Effect of Continuous U - Shaped Groove on Solar Absorber Plate for Enhancement in Heat Transfer by using Finite Volume Method

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Abstract

When warmness switch turned into carried with smooth and rough ribs with one-of-a-kind grooves absorber plates it changed into observed that; The most increment within the cost of Nusselt number has been found at Continuous U Shaped wavy grooves absorber plate; but the lowest determined value of friction component similar to Continuous U Shaped wavy grooves absorber plate. Providing the Continuous U Shaped wavy grooves, V formed, U fashioned and Transverse fashioned grooves effects in widespread enhancement in Nusselt range. Average enhancement in Nusselt variety for Continuous U Shaped wavy grooves absorber plate is observed to be 36.84% higher over clean absorber plate while friction component of grooves gets decreased with the aid of 37% of the cost as observed in Continuous U Shaped wavy grooves absorber plate.

Thus with the aid of developing grooves the cloth is eliminating for plate for unique design, low-cost fee is decreased and higher heat transfer is done, Hence on behalf of presenting artificial roughness grooves must be used for optimization of sun absorber plate.

Keywords— *Computational Fluid Dynamics, V shaped, U shaped Transverse shaped grooves, artificial roughness, Nusselt No., Friction factor*

1. INTRODUCTION

Due to depletion of fossil fuels and the fuels like coal, crude oil which produces petrol, LPG, coal tar and many others. For energy era like electrical power ,mechanical power and in aerospace applications ideally harms the environment and ozone layer of our earth because of this dangerous impact takes area in our surroundings and causes the impact of green residence ,major troubles like for air flow in industries ,places of work ,houses basically an aircon system is preferred and different criteria if we see in refrigeration gadget cloroflouro carbon is used this substance is also used in aeroplanes and satellites launching structures this substance performs an essential role in these such packages as a primary part of gasoline combustion to keep away from those consequences a Solar power performs an important function now a day's Solar panel operated aeroplanes have been manufactured to preserve our fossil fuels and to shield our environment from harmful gasoline combustion fume in ventilation and air drying technique Solar duct performs an important role the assembled view of solar duct is shown in fig 1.1 Solar duct made of different substances basically if we see the aluminium made Solar duct it has successive heat switch fee beneath running conditions at some stage in air glide it plays essential function in drying air and in heating and dehumidification of air by using Solar power as a source basically it's far assembled with duct carry out its movement in the direction of drying air in Solar duct plate to gain higher heat transfer charge a roughness parameter had been taken into consideration to increase warmness switch and to decrease friction element for better convection at some point of working circumstance roughness performs critical function in solar duct the roughness form also indicates impact of warmth switch charge for the duration of go with the flow of fluid as a air the thermal conductivity of an Solar duct plate is to be excessive so that it can burn up a heat to the fluid go with the flow medium as quickly as possible a few substances were elaborated are as follows:-

- Galvanized steel
- Aluminium
- Polyurethane and phenolic protection boards
- Fibreglass duct board
- Adaptable ducting
- Texture Duct
- Waterproofing.

2. PERFORMANCE EQUATIONS FOR A SOLAR COLLECTOR

The overall performance of solar collector is described with the aid of an energy stability that indicate the distribution of incident solar energy into useful electricity advantage (Qu) and heat losses like bottom (Qb) and pinnacle (Qt) as shown in Fig.1.2. The information of the performance analysis of a solar collector are mentioned by using Duffie and Beckman [31] and Goswami [41].The heat switch in a Solar collector takes area by way of simultaneous radiation, convection and conduction. The warmth transfer from the pinnacle takes vicinity with the aid of convection and radiation even as from the side and bottom is through conduction. The net fee of beneficial strength gathered in keeping with unit area is the distinction of the amount of solar electricity absorbed and the energy loss with the aid of the collector to the environment.

