not adversely affect the engine performance. Backpressure acting on engine is most important controllable factor which basically deteriorates the engine and emission control performance. So numbers of methods to increase the performance of the CI engine have been established. A better method of utilising the exhaust is being achieved by this paper. The method uses the exhaust gases from an optimal sized engine currently used, to convert available Kinetic energy and enthalpy of exhaust gases into the pressure energy for useful after treatment of exhaust gases. This pressure is being used and sent through diffuser which reduces the back pressure.[1]

Backpressure on engine cylinder is completely dependent on exhaust system design, its operating condition and atmospheric pressure (i.e. almost constant). The exhaust system routes exhaust gas from the engine and exhaust it into the environment, while providing noise attenuation, after treatment of the exhaust gas to reduce emissions and energy recovery. One of the most important sources of vehicle noise, the noise associated with exhausting combustion gases from the engine, is controlled using mufflers. A number of sound reduction techniques are employed in mufflers, including reactive silencing, resistive silencing, absorptive silencing, and shell damping. Exhaust gas properties which are important for the exhaust system design include its physical properties; exhaust gas temperature, which depends on the vehicle duty and/or test cycle and the exhaust gas flow rate. Exhaust system materials are exposed to a variety of harsh conditions, and must be resistant to such degradation mechanisms as high temperature oxidation, condensate and salt corrosion, elevated

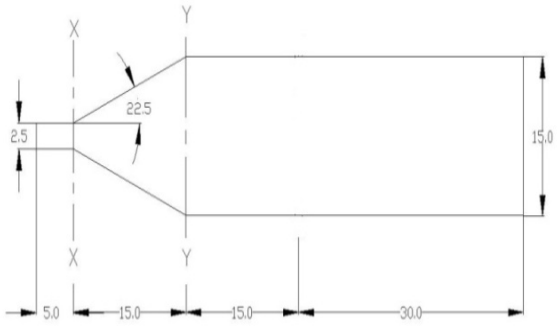
temperature mechanical failure, stress corrosion cracking, and intergranular corrosion. Traditional manifold optimization has been based on tests on Exhaust Manifold. This trial & error method can be effective but is very expensive & time consuming. Beside this method cannot provide any information about the actual flow structure inside the manifold. This vital information can be obtained using 3-D CFD analysis. The design engineers can study the flow structures & understand whether a particular manifold performs correctly or not. The steady state and Quasi steady state analysis was performed in ANSYS FLUENT, from this we can get the flow structure, pressure drop etc. higher the pressure drop higher will be the back pressure and there is power loss due to back pressure since piston has to overcome this pressure. So ultimate goal is to reduce the pressure drop in the system and make the necessary geometry changes.[2][3]

2. Problem Definition

The Component Exhaust System datafor the same engine output condition that is at 5 kg load and 1500 rpm was given for optimizing its performance using CFD. The diffuser with different angles i.e. Model 1=22.5°, Model 2=30°, Model 3=45°, Model 4=60°, Model 5=75°, Mode6 =90° degree is developed .The major objective of analyzing such a system is to determine thepressure drop across the exhaust system geometry.

3.Construction of the Device

The coordinates are provided for the development of the 2D model of The exhaust system. The model is then rotated about 360 degrees to get the 3D profile. For design purposes, the diffuser can be seen as an assembly of three separate sections operating in series a short parallel section and the diverging section. The short parallel section of the system acts as a casing to the engine. The straight portion of the diffuser helps in reducing the non-uniformity of flow, and in the diverging section, the pressure recovery takes place. The geometrical specifications of the diffuser have chosen somewhat arbitrarily. Diameter of diffuser inlet 0.0254m and diameter of the engine outlet 0.15m.[4]



All dimensions are in CM
FIGURE 1:Schematic view of the Exhaust System (22.5° angle)

4. Methodology

The geometry model of exhaust Manifold is made in CAD Package CATIA. For CFD Modeling internal volume of geometry is required. Internal volume is got from CATIA. Iges/Stp Format of it is imported to ANSYS ICEM CFD Meshing Software. Geometry is repaired in ANSYS ICEM CFD. [5]

