THERMAL ANALYSIS OF A FLAT PLATE WITH DIFFERENT MATERIALS UNDER FORCED CONVECTION

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Abstract –

Forced convective heat transfer from narrow vertical plates which have a uniform surface heat flux has studied. With a narrow plate the heat transfer rate is dependent on the flow near the vertical edges of the plate. The magnitude of the edge effects will depend on the conditions existing near the edges of the plate. In this thesis, the effect of the edge condition of a flat plate on the heat transfer rate has been analytically investigated under forced convection. Thermal analysis and CFD analysis is done on the plates with two different edge conditions circular and slant to determine the heat transfer rate by considering laminar flow and forced convection. Thermal analysis and CFD analysis is done in Ansys. Three materials Cast Iron, Copper and E – Glass Epoxy are considered for analysis.

1. INTRODUCTION

Convection is the instrument of warmth exchange through a liquid in the vicinity of mass smooth movement. Convection is delegated normal (or free) and constrained convection relying upon how the smooth movement is started. In common convection, any smooth movement is brought on by regular means, for example, the lightness impact, i.e. the ascent of hotter liquid and fall the cooler liquid. Though in constrained convection, the liquid is compelled to stream over a surface or in a tube by outer means, for example, a pump or fan. The general definition for convection may be compressed to this definition "vitality exchange between the surface and liquid because of temperature distinction" and this vitality exchange by either constrained (outer, inner stream) or regular convection. Warmth exchange by constrained convection for the most part makes utilization of a fan, blower, or pump to give high speed liquid (gas or fluid). The high-speed liquid results in a diminished warm resistance over the limit layer from the liquid to the warmed surface. This, thusly, builds the measure of warmth that is diverted by the liquid. Warmth and Mass Transfer by convection concentrates on warmth and mass streams at dividers; so that, after the fair instance of the constrained stream over a level plate displayed aside, and the impacts of bended limit layers around bodies considered above, we bargain now with warmth and mass convection at inside dividers of channels and tubes because of a forced liquid stream along them.

2. LITERATURE SURVEY

In the paper by Patrick H. Oosthuizen, etal, trademark convective warmth trade from thin vertical plates which have a uniform surface warmth flux has focused on. With a dainty plate the glow swapping scale is dependent on the stream near the vertical edges of the plate. The edge's degree effects will depend on upon the conditions existing near the plate's edges. Three circumstances have here been seen as these being a warmed plate imbedded in an immense plane adiabatic surface, the surfaces of the warmed plane and the adiabatic surface being in the same plane, a warmed plate with plane adiabatic surfaces above and underneath the warmed plate, and a warmed plate that is associated with a sweeping parallel plane adiabatic surface however extends from the adiabatic plane surface. The edge's effect condition on the glow conversion scale has here been numerically inquired about.

In the paper by Rajesh Khatri, etal, speculative estimations of cutoff layer thickness and warmth trade coefficient is reviewed using Computational Fluid Dynamics (CFD) for laminar wind current. The achievability and precision of using CFD to figure convective warmth trade coefficients is reviewed. A system affectability examination is performed for the CFD game plans, and it is used to center the convective warmth trade coefficients. The coefficients are endorsed using investigative game plan. In addition the adjacent Nusselt number are obtained, which can be used as a piece of estimation of stream and warmth trade execution over a level plate. The results let us realize that for the laminar obliged convection diversions the convective warmth trade coefficients shifted from logical qualities by 5%. The result also tells us that the point of confinement layer thickness for laminar stream reduces with detachment from the fundamental edge of the level plate and augmentations with Reynolds number. The effect of Reynolds number, Prandtl number on stream is moreover analyzed. These estimations can quickly give us the completion of conditions between the variables of side interest.

