Experimental Analysis of Helical Coil Induction and Electric Immersion Type Water Heater

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Abstract: This work presents a comparative experimental analysis for energy consumption of Helical Coil Induction and Electric Immersion type water heater. The experimental setup is developed using Induction cooker with different helical coil and Electric Immersion heater of 1200 Watt power. The Energy consumption for Helical coil induction water heater with different configurations and immersion water heater is taken at constant values of water outlet temperature of 54°C for 5 Liters of water. It is observed from results energy consumptions for helical coil induction water heater shows less energy requirement as compared to Electric Immersion water heater. The energy consumption for experimental setup with Helical Coil with number of turns equals to four shows least energy consumptions.

Keywords: Helical Coil, Electric Immersion Type Heater, Energy Consumption

I. INTRODUCTION

A green and renewable energy, high cost and clean environmental are important issues that influenced the technology in home appliances recently such as in stove and water heating. Induction heating is one of the new technologies in home appliance. [1]

Helical coils are used for transferring heat in chemical reactors and agitated vessels because heat transfer coefficients are higher in helical coils. Chemical reactions have high heats of reaction and the heat generated (or consumed) has to be transferred rapidly to maintain the temperature of the reaction. Helical coils have a compact configuration with provision of more heat transfer surface per unit of space than by the use of straight tubes. [2]

To fulfill the demand of water at specific temperature 80⁰C-90⁰C in industry required lot of electricity or fuel for different techniques including Electric Heater, Gas Water Heater, Storage Heat Pump water heater, Heat Exchanger using burning of fuel etc. Due to degradation of resources in environment, alternative energy resources needed or available resources effectively utilized; so for water heating process it should aimed at having effective use over the supplied electricity, the new technique of induction heating process for water heating is being developed. [3]

The work presented by Ordoñez Flores Rafael, Reyes Castillo Fabiola and Carreño Hernández Carlos (2013) is an attempt made to heat shower water wasted at the beginning due to water is not hot immediately in case of gas geyser and solar heater. Magnetic induction is applied at pipe carrying water for shower which assumed as conductor. Water heater consists of solenoid coil and pipe as its core is inducts a big current on the pipe in which its dissipated power follows the relation P(t) = I²R(t); so the water gets warm immediately when getting in touch with the hot pipe. This is experimentally tested and concludes water heater by magnetic induction contributes to environment preserving and water saving into reliable and proficient device, it can be used in houses or hotels, generating comfort and benefits for the user. [4]

This work concentrates on length of the helical coil which is specific interest for design of helical coil. These change in length of helical with change in tube diameter had been increase in experimentation briefly explained. In this presented work the length of the coil tube varied and results shows that it was affected on the outlet and bulk temperature of the test fluid used. The smaller length of helical coil shows an increasing trend in temperature distribution of fluid inside the coil as compared to larger length of helical coil for same flow rate and heat input. This investigation also concluded with experimentation work of helical coil, change in diameter of tube the heat transfer coefficient is also changes. Also temperature difference of each flow rate shown increasing trend for lesser length of the coil tube compare to the larger length of the coil tube. [5]

J.S. Jayakumar, S.M. Mahajani, J.C. Mandal, P.K. Vijayan and Rohidas Bhoi have Utilize a constant value for the thermal and transport properties of the heat transport medium which results in prediction of inaccurate heat transfer coefficients. Experimentation is carried out with
different flow rates and different inlet temperature of water at the inlet of helical coil and heat transfer characteristics heat exchanger with helical coil. [6]

Induction Heating Process induction coil design for particular application because it governs other factor of induction heating system and for the different type of induction coils used in industry especially based on geometry like Helical, Round, Pancake coil etc. [7]

The efficiency of the induction cooking may be up to 80-90%. The thermal performance of an induction cooker system is correlated to the distribution of eddy currents which are directly associated with the quantity and position of the heating generation on the induction top. [8] Induction cooker used a pancake coil, with which the flux from only one surface intersects the work piece or utensils placed on it. [9] Simulations were carried out to find out heating efficiency of induction cooker which states thickness of pan which is placed on induction cooker increases the heat energy supplied to water present in pan from induction cooker decreases. [10] The experimental work done by author shows condensation heat transfer coefficient increases with the decrease in pipe diameter as well as helical coil diameter and also increases with increase in the coil pitch up to certain value then it decreases. [11] The work presented by author shows heat transfer in helical coil with circular cross section varied by altering basic geometry of the coil and different fluid types with different flow rates. [12]

The working of helical coil with induction cooker shows flow rates of water and different helical coil configurations plays vital role in heat transfer analysis from induction heating process and validated with CFD software. [13] Coil pitch has significant effect on shell-side heat transfer coefficient, with increasing coil pitch in medium range, the heat transfer coefficient decreases while with increasing pitch to tube diameter, heat transfer coefficient is increased. [14]

With the advantages of induction heating process combine with helical coil is utilized for experimentation to reduce the energy consumption for water heating Process.

