Performance studies on solar parabolic dish collector using cylinderical cavity receiver for community heating applications

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Abstract— **In high-temperature applications, the Solar Parabolic Dish Collector (SPDC) is an important component of the solar thermal energy conversion process. The main goal of this project is to improve the performance of a solar dish collector with a cylindrical cavity receiver. SPDC's design incorporates aluminium leaflets with a mirror finish. The cylindrical receiver design is used to achieve the improved thermal efficiency. For varied design and operating conditions, it has been established that the average collector efficiency of solar dish collectors ranges from 44 to 61 percent. The parabolic dish collector's heat transfer properties and thermal performance were investigated. The results of these experiments will be used to make suitable SPDC assessments on a regular basis.**

1.INTRODUCTION

Non renewable energy sources such as coal, petroleum, and natural gas have negative consequences for both humans and the environment. As a result, the earth's average temperature rises, causing global warming. It causes the ozone layer to deplete, causing glaciers and ice pieces to melt and the sea level to rise.

The use of fossil fuels in industry, coal-fired power plants, and automobiles is the primary cause of global warming. Renewable energy sources can be used instead of fossil fuels for energy production because they are clean and non-polluting. Flat plate collectors, evacuated tube collectors, solar parabolic trough collectors (SPTC), and solar parabolic dish collectors are examples of different collectors. A widely used solar collector for thermal applications is the SPTC system. Range from

150 to 400 ° C. Solar Trough Collector is Straight Focusing Centerline absorption tube for absorbing the reflected radiation structure of the reflector. There are many studies that have verified the performance of solar panels using various techniques. Recently, there have been many notable studies on increasing convective heat transfer coefficient using nanofluids as the working fluid for solar parabolic collectors. Another important energy recovery method is the use of solar parabolic dish collectors (SPDCs). It includes a parabolic-like reflector that focuses all incident rays at a single focal point**.**

Aluminium leaflets is used as a reflective material due to its high reflectance and economy. In another experiment, we examined three different aspect ratios of the conic section, such as 0.8, 1.0, and 1.2. Cavity receiver. The results show that the low aspect ratio (0.8) receiver has the highest thermal performance. RosnaniAffandia showed that increasing the intercept factor improves the utilization of solar energy from the receiver because the radiation loss from the concentrator to the absorber is reduced. M. Abid concludes that the efficiency of SPDCs is slightly higher than that of solar paraboloid trough collectors (SPTCs). This task uses a cylindrical copper absorber as the receiver because it is more thermally efficient than a low cost spiral receiver. The main scope of this work is to analyze the effectiveness and heat transfer properties of the SPDC bowl using a conical cavity receiver to heat the water under different flow conditions. In this study, we designed a cylinderical absorber for a solar dish collector and tested it for optimum optical performance. The optical

performance of the parabolic collector is performed for a variety of design and operating parameters. Parameter studies of heat transfer coefficient and performance improvement were performed at SPDC based on Various design and operational parameters.

2. SOLAR PARABOLIC COLLECTOR DESIGN

The aperture diameter and depth of the parabola are assumed to be 1.68 m and 0.21 m, respectively. Additional design parameters for the SPDC for design are shown in **. Table 1** shows the main design specifications and derived parameters. CNC machined to support the steel skeleton frame and attach the plate reflector sheet to the frame. The plate reflector sheet is made of aluminium steel with a thickness of 0.8 mm. The parabolic disk collector was designed using SolidWorks software, with different views.

3. EXPERIMENTAL SETUP AND METHODOLOGY

The SPDC consists of a reflector, a cylindrical receiver, and a base structure, as shown in **Fig 3.** Aluminium sheet with a thickness of 0.8 mmis used for the reflectivematerial. This is due to its high reflectance and low cost. Aluminium sheet is cut using a sheet cutter. Thecylindercal receiver is made of bendable copper and has high conductivity (K = 400W / m). Table 2 shows the details of the conical receiver.