In the paper by S.E. Mahgoub, Non-Darcian obliged convection warmth trade over an even level plate in a penetrable medium of roundabout particles has been focused likely. With air as the working fluid, the effects of atom estimation and particles materials of particular warm conductivities were dissected. The glow trade estimations were gained by warming the test plate under the condition of steady warmth flux. The investigations have been made for Reynolds numbers stretching out from 105 to 106 in perspective of the test plate length. The porous media used as an examinations' piece were made of glass, shake, and steel covering a broad mixed bag of solid warm conductivity. Particles separations crosswise over of 2.7 mm, 4.2 mm, 5.6 mm, 8.1 mm, and 11 mm for rock material and 11 mm atom broadness for glass and steel materials were used. It was found that higher warmth trade coefficients were gained with greater particle size and higher atom warm conductivity.

In the paper by Matti Lindstedt, etal, Simple illustrative responses for the immovable state total warmth conversion standard are shown for a flat plate cooledon one surface by compelled or normal convection while the other side stays at uniform temperature.These courses of action are also used to center the dark interface temperature of the surface. The solu-tions rely on upon one-dimensional conduction in the plate and on the glow trade coefficients of anisothermal surface. The results are differentiated and those in the composition joined with a brief circle sionof the most applicable studies in the field. In like manner, presented are moreover numerically registered results that consider two-dimensional conduction in the plate and the effect of non-uniform surface temperature on convection. The estimations exhibit that the results are true blue similarly for thick plates. The solu-tion method showed greatly exact and made new essential results for outlining applications.

3. OVERVIEW OF THERMAL ANALYSIS

A thermal analysis calculates the temperature distribution and related thermal quantities in a system or component. Typical thermal quantities of interest are:

- The temperature distributions
- The amount of heat lost or gained
- Thermal gradients
- Thermal fluxes.

Thermal reproductions assume a vital part in the outline of numerous designing applications, including inward burning motors, turbines, heat exchangers, channeling frameworks, and electronic segments. Much of the time, architects take after a warm investigation with an anxiety examination to figure warm burdens (that is, anxieties brought about by warm extensions or constrictions).

Types of Thermal Analysis

ANSYS underpins two sorts of warm investigation:

1. A consistent state warm investigation decides the temperature appropriation and other warm amounts under enduring state stacking conditions. An enduring state stacking condition is a circumstance where heat stockpiling impacts differing over a timeframe can be overlooked.
2. A transient warm examination decides the temperature dispersion and other warm amounts under conditions that fluctuate over a timeframe.

