Industrial Engineering Journal
ISSN: 0970-2555
Volume : 52, Issue 4, April : 2023

Design and Analysis of Porous size object to Enhance Thermal efficiency using in Solar Parabolic Trough Collector

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Abstract: Nowadays world is advancing towards the latest technology and day by day new innovations are happening for the comfort of human beings. Researchers are finding and studying continuously on new materials to enhance the performance of the product by considering the economic and environmentally friendly factors. Porous materials are used in so many sectors and also it is found that it can be used for the energy storage purpose. Porous material is used as receiver tube in solar parabolic trough collector enhances the overall thermal efficiency of the setup compare to hollow pipe tube. In this article design of metal foam pipe which have 3mm pores is created and also analysis of pipe is done in the Ansys software. It is found that at the end of results it increases heat transfer rate and pressure drop is also found in the metal foam pipe. Water is used as working fluid in the metal foam pipe.

Keywords: Porous object, Metal foam, Solar parabolic trough collector, thermal efficiency.

1. INTRODUCTION

Currently, energy generation and conservation provide the greatest difficulty. It is extremely difficult and complex work for the experts to produce energy to satisfy the wants and requirements of a nation like India, which has a population of about 130 crores. While conventional energy is used to produce India's energy, pollution may occur from it.

Considering pollution control laws might also make it difficult to work towards producing energy. When all of these factors are taken into account, unconventional energy can satisfy human needs while not harming the environment. Solar panels, solar discs, solar towers, solar engines, solar parabolic trough collectors, etc. are only a few examples of the various solar technologies that have been developed. Regarding Solar Parabolic Trough Collector, experiments are being considered to increase efficiency. When inserting metal foam or another porous material inside the collector pipe or tube, this can be made guaranteed.

Numerous businesses, including those in the aerospace, automotive, military, and armour industries are focusing on the research and development of porous materials as they enter the marketplace. The molten metal exhibited 45% solidity and 55% porosity as a result of the blowing agent. Due to its lightweight design, aluminium metal foam is used in a variety of applications.

Casting can be used to create the difficult task of making metal foam. An increase in melting pressure, foam expansion, and gas losses were the results of adopting a powder metallurgy method without a blowing agent. The expansion of the foam is increased, and the uniformity of the emerging foam is also improved, by employing titanium hydride (TiH_2) for the production of aluminium foam. Melting paraffin with aluminium served as a trial run for experiments involving the production of metal foam. High heat transfer rate was the outcome. The Multi Pass Sun Absorber Heat Collector system's highest thermal collector efficiency, which was initially 36.38%, was increased to 72.59% by employing granite pebble beds.

Fluid transfer reduces the solar parabolic trough collector's heat loss. The characteristics of heat loss include high glass temperature, high measurement, low efficiency, and other factors. It is possible to limit heat loss by using two distinct coating materials. In comparison to black chrome coating, ceramic coating has better performance in reducing heat loss. The heat loss coefficient is reduced by 50% when water is used as the working fluid for unshielded receivers, yielding a thermal efficiency of 53.8%. A one-dimensional numerical model of a parabolic trough collector was used to reduce the convection heat transfer losses by 41.8%.

Conduction, convection, and radiation are the following three processes that transfer heat. By having a greater fluid temperature and glass temperature, the Sun Combined Cycle Plant's (ISCC) receiver performed better. 40% more heat is lost from the lost vacuum (air) tube than from the vacuum tube. The composite absorber was created with the goal of improving effectiveness. According to the results, the glass cover, non-porous absorber, porous absorber, and air stream all saw an increase in temperature. Although nanoparticles are a wonderful alternative, they will cause more heat transmission and condensation. It was discovered that the impact of nano fluid and nanoparticles led to lower effectiveness.

The same experiment has been carried out with copper foam. Copper foam absorbers noticed the change and recognised that improving the mass flow rate made the collector operate better. Placing a metal foam block against the interior of the absorber and pulse-feeding it is a useful technique for enhancing heat transfer.

