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# Designing and Analysis of metal composite fin

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**Abstract -** *Making and designing fins are a tremendous task. It is most important task for a designer to lower the weight and cost of the material, with wide spread applications. In the current research we have designed a metal fin using Cu, Alluminium and Carbon steel. We have developed a low cost method to design the fin. The mechanical and chemical strength were checked by mechanical instruments. It was used as cooling fans with high RPM and maximum cooling efficiency.*

***Key Words***: Fin, maximum cooling efficiency, low cost method.

## 1.INTRODUCTION

Metals have wide applications in daily life including their engineering applications. Big machinery has a lot to do with the metals tanks and other equipment [1]. Small electronic devices have also an indistinguishable part of life, which are made up of several metals clusters. Cooling devices have alloy fins mostly consisting of Aluminum, a lighter metal. The steady state temperature distribution in a composite medium consisting of several layers of different physical properties in contact with each other has numerous applications in science and engineering. Such a configuration has applications in power plants particularly in nuclear plant, where large amount of heat is to be transferred effectively. One of such device is an extended surface, which is composed mainly of a very conductive material, such as copper, oxidizes readily [2]. To overcome the difficulty, copper is protected strengthened by a sheath of stainless steel which has a lower thermal conductivity then that of copper. The large difference in values of thermal conductivities of the material causes the heat to flow in 2-d a typical approximation in the analysis of extended surfaces.

When additional metal pieces are attached to ordinary heat transfer surface such as pipes, tubes, they extend the surface available for heat transfer. While the extended surface increases the total transmission of heat, its influence as surface is treated differently from simple conduction and convection. Consider a convectional double pipe heat exchanger, Assume that the hot fluid is flowing in the annulus in cold inner pipe [3]. Both in turbulent flow and the effective temperatures inside the cross section. The heat transfer can be computed from the inner pipe surface, annulus coefficient and the temperature difference [7]. If the metal strips do not reduce the valve of convection heat transfer coefficient to such amount, more heat that will be transferred from the annulus fluid to the pipe fluid. Pieces which are employed to enhance the heat transfer surfaces are known as fin [11].

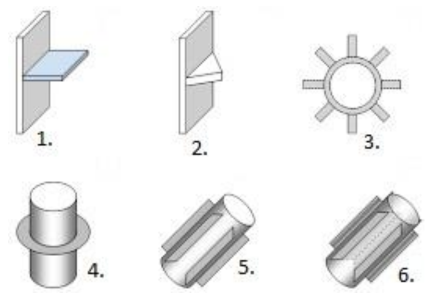



**Fig -1**: Metal fins type. 1 and 2 straight fins, 3 -6 annular fins (circular fins)

### 1.1 TYPES OF FINS

Transverse fins are made in a variety of types and employed primarily for the cooling and heating of gases in cross flow. The strip is attached to the outer periphery in this type of fins. The strips are attached either by grooving or peening. When channels are attached thereisintegrally welded to the tubes (fig. 1). They are most commonly used in double pipe heat exchanger, unleveled shell and tube exchanger. Basically these are of pyramids or cylindrical shapes. It extends from the pipes surface so that they are usable for either longitudinal flow or cross flow.

### 1.2 TRANSIENT HEAT TRANSFER

The term transient or state designates a phenomenon which is time dependent conduction of heat in unsteady state refers to the transient condition where in the heat flow and the temperature distribution at any at a point of the system vary continuously with time. The temperature and rate of heat conduction are then undoubtedly dependent both on the time and space coordinates i.e. t=f(x,y,z,£) transient conduction occurs in:

i. Heating or cooling of metal ballets
ii. Cooling of I.C engine cylinder
iii. Cooling and freezing of food
iv. Brick burning and vulcanization of rubber
v. Starting and stopping of various heat exchange units in power installation.

Change in environmental temperature during steady state would follow a periodic or a non-periodic change. The temperature change in repetitive cycle and the condition get replaced after some fixed time interval. Temperature variation the cylinder of the I.C is considered periodically. During each cycle a definite variation of temperature occurs with respect to the crank angle for one cycle is called period. The temperature changes as some nonlinear function of time. This variation is not different pattern or in a particular trend.

## 2. METHODS OF PREPARATION

### [A] Parameter of analysis

Parameter and tolerance design relied on experiment and mathematical techniques subject to noise factors. Various strategies may be used to conduct the experiments. A system whichinvolves five design parameters and three levels of settings as high, medium and low for each parameter. The simplest strategy is to investigate all possible combinations of parameters, which would require around 243 sets of experiments. Instead orthogonal arrays are efficient and economical alternatives to complete the enumeration.