S.No	specifications	value
1.	Dish diameter	1.77m
2.	Dish depth	0.21m
3.	Focal length	0.70m
4.	Aperture area of dish	1.89m2

Table 1: specifications of parabolic dish

The basic structure acts as a mount and support a parabolic dish that functions under stable conditions. This stand is provided with an arrangement for tilting the parabolic dish to any angle. The basic structure consists of mild steel rods and square channels. All Aluminium sheet reflectors are connected with strong bonding gum.

Figure 1 : photographic view of parabola

S.No	Receiver	Specifications
1.	Material	Copper
2.	Copper tube(OD)	13mm
3.	Copper tube (ID)	11mm
4.	Thickness	2mm
5.	No of Turns	2

Table 2 : specifications of spherical recevier

shows a schematic diagram of the SPDC plant experiment. Water is used as the working medium of the experimental equipment and is forced to flow through acylinderical receiver to absorb the focused solar radiation. Experimental studies at SPDC have tested different flow rates of water. First, water is stored in an atmospheric temperature tank and pumped to high pressure using a water pump. Water enters the cylinderical cavity tank under high pressure. Two Type K thermocouples are located at the inlet/outlet of the cylindrical receiver tube. The hot water is sent to the heat exchanger, which cools the water and collects the hydraulic fluid in the tank. Thermocouples (Type K) are used to determine the (internal/external) temperature of the working medium and storage tank.

S.no	Apparatus	Specifications	Accuracy
1.	Rotameter	0 - 10 m3/s	±5%
2.	Thermocouple	-10 - 1000	±0.1%
3.	Lux meter	1 - 200000 lux/m2	± 3%
4.	Pump	1 - 1.4	±0.3%

Table 3: specifications of apparatus used

The storage tank has a capacity of 10liters and is made of mild steel plate. The uncertainty of the dish collector experiment was estimated and applied as recommended in the study. The test capacity of the

full solar panel was assembled outdoors at normal wind speeds of 1-10 m/s. In addition, the support structure is robust against the tested wind speeds and the SPDC device specifications are shown in Table 3.
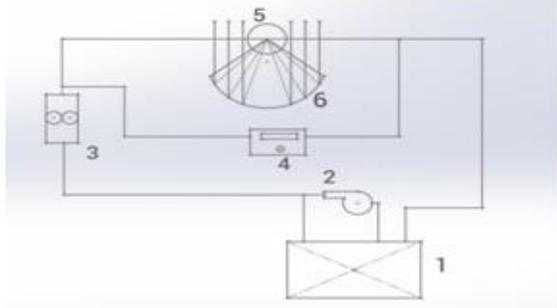

FIG 2: SYSTEMATIC DIAGRAM OF SPDC

1.   Storage tank
2.   Pump
3.   Watermeter
4.   Temperature indicator
5.   Spherical absorber
6.   Dish collector

4. DATA COLLECTION AND CALCULATION

Data such as solar irradiance, temperature, (inlet/ exit) water temperature, surface temperature of cylindrical receiver, etc. are in the mass flow range of 0.5 to 3 l/min between 11:00 and 3. Will be collected for a few days. Collector efficiency and heat transfer parameters are obtained from the equations, and useful parameters are also calculated Table 4 shows the parametric test results of the parabolic solar collector.

The parameters of the solar collector can be calculated using the following formula.

• Heat supplied $Q = mc (T_{out} - T_{in})$
• Convective heat transfer coefficient h =
• Collector efficiency

The collector efficiency depends upon the heat gained by the water, collector aperture area and Irradiation

$\eta=$

5. RESULTS AND DISCUSSION:

The outlet temperature shows the change in gradient temperature for different flow rates. At a flow rate of 0.0354 kg/s, the maximum gradient temperature $(T_{out} - T_{in})$ of C is reached. The gradient

temperature of the shell collector rose to about 7 ° C at the lowest flow rate. This is due to the long contact time between the liquid and the inner surface of the cylinderical absorber tube. In addition, the thermal conductivity of the working medium improves heat transfer. A minimum gradient temperature of 3 ° C is observed for mass flow of 0.0547 kg / s. Figure 3 shows the changes in mass flow rate and efficiency of the disk collector. Due to the temperature difference between the inlet and outlet hydraulic fluids, a plate collector efficiency.