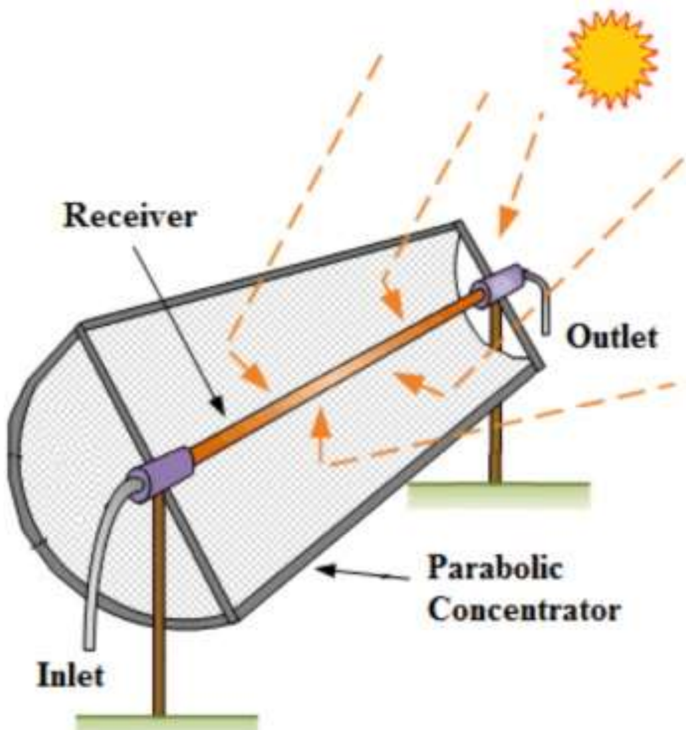

Fig 1. Solar parabolic trough collector [1]

2. Literature Review

" Experiments of manufacturing metal foam were also practiced by melting of paraffin with aluminium. This resulted in high heat transfer rate [2]. Using two different coating materials, heat loss can be reduced. Ceramic coating has higher performance to reduce the heat loss compared to black chrome coating [3]. Using water as a working fluid for unshielded receivers resulted in a thermal efficiency of

53.8% the heat loss coefficient is also decreased by 50% [4]. Some experiment work has been done by using copper foam. The shift was observed by copper foam absorbers, who noted that increasing the mass flow rate improved the collector's performance. [5-6]. Research and new innovative technologies have started a new revolution in the area of energy development with storage capacity. One or other issues is that researchers are lacking with the conservation or storage of this energy. Porous Materials could be the concept which can be used to conserve energy in the solar sector. Metal foam or porous material which results in an increase in surface area can be taken as a source for energy conservation or storage received from the energy source. Solar Parabolic Trough Collector which is solar operated device can be an approach of the energy conversion. In this research article, performance and working of solar parabolic trough collector is been observed utilization of porous material as receiver of solar energy. The temperature of water flowing through the system was increased with the use of porous material in the solar parabolic trough collector. Finally, the efficiency of the system is improved [7]. In this paper, the design stages of a solar parabolic trough collector is presented. The design of prototype was done using Creo parametric 2.0 software. The design parameters are decided on the basis of analysis and its effects due to variations in the parameters. This design process will be useful in fabrication of solar parabolic trough collector [8]. The interaction of nano fluids with extended surfaces in the form of porous structures and its effect on the thermal performance of the heat exchanger is not well documented. In this study, the forced convective heat transfer due to flow of Al2O3/Water nano fluid through a circular tube filled with a metal foam is investigated experimentally. An isothermal boundary condition is created and the pressure drop and the heat transfer rate are measured over a range of flow rates. The results are compared with values for water flowing through a similar tube without the metal foam insert. The experimental data indicate a significant improvement in the heat transfer rate at the cost of a pressure drop increase. Our experimental data also show a direct relationship between the Nusselt number and the volumefraction of Al2O3 [9]. A numerical study has been conducted to examine the heat transfer from a metal foam-wrapped tube bundle. Effects of key parameters, including the free stream velocity, longitudinal and transversal tube pitch, metal foam thickness and characteristics of the foam (such as porosity, permeability, and form drag coefficient) on heat and fluid flow are examined. It can be observed that the performance of the metal foam heat exchangers, measured in terms of area goodness factor, can noticeably be better than that of the conventional design of finned-tube heat exchangers. It is also found that even a very thin layer of metal foam, when wrapped around a bare tube bundle, can significantly improve the area goodness factor. Finally, it is shown that while friction factor is more sensitive to the metal foam permeability than its porosity, the converse is true when it comes to the Colburn factor [10]. Generally, porosity is not a desirable characteristic of any material. In today's Industrial scenario, this parameter becomes necessity of materials for different applications like structural, solar absorbers, and sound absorption as well as biomedical applications. Metal foams are cellular structures contain porosity which increases mechanical, thermal and other physical properties of conventional materials. There are manufacturing issues concern with these materials like homogeneity and location of pores, controlling of parameters. In this article, the techniques of manufacturing of porous materials are discussed with their limiting parameters and pros & cons. Powder metallurgy is found suitable for better porosity but the cost for this process constrain its usage among the researchers and Industry as well. Space holder method is one of the found appropriate among all other used for the manufacturing of open and closed cell foam in perspective of cost as well porosity. The orientation of space holder plays a crucial role for the development of better porous object. This article reviews the different methods of manufacturing and their properties for the better future perspective in terms of cost, structure and application of porous foams [11]."

