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Parabolic Trough Collector, a Novel Design for Domestic Water Heating Application

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Abstract**: *CSP technology is grooving up with various applications and different devices due to high thermal efficiency. Parabolic trough collector attracts researchers' due to its versatility. Many researchers were working on designing trough to improve the efficiency of the collector. As per the literature serve carried out most of them are working on high-temperature applications. Our aim is to design a novel parabolic trough collector which is useful in low-temperature applications like domestic water heating. This paper discusses detailed drawing and dimensions of PTC which is useful to researchers. The main advantage of this design is easy assembly and maintenance.***
Keywords**: *parabolic trough collector (PTC), heat transfer fluid (HTF), receiver, collector, solar thermal***

I. INTRODUCTION

Solar thermal is the fast-growing technology now a day due to research being done to explore its applicability in different fields [1,2,3,20,24] and to enhance its thermal efficiency [4,21,22,25,28,30,32,38]. CSP technology is the most effective part of solar thermal with various applications and different devices [2, 24]. Parabolic trough collector (PTC) attracts researchers' due to its versatility in applications resulting in a large number of reports on designing trough to improve the collector efficiency for high-temperature applications and testing[9,10,15,17,30,31,34,36]. PTC is line type concentrator which is designed based on the parabola. Normally it is available with a tracking system to improve the efficiency and effectiveness. Maximum temperature achieved by PTC is reported to be 520 °C by using molten salt as a Heat Transfer Fluid (HTF) [12].

Many researchers are working on PTC and reported different designs[1,3,5,15,18,27]; some of them are working on various applications of PTC [6,8,11,16,19,23,26,33,35,37]. The main area of research focuses on improvement in efficiency [7,12,16,18,21], the effect of the receiver and reflective material [13,14,27,32,35,37,38], heat transfer fluids and storage [4, 12,25,29].

However, the Parabolic trough collector can be a very useful tool to harvest the solar energy for domestic applications, work done in this field is very less. In this paper, we present a novel design of a parabolic trough collector useful for the domestic heating applications.

II. DETAILED DESIGN OF A NOVEL PTC

As per the literature survey, the main parameters for the geometrical description of a PTC are trough length, focal length, aperture width and rim angle [1, 4]. At the time of designing a trough collector, apart from these main parameters, average wind speed in the region, application, HTF, the diameter of collector pipe, number of loops, storage device, and reflective material are also being kept in mind as they also contribute the final conversion efficiency of a system.

Considering all above parameters we designed a novel parabolic trough collector which is easy to assemble and carrying facility to use different collector pipes, different reflector sheets, and different heat transfer fluids. Present design also allows changing the trough length. The design has provision to attach automatic tracking system and storage device.

A. The geometric description of a parabolic trough

PTC is defined by its geometrical parameters. The main parameters are trough length (l), aperture width (a), rim angle (ψ) and focal length (f) as shown in figure number 1.

In this design, we can change the trough length by changing the length of square pipe. This square pipe is bolted with the crossed pipe attached with bearing. In the present design, trough length is 110 cm. Aperture width denoted as (a) is the width of the trough. In this design a=60 cm and it is fixed on bearing.

The rim angle (ψ) is the angle between the axis of collector pipe and the line between the focal point and the mirror rim. Selection of rim angle is very important. Rim angle effects on trough size and efficiencies like lower rim angle results in nondimensional aperture area and less curvature of the concentrator with high focal length [4].The concentrator requires lengthy and stronger receiver support which shifts the center of gravity of the collector away from its axis. Therefore, the system requires higher torque for tracking and stronger receiver support to avoid bending, which is undesirable. Also, it involves the concentration of solar energy in a small fraction of the receiver surface; it results in higher local concentration ratio and thermal gradient across the receiver surface. The advantage of higher rim angle is smaller the focal distance but it needs higher curvature of the concentrator. [4]. For this design, rim angle is taken as 98^0.

The focal length (f) is the distance between the vertex of a parabola and the focal point. It is a parameter which determines the parabola completely. For this design, it is taken as 15.2 cm i.e. 6 inches. The trough is made from mild steel square bar of one inch and having provision of glass cover to avoid dust particles and improve thermal efficiency.

