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A Report on Parabolic Through Collector by Using Nano Fluid

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ABSTRACT:

A numerical study of the performance of a solar Parabolic Trough Collector (PTC) has been done focusing on its receiver. The receiver consisting of a glass-shield enclosing a Heat Collector Element (HCE) with vacuum in the annular space has been subjected to seasonal and diurnal variations of solar radiation along with the concentrated heat flux reflected from the parabolic trough mirror for conditions at Visakhapatnam, India. Different parameters of the system such as receiver tube diameter, material of the receiver tube and heat transfer fluid are chosen for the study and evaluating the performance of the system. In the present work stainless steel with mirror finish is taken as the reflecting material for the trough. Stainless steel and copper are taken as the material for the receiver tubes.

Tubes modeling is done in CATIA V5 R20 and Meshing simulation has been done using ANSYS FLUENT software. Properties of water and nano fluid has been Calculated with equations given On the basis of recorded parameters efficiency of the system was calculated. Fluid as water and nano fluid (TiO2) are taken as medium in the tube, by using these fluids the experimental work is proceeded. Overall heat loss coefficient (U_L) and Heat removal factor (F_R) and thermal efficiency also calculated. By comparison between theoretical and experimental values it was concluded that nano fluid (TiO2) performs better than water.

1Solar Spectrum:

Sun's radiation is a combination of different layers which absorb and emit radiations that differ in wavelengths. Harmful portion of these wavelengths i.e. is the Gamma and X-rays are filtered out by the atmosphere.

About 48% of the sun's radiation falls in visible region, whereas about 45.6% is in the infrared region [2] and the rest is in ultraviolet spectrum.

The solar spectrum is shown in the figure 1.1 [2]. **1.2.2**

Direct and Diffuse solar radiation:

The solar energy that reaches the earth is further categorized in the form of direct and diffuse radiations.

Diffuse:

As the white light passes through the sun's atmosphere it gets scattered, reflected and absorbed by various elements such as the clouds, pollutants, dust, air molecules etc. This radiation is known as diffuse radiation.

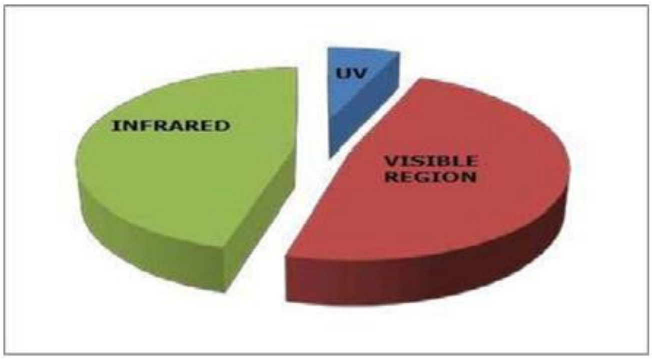

Figure 1.1: Solar Spectrum

1.3 Sun and Earth angles:

Various important sun and earth angles are shown in the figure 2 below are as follows:

Altitude angle (α):

Angle formed between a horizontal surface and sun rays.

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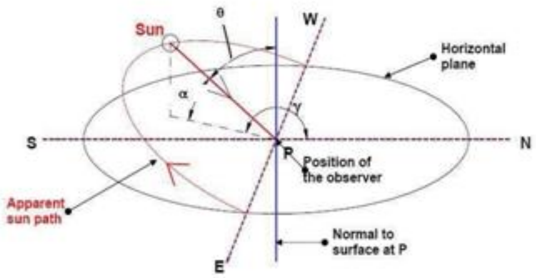
Zenith angle (θ):

Angle formed between a line which is perpendicular to the horizontal plane and the sun ray



1 Parabolic Trough Collector

A parabolic trough collector system consists of a reflecting surface which resembles a parabolic shape. This reflecting surface is mostly made of reflecting mirrors or anodized. Aluminum sheets. The solar radiations falling on the reflecting surface is concentrated on the focal line of the parabola where a receiver tube carrying the heat transfer fluid is placed. Absorber tube either painted black or electroplated with nickel or chromium in order to increase the absorptivity of the tube. The heat transfer fluid picks up the heat from the absorber tube which is utilized later in the desired way. The temperature in this type of system can reach as high as 400^0c, depending upon the type of reflecting surface, absorber tube materials and heat transfer fluid.