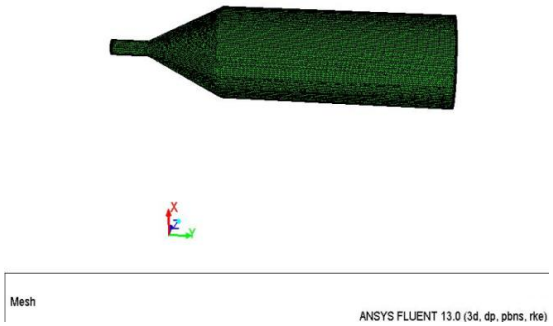


FIGURE 2:MESH of Exhaust System

5. Grid generation of the Exhaust Manifold

The ANSYS ICEM-CFD is used for discretization of domain. The mesh used for flow domain is Tetrahedron mesh. Details of mesh is as under:

Table 1: Mesh Details

Parameter	Details
1.Global Mesh Size	3 mm
2. Surface Mesh Size	3 mm
3. Curve Mesh Size	3 mm
4.Mesh Type	Tetra
5.No.of Elements	685303
6.Mesh Quality	0.3

Mesh is checked first for duplicate elements, unconnected vertices and then mesh is smoothened

by smoothing tool. Then file is exported to FLUENT file, which is imported in ANSYS-FLUENT. The Mesh domain is as under:

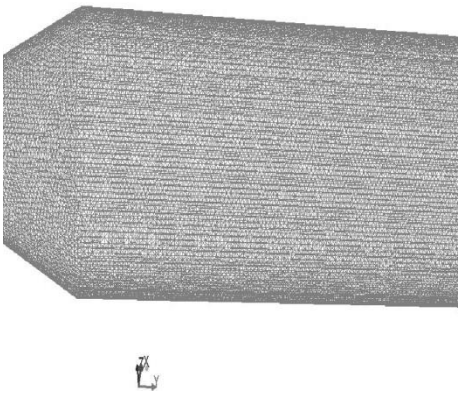


FIGURE 3: Meshing Domain of Exhaust System.

Exhaust gas will be considered as an incompressible fluid air operating at 300°C. The k-ε turbulence model is used for analysis of Exhaust system. Initially both SST (shear stress transport) model and k-ε model is used for checking the influence of turbulence model on result. There is no such difference in result between these two models, but time consuming for SST model is more than k-ε model, so k-ε model is preferred for analysis.

6.Boundary Conditions:

Boundary conditions used at inlets mass flow rates and Temperatures of Fluid are applied and at outlets pressure outlet is applied. Domain surface is used as a wall with 'No Slip condition' and heat transfer coefficient of 45 w/m^2 ºk and wall surface roughness as 0.00508 mm is used. [6][7][8][9][10]

7. Results and Discussion

The models are analysed using fluent and the results obtained are shown in the color Contours for Simulative Analysis of Flow through the Exhaust system

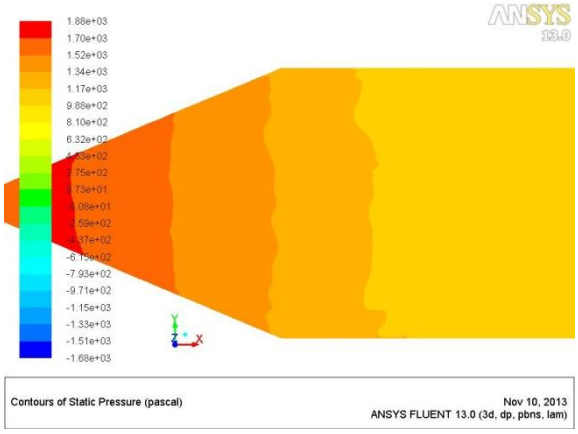


FIGURE4: Pressure Contour for exhaust system diffuser with 22.5° angle.