The practical aspects of QC equipment the design process into three steps: system design, parameter design and tolerance design. System design refers to the conceptual phase of design when consumer's needs are formulated into a design problem and solutions are generated and evaluated. Once a solution is established and defined in terms of its parameter settings so as to reduce the design's sensitivity to uncontrollable sources of vibrations it refers to as noise factor. Environmental factors (e.g. people and ambient temperature) and time dependent phenomenon (such as tool wear and material shrinkage) are examples of noise factors. As a lost step, tolerance design is used to tightening tolerance.

### [B] Material requirement

The construction of fin is not so easy it needs lots of considerations, we have although prepared the fin using below mentioned materials:

**Table-1:** Materials and their quantity used in fin preparation

| S.No. | Material | Quantity (Kg) |
|---|---|---|
| | Cu | 0.157 |
| | Al | 0.13 |
| | Fe | 0.04 |
| | Cr | 0.18 |
| | Mg | 0.05 |

### [C] Equipment used

LCD portal digital multi-stem Thermometer with external sensing probe, Model No.: ST-9239 A/B/C.

### [D] Construction

The fin is prepared by using above mentioned metals. Metals were layered using the heater. The first layer is Chromium followed by Aluminum, Iron, Magnesium and Copper. All the layers were joined together using soldering and melting process. It was kept in our consideration to avoid rusting is fin, so Chromium and Aluminum is used. The fin (composite fin) of size, diameter 1.6 cm and length 7 cm is jointed at the outer surface of plywood. A fan of 1350 rpm is fixed at one end of the plywood (Table 1). A hole size of object is made in duct, through which object can be fit inside the duct. The heater is fixed in the plywood, just below the hole in duct. A small hole in duct of diameter is made, so that the temperature inside the body can be measured by thermometer.

### [E] Testing of Fin

The testing is started by starting the heater. After heating the body at a temperature of 250°C, switch off the button. Take the reading of the thermometer of the body, after each two minutes. Precede the same procedure for each object. Now after completing the free convection reading. Start the fan and check the performance.

### [F] Modeling

The dynamic performance of a control system is assessed by mathematical modeling (or experimentally measuring). The outcome of the system in correlation to a specific set of test input conditions. Modeling techniques CAD/CAM or Pro-E systems provide the computer tools. For a wide range of engineering applications. Central too many of the task is the computerized model of a product replacing a traditional engineering representation.

## 3. RESULTS AND DISCUSSION

a) Heat dissipation from a fin with insulated tip,

$Q = \sqrt{hPkA}\ (t_0 - t_a).\tanh(mL)$

Where,

P= parameter of the fin.
K= thermal conductive of fin material.
A= cross-section area of the fin.
h= co-efficient of heat transfer.
$t_0$= base temperature of the body.
$t_a$=ambient temperature.
L= length of the fin.

### [A] Forced convection

For the forced convection the convective heat loss is given by,

$$Q = h.A.(t_0 - t_a) \qquad \text{..................(1)}$$

Where h is calculated by, Nusselt number.
Find the velocity of fluid = V
Diameter of duct or area of passage = A
Find out the properties of air, at mean film temperature,

$$t_m = \frac{t_0 + t_a}{2}$$

Properties are at the mean film temperature,

1. Thermal conductivity of air, $K_{air}$(W/mk)
2. Prandtl number, (Pr)
3. Density, p (km/m$^3$)
4. Kinematic viscosity, û(m$^2$/s)

5. Specific heat, C (J/kg k)
6. Dynamic viscosity, μ

Find Reynold number =

$$R_e = \frac{\rho v d}{\mu}$$

According to the Reynold number,
Select the formula for Nu number,

$Nu = 0.023\ (Re)^{0.8}\ (Pr)^{0.4}$ ……… for turbulent flow

$Nu = 0.615\ (Re)^{0.466}$ ……….for laminar flow

Co-efficient of heat transfer,

$$h = \left( \frac{Nu.Kair}{d} \right)$$

**[B] Discussion**

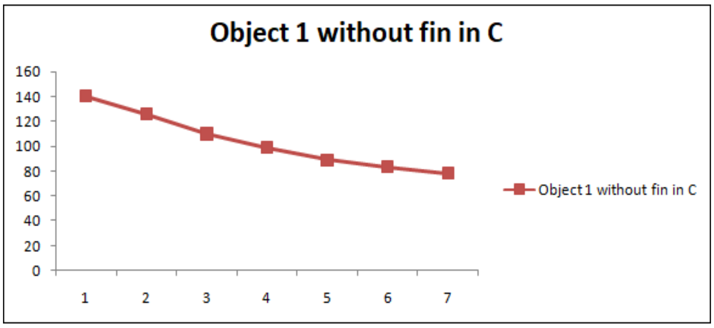
Table shows that finned surface has better than the non-finned surface. Heat transfers through the fin approximately 1.22 times the heat transfer without fin (Fig.2).Table indicates that the implementation of finned surface in the heat exchanger increase the cost of material (Table 2& 3 , 4).Composite fin of Cu and Al is found the best one as having less weight, comparatively lower cost and better heat transfer.

