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Review paper on experimental analysis of aluminium rod of heat transfer rate with changing tapered angles and changing cross section area

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Abstract
Aluminium material mostly use in automobile and air craft system. In IC engine aluminium is base component as heat transfer and cool engine. In this experimental analysis of heat transfer rate of aluminium rod with changing tapered angles and changing cross section area. Also there is comparison of heat transfer between natural convection and forced convection. Here we can find tapered angle of jib which is very effective for heat transfer rate. Final results are compared by thermal analysis.

Keywords: aluminium rod, heat transfer rate, tapered angles, thermal analysis

1. Introduction
Aluminium material use mostly in heat transfer rate as fins in engine system. The Aluminium is a chemical element with symbol Al and atomic number 13. It is a silvery-white, soft, nonmagnetic, ductile metal in the boron group. By mass, aluminium makes up about 8% of the Earth's crust. It is the third most abundant element after oxygen and silicon and the most abundant metal in the crust, though it is less common in the mantle below. Aluminium is remarkable for its low density and its ability to resist corrosion through the phenomenon of passivation. Aluminium and its alloys are vital to the aerospace industry and important in the transportation and building industries, such as building facades and window frames. The oxides and sulfates are the most useful compounds of aluminium. Despite its prevalence in the environment, no known form of life uses aluminium salts metabolically, but aluminium is well tolerated by plants and animals. Because of these salts' abundance, the potential for a biological role for them is of continuing interest, and studies continue.

2. Literature review
2.1 General
Heat transfer is a very important subject and has long been an essential part of mechanical engineering curricular all over the world. Heat transfer is encountered in a wide variety of engineering applications where heating and cooling is required. Heat transfer plays an important role in the design of many devices, such as spacecrafts, radiators, heating and air conditioning systems, refrigerators, power plants, and others.

2.2 Literature review
Following is the literatures for the experiment done by the various researcher references for the present research.

Hosni I. *et al* investigated Heat transfer Coefficient correlation for circular fin rods [1]. The objective is to develop and present a correlation equation for the average heat transfer coefficient associated with long horizontally oriented circular fin rods that accounts for the effect of both modes of heat transfer: convection and radiation. Four aluminium circular cross-section test rods with diameters of 3.18, 6.35, 9.53, and 12.7 mm were used to develop such a correlation equation. This correlation will be supplied to the students to be used in the design of a fin attachment using the Design-Build-Test approach. The objective has been achieved. An empirical correlation equation for the average heat transfer coefficient associated with long horizontal circular fin rods has been developed. The correlation depends on the fin diameter. The average heat transfer rate is inversely proportional to diameter. For the temperatures considered, the effect of the base temperature was not significant. It should be noted that the average heat transfer coefficient values deduced from the correlation equation reported in this paper accounts for the effects of convection and radiation.
Vladimir A N and Charles De *et al* investigated for Measurement of Thermal Conductivity of aluminium nano powder by photo acoustic spectroscopy [2]. This work concerns the use of photoacoustic spectroscopy (PAS) as a powerful technique to estimate thermal properties of aluminium nanosized powders. Aluminium nanopowders are considered as effective constituents of energetic materials. Thermal conductivity is an important factor in ignition behavior of aluminium nanopowders. For this work, graphite was used as reference material. The experiments showed that nanosized aluminium revealed the same behavior as that of graphite at photoacoustic measurements (similar values of the signal amplitude at various frequencies). It allowed us to assume that both materials have the same thermal diffusivity

length. The thermal conductivity of aluminium nanopowders was measured using the photoacoustic spectroscopy technique. It was found that the PA amplitude for the compacted aluminium was practically equal to that for graphite taken as a reference material. The log-log plot of the PA signal versus frequency indicated that both graphite and nanosized aluminium revealed f-1 behavior. According to the Rosencwaig- Gerscho theory, this corresponds to the case of thermally thick solid for which the sample thickness is more than the optical absorption length. It was assumed that graphite and aluminium nanopowder have the same thermal diffusion length. The photoacoustic measurements showed that the thermal conductivity coefficient of aluminium nanopowder increased with the increase in density, from 47, 17 to 81,84 W.m-1·K-1 when specific mass evolves from 800 to 1390 kg.m-3.

