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Finite Element Analysis to Determine Heat Transfer from a Flat Plate with Different Plate Edge Conditions for 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.

Key Words: Heat Exchanger, Plates,CFD.

1. INTRODUCTION TO HEAT TRANSFER:

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.

Laminar Boundary Layer Equations over Flat Plate (Rex ≤ 5x105)
The assumptions made to give the straightforwardness on the examination are:
1-Steady stream
2-Two-dimensional incompressible gooey stream
3-No weight mixed bag in the y course
4-No shear power in the y course
5-Neglect body power in view of gravity all the crucial differential examinations can be dictated by considering a part control volume inside the laminar region.

2. INTRODUCTION TO CAD:

All through the chronicled setting of our cutting edge culture, various improvements have been authorized and whole new advancements have created. Perhaps the single change that has influenced collecting more quickly and basically than any past advancement is the modernized PC. PCs are being used logically for both arrangement and specifying of building sections in the drawing office. PC assisted design (CAD) with using described as the use of PCs and representation programming to assist or with enhancing the thing arrangement from conceptualization to documentation.

PC supported configuration is most conventionally associated with the usage of a wise PC delineations system, implied as a CAD system. PC helped arrangement systems are successful contraptions and in the mechanical setup and geometric showing of things and parts. There are a couple of respectable clarifications behind using a CAD structure to reinforce the building design capacity:

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» To assemble the benefit
» To upgrade the diagram's temperament
» To uniform layout rules
» To make a collecting data base
» To abstain from slip-ups realized by hand-copying of drawings and inconsistent.

2.1 CAD/CAM Software:

» Programming allows the human customer to change a hardware setup into a proficient blueprint and delivering structure. PC helped configuration/CAM programming falls into two general categories,2-D and 3-D,
» Considering the amount of estimations is called 2-D representations of 3-D articles is unavoidably overwhelming. Thus issue has been the feebleness of collecting work power to properly read and disentangle convoluted 2-D representations of things. 3-D programming permits the parts to be seen with the 3-D planes-height, width, and significance self-evident. The example in CAD/CAM is toward
» 3-D representation of sensible pictures. Such representation evaluated the genuine shape and appearance of the thing to be conveyed; in like manner, they are less requesting to examine and get it.

2.2 APPLICATIONS OF CAD/CAM:

» The ascent of CAD/CAM has had a vital impact on institutionalizing in order to gather, diminishing so as to thin progression and arrangement effort, tryout, and model work; it has made possible in a general sense diminished costs and upgraded productivity.
» Some typical employments of CAD/CAM are according to the accompanying:
» Programming for NC, CNC, and cutting edge robots;
» Framework of fails horrendously and molds for tossing, in which, for occasion, shrinkage
» settlements are prearranged;
» Framework of mechanical assemblies and establishments and EDM cathodes;
» Quality control and survey - for event, course measuring
» machines modified on a CAD/CAM workstation;
» Technique organizing and booking.

3.INTRODUCTION TO PRO/ENGINEER:

» Expert/ENGINEER, PTC's parametric, coordinated 3D CAD/CAM/CAE arrangement, is utilized by discrete makers for mechanical building, outline and assembling.
» Made by Dr. Samuel P. Geisberg in the mid-1980s, Pro/ENGINEER was the business' first successful parametric, 3D CAD exhibiting system. The parametric showing technique uses parameters; estimations, segments, and associations with catch arranged thing lead and make a recipe which enables plot computerization and the upgrade of design and thing change frames.
» This exceptional and rich layout strategy is used by associations whose thing system is family-based or stage driven, where a prescriptive design method is essential to the arrangement's achievement process by embedding building necessities and associations with quickly streamline the framework, or where the resulting geometry may be brain boggling or based upon examinations. Master/ENGINEER gives a complete course of action of arrangement, examination and amassing limits on one, essential, adaptable stage. These limits fuse Solid Modeling, Surfacing, Rendering, Data Interoperability, Routed Systems Design, Simulation, Tolerance Analysis, and NC and Tooling Design.

3.1DIFFERENT MODULES IN PRO/ENGINEER:

» PART DESIGN
» ASSEMBLY
» DRAWING
» SHEETMETAL
» MANUFACTURING

3.2MODELS:

» CIRCULAR EDGE
» SLANT EDGE

4. INTRODUCTION TO FEA:

Restricted Element Analysis (FEA) was at first made in 1943 by R. Courant, who utilized the Ritz methodology for numerical examination and minimization of variation math to gain assessed responses for vibration systems. In the blink of an eye, a paper dispersed in 1956 by M.