**Table-2:** Observation table for experiment conducted for free convection

| S.no. | Time in minute | Object 1 without fin in C | Object 2 (Cu) in C | Object 3 (Cu+Al) in C | Object 4 (Cu+C.S.) in C | Object 5 C.S. in C |
|---|---|---|---|---|---|---|
| 1 | 0 | 140 | 140 | 140 | 140 | 140 |
| 2 | 2 | 135 | 110 | 125 | 128 | 130 |
| 3 | 4 | 120 | 96.3 | 110.5 | 113 | 115 |
| 4 | 6 | 113.2 | 90.1 | 105.4 | 108 | 110 |
| 5 | 8 | 110 | 87.6 | 103.2 | 106 | 108.3 |
| 6 | 10 | 108.3 | 86 | 97.5 | 99.3 | 103 |
| 7 | 12 | 106.2 | 84 | 94 | 97 | 100.5 |

**Table-3:** Observation table for experiment conducted for forced convection

| S.NO. | Time in minute | Object 1 without fin in C | Object 2 (Cu) in C | Object 3 (Cu+Al) in C | Object 4 (Cu+C.S.) in C | Object 5 C.S. in C |
|---|---|---|---|---|---|---|
| 1 | 0 | 140 | 140 | 140 | 140 | 140 |
| 2 | 2 | 125.64 | 85.5 | 96.1 | 103.3 | 104.7 |
| 3 | 4 | 109.56 | 72.4 | 79.3 | 85 | 91.3 |
| 4 | 6 | 99 | 66 | 72.2 | 77 | 82.5 |
| 5 | 8 | 88.87 | 62.6 | 68 | 72.5 | 74 |
| 6 | 10 | 82.8 | 60 | 65.2 | 67.5 | 69 |
| 7 | 12 | 78 | 57.2 | 61.3 | 63.5 | 65 |



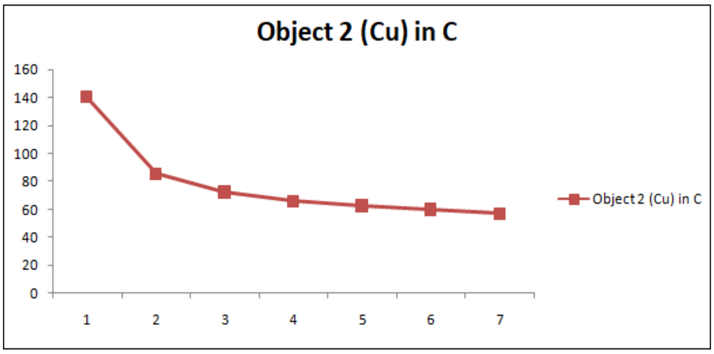




**Fig-2:** experiment conducted for forced convection

**Table-4:** Economic Analysis and their cost in manufacturing

| S.NO. | Object | Material | Weight (Kg) | Cost |
|---|---|---|---|---|
| 1 | Object1 | Without fin | 0 | 0 |
| 2 | Object2 | (Cu) | 0.1108 | 33.67 |
| 3 | Object3 | (C.S.) | 0.0968 | 4.356 |
| 4 | Object4 | (Cu+Al) | 0.0593 | 12.411 |
| 5 | Object5 | (Cu+C.S.) | 0.1139 | 12.777 |

Cost of the material per kg
Copper – 350 Rs. per kg

Aluminum – 115 Rs. per kg
Carbon steel – 35 Rs. per kg

## 4. CONCLUSION

From the experimental analysis of composite fin, it is resulted that the composite fins can replace the single material because it has 1.768 times lower weight and 2.158 to 3.784 times lower cost. Composite fin has 1.50 times higher heat transfer rate as compare to normal fin of 1.234 to 1.269 times. This can reduce the cost of material by proper aerodynamic fin design and other manufacturing process. Composite fin has a large scope as its manufacturing difficulties are solved. The above result shows that the composite fins have wide applications and strength also supports the physical and chemical strength. Modification and more intense research will exploration of the fins.

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