Bin Shen and Albert J. Shih *et al* studied in work a heat transfer model based on finite difference method for grinding [3] A heat transfer model for grinding has been developed based on the finite difference method (FDM). The proposed model can solve transient heat transfer problems in grinding, and has the flexibility to deal with different boundary conditions. The model is first validated by comparing it with the traditional heat transfer model for grinding which assumes the semi infinite workpiece size and adiabatic boundary conditions. Then it was used to investigate the effects of workpiece size, feed rate, and cooling boundary conditions. Simulation results show that when the workpiece is short or the feed rate is low, transient heat transfer becomes more dominant during grinding. Results also show that cooling in the grinding contact zone has much more significant impact on the reduction of work piece temperature than that in the leading edge or trailing edge. The model is further applied to investigate the convection heat transfer at the work piece surface in wet and minimum quantity lubrication (MQL) grinding. Based on the assumption of linearly varying convection heat transfer coefficient in the grinding contact zone, FDM model is able to calculate convection coefficient from the experimentally measured grinding temperature profile. A FDM based heat transfer model for grinding, which is more capable and flexible when dealing with transient heat transfer and different boundary conditions, was developed and validated by comparing with the traditional heat transfer model. The FDM heat transfer model was used to study effects of workpiece size, workpiece velocity (feed rate), and cooling in the leading edge, trailing edge and grinding contact zone. Simulations results showed that transient heat transfer occurred in the cut-in and cut-out regions even though the steady-state can be reached during the process, and when the workpiece was short or the feed rate was low, the transient heat transfer effect was more significant. Results also showed that the thickness of the workpiece could influence the temperature profile along the z-direction in the workpiece. In addition, from the simulation results it was concluded that cooling in the leading edge was insignificant; cooling in the trailing edge helped to cool the workpiece but could not reduce the peak temperature; and the most efficient cooling occurred in the grinding contact zone. The FDM heat transfer model was further applied in the grinding experiments to estimate the energy partition and the convection heat transfer coefficient. Due to the fact that the actual depth of cut in the grinding contact zone decreases from the leading edge to the trailing edge for down grinding, which forms a non uniform flow channel, an assumption of linearly varying convection heat transfer coefficient in the grinding contact zone has been proposed.

Bowang Xiao *et al* investigated in research that an experimental study of heat transfer during forced air convection [4] Cast aluminium alloys are usually subject to solution treatment, quenching, and aging hardening for improved mechanical properties. Cooling rate during quenching plays an important role in residual stress, distortion, and transfer coefficient (HTC) between work pieces and quenchants, it is important to understand how HTC varies with different quenching conditions so that optimal quenching process can be achieved. In this study, a quenching system and an experimental procedure of obtaining HTC are presented. A series of experiments have been conducted to study the variations of HTC with respect to air temperature, air humidity, air velocity, and part orientation. The convection heat transfer of cast aluminium alloy (319) during air quenching has been investigated with a simple cylindrical probe under different quenching conditions including air velocity, air temperature, air relative humidity, and part orientation. It was found that the HTC data increase significantly with increasing air velocity. The probe orientation also affects HTC considerably. The inclined quenching orientation (45) results in a better heat transfer in comparison with vertical or horizontal orientations. The air humidity and air temperature have little effects on HTC data. The relationship between HTC and air velocity developed in study can be used in production to optimize the desired air velocity for the required cooling rate.

Nur Hanim Hassan *et al* experimented that effect of convection mode on radiation heat transfer distribution in domestic baking oven [5]. This analysis is important to understand the fundamental principle of heat transfer occur in an oven. Most previous work focused on conduction and convection process in an oven instead of radiation which leads to this research. The experiment was conducted using the baking oven with temperature ranges from 180°C, 200°C and 220°C. The oven was pre-heated 10 minutes prior taking the temperature reading for duration of maximum 20 minutes. The data collected were recorded in the data logger. Based on these data, analysis on the radiation exchanges that occurred inside the oven chamber were performed by the network representative method. The radiation rates of all surface involved were successfully determined. With the calculated radiation rate, analysis on the effects of radiation under natural convection and forced convection modes were performed. Based on the temperature profiles and radiation rate patterns, it was proven that the forced convection mode has more radiation effect compared to natural convection mode. The results demonstrated that the temperature profile of the oven walls fluctuated indicating there was a heating and cooling process for all convection modes. The electrical network can be used to calculate the radiation rate for all enclosed surface of the oven. Furthermore, the network also allows identification possible paths for radiation process to take place. This indicates the potential direction of heat flow from the heat source by illustrating whether the modes of surfaces are emitting or absorbing the heat. The forced convection mode has higher calculated radiation rate compared with the natural convection mode.