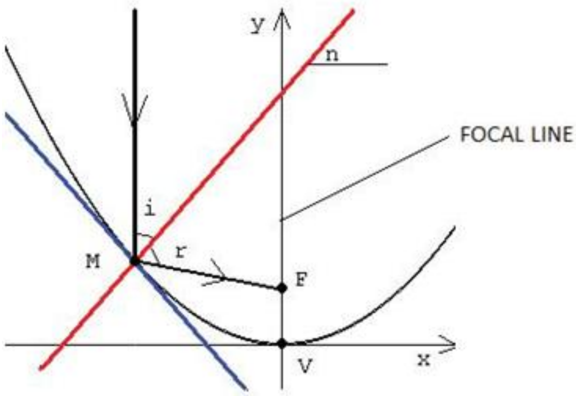
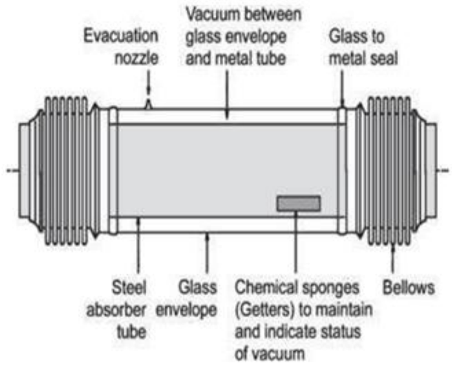
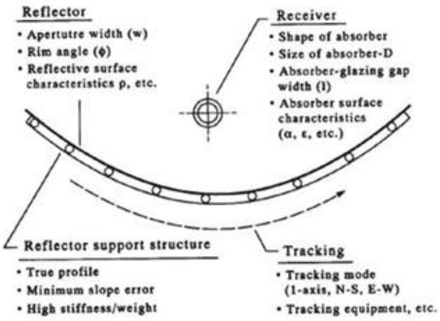


Figure1.4: Design specification of a reflector

3.1 REFLECTOR:



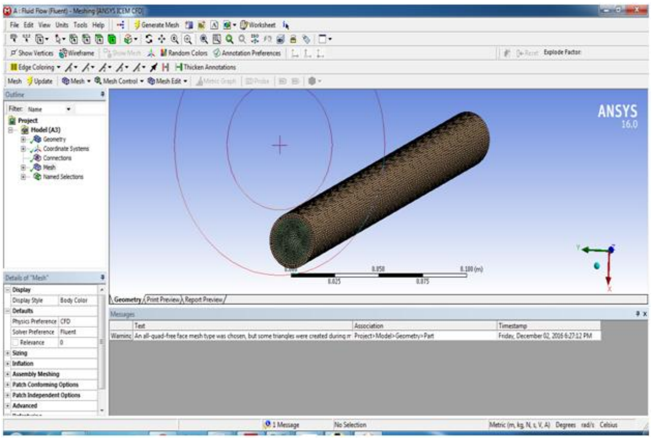


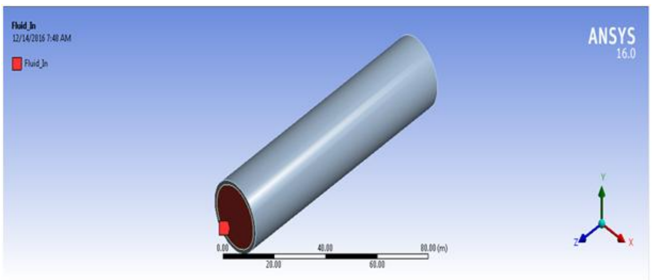
S.NO.	COMPONENTS	
1.	Heat generating units with tracking system	Speciation
	Parabolic reflector	
	length	4ft
	Arc length	6ft
	Depth	0.689ft
	Focal length	1.99ft
	Material	Ss with mirror film
	Sun Tracker	Single axis
	Absorber tube	
	length	4ft
	diameter	1 inch
	Absorber material	Copper , SS
	Insulation material	PUF
	Piping material	GI & Copper
2.	Storage unit	speciation
	Storage tank	One for water and other for nano fluid
	capacity	46(lit)for water , 10 lit of nano fluid
	Pipe insulation thickness	1cm
	Tank insulation thickness	2cm
	Working fluid	Water and nano fluid