3. LITERATURE REVIEW

Sompol Skullong et al. [1] - The research suggests that the TW collectively with the groove gives the considerable growth in heat transfer over the smooth channel. The TW on my own gives a high-quality deal higher warmth transfer but the groove yields substantially decrease stress drop. The blended groove and TW gadgets at a given BR, carry out the highest warmth transfer and friction factor at smaller PR and additionally offers substantially better thermal overall performance than the single tool acting on my own. At PR = 1, the compound tool with BR = zero.28 gives the best warmth switch and friction factor on the identical time as the only with BR = 0.24 offers the most thermal overall overall performance.

Anil Kumar et al. [2]–Stated artificial roughness in the form of repeated ribs is one of the effective way of improving the general overall performance of a Solar air heater ducts. It has been achieved to determine the impact of numerous synthetic roughness geometries on warmness switch and friction traits in sun air heater ducts. The objective of that study is to test severa studies, in which remarkable artificial roughness factors are used to enhance the warmth transfer co-green with little penalty of friction issue. On the premise of correlations advanced with the aid of way of numerous investigators for warmth switch coefficient and friction factor, an attempt has been made to evaluate the thermo-hydraulic overall performance of roughened solar air heater ducts. It has been found that lot of experimental and analytical research pronounced in that paper.

Kumar and Saini [3] completed CFD based evaluation to fluid glide and warmth transfer characteristics of a solar air heaters having roughened duct provided with synthetic roughness in arc shaped geometry. The heat transfer and glide assessment of the chosen roughness detail were completed using three-D models. Authors stated that Nusselt variety has been determined to growth with growth in Reynolds range in which friction factor decreases with increase in Reynolds range for all combos of relative roughness peak (e/D) and relative arc attitude (á/90).

Karmare and Tikekar [4] completed a CFD simulation of fluid waft and warmth transfer in a solar air heater duct with steel grit ribs as roughness elements hired on one massive wall of a sun air heater. The round, triangular and rectangular shape rib grits with the angle of attack of 54°, fifty six°, fifty eight°, 60° and sixty two° have been tested for the same Reynolds variety. Authors pronounced that the CFD outcomes deliver the exceptional agreements with experimental results. Hence, CFD techniques can be used for reading and optimizing complicated sort of roughness floor. Soi et al. Offered a CFD primarily based research of warmth switch and friction developments of artificially roughened duct of a Solar air heater. K-fashioned (mixture of transverse and V-up) roughness geometry come to be used as an synthetic roughness. Authors determined, for a given shape of artificial roughness, Nusselt variety will increase with an boom in Reynolds range for clean further to roughened plate. Sharma et al. Designed a Solar air heater duct that allows you to perform CFD primarily based completely research. CFD based usual performance evaluation of sun air heater duct provided with artificial roughness within the shape of square kind protrusion form geometry changed into pronounced. 2-D computational location and grid have been determined on. Non-uniform meshing changed into generated over the duct.

Sharma and Thakur [5] achieved a CFD take a look at to research the warmth switch and friction loss traits in a sun air heater having attachments of V-formed ribs roughness at 60° relative to waft route pointing downstream on underside of the absorber plate. Authors determined,Nusselt huge variety will boom with growth in Reynolds amount in which friction component decreases with growth in Reynolds variety for all combinations of relative roughness peak (e/D) and relative roughness pitch. In the prevailing paintings a computational research of turbulent forced convection in a -dimensional duct of a Solar air heater having rectangular rib roughness on the absorber plate is achieved. The better wall is subjected to a uniform warm temperature flux situation while the decrease wall and different side walls, except inlet and outlet are insulated.

Sachin Chaudhary et al. [6] having more problem with enhancement of warmth switch coefficient the usage of synthetic roughened absorber plate on Solar air heater. The increment in warmth transfer moreover results in increase in friction detail which results in increase in pumping strength. In this have a study M form geometry has been studied this is having specific orientation. The effect of roughness parameters relative roughness peak (e/D), relative roughness (P/e) and

attitude of assault (á) on Nusselt variety and friction component had been visible. The form of Reynolds range 3000-22000, e/D, P/e and á are 0.037-0.0776, 12.Five-seventy five and 30-60° respectively. It has been positioned out that supplying the artificial roughness of M shape will increase warmth switch upto 1.7-1.Eight instances over the clean duct