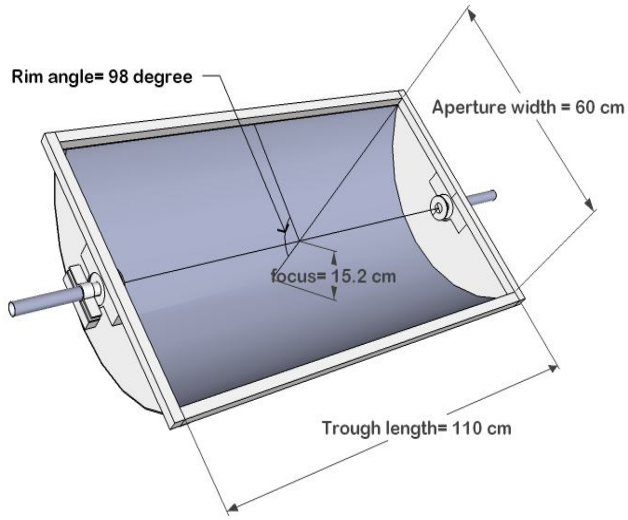

Figure 1 Geometrical descriptions of Trough

B. Stands

The stand is designed like a cradle. Due to which it has more stability when the trough is swinging. Vertical pipe is welded for stability. Two stands are connected with horizontal square pipe for resisting vibration and deflection. Top of the stand is having clamping arrangement which is holding the trough. It is shown in figure number 2.

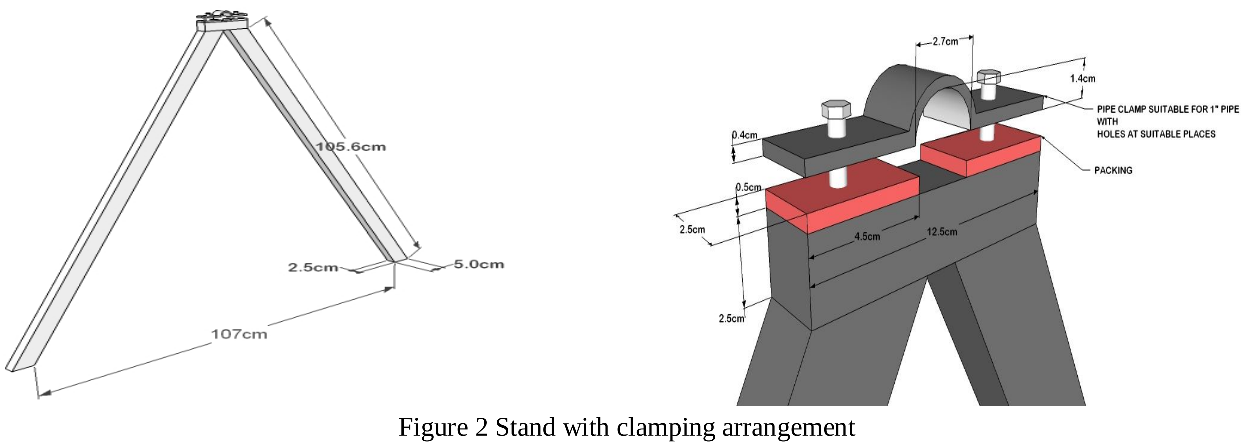

Figure 2 Stand with clamping arrangement

C. Fluid pipe ends

Fluid pipe of 1-inch diameter is selected for the design. It has a flange in trough side so we can attach different collector pipe to the system. It is inserted in bearing for smooth rotation of trough. It is stationary to prevent receiver or fluid pipe and easy connections. It is fixed on clamp of the stand. Stainless steel is selected as material. It is shown in figure number 3.

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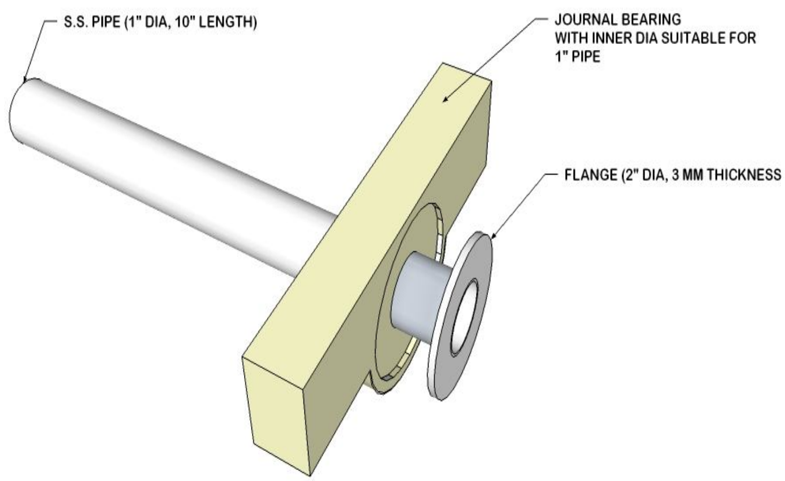

