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Evaluation Performance ofan Annular Composite Fin by UsingMATLAB Programming

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ABSTRACT
The aim of this project is analysis the efficiency ratio in an annular fin by the variation of heat transfer coefficient for any surface condition by using MATLAB software to calculate the base fin efficiency and the coated fin efficiency by the variation of heat transfer coefficient, radius ratio and base fin thickness of an annular fin and compare the coating fin efficiency to base fin efficiency. If the heat transfer coefficient is $50 W/m^2K$ the increase efficiency ratio is 10.46 – 28.02% for zinc coating fin from the literature but the MATLAB result is 9.3 - 25.54% , the gain efficiency ratio at thicker base fin (d=0.001m) is 11.72%, at the thinner base fin (d=0.0002m) is 33.57% from the literature but the MATLAB result is 7.45% (d=0.001m) and 32.14% (d=0.0002m) for zinc coating fin and the gain efficiency ratio at thicker base fin (d=0.001m) is 11.92%, at the thinner base fin (d=0.0002m) is 33.61% from the literature but the MATLAB result is 7.51% (d=0.001m) and 32.16% (d=0.0002m) for zinc alloy coating fin.

Keywords –Annular composite fin, Efficiency ratio, MATLAB simulation

I. INTRODUCTION

Now days, most of the engineering processes require better design of fin configuration for any heat transfer application with progressively less weight, volume, accommodate shape, new manufacturing process and cost as well as the thermal behaviour. The rate of heat transfer depends on the surface area of the fin. The annular composite fin is one of the most popular choices for exchanging the heat from the primary surface to surrounding. An extended surface is a heat absorbing or heat rejecting surface from base surface to surrounding fluid, when it is connected with the prime surface. Through the convection heat transfer takes place between the extended surface and atmosphere, so that heat transfer rates can be increased by connection from extended surface (fin) of thin strips metal. Now days, thedesign and manufacturing technique process for the different types of heattransfer element such as constant area straight fin, pin fin and plates are used to increasing the heat from base to surrounding. An extended surface geometry is divided in two types such as a straight fin and annular fin. The heat transfer takes place by an extended surface through the conduction mode within the boundary condition as well as convection heat transfer from boundary condition of the conduction to the surroundings. The radial or concentric annual fins are one of the most common choices for improving the rate of heat transfer from circular tubes. The annular fins can be generally used in transformer, motor cycle and

compact heat exchangers because during the compact heat exchanger needs less volume and large surface area, but in present report the composite fin has been investigated efficiency ratio between with and without coating over the base metal through MATLAB progarming. Generally the fins are connecting to the zone where the heat transfer coefficient is much lower than the other fluid side. The fin generally works under the high temperatures condition and may have corrosion atmosphere. If we use the fins in high temperature side the life of the fin can be reduced, so that increase the life of the fins or protected the core material under the high temperature we use an anti-hostile coating material is coated over the core material by the galvanization process. When used an extended surface is made of two or more different materials it is called composite fin. The construction of the composite fins either the galvanization process or electrochemicalprocess. Galvanization process is a process melting the coating material in a pattern, after melting the coating material the base or core metal is fall down over the melting coating material. After few seconds' core metal are removed from the pattern and just look like a composite material. The different types of the coating materials are used over the base material such as Zinc, Aluminium, Silicon, Copper, Silver, Nickel, Lead, Aluminium Oxide, Tin and the alloys of Aluminium, Tin, Lead andCopper. The coating of different materials and their alloys are used to protect the base material from the different environmental condition such as morehighly polluted air in industrial regions, high intensity of rain falls,moistures content of theair,water contains chemical pollutants and marine water are effects on the coating materials. Due to these effects the coating materials are destroyed by corrosion but the base material is protected, so that the life of the fin is increase.

Balaji and Srinivas[1]discussed the effect of coating on the efficiency of annular fin. He has observed that high thermal conductivity coating materials are reducing the temperature variation from base to tip.

Kundu and Das[2] reported the performance of elliptic fin has been analysed using a semi analytical technique. He has also shown the efficiency of elliptic fin by using sector method.

Lalot, Tournier and Jensen[3] discussed the fin efficiency of annular fin made of two materials by using the arithmetic special mean approximate method.

Chi-Yuan Lai[4] reported the thermal performance of singular annular fin with variable thermal properties such as heat transfer coefficient and thermal conductivity. He has also describe the singular annular fin can be divided into several circular sections and each section is taken its variable thermal properties. The results obtained from each section have been combined each section and calculated by using recursive formula.

Mokheimer[5] investigated the performance of annular fins of different profiles subject to locally variable heat transfer coefficient. The performance of the fin expressed in terms of fin efficiency in the form of curves known as the fin-efficiency curves for different types of fins.