4. RESULTS TABLES

FINAL RESULTS TABLE

A. THERMAL ANALYSIS

CIRCULAR EDGE

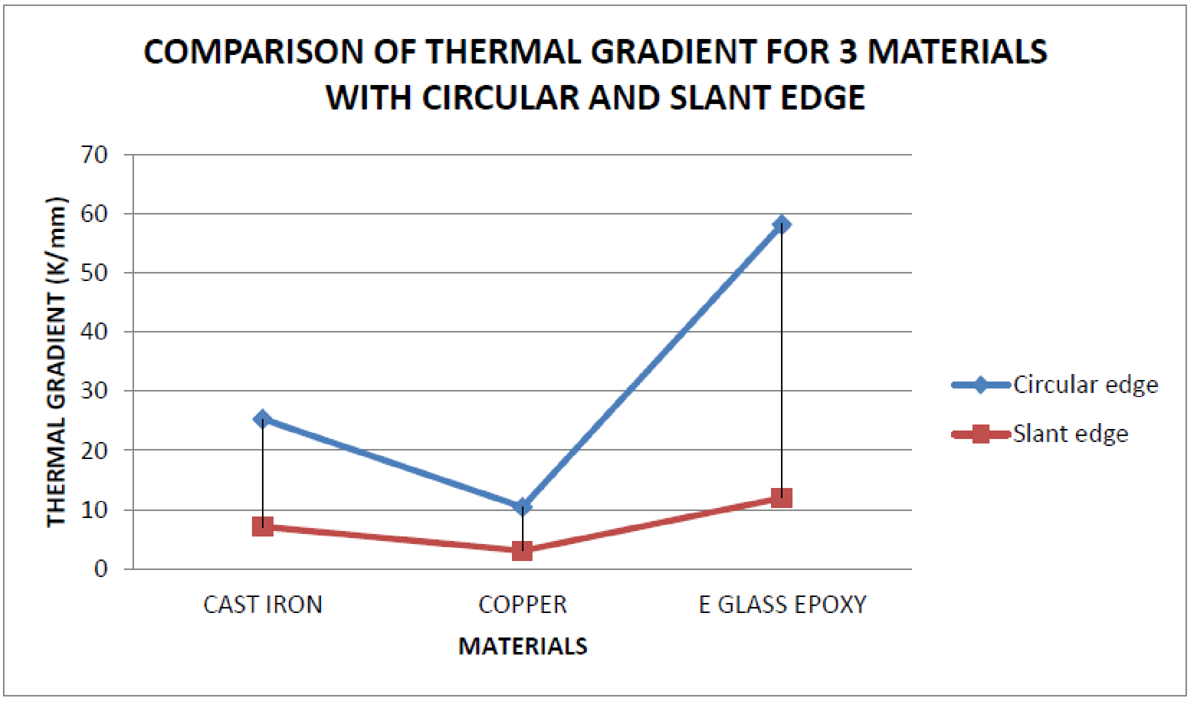
	NODAL TEMPERATURE (K)	THERMAL GRADIENT (K/mm)	HEAT FLUX (W/mm^2)
CAST IRON	350	25.2694	1167.45
COPPER	350	10.4275	4014.59
E GLASS EPOXY	350	58.1893	75.6461

Table:4.1 Result Table of Thermal Analysis of circular edge.