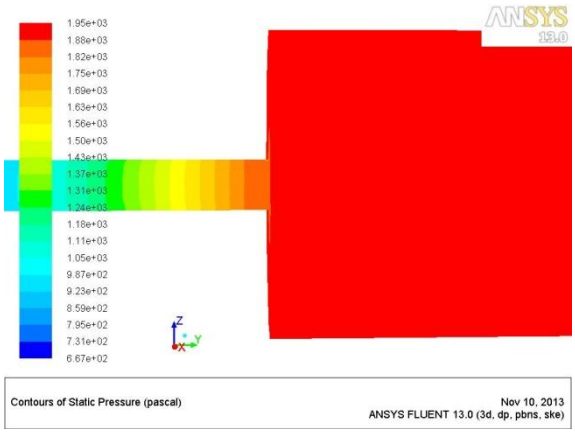


FIGURE5: Pressure Contour for exhaust system diffuser with 90° angle.

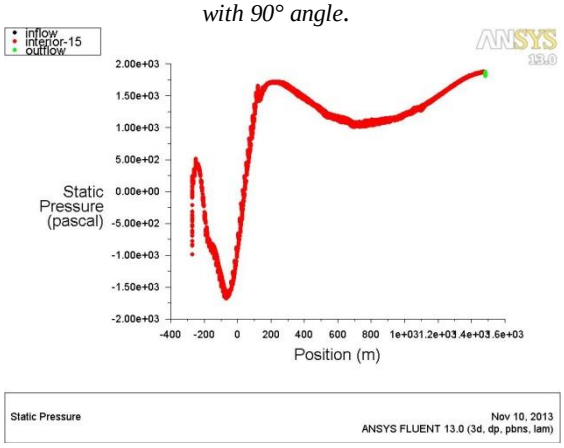


FIGURE 6: Pressure VS Distance for exhaust system diffuser with 22.5° angle.

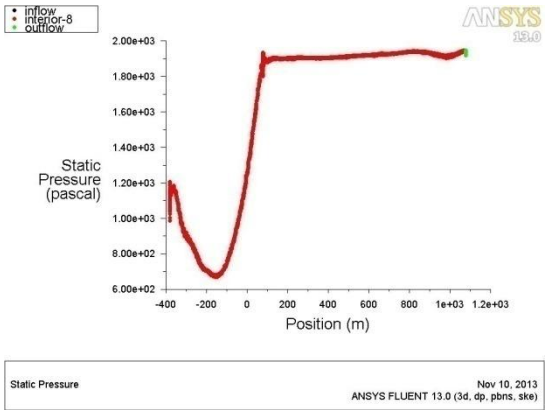
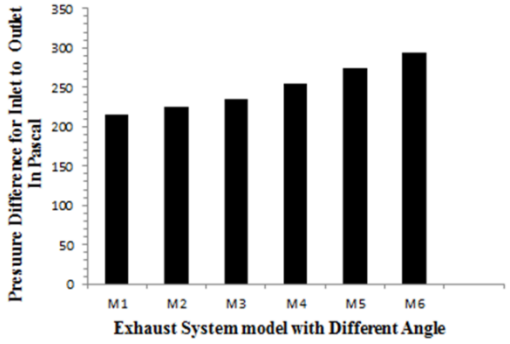


FIGURE 7: Pressure VS Distance for exhaust system diffuser with 90° angle

.



GRAPH 1: Pressure Difference for Inlet to Outlet of Diffuser Vs Exhaust System Diffuser Models with Different Angles

Exhaust system outlet pressure of engine cylinder is completely dependent on exhaust system design, engine as well as exhaust system operating condition and atmospheric pressure. There is confirmation from the Figure 4,5,6,7of Simulative Analysis of Flow through the Exhaust systemand Graph 1, that pressure at outlet of diffuser is directly proportional to the diffuser angle of exhaust system. At the same engine output condition that is at 5 kg load and 1500 rpm.

8. **Conclusion**

The decrease in back pressure is shown using contour and Pressure Vs Distancediagram. The flow is made efficient by decreasing the exhaust gas back pressure in the exhaust system design. The geometry, which gives minimum pressure drop and hence minimum backpressure, is the optimized geometry. Again for the optimized geometry CFD results would be finding out. Also the Non-dimensional stiffness rigidity is sufficiently high. Finally it can be stated that 3-D CFD simulation can be used as a strong and useful tool for design or optimization of Exhaust system.

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