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J. Turner, R. W. Clough, H. C. Martin, and L. J. Top set up a more broad importance of numerical examination. The paper concentrated on the "robustness and evasion of complex structures". A broad mixed bag of target limits (variables within the structure) is available for minimization or growth:

•Mass, volume, temperature
•Strain essentialness, uneasiness strain
•Force, evacuation, velocity, expanding rate
•Synthetic (User portrayed)

There are distinctive stacking conditions which may be associated with a structure. A couple of delineations are showed up:

•Point, weight, warm, gravity, and diffusive static weights
•Thermal weights from course of action of warmth trade examination
•Enforced evacuations
•Heat flux and convection
•Point, weight and gravity component loads

4.1 SORTS OF ENGINEERING ANALYSIS:

Auxiliary examination contains direct and non-straight models. Direct models use essential parameters and acknowledge that the material is not plastically mutilated. Non-direct models involve concentrating on the material past its adaptable limits. The nerves in the material then contrast with the measure of deformation as in.

1.Pre Processing
2.Analysis
3.Post Processing
5.INTRODUCTION TO ANSYS

ANSYS is universally useful limited component investigation (FEA) programming bundle. Limited Element Analysis is a numerical technique for deconstructing an unpredictable framework into little pieces (of client assigned size) called components. The product executes mathematical statements that oversee the conduct of these components and illuminates every one of them; making a thorough clarification of how the framework goes about all in all. These outcomes then can be displayed in classified, or graphical structures.

This kind of examination is regularly utilized for the outline and improvement of a framework excessively complex to break down by hand. Frameworks that may fit into this classification are excessively mind boggling due, making it impossible to their geometry, scale, or overseeing mathematical statements.

6. 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

6.1 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.

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RESULTS TABLE:

	NODAL TEMPERATURE (K)	THERMAL GRADIENT (K/mm)	HEAT FLUX (W/mm²)
CAST IRON	350	25.2694	1167.45
COPPER	350	10.4275	4014.59
E GLASS EPOXY	350	58.1893	75.6461

7. INTRODUCTION TO CFD:

Computational fluid motion, typically abridged as CFD, is a branch of liquid mechanics that uses numerical techniques and calculations to tackle and break down issues that include liquid streams. PCs are utilized to perform the estimations needed to reproduce the communication of fluids and gasses with surfaces characterized by limit conditions. With rapid supercomputers, better arrangements can be accomplished. Continuous examination yields programming that enhances the exactness and rate of complex recreation situations, for example, transonic or turbulent streams. Introductory trial acceptance of such programming is performed utilizing a wind burrow with the last approval coming in full-scale testing, e.g. flight tests.

7.1 METHODOLOGY:

In these methodologies the same essential strategy is taken after. During preprocessing

•The geometry (physical bounds) of the problem is defined.
•The volume possessed by the liquid is partitioned into discrete cells (the lattice). The lattice may be uniform or non-uniform.
•The physical displaying is characterized – for instance, the mathematical statem
• of motion + enthalpy + radiation + species protection
•Boundary conditions are characterized. This includes indicating the liquid conduct and properties at the issue's limits. For transient issues, the introductory conditions are likewise characterized.
•The reproduction is begun and the comparisons are settled iteratively as a relentless state or transient.
•Finally a postprocessor is utilized for the examination and perception of the subsequent arrange

7.2 RESULTS TABLE 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

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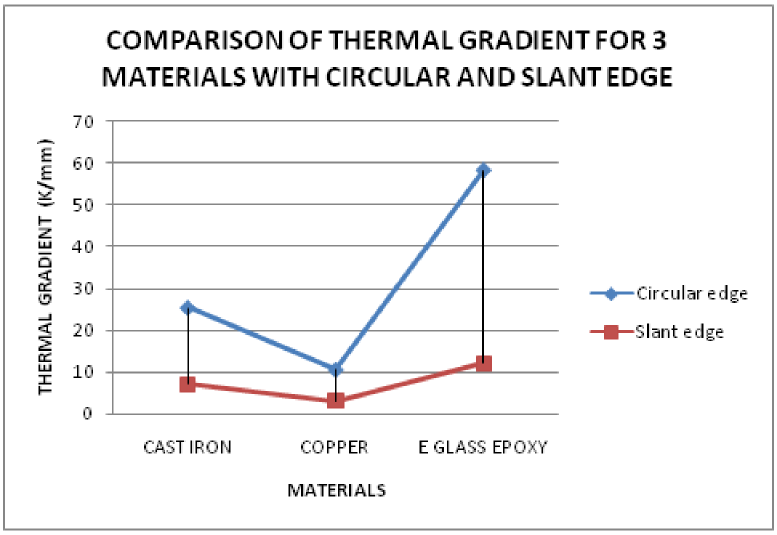
7.3 FINAL RESULTS TABLE
THERMAL ANALYSIS
CIRCULAR EDGE

