

# Heat Transfer Analysis of a Radiatively Participating In a Channel Flow

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# Abstract

The main aim of this project is to investigate heat transfer by radiation and convention simultaneously in a channel flowof solar flat plate collector. The effect of radiation on the heat transferis determined. The parameters thickness of plate 5mm, 10mm, the time zones 8.55AM, 1.55PM on a certain day of summer season are considered and compared for the heat transfer.3D models of the flat plate collector are done in Creo 2.0. CFD and thermal analysis is done in Ansys to determine radiation heat transfer, heat flux.

# I. Introduction

Radiation is that the method by that energy is emitted as either particles or waves. Broadly, it will take the shape of sound, heat, or light. However, the majority typically use it to see radiation from electromagnetic waves, ranging from radio waves, tho' the visible radiation spectrum, and up through to gamma waves.

#### **Solar Water Heating**

Solar water heaters use 2 natural phenomena to work: rises hot water since heat is absorbed by dark-coloured objects. Technology has currently made it attainable so that these phenomena is harnesses so that a reliable supply of hot water in our houses is produced.

# **II.** Literature Survey

byDeodatMakhanlall, In the paper PeixueJiang[1],to assess the losses in channel flows with combined convection and radiation heat transfer, the fictional head loss parameter is done during this study. A 3D turbulent channel flow is applied to the analysis and identifies the important locations within the flow domain wherever the losses are focused. The influence of Boltzmann no. is mentioned, and also the best geometry of channel for flows with combined heat transfer modes is additionally determined.In the paper byndzanabenoit [2], investigates heat transfer by convection and radiation simultaneously during a channel flow between 2 infinite black parallel plates. The impact of radiation on the heat transfer and therefore the full thermal development of the flow is studied. The impact of parameter of conduction-radiation, scattering albedo, and therefore the optical thickness are determined. The radiation is shown to well alter the heat transfer downstream before the fully thermally developed conditions. For constant wall temperature the full thermal case. development is shown to be existed, while it's pushed downstream further and will not be seen for the constant wall heat flux case. While the radiation affects greatly the heat transfer once the fluid is heated, for the cooling case radiation impact decreases on the stream wise direction and vanishes at the fully developed conditions.



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# III. 3D Modeling of Solar Flat Plate Collector

http://www.alternative-energytutorials.com/solar-hot-water/flat-platecollector.html

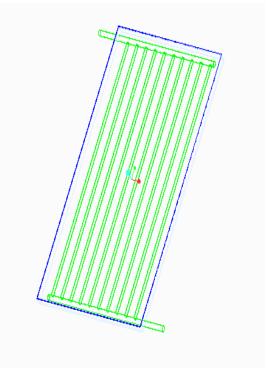


Fig.1. final assembly of the plate, tubes and insulation body

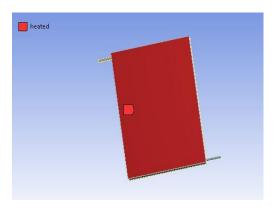
#### **Boundary Conditions**

Taking the radiation plates, which are exposing to the sun radiation and the plates are transferring energy to the pipe which converts cold water to the hot water. In our project, we are taking the radiation in summer season in India, dated APRIL  $25^{\text{th}}$  at 8:55 AM and 1:55PM. Temperature at morning is around 30 to  $33^{\circ}$ c and afternoon is near to  $45^{\circ}$ C, Time zone for Kharimnagar is latitude –  $18^{\circ}$   $48^{\circ}$  and longitude –  $79^{\circ}$   $06^{\circ}$ , For insulation – the material is glass epoxy.