Figure 3 Fluid pipe ends

D. Pipe on journal bearing

Vertical square pipe of 65 cm is connected with journal bearing. It is representing aperture width (a) of the trough. It made by mild steel square pipe of 1 inch. Holes are drilled at ends to join trough length pipes. It is shown in figure number 4.

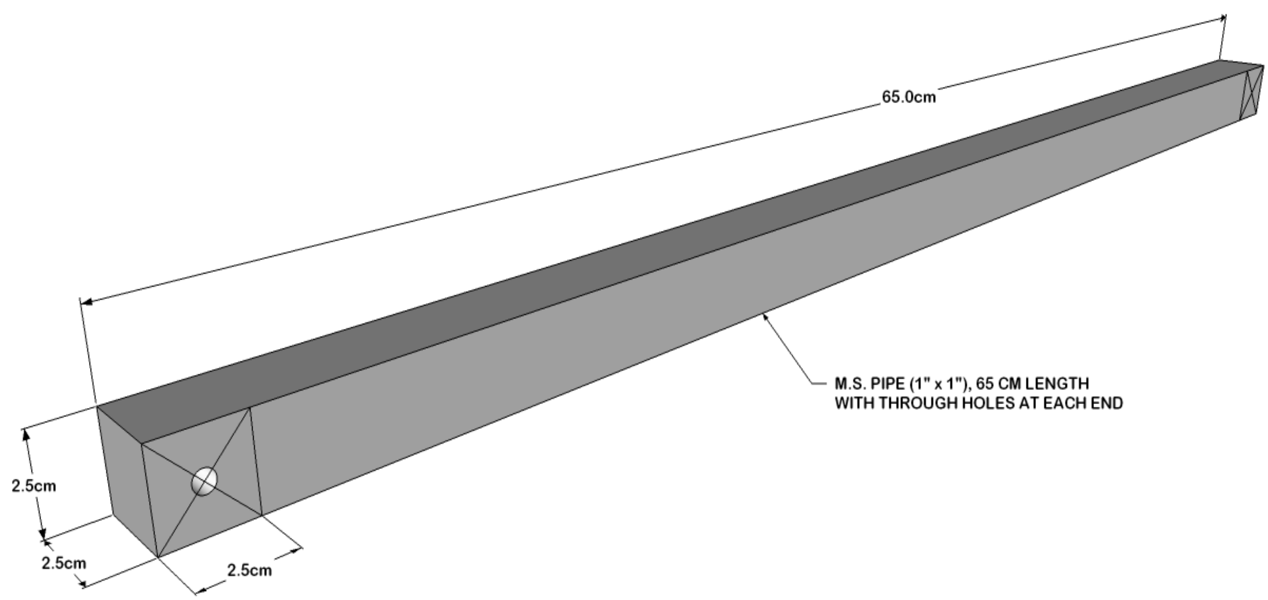

Figure 4 pipe on journal bearing

E. Reflector holding clamp

The rectangular shape is made by square pipes with trough length and width size. The parabolic shape of the reflector is made by this strip type holding clamps. These clamps are bolted with length bar pipe of the trough at ends and at the middle. This holding clamp gives support to a reflective sheet of various reflective materials. By this arrangement, we are able to change reflectors as well as the focal length of the parabola. It is shown in figure number 5.

