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 meet 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.
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 (floculation) 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 un-stirred 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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