	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

7.4 SLANT EDGE

	NODAL TEMPERATURE (K)	THERMAL GRDIENT (K/mm)	HEAT FLUX (W/mm^2)
CAST IRON	350	7.0831	327.239
COPPER	350	3.04172	1171.06
E GLASS EPOXY	350	11.9726	15.5643



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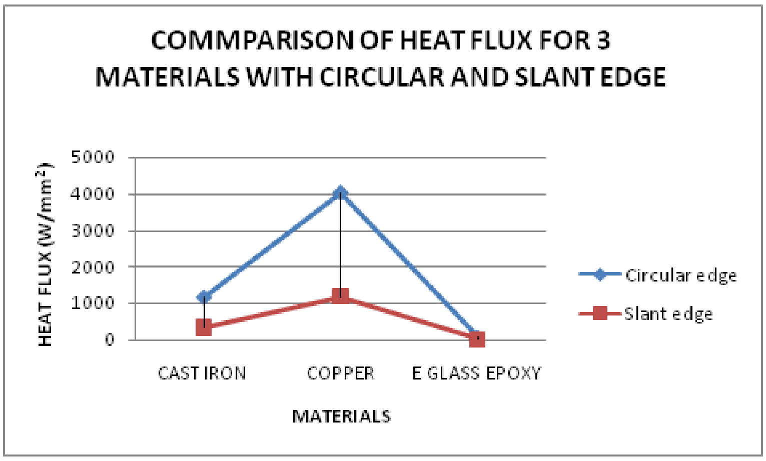
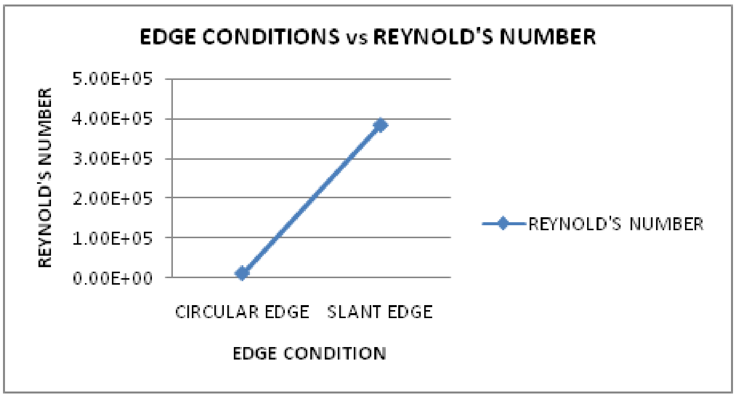


By observing the above results, heat flux is more for Copper than Cast Iron and E Glass Epoxy so the heat transfer rate is more. Thermal gradient is more for copper than other two materials, so the change in temperature is more for copper. When compared results for the edge conditions, the heat transfer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

7.5 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

7.6 GRAPHS



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.