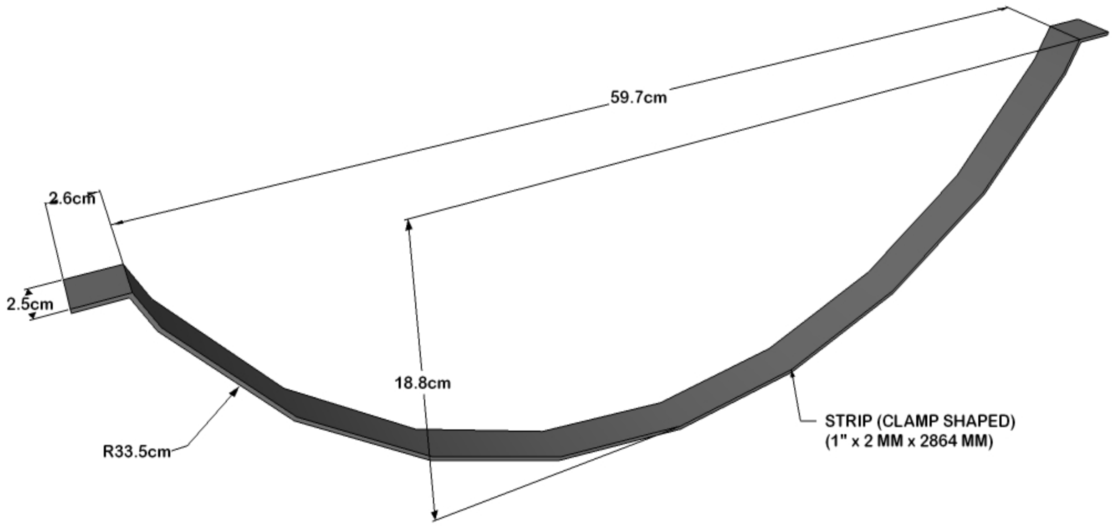

Figure 5 Reflector Holding Clamp

F. Length pipe

Square pipe of 1inch mild steel is used here. This is representing trough length. Ends are treads so it can connect to pipe with journal bearing. By changing its length we can change the length of the trough. It is shown in figure number 6.

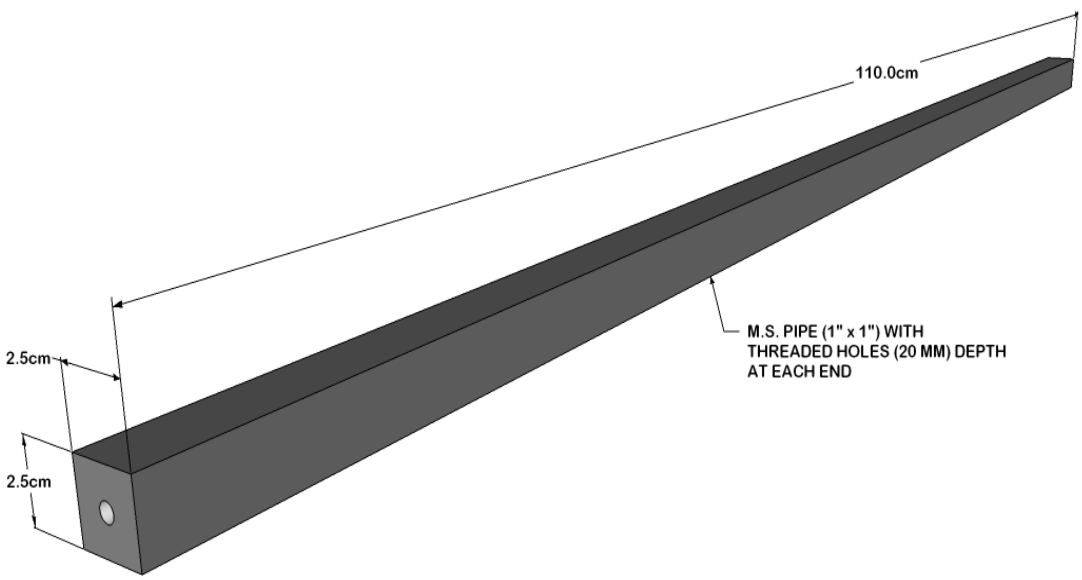

Figure 6 Length Pipe

III. COMPLETE SETUP

Actual model has been fabricated using CAD design. A full assembly of the cad model and actual fabricated model are shown in figure number 7 and 8.

Figure 7 CAD model of complete assembly

Figure 8 Actual Model under Fabrication

IV. CONCLUSIONS

A novel and flexible design of PTC is created which can attract researchers to test the suitability of various parameters; i.e. different reflective materials, collector pipe diameter and types, various HTF and focal length; for different domestic applications and the region of installation. Main advantages of the design are as follows.

A. The design is easy to manufacture.

B. Easy to maintenance. In a conventional domestic solar water heater, the main disadvantage is maintenance and dis-assembling which is too simple in this design.