Horibe, ZhongminandHaruki[6] discussed the composite fin are made of coating layer over a core metal then calculation efficiency of the fins by an analytical process. He has also investigated the theoretical results show that fin efficiency of a coated fin decreases with an increase of the coating layer thickness if the thermal conductivity of coating layer is much less than that of the substrate metallic fin and vice versa.

II. METHODOLOGY

II.1.Material selection

In the present study, the base fin material will be selected is steel and the coating fin material are use zinc and zinc alloy (Zn 95.37%, Al 4.3%, Cu 0.25%) over the base fin to see the table no. 2.1

II.2.Modeling of annular fin using MATLAB –

Using MATLAB software to simulate the result and that resultwill be comparewith the journal data that are available in the literature [1].

II.3. Physical model

The sketch of an annular composite fin with rectangular profile is shown in the fig. 2 (a) & (b) with the coordinate system and the dimensions are adopted for the development of formulation in this model.

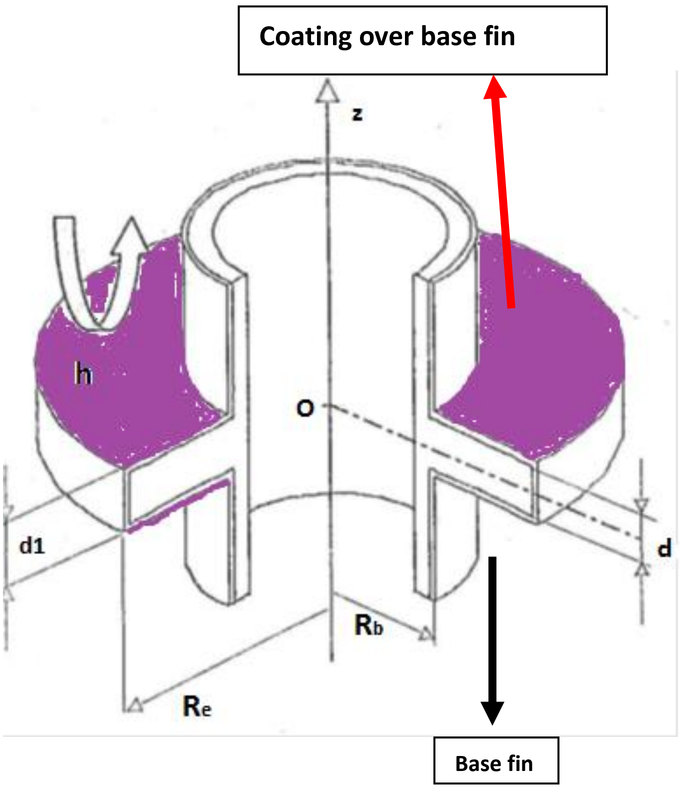

Fig. 2.(a) physical model of an annular composite fin with rectangular profile

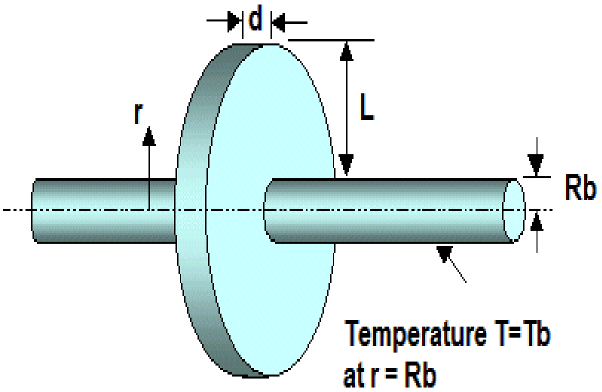

Fig. 2.(b) Circular fins without coating

The mathematical formulation is based upon the following assumption:

1. The fin materials of each zone are considered as homogeneous.
2. The fin materials of each zone are isotropic.
3. Neglected the heat transfer at the fin end.
4. Neglected the physical contact resistance between the cylindrical tube and fin base.
5. Neglected the physical contact resistance between the base fin (steel) and coated fin (zinc).

Control volume element for heat (energy) balance Consider a small control volume element having sides of length ‘dr’ and thickness ‘dz’.
Solve the equations (partial differential form) of heat propagation in the core material (region-1) of the fin and the coated material (region-2) of the fin.