Mass flow rate(kg/s)	Solar irradiation (w/m2)	Temparature (T in)	Temparature (T out)	Heat gained (Q)	Convective heat (h)	Efficiency (%)
0.0354	818.44	39	44	1036	2049.8	67.01
0.0375	783.54	40	45	784.12	2171.74	52.9
0.0396	778.15	42	46.5	745.20	2293.68	50.6
0.0444	777.36	42	46	742.72	2571.74	50.5
0.0463	773.41	43	47	774.50	2681.80	52.9
0.0547	730.75	46	49	686.26	3168.14	49.6

TABLE 4: VARIOUS PARAMETERS OF PDSU.

For different flow rates of solar collectors, the outlet temperature of the working medium (DI water) is measured and displayed in Figure 5. 49.6 % is observed at a flow rate of 0.0547 kg / s. Interestingly, increasing the mass flow rate reduces
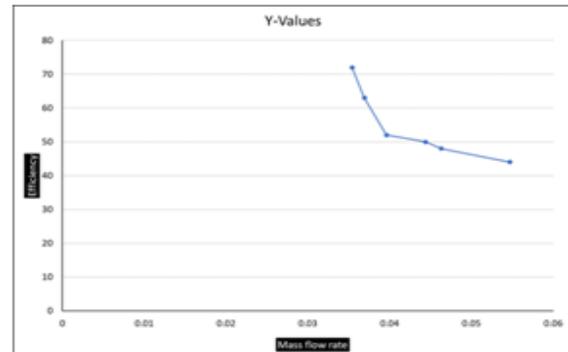

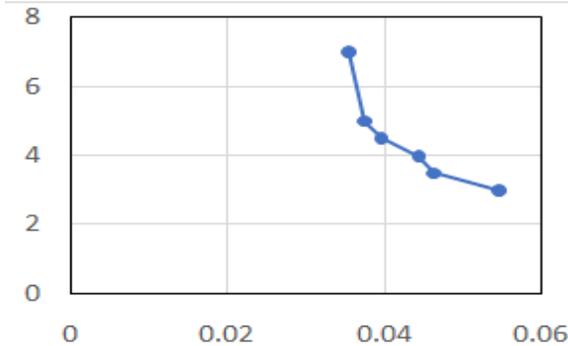Fig 3: Variation of Mass Flow Rate And Efficiency

Fig4 : VARIATION OF MASS FLOW RATE AND TEMAPARATURE GRADIENT

The SPDC temperature difference and reduces efficiency.

The minimum collector efficiency is 49% at a mass flow rate of 0.054 kg / s. The change in convective heat transfer coefficient when the Reynolds number is increased. As the Reynolds number (Re) increases, the working fluid absorbs heat from the cylinderical surface, whi in turn increases the convective heat transfer coefficient (h), which in turn increases the convective heat transfer coefficient. Optimal convective heat transfer coefficient (2293 W / m2K) was obtained at a flow rate of 0.0396 kg / s. This is due to the optimal absorber contact time compared to the increased mass flow rate. This is due to the increase in the convective heat transfer coefficient. Figure 3 shows the relationship between time and dish efficiency.

You can see that the efficiency of the dish is maximized between 12:30 pm and 1:00 pm due to the high amount of solar radiation. The maximum effect of the plate collector was achieved by the higher temperature difference, thermal conductivity, and extinction coefficient of the working medium. In particular, increasing the flow rate of hydraulic oil (DI water) will significantly improve the convective heat coefficient of the solar shell collector.

6. CONCLUSION

In this study, we will investigate the performance of a 1.69 m diameter solar parabolic collector for various flow rates of DI water. The following results were obtained. It was found that the maximum gradient temperature was 7 ° C for a mass flow rate of 0.0354 kg / s. A maximum heat transfer coefficient of 3168 W / m 2K was achieved at a flow rate of 0.0547 kg / s. With a mass flow rate of 0.0354 kg / s, the maximum collector efficiency is 67.01%. At a maximum mass flow of 0.0547 kg / s, a higher gradient heat coefficient was achieved with a lower gradient temperature s (30C).

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