Sourabh Khurana et al. [7] took synthetic roughness on the heat switch ground within the form of projections that created turbulence near the wall or breaks the laminar sub-layer and consequently enhances the warmth switch coefficient. In the present paintings the general overall performance of a solar air heater duct with synthetic roughness within the shape of skinny circular cord in discrete angled rib geometries has been analyzed the use of Computational Fluid Dynamics (CFD). The effect of this geometry on warmth switch and friction factor and ordinary performance enhancement modified into investigated defensive the style of roughness parameters, P/e=eight, e/D=0.043, d/W=zero.25, g/e=1.0, á=60° and running parameters (Reynolds number, Re from 2,000 to 20,000). Different turbulent fashions had been used for the evaluation warmness transfer and friction thing and their effects are compared with DittusBoelter Empirical relationship for easy ground. Renormalization k-epsilon model primarily based outcomes have been located in applicable settlement and for this reason this version is used to expect warmness switch and friction difficulty in the duct.

Singh et al. [8] completed a 3-dimensional CFD (computational fluid dynamics) research to take a look at the warm temperature transfer and friction tendencies of sun air heater duct roughened with periodic transverse rib. The good enough-ε turbulence model became selected for analysis. The non-uniform skip-phase noticed enamel rib turned into located to bring about higher Nusselt variety than uniform move-segment ribs for Reynolds quantity above 7000 due to decreased low warmness transfer place downstream of the rib due to disruption in re-circulations. The most enhancement in Nusselt wide variety for duct roughened with noticed-teeth rib and trapezoidal rib turned into 1.78 and 1.50 respectively. Amraoui and Aliane carried out a CFD assessment to simulate the solar collector for higher facts of its heat switch capability. Using a 3-D model of the collector regarding air inlet, the collector is modelled via ANSYS Workbench and the grid emerge as created in ANSYS ICEM. The results were received by way of the use of the usage of ANSYS FLUENT. The outlet temperature of air modified into compared with experimental results and there was an amazing agreement among them.

Sandeep M Joshi et al. [9] investigated a Mathematical modeling has end up an traditional tool for predicting the general performance, and optimization of thermal strategies. Solving the mathematical models representing solar air heating method and structures is one of the most tedious and repetitive issues. Mathematical modeling of conventional Solar air heater with single glass cowl is supplied. Calculations for a collector of aperture location 2m2 have been completed for Chennai. It has been determined that at solar insolation of 734 W/m2, common temperature of outlet air is 328.352 K (fifty 5.32˚C) i.E. Upward push in temperature of air through the collector is eight˚C for air float fee of 440 kg/h, Instantaneous performance of collector is discovered as fifty one.Eight % and the pressure drop is 36.982 Pa. Results are cautiously matching with such experimental consequences. Finite Difference Method additionally can be used to remedy warm temperature switch equations for traditional solar air warmers.

Yadav and Bhagoria [10] performed a numerical investigation on a rectangular duct of a Solar air heater having triangular rib roughness on the absorber plate. A business finite amount package ANSYS FLUENT 12.1 changed into used as a solver. Solar air heater with triangular rib roughness furnished 1.Four to 2.7 instances enhancement in Nusselt quantity as compared to smooth duct. Good agreement turned into observed with experimental outcomes..

4. MODELING AND ANALYSIS

Design procedure of Flywheel

The procedure for solving the problem is

- Modeling of the geometry.
- Meshing of the domain.
- Defining the input parameters.
- Simulation of domain.

Finite volume analysis of Absorber plate

Analysis Type - Fluent

Preprocessing

Preprocessing include CAD model, meshing and defining boundary conditions.