Mahendrakumar Maisuria *et al* researched on Effect of surface roughness on heat transfer [6]. There is always the loss of heat when passed through body having a contact with another. The loss may take place due to the heat leakage to the atmosphere or due to the roughness between the two surfaces. This heat loss at the interface is being calculated and the effect of surface roughness and the heat transfer is also being found out. An experiment is carried out to measure heat conductance at the interface of metal plates of known surface finish. A known energy source is applied to one of the plates, induced a measurable temperature difference between the plates. Other variable that affect interface heat transfer such as type of material, contact area, pressure, environmental factors inside insulating box and surface finish are documented and held constant for each test configuration. The film heat was energy source for these tests. Good heat transfer across the interface is necessary to keep component temperatures within allowable limits. The results quantify the effect of flatness variation on heat transfer across the interface. This experiment concludes that with increase in roughness at contact of two materials the heat transfer rate is decreasing. With increase in surface roughness the heat loss will also increase. The results of experiment can be implemented in the fields where heat transfer takes place. The nature of surface determines the heat transfer rate, so the optimum surface finish should be provided to prevent heat losses.

Uzorh Augustine *et al* studied thermal aspects of machining: evaluation of tools and chip temperature during machine process using numerical method [7]. Elevated temperatures generated in machining operations significantly influence the chip formation mechanics, the process efficiency and the surface quality of the machine parts. The temperature fields generated in the cutting process are subject of extensive research. The studies of these thermal fields in machining are very important for the development of new technologies aiming to increase the tool lives and to reduce production costs. Particular attention is given to modeling of the tool-chip, chip-work piece and tool-work piece interfaces. Since the direct temperature measurement at the chip-tool interface are very complex, this work proposes the estimation of the temperature and the heat flux at the chip-tool interface using the inverse heat conduction problem technique. The shear energy created in the primary zone, the friction energy produced at the rake face-chip contact zone and the heat balance between the moving chip and the stationary tool are considered. The temperature distribution is solved using finite difference method. The mathematical models and simulation results are in satisfactory agreement with experimental temperature measurements. The temperature field in any region of the tool set (insert, shim and tool-holder) is calculated from the heat flux estimation at the cutting interface. The determination of the temperature and of the heat flux at the chip–tool interface is done by using the inverse heat conduction problem technique. Heat balance equations were determined in partial differential equation forms for the chip and for the tool. The finite difference method was utilized for the solutions of the steady-state tool and chip temperature fields. The chip thickness was discretized and Steady-state chip and tool temperature fields were determined for each of these discretized machining intervals. Based on thermal properties and boundary conditions, time constants were determined for each discrete machining interval. Simulations were performed for different materials under various cutting conditions. The results for continuous machining processes agreed well with experimentally measured temperatures. The proposed algorithm can be utilized in selecting cutting speed, feed rate and tool rake and clearance angles in order to avoid excessive thermal loading of the tool, hence reducing the edge chipping and accelerated wear of the cutting tools.

M. Srinatdh *et al* worked on Static and thermal analysis and piston ring [8]. A piston is a component of reciprocating engines, reciprocating pumps, compressors and pneumatic cylinders, among other similar mechanisms. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. The piston transforms the energy of the expanding gasses into mechanical energy. The piston rides in the cylinder liner or sleeve. Pistons are commonly made of aluminum or cast iron alloys. The piston and piston rings are modeled using Pro/Engineer software, The stress and displacement are analyzed for the piston and piston rings by applying pressure on it in Structural analysis. By observing the analysis results, we can decide whether our designed piston is safe or not under applied load conditions. The thermal flux, thermal temperature distribution is analyzed by applying temperatures on the piston surface in Thermal analysis. piston and Ring's calculations are done for 1300cc diesel engine. Modeling of piston and Ring's are prepared using parametric software creo (pro-engineer) and assembled. Assembly was exported to Ansys work bench to conduct structural and thermal analysis. In the analysis piston and Ring's were analyzed using 3 various materials Cast iron, Aluminium (A360) and Zamak. According to the results obtained from Ansys Zamak material for piston is selected. In the analysis 3 different rings were analyzed using 3 various materials Cast iron, Aluminum and Zamak. In 3 different ring profiles semicircular face ring is best as per the ansys results in deformations, strains and heat flux. Zamak is having low deformation and high heat flux properties compare to other 2 materials. As per above results piston with Zamak is having high heat flux value than traditional materials. As per analyses values Zamak is having good value so we can use Zamak.