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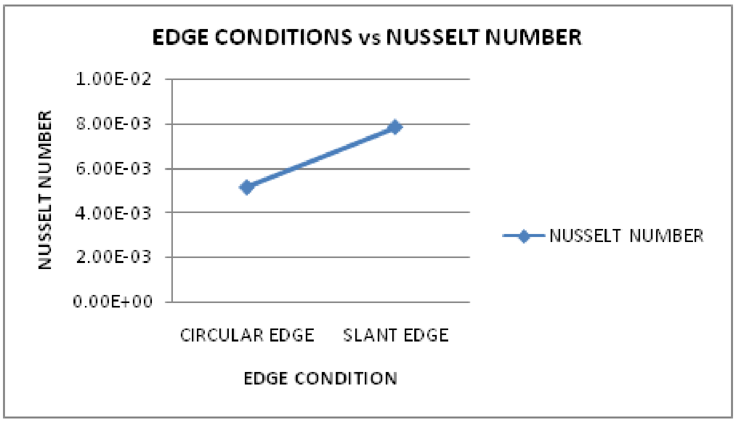
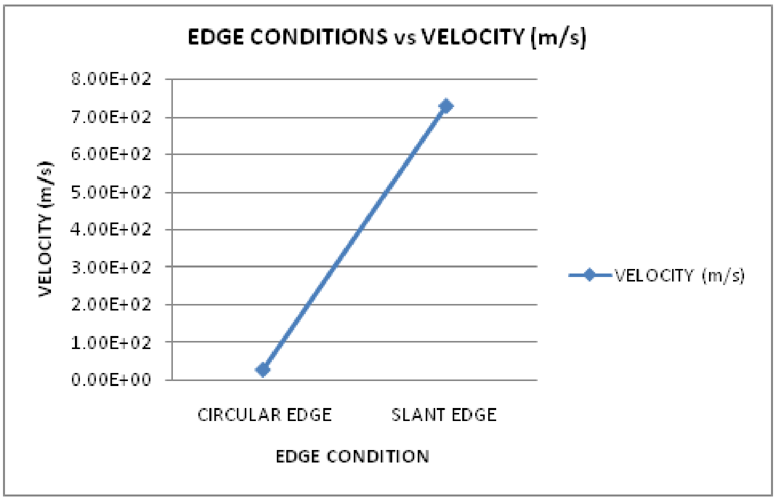
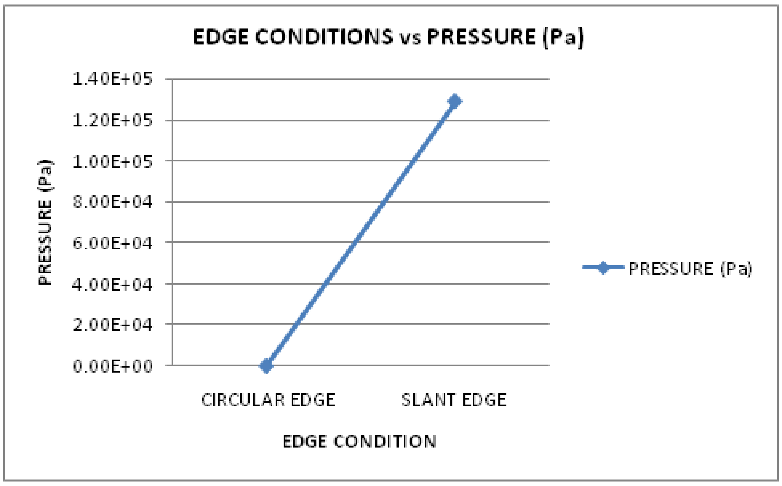


In heat transfer at a boundary (surface) within a fluid, the Nusselt number (Nu) is the ratio of convective to conductive heat transfer across (normal to) the boundary.The nusselt number is more for slant edge than circular edge.





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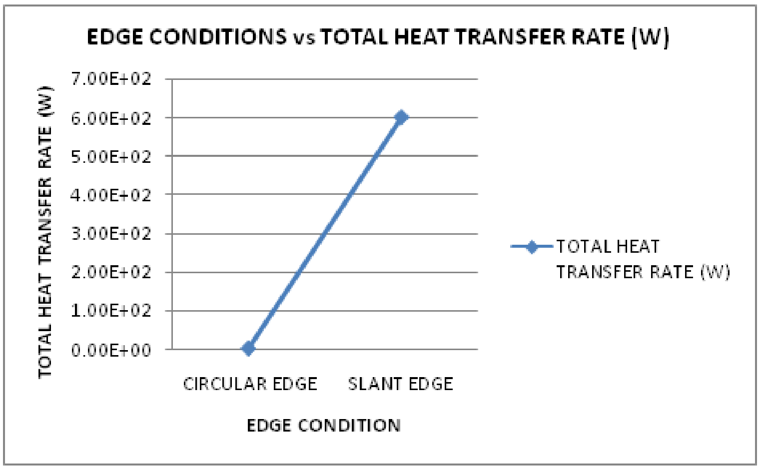

By observing the above graphs, the pressure, velocity and heat transfer rates are more for slant edge than circular edge.

8. 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, copper 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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