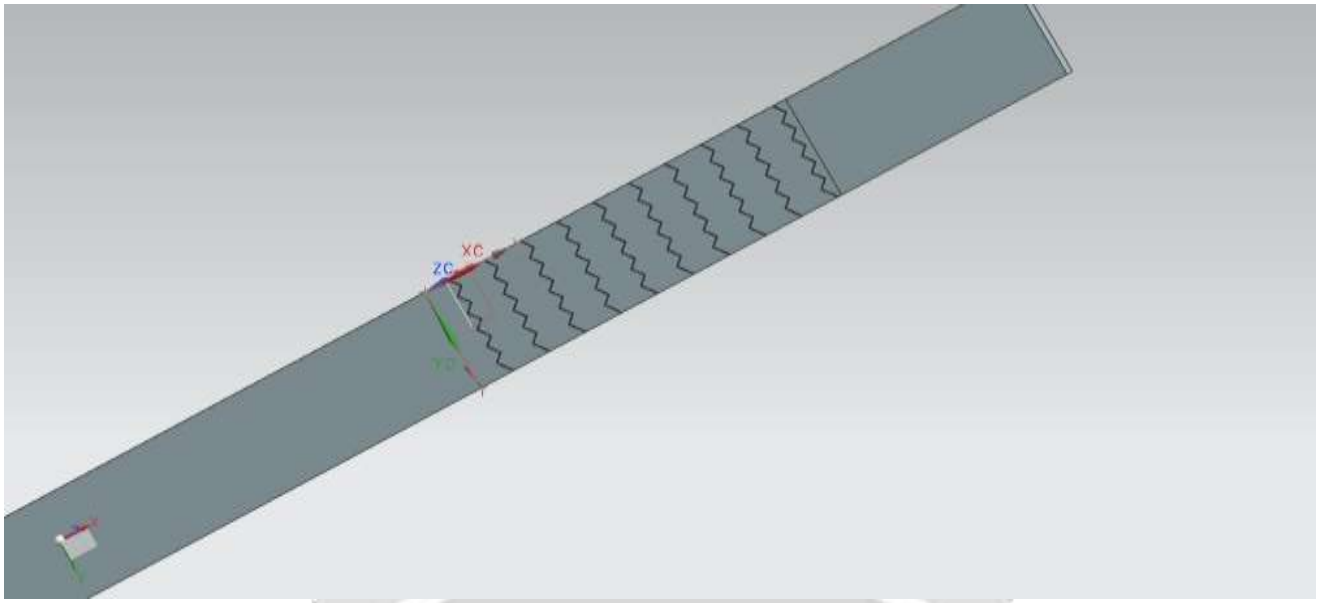

***Figure**: 5.1 Rectangular winglet absorber plate*

5. RESULT AND DISCUSSION

The effects of V, U and Transverse Shaped with Reynolds number (Re) on the heat transfer and friction characteristics for flow of air in a roughened rectangular duct are presented below. The results have been compared with experimental value of same parameter and also compare with smooth ducts operating under similar operating conditions to discuss the enhancement in heat transfer and friction factor on account of artificial roughness..

6.1 Heat transfer characteristics

Table 6.1 Nusselt No. of absorber plate

Reynolds no.	(Smooth Plate)	(Rectangular Winglet roughened plate)
4500	18.6	90.2
8000	27.2	140.3
12000	36.8	200.5
18000	50.5	270.3
22000	60.4	310.2