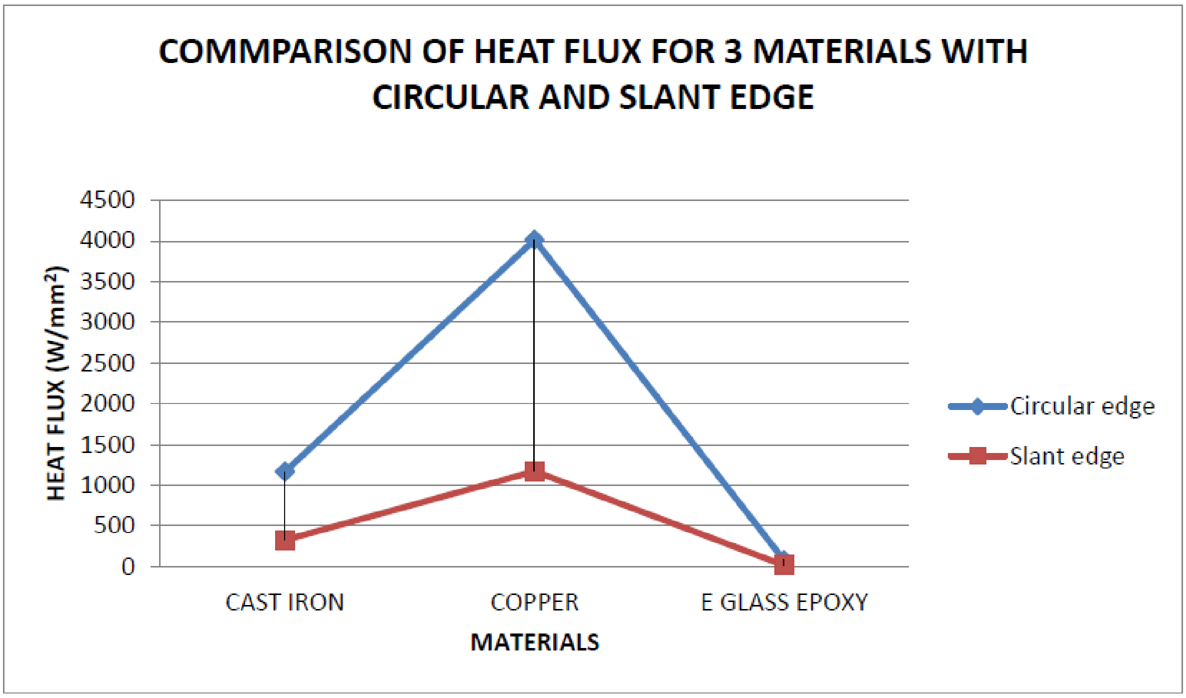
SLANT EDGE

MATERIAL	NODAL TEMPERATURE (K)	THERMAL GRDIENT (K/mm)	HEAT FLUX (W/mm²)
CAST IRON	350	7.0831	327.239
COPPER	350	3.04172	1171.06
E GLASS EPOXY	350	11.9726	15.5643

Table:4.2 Result Table of Thermal Analysis of Slant edge.



Graph: 4.1 Comparison of thermal gradient for 3 materials with circular and slant edge.



Graph: 4.2 Comparison of Heat flux for 3 materials with circular and slant edge.

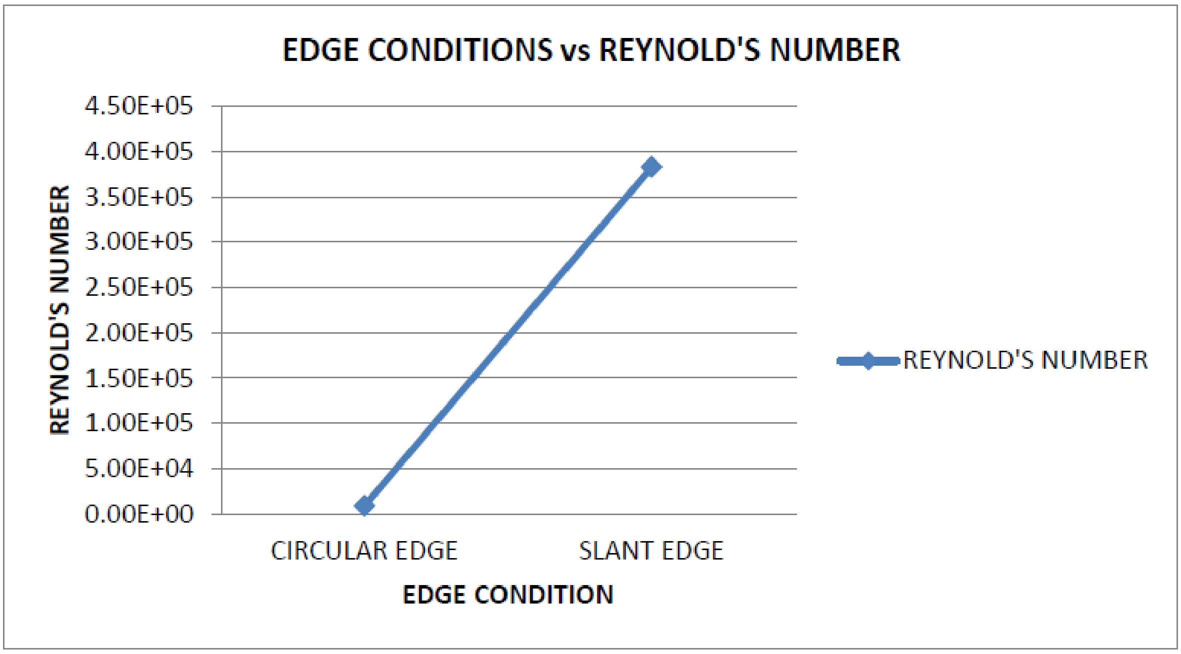
By observing the above results, heat flux is more for Copper than Cast Iron and E Glass Epoxy so the heat transfer rate is more. Thermal gradient is more for copper than other two materials, so the change in temperature is more for copper. When compared results for the edge conditions, the heat transfer rate is more for circular edge than slant edge.