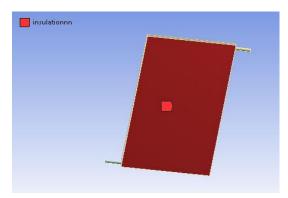
IV. Radiation Analysis of A Channel Flow In A Solar Flat Plate Collector

**Thickness of Plate – 10mm** 

TIME - APRIL 25th, 1:55 PM



#### Fig.2. Heated region



### Fig.3.Insulation

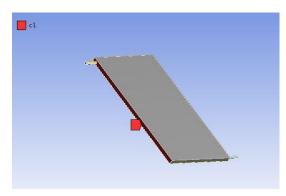
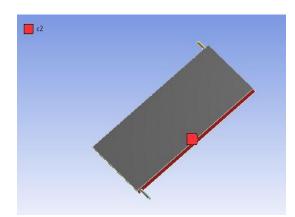


Fig.4. Convection side 1



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# Fig.5. Convection side 2

lodel	Iteration Parameters				
Off     Rosseland	Energy Iterations per Rad	iation Iteration	10		
P1     Discrete Transfer (DTRM)	Maximum Number of Radiation Iterations		5		
Surface to Surface (S2S)     Discrete Ordinates (DO)	Residual Conve	rgence Criteria	0.001		
	View Factors and Clustering				
				2	
	Settings				
	Compute/Write/Read				
	Read Existing File				
	ricos existing hierri				
olar Load					
Model Sur	Direction Vector				
© off x		28147 Z	0.944990	3	
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© Off © Solar Ray Tracing D D Irradiation	0.326975 V 0.008 Use Direction Computed from mination Parameters Direct Solar Irradiation (w/m2) iffuse Solar Irradiation (w/m2)	constant 1423 constant 200	r	•]	
© Off © Solar Ray Tracing D D Irradiation	0.326975 V 0.008 Use Direction Computed from mination Parameters Direct Solar Irradiation (w/m2) iffuse Solar Irradiation (w/m2)	constant 1423 constant	r	•	

# Fig.6. Selection of solar ray tracking and parameter values

obal Posi	ion				Mes	n Orientation		
		Lo	ongitude (deg)	79.06	1.1.1	lorth 0	x	East
			Latitude (deg)	18.48	Y	1	Y	0
		Time	zone (+-GMT)	le e				
				5.5	Z	0	z	0
ate and T	me			5.5		0 r Irradiation M		0
ate and T Day of Ye			Time of Day	5.5	Sola	r Irradiation M Theoretical M	Aethod Aaximum	
	ar				Sola	r Irradiation M Theoretical M Fair Weathe	Aethod Aaximum	

Fig.7. Solar calculator along with time, date and time zone

djacent Cel Zone mobr Momentum Thermal Radiation Species DPM Multiphase UDS Wall Film Thermal Conditions Meat Flux Constant Convection Internal Ensistivity Radiation Made Wall Thickness (n) 0.01	one Name				
mdsr           Momentum         Thermal         Radiation         Species         DPM         Multiphase         UDS         Wal Film           Temperature         00         3201         constant         Image: Constant	heated				
Momentum         Thermal         Radation         Species         DPM         Multiphase         UDS         Wall Film           Thermal Conditions	djacent Cell Zone				
Thermal Conditions         Temperature (k)         320         constant                • Temperature               • Temperature               0.98          constant                 • Radation               • Wash Stem Coupling               Wall Thickness (m)             0.01               0.01            Material Name         Heat Generation Rate (w/m3)               0               constant	msbr				
Heat Flux         Temperature (k)         320         constant           @ Temperature         0.38         constant         -           Convector         Internal Emissivity         0.98         constant         -           @ Radiation         Material Name         Wall Thickness (m)         0.01         -	Momentum Thermal Radiation	n Species DPM Multiphase	JDS   Wall Film		
Material Name         Internal Emissivity         0.98         constant           Water         Material Name         Wall Thickness (m)         0.01	Thermal Conditions				
Oronection         Internal Emissivity         0.98         constant           Madelton         Wall Thickness (m)         0.01           Wash         Heat Generation Rate (w/m3)         0         constant		Temperature (k)	320	constant	
Readation         Wall Thickness (m)         0.01           Wasystem Coupling         Heat Generation Rate (w/m3)         0         constant		Internal Emissivity	0.98	constant	
O via System Coupling           Heat Generation Rate (w/m3)           0           Constant	Radiation		CORD.015	Landstein Contraction	
Heat Generation Rate (w/m3) 0 constant			Wall	Thickness (m) 0.01	
		Heat Generation Rate (w/m3)	0	constant	
gas-epoxy Edit		] [=24]		Control Contro	Canadiant
	giass-epoxy •	L'uu		i sie	Conductor