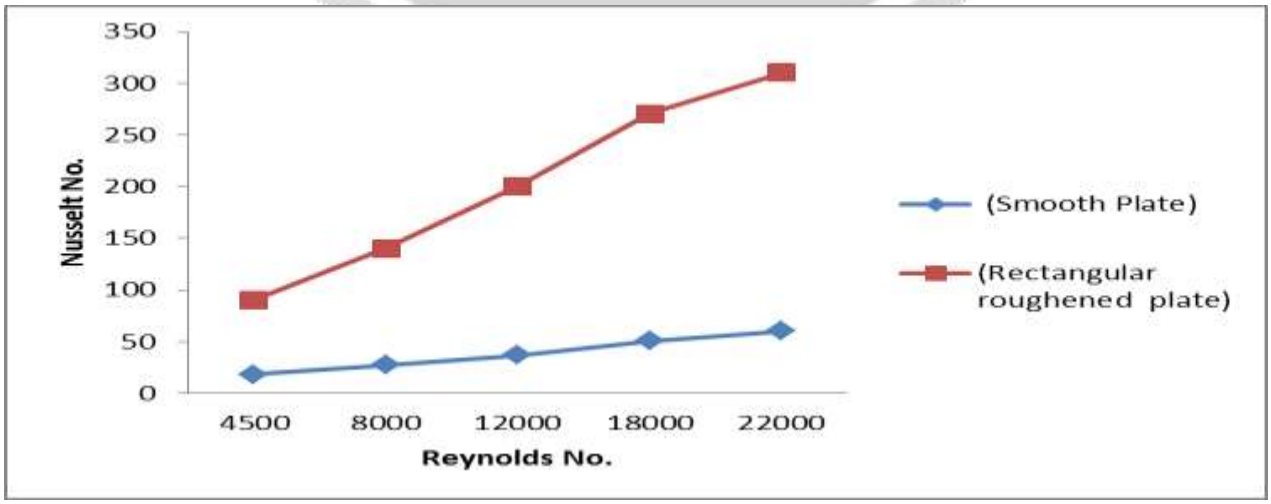

Figure: 6.1 Nusselt No. of absorber plate

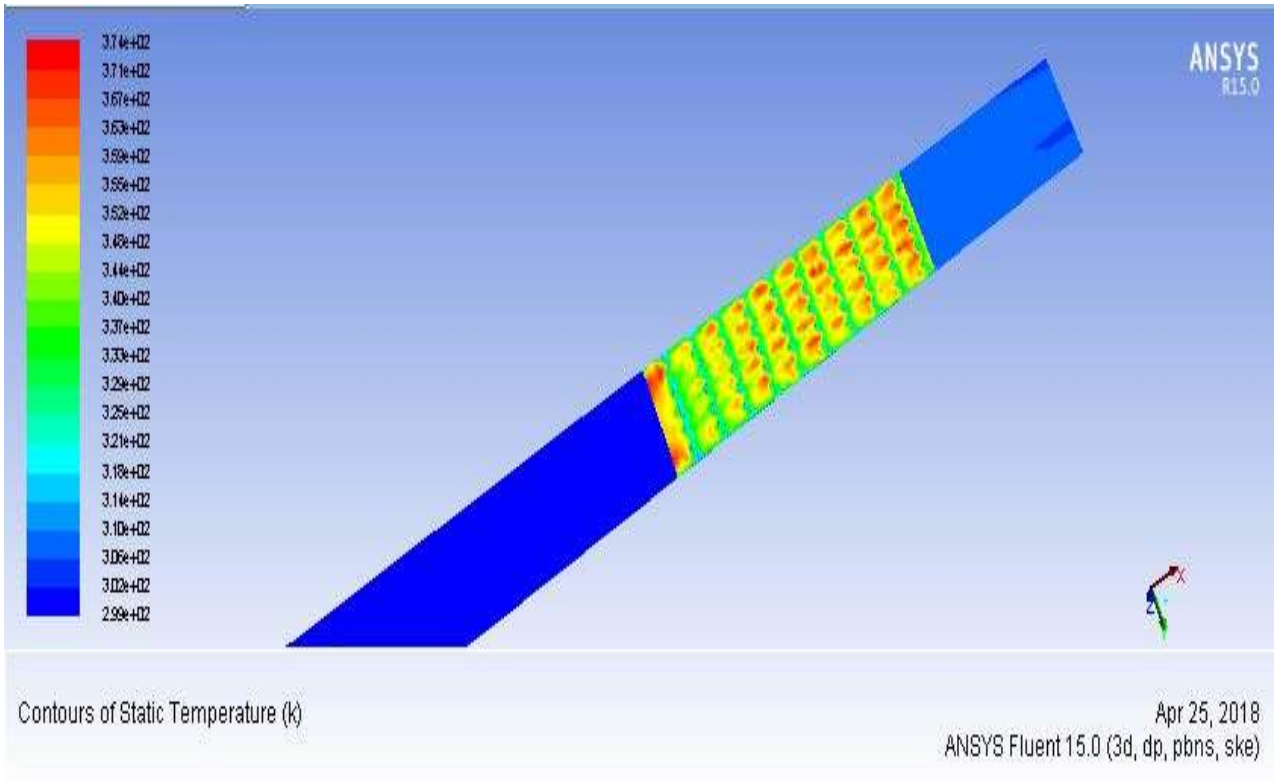

Figure 6.2 Temperature distribution in Rectangular winglet absorber plate with 12000 Reynolds number