3. Methodology

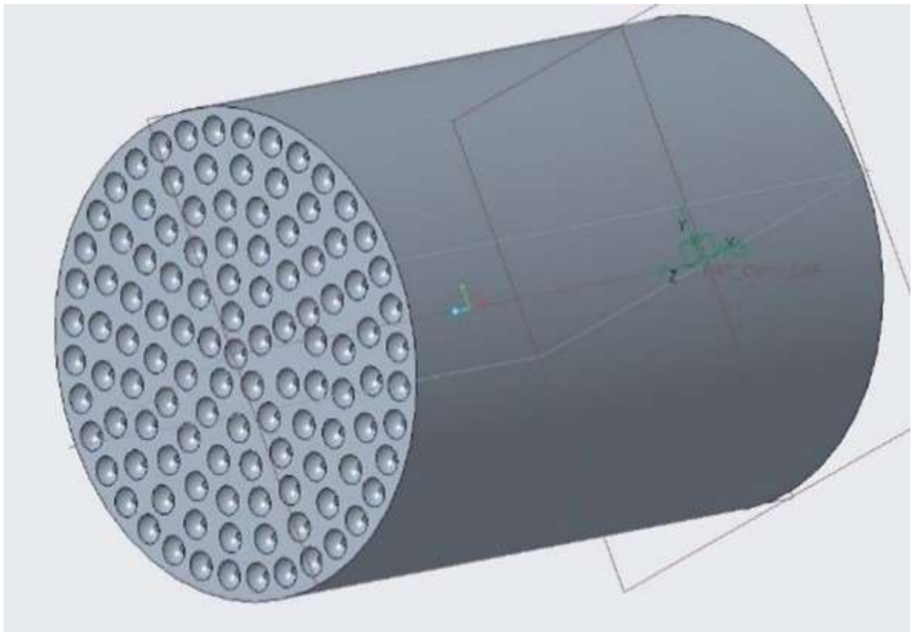

Fig 2. Design of metal foam pipe

- The dimensions of metal foam pipe are 50mm diameter and 75mm extruded length of pipe.
- There are 113 pores on the face of pipe which are 3mm in size and these all pores are extruded throughout the length of pipe.
- This is the sample size for the experimental purpose to calculate results by applying boundary conditions.
- Material of the metal foam pipe is aluminium 6061 Alloy.
- This metal foam pipe is manufactured by solid space holder technique.
- This metal foam pipe is used as receiver tube in solar parabolic trough collector.

1) CFD analysis of metal foam pipe: -

- Analysis of metal foam pipe is taken in the Ansys software by applying boundary conditions to find out the results.
- Water is used as working fluid flowing inside the pipe to obtain outlet temperature of water at end of pipe.
- The velocity of water is taken as 0.5m/s for the calculation purpose.
- For the calculation purpose inlet reference temperature of water is taken as 298 kelvins.
- Heat flux on the pipe wall is taken as 5000W/m2.
- Default fine meshing size is taken for the analysis purpose.

4. Result and Discussion: -

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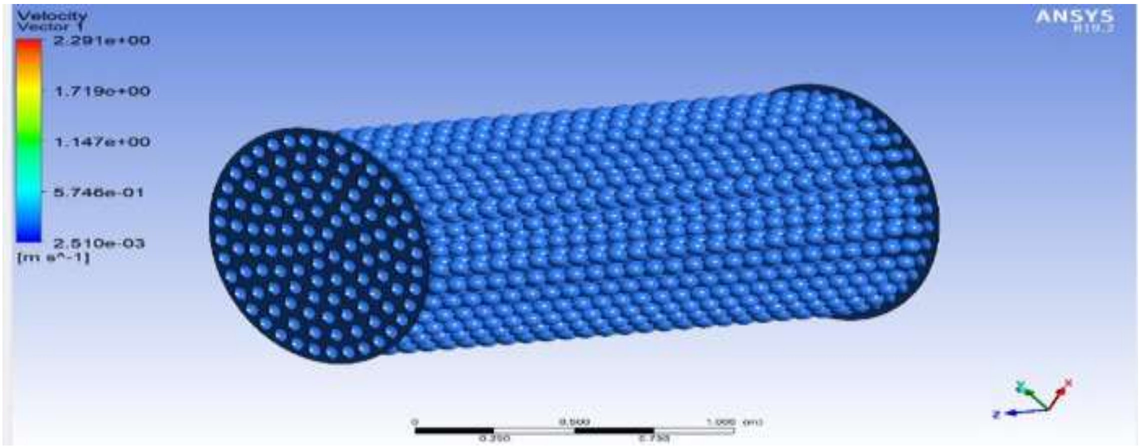