## Fig.8. Temperature acted on solar plate

Cone Name					
insu					
Adjacent Cell Zone					
msbr					
Momentum Thermal Radiati	on Species D	PM   Multiphase   U	DS Wall Film		
Thermal Conditions					
O Heat Flux	Heat Tra	nsfer Coefficient (w/m	2-k) 5	constant	•
Convection	Fre	e Stream Temperature	e (k) 305	constant	•
<ul> <li>Mixed</li> <li>via System Coupling</li> </ul>		External Emiss	ivity 1	constant	•
Material Name	External	Radiation Temperature	≥ (k) 305	constant	-
glass-epoxy	▼ Edit	Internal Emiss	ivity 1	constant	
			Wall	Thickness (m) 0.01	
	Hea	t Generation Rate (w)	(m3) 0	constant	-
				C She	ell Conduction

#### Fig.9. Insulation conditions

Adjacent Cell Zone					
Momentum Thermal Radiation Species DFM Multiphase LDS Wal Film Thermal Conditions Heat Flux Temperature Convection Radiation Moded Wis System Coupling With System Coupling Wal Thidness (m) [n n1	jacent Cell Zone				
Thermal Conditions           Heat Flux         Heat Transfer Coefficient (w/m24)         50         constant           Temperature         Go Convection         313         constant           Madaton         Internal Emissivity         1         constant           Wided         Via System Coupling         Wall Thickness (m) (n n1	msbr				
Heat Transfer Coefficient (w/m24)         50         Constant           Temperature         So         Constant           Convection         Redation         31.51         Constant           Meed         Meed         Internal Emissivity         1         Constant           Wead         Via System Coupling         Wall Thidones (m) (n n1         Via Thidones (m) (n n1	Nomentum Thermal Rad	diation Species DPM Multiphase	UDS Wall Film		
Teoperature     Convector     Readation     Meed     Vas System Coupling     Washing Convection     Washing C	hermal Conditions				
Origination     Originatio     Originatio     Originatio     Originatio     Originatio		Heat Transfer Coefficient (w/r	n2-k) 50	constant	
Mixed Internal Emissivity 1 constant via System Coupling Wall Thickness (m) 1 n1	Convection	Free Stream Temperatur	re (k) 313	constant	
Wall Thickness (m) 0.01	Mixed	Internal Emis		<b>L</b>	
	Naterial Name		Wall 1	hickness (m) 0.01	
glass-epoxy   Edit Heat Generation Rate (w/m3)  constant		Edit Heat Generation Rate (w	r/m3) 0	constant	
Shell Condu				C She	I Conduction