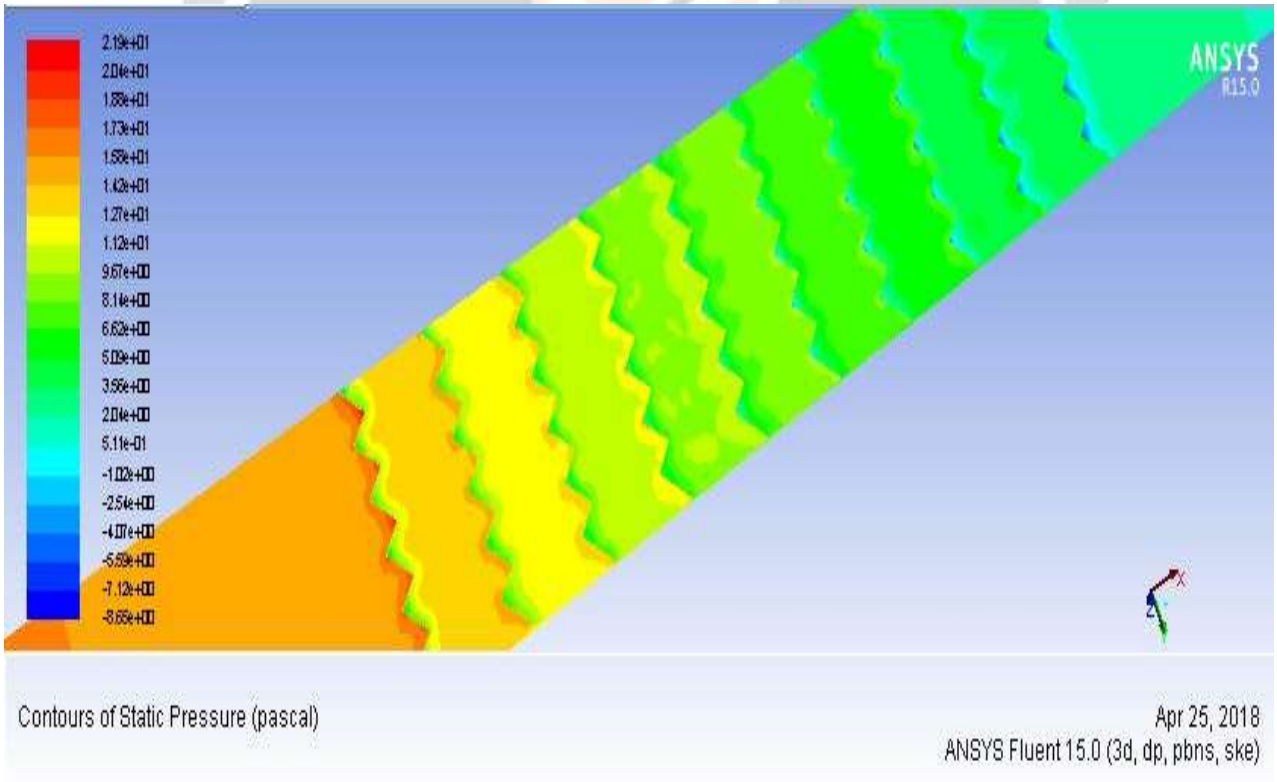

Figure: 6.3 Pressure distribution in Rectangular winglet absorber plate with 12000 Reynolds number