C. Easy to transport.

D. Can change reflector sheet as per season or requirement.

E. Easy to change collector pipe. This can be the great advantage of this design as most of the available designs for domestic water heating systems suffer from the blockage of collector pipes due to scaling inside it, and rigid design limits the changing of collector pipe.

F. High rim angle and rectangular frame structure so we can place glass sheet to minimise wind effect, dust effect and improve the thermal efficiency of the system.

G. Suitable for connecting domestic water line connections.

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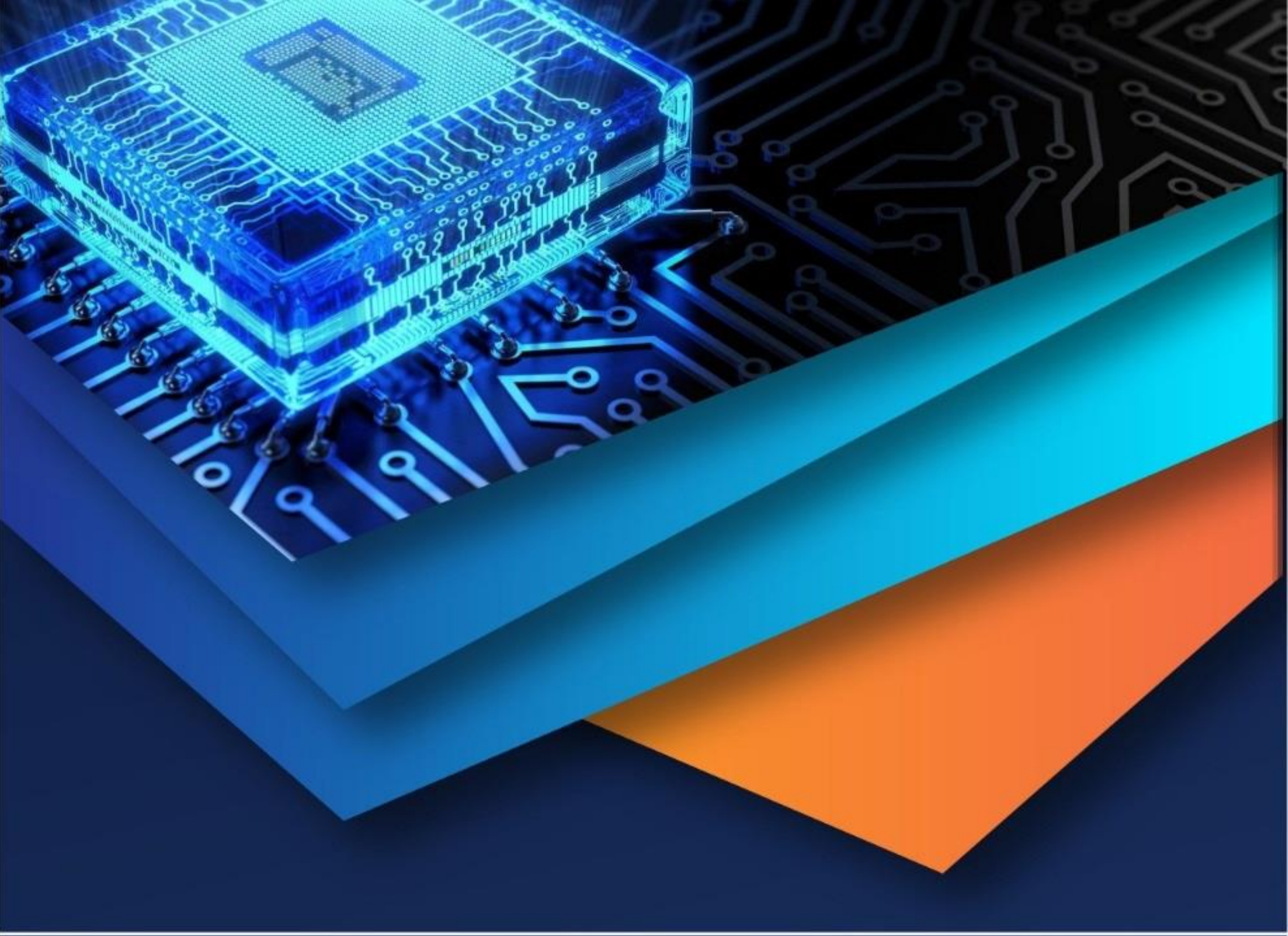

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