PARAMETERS OF PARABOLIC TROUGH COLLECTOR

TABLE 2

parameters	values	units
Air kinematic viscosity ($\acute{\upsilon}_a$)	1.60*10^-6	M²/s
Thermal conductivity of air	0.026	w/m/k
Emmisivity of receive tube coating(ε)	0.66	
Stefan bolzman constant(σ)	5.67*10^-8	W/m²/k⁴
External diameter of absorber tube (D_{ext})	0.025	m





EXPERIMENTAL DATA WITH CFD ANALYSIS

5.1 Parameters used for Analysis:

5.2 Evaluation of water and thermo physical Prosperities: $15^{o}C < T_W < 70^{o}C$

Density of Water:

$$\rho_W = 1000 * \left[1.0 - \frac{(T_{W-4.0})_2}{119000 + 1365 * T_b - 4 * (T_w)^2} \right]$$

Viscosity of water:

$$k_{nf} = k_w 0.8938 (1 + \frac{\phi}{100})^{1.37} (1 + \frac{T_{nf}}{70})^{0.2777} (1 + \frac{d_p}{150})^{-0.0336} (1 + \frac{\alpha_p}{\alpha_w})^{0.01737}$$

Thermal conductivity:

$$\mu_w = 0.00169 - 4.25263 * e^{-5} (T)_w - 4.9255 e^{-7} * (T_w)^2 - 2.0993504 e^{-9} (T_w)^3$$

Specific heat of water:

$$C_w = 4217.629 - 3.20888 (T)_w - 0.09503 * (T_w)^2 - 0.00132 * (T_w)^3 + 9.1425 * e^{-6} * (T_w)^4 - 2.5479 * e^{-8} (T_w)^5$$

5.3 Evaluation of thermo physical properities of nano fluid:

$$\rho_{nf} = \phi \rho_p + (1 - \phi) \rho_w$$

$$C_{nf} = \frac{(1-\phi)(\rho C)_{W+}(\rho C)_P}{(1-\phi)\rho_W + \phi \rho_P}$$

$$\mu_{nf} = \mu_w (1 + \frac{\phi}{100})^{11.3} (1 + \frac{T_{nf}}{70})^{-0.038} (1 + \frac{d_p}{170})^{-0.061}$$

$$k_{nf} = k_w 0.8938 (1 + \frac{\phi}{100})^{1.37} (1 + \frac{T_{nf}}{70})^{0.2777} (1 + \frac{d_p}{150})^{-0.0336} \left(\frac{\alpha_p}{\alpha_w} \right)^{0.01737}$$

Experimental data of inlet temperature of water

Table . 4.Temperature of water at inlet and exit

Ti	To	Tm	mass flow rate (Lpm)	mass flow rate(Kg/s)	hci (w/m2)	Cp (J/kg/K)	Dext	L (mts)	Tr (EXP)
308	338	323	0.6	0.01	706.62	4187	0.025	1.2	341.8707
293.1	294.2	293.7	1.5	0.025	93.913043	4187	0.025	1.2	306.6654
293.8	295	294.4	1.54	0.025667	93.913043	4187	0.025	1.2	308.9773
294.4	295.6	295	1.5	0.025333	93.913043	4187	0.025	1.2	309.388
295	296.2	295.6	1.5	0.025	93.913043	4187	0.025	1.2	309.7987
295.7	297.2	296.5	2.5	0.041667	93.913043	4187	0.025	1.2	326.0305
296.6	297.9	297.3	2.5	0.041833	93.913043	4187	0.025	1.2	322.989
297.1	298.4	297.8	3.1	0.05	93.913043	4187	0.025	1.2	328.5138
297.4	298.8	298.1	3.1	0.051667	93.913043	4187	0.025	1.2	332.3345
297.7	299	298.4	3.1	0.051667	93.913043	4187	0.025	1.2	330.1392
297.9	299.2	298.6	3.1	0.051667	93.913043	4187	0.025	1.2	330.3392

5.4Temperature profile in absorber tubes at :

Temperature profiles in absorber tube are analysed using ANSYS PACKAGE with inlet temperature of water and nano fluids , analysis is general purpose software used to simulate fluid dynamics and heat transfer aspects for engineers , so anasys , was used to simulate tests according to the working conditions , to test in virtual environment Inlet temperature of water at 35oc we have highest efficiency theoretically ,