N Sethuraman *et al* investigated of heat transfer rate and temperature distribution of different fin geometry using experimental and simulation method [9]. Convective heat dissipation from the standard surface can be significantly increased by the use of fins. Calculation of heat released from the fin involves a complex conjugate system of conduction and convection. The performance analysis is carried out using simulation and experimental method. Experiment carried out by using different geometry at different heat inputs. In this study, the enhancement of natural convection heat transfer from a horizontal rectangular fin embedded with rectangular perforations of aspect ratio of two has been examined using finite element technique. A fin experimental value set up is for designed developed and working procedure of the apparatus is simple. The results show that the rate of heat transfer is high for with insulated triangular fin, followed by without insulated triangular fin the results show that the rate of heat transfer is high for tapered pin fin, followed by pin fin. Temperature distribution and heat transfer rates are calculated using simulation method for the aluminium material and compared with the experimental result. The measured and predicted values have good agreement. For all the conditions the temperature at the tip of the fin has to be the same as that of air. But reality the tip temperature of the fin is not the same as that of ambient temperature this shows that heat transfer is enhanced. Simulated valves are calculated for temperature distribution and heat transfer for the pin fin and triangular fin for different materials at the base temperature 90°c.

N. Yu. Dudareva *et al* Experimented Micro Arc oxide coating effect on thermal properties of an aluminium alloy piston head [10]. The purpose of the present study is to investigate the influence of differently sized micro arc oxidation coatings, applied to the bottom of pistons made with an Al-12Si-Mg-Cu-Ni alloy, on its thermal properties by simulating the operation of a real engine. This study is based on the premise that the alumina coating thickness affects the heat transfer and temperature distribution in the piston. The analysis of thermal properties of pistons and suggestions for the optimal thermal barrier coating thickness are presented. This work shows that the correct choice of the thickness of the MAO thermal barrier layer applied to the piston bottom can lower its thermal factor effectively, particularly in conditions of increased thermal loads in the engine. The experiments show that the heat-protective effect of a MAOlayer is 8 % on the average. It has been found that the most effective MAO-layer thickness is 100 μm to provide the best piston thermal protection.

Arigela Jagadish *et al* investigated that Structure and thermal analysis for friction stir welding of aluminium alloy and copper [11] Friction Stir Welding (FSW), invented by Wayne Thomas at TWI Ltd in 1991 overcomes many of the problems associated with traditional joining techniques. FSW is a solid-state process which produces welds of high quality in difficult-to-weld materials such as aluminium, and is fast becoming the process of choice for manufacturing lightweight transport structures such as boats, trains and aeroplanes. FEA analysis will be performed for friction stir welding of aluminium and copper at different speeds using Ansys. Coupled field analysis, thermal and structural will be performed. A parametric model with the weld plates and cutting tool will be done in Pro/Engineer. The speeds are 750rpm, 560 rpm and 410rpm. The temperatures taken for thermal analysis, at 410rpm 4200C, at 560rpm 5300C, at 750rpm 6270C respectively. The effects of different tool pin profiles on the friction stir welding will also be considered for analysis. Different tool pin profiles are circular, tapered Circular. In this project 2 types of cutting tools Round and taper are designed for doing Friction Stir Welding of two dissimilar materials Aluminium alloy 5083 and Copper running at speeds of 750rpm, 560 rpm and 410rpm. The temperatures taken for thermal analysis, at 410rpm 4200C, at 560rpm 5300C, at 750rpm 6270C respectively. Modeling is done in Pro/Engineer. Coupled field analysis is performed on the tools Round, taper tool to verify the temperature distribution, thermal flux, gradient and stresses. By observing the thermal results, thermal flux and thermal gradient are more for taper tool but the stresses produced are more than round tool. Temperature is also produced for required melting point of plates. So it can be concluded that using taper tool is better in terms of heat transfer rates but as per structural, round tool is better.

