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HEAT TRANSFER FLUIDS IN CONCENTRATED SOLAR POWER PLANTS (CSP)

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ABSTRACT

Now a day researches are going on the different alternatives of electricity from Renewable sources such as sun, wind, water etc. Concentrated Solar Plant has became a very rapidly growing research subject. To convert solar energy into heat a medium is required and hence so many researches' are going on the Heat Transfer Fluid (HTFs). HTFs are the way to store and transfer the heat from sun to the water. In this paper we are giving the properties which should be considered during selection of these HTFs, the problems associated with different types of fluid, and at the last but not the least the advantages of fluid over others.

Keywords: Concentrated Solar Power; Heat Transfer Fluids; Analysis; Review

I. INTRODUCTION

While searching for alternative ways to generate electricity the Journey of our scientists reached to the invention of a new way to generate electricity by using Solar Energy. This method produces electricity by concentrating the sunlight on a particular point, which leads it to get its name as Concentrated Solar Plant. Mostly in this method trough systems are used. Troughs are basically a duct like structure that contains a fluid which has ability to store the heat and are called as HTFs (Heat Transfer Fluids). These fluid through a circulating pump goes into the heat exchanger, where the water is converted into steam. This steam is used to rotate turbine. CSP should not be confused with PV cells, as they are totally different from the CSP. PV cells convert solar energy directly into electricity but this is just inverse with CSP.

II.SELECTION OF HEAT TRANSFER FLUIDS

Before selection of HTFs we should know some of its properties which should be analysed before selecting any fluid as HTFs. Before examining the researcher or customer must think about its compatibility, cost, environmental effects, its toxicity etc.

The HTFs used in CSP are air, water, molten salts (generally salts of potassium and nitrates are used), glycerol based oils and synthetic oils. Water and air has loosen the interest of scientist by serving several problems during operations. Air on heating at high temperature gets expanded and its volume increases so that the machinery used as heat exchanger needs larger size, which leads to increase in required area for plants and ultimately results in increasing the installment cost. On the other hands the water gets oxidized at higher

temperature and reacts with the ducts and causes corrosion. Which results into increase of the maintenance cost and material cost of the trough.

Molten salts get solidified when reaches at high temperature. The other fluids available are used for different operating temperatures. Glycol based fluids are used for applications below 175ºC and synthetic fluids for applications above 400ºC. The basic idea for the CSP-PT plant to use heat transfer fluids in their operation is shown in the figure below.

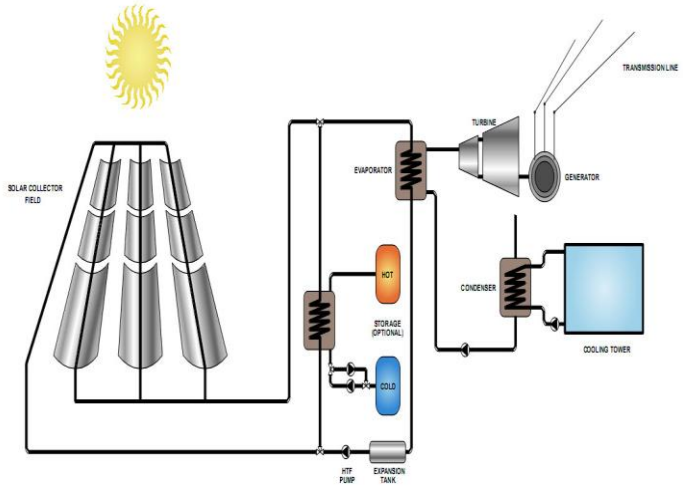

Figure: Typical power system trough system

For the CSP plants to be operated at colder regions water cannot be used as it freezes at 0°C. So there should be some HTFs selected with anti-freezing properties and the fluid lifetime should be for over 20 years. Adding anti-freeze agents to water will have negative impacts on system performance by increasing the boiling point thereby resulting in higher power consumption as the viscosity increases. Also the heat transfer efficiency gets reduced because the thermal conductivity and specific heat decreases by introduction of anti-freeze agents.