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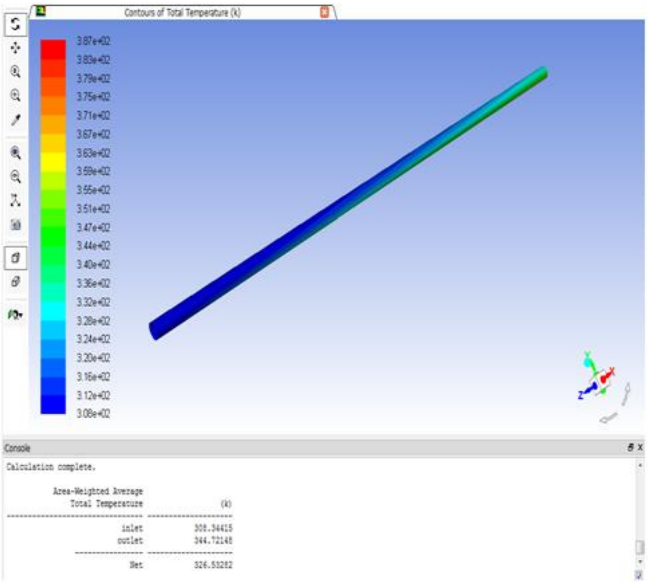
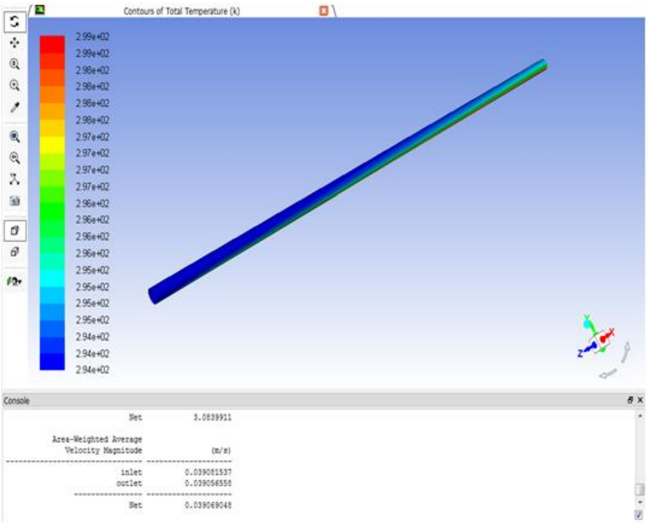




Ti	To	Tm	mass flow rate	mass flowrate	hci	Cp	Dext	L	Tr
			Lpm	Kg/sec					exp.
308	344.72	326.36	0.6	0.01	706.62	3078	0.025	1.2	339.0949
293.1	295.7073	294.4037	1.5	0.025	93.91304	3078	0.025	1.2	332.2019
293.8	296.33	295.065	1.54	0.025667	93.91304	3078	0.025	1.2	331.8893
294.4	296.95	295.675	1.5	0.025333	93.91304	3078	0.025	1.2	340.0361
295	296.871	295.9355	1.5	0.025	93.91304	3078	0.025	1.2	329.5693
295.7	297.76	296.73	2.5	0.041667	93.91304	3078	0.025	1.2	333.7613
296.6	298	297.3	2.5	0.041833	93.91304	3078	0.025	1.2	322.4669
297.1	298.3	297.7	3.1	0.05	93.91304	3078	0.025	1.2	297.7
297.4	298.3	297.85	3.1	0.051667	93.91304	3078	0.025	1.2	297.85
297.7	299.4	298.55	3.1	0.051667	93.91304	3078	0.025	1.2	298.55
297.9	299.96	298.93	3.1	0.051667	93.91304	3078	0.025	1.2	298.93

EFFICIENCY = 202400*mfr*(To-Ti)/Ib

mass flowrate	mass flow rate	Ti	To water	To nano fluid	radiation	efficiency of water	efficiency of nano fluid
Lpm	Kg/sec	oC	oC	oC	(Ib)		
0.6	0.01	308	338	344.72	1000	60.72	74.3
1.5	0.0249	293.1	294.2	295.7073	534	10.42	24.7
1.54	0.0256	293.8	295	296.33	530	11.76	24.7
1.5	0.0253	294.4	295.6	296.95	587	10.48	22.2
1.5	0.0249	295	296.2	296.871	558	10.88	16.9
2.5	0.0416	295.7	297.2	297.76	560	22.58	31.0
2.5	0.0418	296.6	297.9	298	580	18.97	20.4
3.1	0.0499	297.1	298.4	298.3	563	23.36	21.5
3.1	0.0516	297.4	298.8	298.3	560	26.14	16.8
3.1	0.0516	297.7	299	299.4	535	25.41	33.2
3.1	0.0516	297.9	299.2	299.96	540	25.17	39.8