Fig 3. Velocity contour of pipe

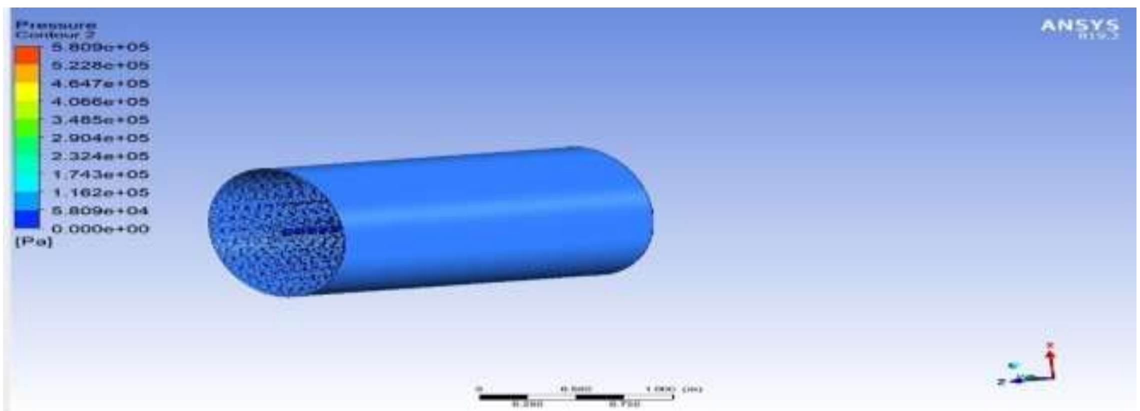

Fig 4. Pressure contour of pipe

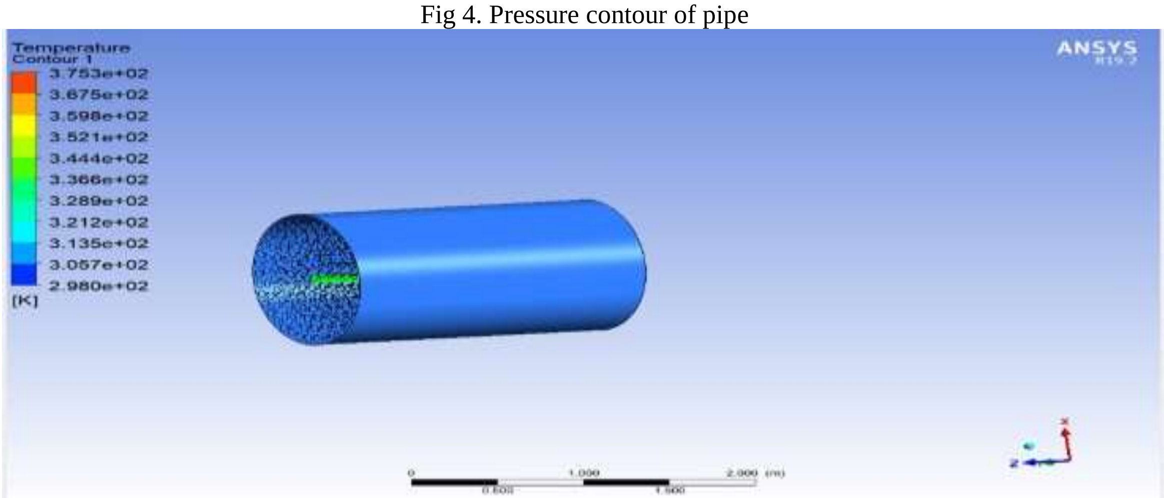

Fig 5. Temperature contour of pipe

- Velocity of water flowing from the pores of the metal foam pipe is remain unchanged with negligible difference.

- Pressure of water flowing through the pipe is drop because of contact surface area increases in metal foam pipe.
- Outlet temperature of water from this metal foam pipe is obtained 375 kelvins.

5. Conclusion: -

- Heat transfer rate increases in metal foam pipe compare to hollow pipe.
- It is obtained from the results that when the pressure of water drops in the pipe than the temperature of water is increases at the outlet of pipe.
- Minimum pore size in the metal foam pipe enhances thermal efficiency of working fluid

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