M.A. Razzaq *et al* studied Enhancement of heat transfer of water for turbulent flow through tube using U-cut twisted tape inserts [12]. In this experiment tube side heat transfer coefficient, pressure drop, friction co-efficient and percentage of increase in those parameters for water using U-cut twisted tape inserts into the tube were measured. The test section consists of a circular tube made of copper having 26.6 mm inside diameter, 30 mm outside diameter and 900 mm in effective length. A stainless steel U-cut twisted tape insert of 5.29 twist ratio and 0.4 mm in thickness was inserted into the smooth tube. The U-cut had 8 mm depth and 8mm width. In this investigation, the test section was electrically heated. Five K-type thermocouples were used in the test section for measuring the wall temperature. The heat flux was found in the range of 18.33~28 kW/m2for smooth tube whereas 32.07~47.24.00 kW/m2for tube with insert for Reynolds number range of 10153~19217. At comparable Reynolds number, Nusselt number in the tube with U-cut twisted tape insert was enhanced by 2.76 to 3.24 times with compared to smooth tube and friction factor in the tube with U-cut twisted tape insert was also increased by 1.6 times with compared to plain tube. An experimental investigation was carried out to determine tube-side heat transfer coefficient, friction factor, heat flux of water for turbulent flow in a circular tube which was fitted with stain less steel U-cut twisted tape insert. From the experiment, it was found that, in case of plain tube, Nusselt number for U-cut twisted tape was increased by 2.76 to 3.24 times than that of the plain tube. Friction factor for U-cut twisted tape insert was increased by 1.6-2.0 times than plain tube. Friction factor was decreased with the increase of Reynolds number for both of the case. Heat flux was increased by 1.54 to 1.75 times for UTT compared to plain tube. Coefficient of convective heat transfer was also increased by 2.77 to 3.04 times for U-cut twisted tape insert compared to plain tube. Further investigation can be carried out to investigate heat transfer enhancement efficiency for U-cut twisted tape insert and for different spacing of the twist and twist ratio.

Vedullua manoj kumar *et al* worked on thermal analysis of rectangular and tapered pin fin heat sink using icepak [13] Heat sink is a device which is used to dissipate the unwanted heat to ambient. Heat sink constitutes geometrically simple structure but to find out the accurate fluid flow path pose enormous difficulty to the attempt to perform thermal analysis. These are used in a wide range of applications wherever efficient heat dissipation is required, major examples include Cooling electronics devices like microprocessors, DSPs, GSPs, Refrigeration, Heat engines, Cooling electronic devices and lasers. This work is concerned with the comparative study of taper pin fins heat sink with Rectangular pin fins heat sink using the commercial CFD software Icepak. The heat sink is made from aluminum and air is used as the cooling fluid and a constant heat flux of 100 W/cm2 from bottom and flow velocity of 2m/s. The results showed that for a given boundary conditions, the taper pin fins got very low thermal resistance than rectangular pin fins heat sink. The challenge of heat removal is very prevalent in nature and usually crucial in many engineering applications. Here we considered different geometries of pin fins heat sink those are rectangular, cylindrical and taper in both inline and staggered arrangements. A comparison was made for different geometries of pin fins heat sink by using Ansys ice pack 16.0. From this analysis it is observed that for taper pin fins geometry performed better than rectangular geometries with the thermal resistance is of 0.09oC/W at 2 m/s velocity. From this analysis it is concluded that taper geometries performed better heat sink characteristics than rectangular geometries. Lastly, this study clearly shows that the low thermal resistance and rectangular geometries of pin fins heat sink. A three-dimensional mathematical model, developed using Navier-Stokes equations of motion, is capable of predicting correctly the fluid flow and heat transfer characteristics in the heat sink. It has been validated using experimental data reported in the literature, and a good agreement has been found between the model predictions and measurements. Finally, the growing interest in the pin fin heat sinks, which is evident by the number of available studies, leads to conclusion that research in this area will give us optimized solution in this decade for cooling of electronic devices.