CFD ANALYSIS

	CIRCULAR EDGE	SLANT EDGE
INPUT VELOCITY (m/sec)	20	20
REYNOLD'S NUMBER	8.75e+03	3.83e+05
NUSSELT NUMBER	5.15e-03	7.83e-03
PRESSURE (Pa)	236	1.29e+05
TOTAL HEAT TRANSFER RATE (W)	2.352	602.55817
VELOCITY (m/sec)	26.3	727

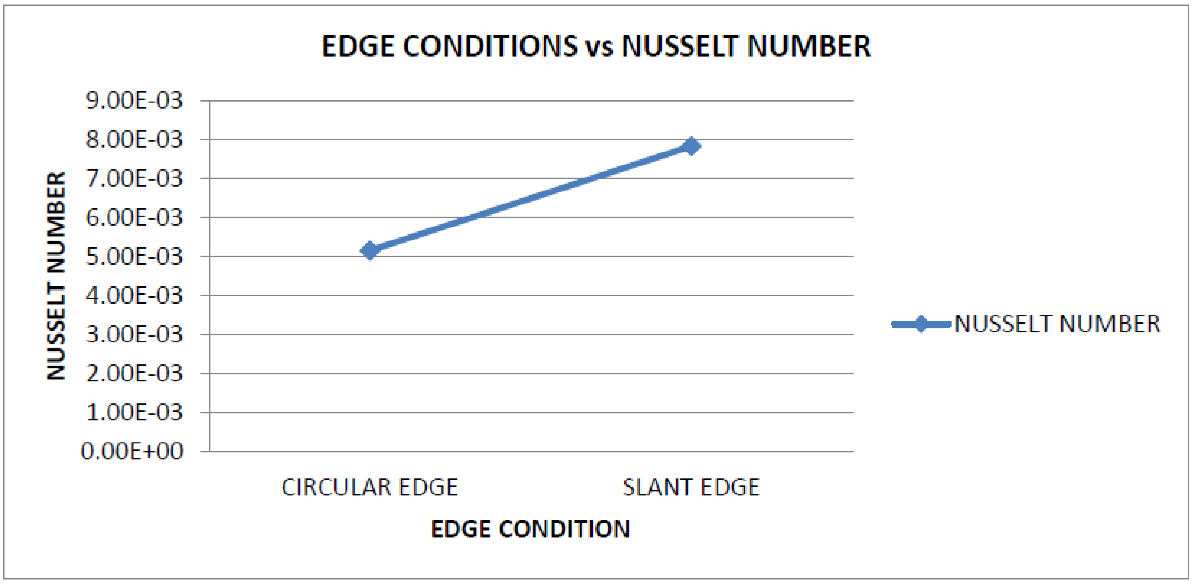
Table: 4.3 Result Table of CFD Analysis of both circular and Slant edge