Table6.3 Result of Friction Factor for the Solar Duct

Reynolds No.	Smooth plate	Rectangular Winglet Shaped roughened plate
4500	0.04	0.038
8000	0.035	0.031
12000	0.03	0.028
18000	0.027	0.0247
22000	0.024	0.0225

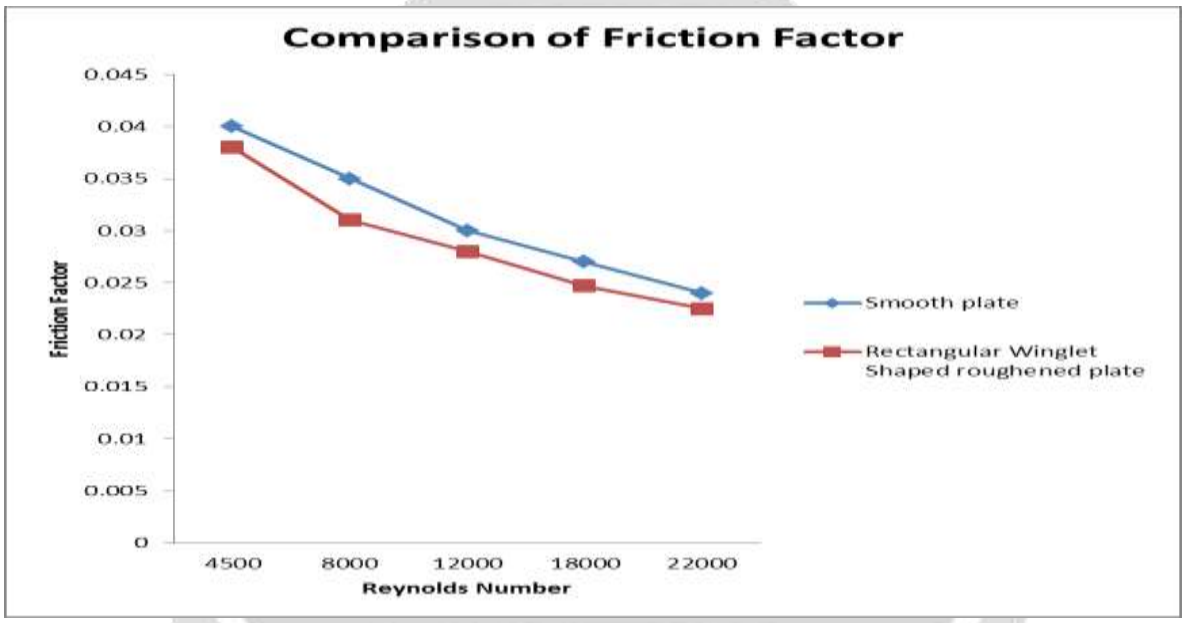

Figure 6.4 Result of Friction factor for the Rectangular winglet absorber plate

6. CONCLUSION

(1) Continuous U Shaped wavy grooves absorber plate has been found to result in higher heat transfer as compared to other absorber plate with same open area ratio.

(2) Maximum enhancement in Nusselt number is found to Continuous U Shaped wavy grooves absorber plate.

(3). We found that the optimum value of friction factor of rectangular winglet and Continuous U Shaped wavy Grooves Absorber Plate in compare to other absorber plate.

(4) The maximum increment in the value of Nusselt number has been observed at Continuous U Shaped wavy grooves absorber plate; however the lowest observed value of friction factor corresponding to Continuous U Shaped wavy grooves absorber plate.

(5) Providing the Continuous U Shaped wavy grooves, V shaped, U shaped and Transverse shaped grooves results in considerable enhancement in Nusselt number. Average enhancement in Nusselt number for Continuous U Shaped wavy grooves absorber plate is found to be 36.84% higher over smooth absorber plate while friction factor of perforated blockages gets decreased by 37% of the value as found in Continuous U Shaped wavy grooves absorber plate.

(6) In comparison to smooth duct, the presence of Continuous U Shaped wavy grooves blockages with Nusselt number up to 6.6 times while friction factor rises up to 26.66 times.

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