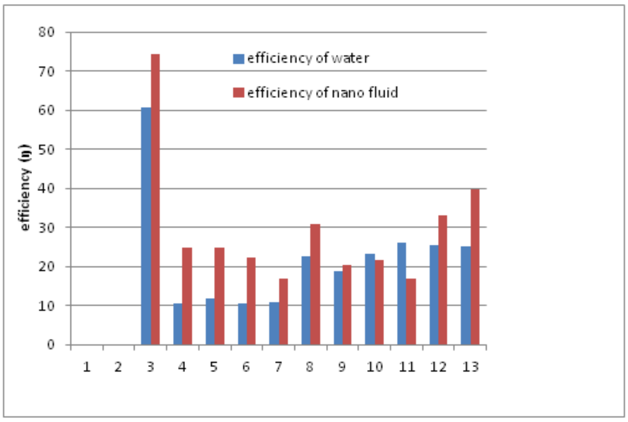
6.2Over all heat transfer coefficient of water

Table 6 :Over all heat trans fer of water .

Wind vel	Tr	Ta	Re(a)	Nu(a)	hw	hr	Ul
0.1	305.4	293.1	1562.5	24.740	25.730	4.013	29.74
0.1	306.5	296.8	1562.5	24.7407	25.730	4.109	29.84
0.1	306.6	299.6	1562.5	24.74077	25.730	4.168	29.89
0.1	307.5	298.7	1562.5	24.74077	25.730	4.169	29.89
0.1	308.2	298.4	1562.5	24.74077	25.730	4.177	29.90
0.1	308.1	298.5	1562.5	24.74077	25.730	4.177	29.90
0.1	308.6	298.9	1562.5	24.74077	25.730	4.196	29.92
0.1	308	298.6	1562.5	24.74077	25.730	4.177	29.90
0.2	308.8	298.3	3125	37.5	39	4.188	43.18
0.2	309.4	298.1	3125	37.5	39	4.196	43.19

6.3 Over all heat transfer coefficienct of nano fluid (TiO_2)

Table 7: Over all heat transfer rate of nano fluid



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Conclusion :

The solar parabolic trough collector system is used for generation of power as the system is caple of producing high temperature . This system is also employed for water heating , process steam application and air heating as well , with the estimation of data of average global solar radiation at visakhapatnam , from this we have done a temperature profile are analyzed using ANSYS PACKAGE, from it we theoretically calculated the properities of water and nano fluid physical properities

1. In experimentally study it was concluded that at a significant temperature the efficiency of nano fluid and water are noted.From that resultant values peak efficiency of nano fluid is clearly observed.
2. In analytical study , the efficiency of nano fluid is more compared to water when subjected to same experimental temperature.
3. Fig.7.1 . Efficiency of water and nano fluid (Tio2)

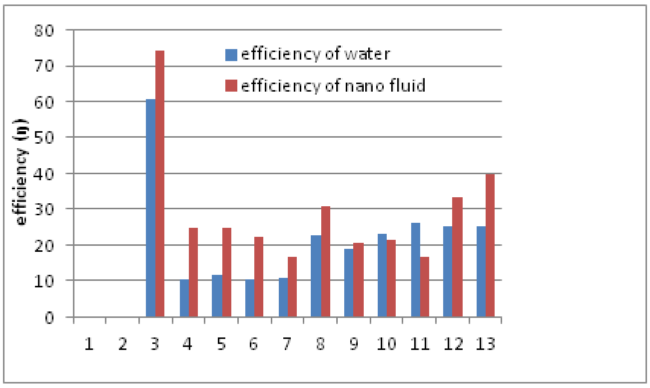

Fig.7.1 . Efficiency of water and nano fluid (Tio2

FUTURE SCOPE:

There is a lots of future investigation that can be carried out which are as followes Parametric analysis can be performed on the fabrication system with a different type of reflecting surface .

1. Other type of nano fluids also can be used, such as aluminium , copper oxide and many other ,
2. Different absorber coating materials can be tested to see their effects on the performance of the system.
3. Different diameter of tube for experimental investigation with various mass flow rates can also be employed.