II.4.Range of investigation of the annular composite fin

Table no. 2.1

Tube Material	Steel
Tube Diameter (outer)	10 to 50 mm
Thermal Conductivity of Steel	50 W/mK
Base metal Fin	steel
Coating material	Zinc and Zinc alloy
Thermal Conductivity of Coating Materials like zinc & zinc alloy	111 W/mK and 113W/mK
Coating Thickness	50 to 150 μm
Base Metal Fin Thickness	0.2 to 1 mm
inner Radiusfin	0.01 m
outer Radiusfin	0.03 m
Surrounding Temperature	303 K
Fin Base Temperature	523 K

III. RESULTS AND DISCUSSION

The following results were obtained by using the MATLAB coding

III.1.Variation of efficiency ratio with respect to the heat transfer coefficient

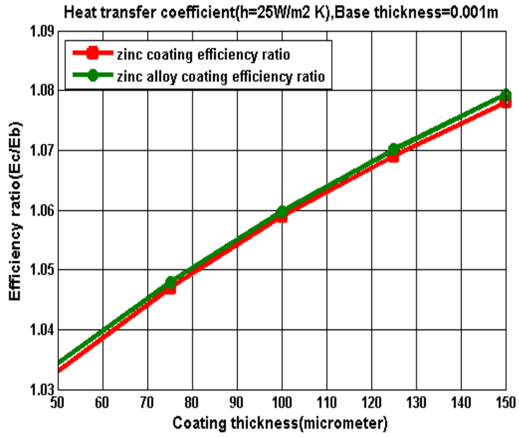

Figure 3.1 (a) Comparison of efficiency ratio against coating thickness at h=25W/m^{2}K for both zinc and zinc alloy coating

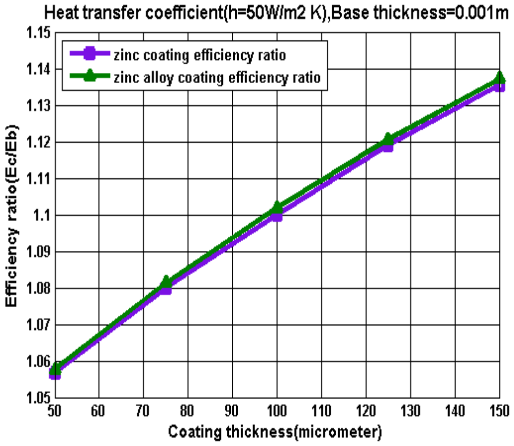

Figure 3.1 (b) Comparison of efficiency ratio against coating thickness at h=50W/m^{2}K for both zinc and zinc alloy

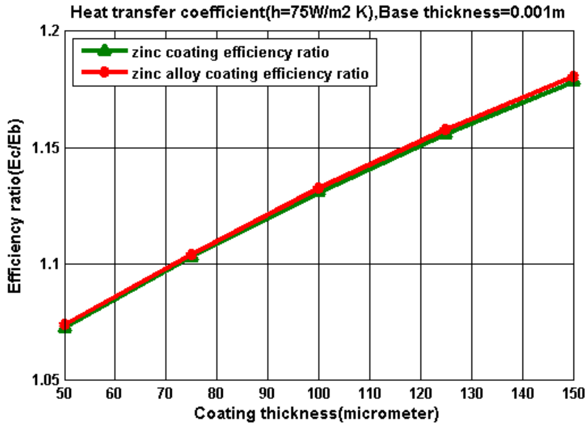

Figure 3.1 (c) Comparison of efficiency ratio against coating thickness at h=75W/m^{2}K for both zinc and zinc alloy coating

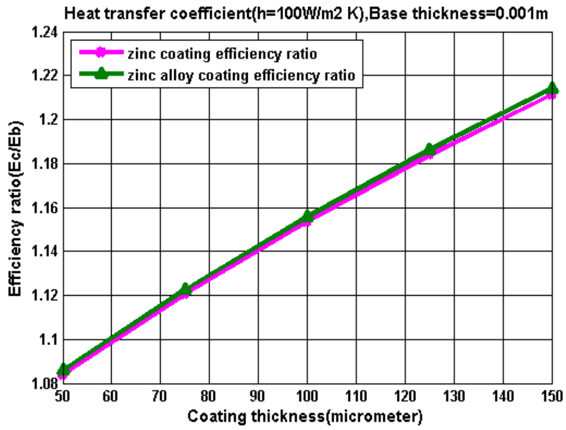

Figure 3.1 (d) Comparison of efficiency ratio against coating thickness at h=100W/m^{2}K for both zinc and zinc alloy coating.

When study the influence of convection heat transfer coefficient such as (h=25W/m^{2}K, h=50W/m^{2}K, h=75W/m^{2}K and h=100W/m^{2}K) the other variable like fin base radius (R_b), fin tip radius (R_e) and core thickness (d) were kept constant. Then the following observations were made from the graphs shown in figure 3.1 (a) to figure 3.1 (d) are given below

(i) Fin efficiency ratio is directly proportional to the coating thickness. If fin efficiency ratio decreases with decreasing the coating thickness and vice versa.

(ii) Fin efficiency ratio is directly proportional to the heat transfer coefficient. If fin efficiency ratio increases with an increase in convection heat transfer coefficient and vice versa.