B. GRAPHS



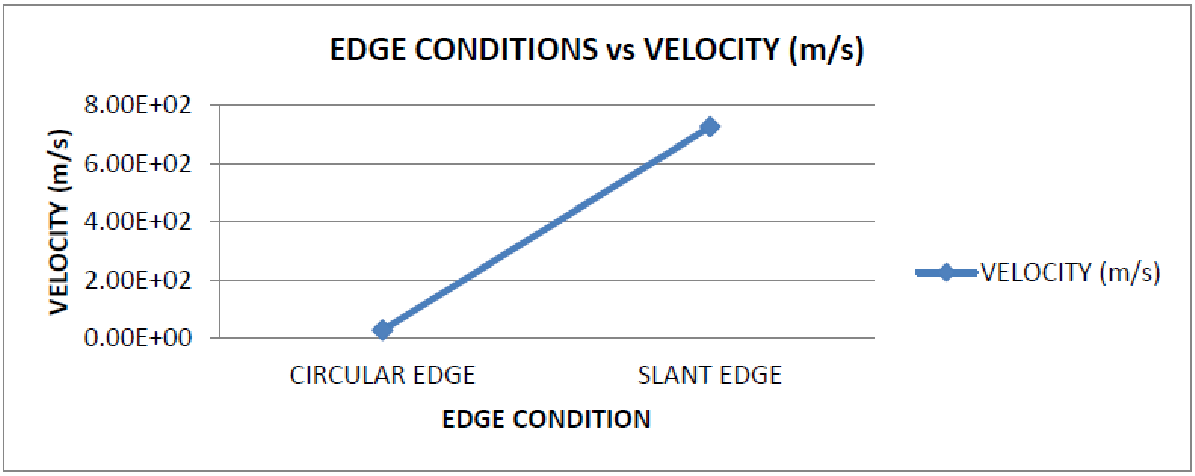
Graph: 4.3 Edge conditions Vs Reynolds Number

The Reynolds number is a measure of the ratio of inertia forces to viscous forces. It can be used to characterize flow characteristics aver a flat plate. Values under 500,000 are classified as Laminar flow where values from 500,000 to 1,000,000 are deemed Turbulent flow. By observing the above results, the flow is a laminar flow.