II. EXPERIMENTAL SETUP AND PROCEDURE:

2.1 Experimental setup:

Design of Experiments consider various aspects of its components. The Experimental setup consists of two different setups. The first test setup consists of helical coil, Induction cooker, Rotameter and thermocouple arrangement as shown in figure 1. This Experimental setup consists of Induction cooker model Bajaj Majesty ICX with rating 1600 w. Induction cooker is works at 1200 Watt as constant heat source for heat transfer to water flow through helical coil. Helical coil is placed at center surface of induction cooker; water is flowing from top to bottom of helical coil after that is return to outlet pipe. During flow of water from top to bottom coil is subjected to induction heating and at last water temperature is increases. These helical coil shown in figure is replaced with other coil has differs in number of turns. Water is supplied to helical coil from the tap through Rotameter so that we can adjust the flow rate so we will get water outlet temperature 54°C. Inlet water temperature is measure by thermocouple is fixed at insulated pipe which shows temperature on display unit provided with it. Heating of water during flow through helical coil increase temperature of outlet water which is by thermocouple is attached to insulated pipe shown in figure 1. This water is collected in bucket for different application in house hold. Also portable thermometer is also used to measure temperature of water outlet temperature is shown in figure 1.

The First experimental set up is designed with the following instrumentation.

- Induction cooker arrangement
- Helical coil arrangement
- Rotameter and thermocouple arrangement

![Schematic View of Experimental Setup of Helical Coil Induction Water Heater](image)

1. Water Tap
2. Flexible Pipe to continue water flow
3. Rotameter
4. Insulated Pipe for thermocouple
5. Portable thermometer
6. Thermocouple fixed at insulated pipe
7. Helical coil 8. Induction Cooker
9. Temperature Display unit
10. Plastic Bucket
11. Supply cable of induction cooker
12. Switch Board

Second test setup consists of Electric immersion heater of rating 1200 w inserted in the bucket with water quantity of 5 litres with for heating and Portable Thermometer for measurement of water temperature as shown in figure 2.

![Fig No.2 Schematic View of Experimental Setup of Electric Immersion Type Water Heater with 5 liters' water in Bucket.](image1)

**2.2 Procedure for Test Run:**

Test is carried out in two sections one is on Helical Coil Induction Water Heater Setup to analyse performance of each configuration of coil and second with Electric Immersion Type Heater separately to achieve 5 litres quantity of water at 54°C.

For Test run of Helical Coil Induction water heater as shown in figure 1, adjust flowrate of water such that water outlet temperature from test setup is 54°C. Measurements are taken only after the temperatures attain steady values. The readings for water outlet temperature, Voltage, Current using Clamp meter and time using Stopwatch required to complete 5 litres quantity of water for energy consumption analysis of helical coils are noted down. During the course of each set of experiments, the heat supply from induction cooker at 1200 w is kept constant, which ensures a constant heat transfer in induction heating process. Again same procedure is applied to different configurations of helical Coil.

In Second section of Electric Immersion Heater test run initially 5 litres of water at 30°C is subjected to resistive heating and parameters such as voltage, current using Clamp meter and time taken by water to reach up to 54°C from initial temperature for Energy consumption is measured.

2.3 Measurement of Energy consumption by Induction Cooker and Electric Immersion Heater:

It is measured from clamp meter separately using voltage and current measurement with power factor consideration, because power is the product of voltage, current and power factor for selected time using stopwatch. From these we can calculate the energy requirement of induction cooker and electric heater.

\[
P = \frac{(V \times I \times \cos \phi)}{1000} \text{ Kw}
\]

Where
- \(P\) = Power consumed by electric devices in Kw
- \(V\) = Voltage in Volt
- \(I\) = Current in ampere
- \(\cos \phi\) = Power Factor

\[
E = \frac{(P \times t)}{3600} \text{ Kw-Hr}
\]

Where \(E\) = Total Energy consumption by devices for fixed time \(t\) in Kw-hr
- \(t\) = time required for process to conducted in sec

**III. RESULTS AND DISCUSSION**

![Fig No. 3 Variation in energy consumption of Helical coil induction heater with different helical coil N=3.25, N=4, N=5 and Electric immersion heater utilized to heat fixed quantity of water = 5 liters up to 54°C.](image2)

It is observed from the above graph variation in energy consumption of Helical coil induction heater with different helical coil \(N=3.25, N=4, N=5\) and Electric immersion heater utilized to heat fixed quantity of water = 5 liters up to 54°C.

It is observed from the above graph variation in energy consumption of Helical coil induction heater with different helical coil \(N=3.25, N=4, N=5\) and Electric immersion heater utilized to heat fixed quantity of water = 5 liters up to 54°C that energy consumption is least in experimental setup with helical coil \(N=4\) among different helical coil configurations selected for experimentation. Energy consumptions by electric immersion heater is found to be maximum as compared to helical coil experimental setup with number of turns \(N=3.25\) which has more energy consumption among different configurations of helical coil. It also shows helical coil induction test setup with helical coil \(N=4\) have least energy consumption.
IV. CONCLUSIONS

It is observed from experimental analysis energy consumption for helical coil induction water heater is less as compared to immersion type water heater. The Experimental Setup of Induction Water Heater with helical Coil using number of turns equals to four requires minimum energy for heating fixed quantity water at particular temperature with contact less, pollution free and safety for water heating process. Finally, Induction Water Heater are more efficient that is 39 percentage saving is evaluated using four number of turns system.

REFERENCES