When taking the effect of corrosion, the salts are corrosive and its effect cannot be protected by corrosion inhibitors. The glycols and alcohols without corrosion inhibitors are corrosive as glycol produces acid on oxidation which will result in lower pH value due to high temperature. This leads to acid formation which is corrosive in nature. So pH buffers should be used to maintain HTF in neutral and proper corrosion inhibitors should be used.

The corrosion can be controlled by design and operation such as selection of materials, temperature limit and exposure to oxygen. The selection of fluids as HTF is also important to select by considering the usage of corrosion inhibitors and purity level of fluid to be used. It is necessary to maintain metals in the passive state rather than active state which reduces the corrosion rate and increases the life time of materials.

When considering the health, safety and environmental aspects of heat transfer fluids it should not be toxic. From the literatures viewed and among the HTFs that are in old practice alcohols and glycols are classified as moderately toxic. Alcohols have flammability and due to fire safety concerns it is avoided. Among the glycols, propylene glycol is formally approved by Food and Drug Administration because of the advantages like freeze protection, non-corrosive, relatively efficient heat transfer, and no adverse health & safety effects and less cost.

The HTFs with higher concentration should not be used in CSP plant as the load increases and so it has to be diluted with distilled or de-ionized water and the minimum concentration achieved can be 20 to 25% to the maximum concentration of 60 to 65%. The HTFs should not be over diluted for example, when propylene glycol is over diluted leads to corrosion and bio-fouling (growth of algae or micro-organisms along the surface of material) which causes unpleasant odour.

III. CRITERIA FOR SELECTION OF HTF

As the success of our plant is dependent on the HTF we are using hence while selecting a liquid as HTF we have to set some properties of the HTFs in our mind so that the plant can be operated at higher efficiency, and the system becomes economical. Those points are as follows:-

- Temperature Range
- Viscosity
- Density
- Specific Heat
- Thermal Capacity
- Non-Corrosive
- Life
- Freezing Temperature

IV. HEAT TRANSFER FLUIDS USED

The heat transfer fluids mainly used in concentrated solar power are based on the selection criteria specified above and few HTFs are listed down with their properties that are collected from different literatures. Out of the heat transfer fluids used in present days, phenyl-naphthalene has been considered as the best on evaluating its performance.

HTF	T_{max} (K)	C_p (KJ/kg.K)	ρ (kg/m$_3$)	K (W/m.K)	μ (mPa.s)
Xceltherm	580	3	672.36	0.113	0.252
Biphenyl	500	2.03	869	0.118	0.32
Phenyl-naphthalene	600	2.6	849	0.077	0.11
Dowtherm A	678	2.73	672.5	0.0771	0.12
Therminol 66	648	-	1011	0.09	0.29
Nitrate Salts	873	1.495	1899	-	3.26
Hitec	720	2.319	1992	-	6.37

*Source: NREL, ORNL for Heat Transfer Fluids

IV. CONCLUSION

The various methods for the selection of the Heat transfer Fluid have been studied with their limitation incurred with the old fluid.

The study has also gone through the present fluids which are in use, and their advantages over others.

REFERENCES

[1]. Praveen Kumar V. & Madhu Sharma "Analysis of Heat Transfer Fluids in Concentrated Solar Power (CSP)", IJERT, Vol. 3 - Issue 12 (December - 2014).

[2]. Vikil D. Malwe, M. B. Mawale "Thermal Analysis of Heat Transferring Components in the Power Plant" IJERT,Vol.2 - Issue 1 (January - 2013)

[3]. New molten salt heat transfer fluid for solar thermal power plant, Published in:Materials for Renewable Energy and Environment (ICMREE), 2013 International Conference on (Volume:2), Date of Conference:19-21 Aug. 2014, Page(s):496 – 499, Print ISBN:978-1-4799-3335-8, INSPEC Accession Number:14566297, Conference Location :Chengdu

[4]. Emerson – Total Solution for Concentrated Solar Power

[5]. J. Mc Farlane, "Phenylnaphthalene as a Heat Transfer Fluid, Oak Ridge National Laboratories, February 2013.

[6]. Patrik Wagner, "Thermodynamic Simulation of solar thermal power stations with liquid salts as heat transfer fluids"

[7]. Blake, "New heat transfer fluids for Parabolic Trough Solar Thermal plants", 11th Solar PACES International Symposium, September2002