3. Problem statement

Heat transfer is a branch of engineering science which seeks to determine the rate of energy transfer between bodies as a result of temperature differences. The concept of rate is the basic difference between heat transfer and thermodynamics. Thermodynamics deals with systems in equilibrium and is concerned with the amount of heat required to change a system from one state to another. The basis of this study applies the heat transfer process. Heat transfer can be categorized into three main processes which are the conduction, convection and radiation of heat. explains the energy transfer between surfaces and with different type of medium involved during the heating process The analysis of heat transfer is important due to it applications within the daily usage and including the large scale implementations. Aluminium Fins are used In Automotive, radiator is the base component of the engine cooling system. In This Experiment aluminium rod use for heat transfer rate for cooling system mostly and study heat transfer rate with changing cross section and size and shape. In this experiment find relation between surface finish and heat transfer rate of aluminium rod.
Experimental analysis of heat transfer rate with changing tapered angles with cross sectional area.

Objectives

1. Study the heat transfer rate with respect to change in tapered angle.
2. Study the heat transfer rate with respect to change in cross section area.
3. Study the comparison between natural convection and forced convection.
4. Study the results by comparison between experimental analysis and thermal analysis.

4. Methodology

In this study work design of tapered fin for given requirements is to be done by using Machine Parameter change dimension of aluminum rod and observed thermal properties of job. For that we need some instruments which are used for measurement some parameter like talysurf, thermocouples etc. Temperature variation will observed by sensor with respect to length that time environment parameter also consider and find relation between thermal properties and heat transfer rate.

- Study of existing system use as fins.
- Use various tapered angle.
- Selection of angle which give best result.
- Validation of Experimentation to check heat transfer rate with changing angle.
- Comparison of Experimental results of heat transfer rate with Thermal Analysis by ANSYS.
- Study the comparison between natural convection and forced convection.
- We can study change of mechanical properties of materials.

5. Experimental setup

Tapered aluminium rod manufacture by CNC machine under changing various parameters like speed and depth of cut. Then after one end of aluminium rod inserted in furnace up to some specific heat after to reach specific temperature rod take out from furnace and observed temperature on sensor means thermocouple choose specific length of rod and observe temperature variation on metallic rod. Very time change tapered angle and find effective method which is best for heat transfer.

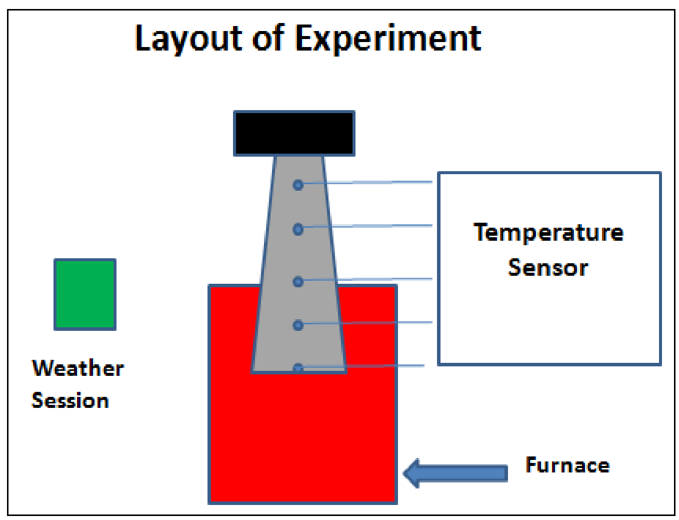

Fig 1: Experimental Set up

Thermocouple are used for temperature measurement. Thermocouples are based on the principle that when two dissimilar metals are joined, a predictable_voltage will be generated that relates to the difference in temperature between the measuring junction and reference junction. We selected K type thermocouple due to vast temperature range of working. The temperature range is -454 to 2300 F (-270 to 1260 C). The

K type thermocouple contains Nickel-Chromel or Nickel-Alumel or Chromel-Alumel. The error may be occurs is only 0.4%.This K type is the most common type of thermocouple. Surface finish measurement instrument is Talysurf in which measured Ra and Rz value.CNC Machine are used for machining as per programming we can varying speed and depth of cut parameter and observed surface finish with changing speed and depth of cut and then after observed heat transfer rate of aluminium rod. The following will be measured:

1. Atmospheric pressure and humidity
2. Inlet and outlet temperatures
3. air temperatures
4. Wind velocity
5. Surface Finish

6. Conclusions

This Experiment will find tapered angle which is give best heat transfer rate so we can use this tapered angle for engine system. Through investigation observe relation between surface finish and heat transfer rate with changing tapered angles with cross sectional area. Also there is comparison of heat transfer between natural convection and forced convection. Final results are compared by thermal analysis.

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