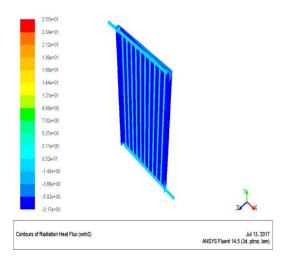
Fig.10. Convection conditions



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#### Results





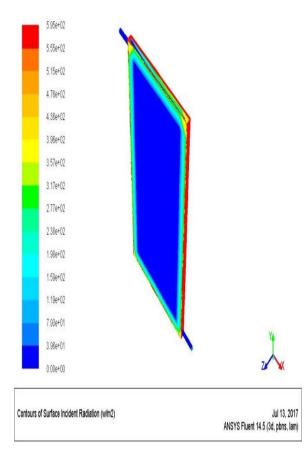


Fig.12. Contours of surface incident radiation

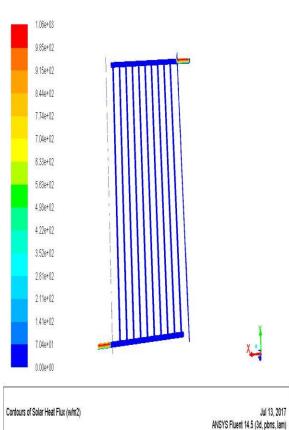


Fig.13.	Contours	of solar	heat flux	

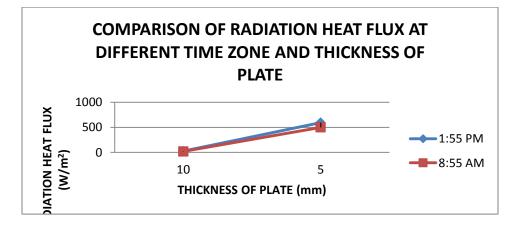
Radiation (w)	Heat	Transfer	Rate
cl	-0.0	060082576	
c2	-0.0	045782756	
heat	ed 0.	00040227032	
in	su	-0.1174429	
wall	_msbr	0.00027169	9354
N	et -(	0.12735547	



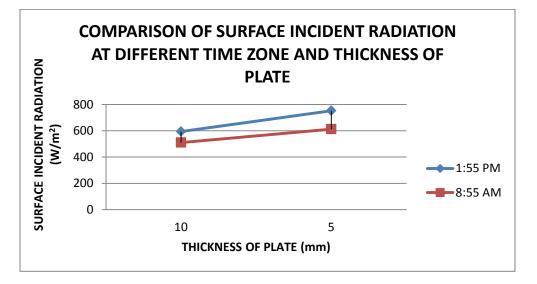
#### V. RESULT TABLE

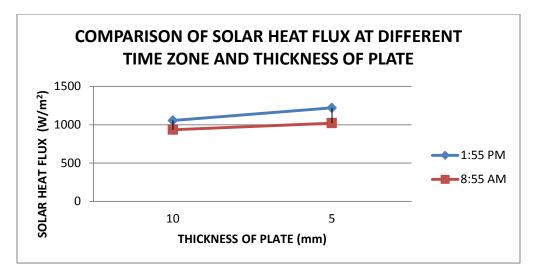
	10mm thicl	ness of plate	5mm thick	ness of plate
	1:55 PM	8:55 AM	1:55 PM	8:55 AM
Radiation residuals	2436	2021.02	2560	2131.2
Temperature (k)	324.72	312.725	321.7	306.956
Total surface heat flux (w/m <sup>2</sup> )	-154.361	-138.9	573	208.76
Radiation heat flux (w/m <sup>2</sup> )	25.67	19.526	594	499
Surface incident radiation (w/m <sup>2</sup> )	594.5	510.22	752.6	612.3
Solar heat flux (w/m <sup>2</sup> )	1055.586	935.025	1220	1020.67
Wall func .heat. trans. coeff. (w/m <sup>2</sup> k)	1906.69	1723.69	2813.23	2811.17
Total heat transfer rate (w)	-1.819	-1.04289	-2.3571565	-1.2996124
Radiation heat transfer rate (w)	-0.1273	-0.0651	0.71089156	0.59747258

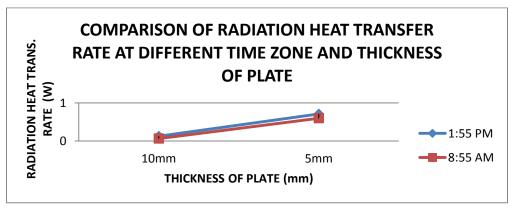
Graphs











### THERMAL ANALYSIS

**THICKNESS OF PLATE – 10mm** 



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#### TIME - 1:55 PM

# All the values are taken from the above CFD calculations.

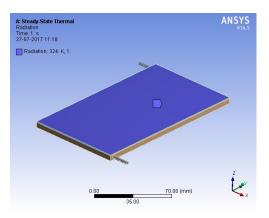
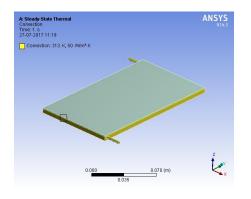