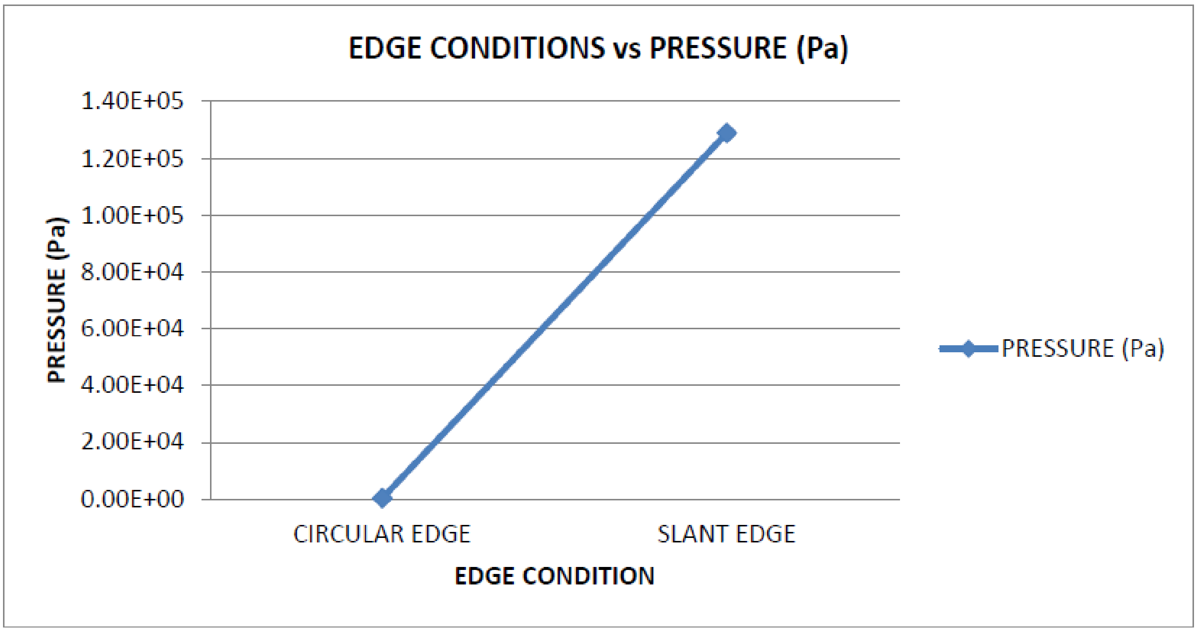


Graph: 4.4 Edge conditions Vs Nusselt Number

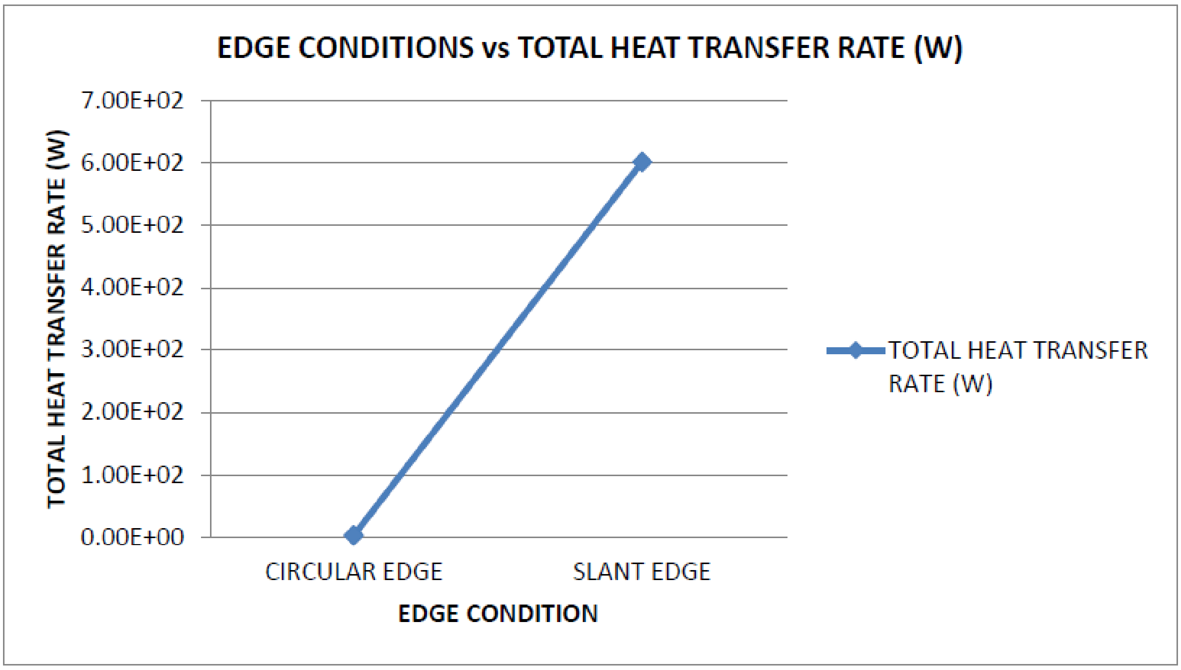
In heat transfer at a boundary (surface) within a fluid, the Nusselt number (Nu) is the ratio of convective to conductive heat transfer across (normal to) the boundary. The nusselt number is more for slant edge than circular edge.



Graph: 4.5 Edge conditions Vs Velocity



Graph: 4.6 Edge conditions Vs Pressure



Graph: 4.7 Edge conditions Vs Total Heat Transfer Rate

By observing the above graphs, the pressure, velocity and heat transfer rates are more for slant edge than circular edge.

CONCLUSION

Thermal analysis and CFD analysis is done on the plates with two different edge conditions circular and slant to determine the heat transfer rate by considering laminar flow under forced convection. Thermal analysis and CFD analysis is done in Ansys. Three materials Cast Iron, opper and E – Glass Epoxy are considered for analysis. By observing the thermal analysis results, the heat transfer rate is more for circular edge than slant edge. The heat transfer rate is more for Copper than Cast Iron and E Glass Epoxy. By observing the CFD analysis results, the Reynolds number for both the edges is less than 500,000, which is a condition for laminar flow. The Nusselt number, pressure, velocity and total heat transfer rates are more for slant edge than circular edge.

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