Fig.14. Radiation





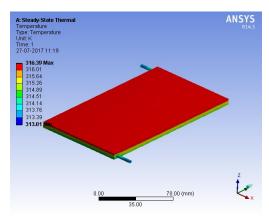


Fig.16. Temperature Distribution on 10mm thickness plate at 1.55PM using Aluminum as pipe material

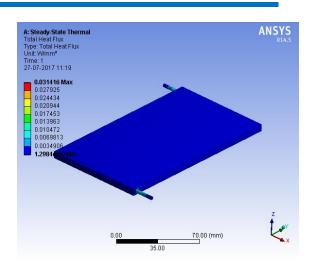
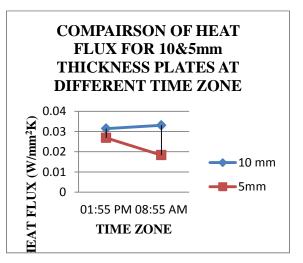


Fig.17. Heat flux on 10mm thickness plate at 1.55PM using Aluminum as pipe material

#### **RESULTS TABLE**

	10mm th	ickness	5mm th	ickness
	1:55	8:55	1:55	8:55
	PM	AM	PM	AM
Tempera ture (K)	316.39	303.61	316.57	302.46
Heat flux	0.03141	0.0330	0.0268	0.0182
(W/mm <sup>2</sup> )	6	44	55	84





#### VI. Conclusion

By observing CFD analysis results, Radiation heat flux is more for 5mm thickness plate at time zone of 1.55PM. The atmosphere temperature is increases then radiation is also increases. With respect to this the rate of heat transfer from the body is increases and transfers the heat to all bodies. Solar heat flux is also more for 5mm thickness plate at time zone of 1.55PM. Incident solar radiation is the amount of solar radiation energy received on a given surface during a given time and the value is more for 5mm thickness plate at time zone of 1.55PM. As well radiation Heat transfer rate is also more for 5mm thickness plate at time zone of 1.55PM.By observing thermal analysis results, the heat flux is more for 10mm thickness plate at time zone of 1.55PM.

# References

- 1. By DeodatMakhanlall, Peixue Jiang, Thermodynamic Head Loss in a Channel with Combined Radiation and Convection Heat Transfer.
- 2. Effect on heat transfer and thermalDevelopment of a radiatively participatingFluid in a channel flow byndzanabenoit.
- 3. ByLee, H.; Chikh, S.; Ma, Y, Full thermal development of radiatively participating media in Poiseuille flow.
- 4. Bym. Hassaba A. m. Khamismansourb,\* and m. Shawkyismaila, Effect of axial wall conduction on heat transfer parameters for parallel-plate channel radiation having participating medium and step change in boundary conditions.

- 5. By Obaid UllahMehmood1, a Note on Radiative Heat Transfer to Peristaltic Flow of Sisko Fluid.
- By A. DehghaniRayeni,Analysis of Combined Radiation and ForcedConvection Heat Transfer in 3D LaminarFlow over an Inclined Forward Facing Step.
- 7. By H. Bouali, combined radiative and convective heat transfer in a divided channel.
- 8. By MeysamAtashafrooz, combined heat transfer of radiation and forced convection flow of participating gases in a three-dimensional recess.
- 9. Effect of Radiation Heat Transfer on Naturally Driven Flow through Parallel-Plate Vertical Channel byN. A. A. Qasem.
- 10. Unsteady coupling of Navier-Stokes and Radiative Heat Transfer solvers applied to an isothermal multicomponent turbulent channel flow by Jorge AMAYA.