(iii) Fin efficiency ratio of zinc coating fin is lesser than that the zinc alloy coating fin.

III.2.Variation of efficiency ratio with respect to the radius ratio –

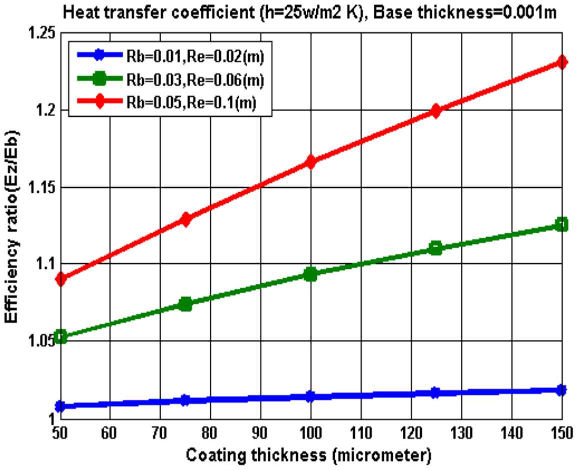

Figure 3.2 (a) Comparison of efficiency ratio against coating thickness at h=25W/m^{2}K for variation of radius ratio using zinc coating

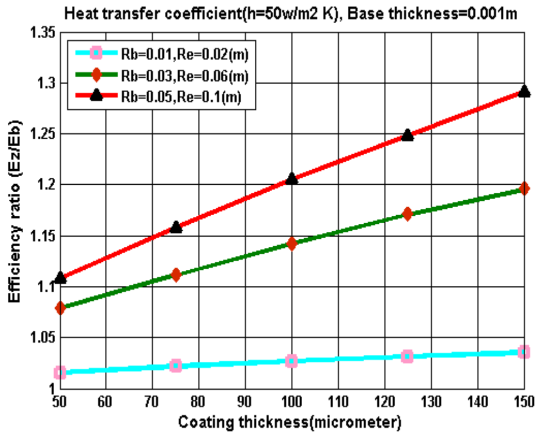

Figure 3.2 (b) Comparison of efficiency ratio against coating thickness at h=50W/m^{2}K for variation of radius ratio using zinc coating

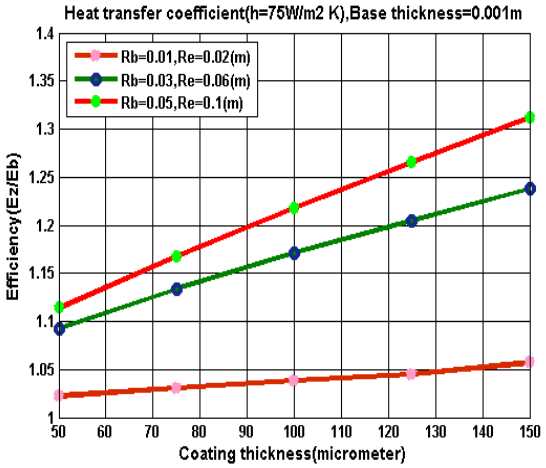

Figure 3.2 (c) Comparison of efficiency ratio against coating thickness at h=75W/m^{2}K for variation of radius ratio using zinc coating

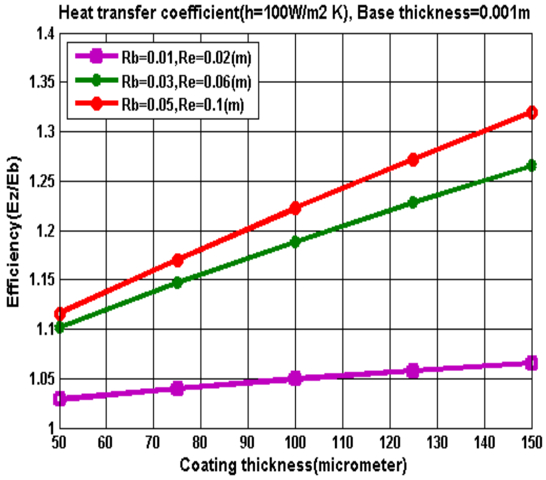

Figure 3.2 (d) Comparison of efficiency ratio against coating thickness at h=100W/m^{2}K for variation of radius ratio using zinc coating

When study the changes of base radius by the variation of heat transfer coefficient, the graphs were drawn against the efficiency ratio vs. coating thickness as shown in figure 3.2 (a) to figure 3.2 (d). The plots were drawn the three different values of base radius i.e. (R_b= 0.01m, R_b=0.02m and R_b=0.05m) but the thickness of base material (d) fin were kept constant. The radius ratio has been taken from the journal [1] i.e. (R_e / R_b) = 2. Then the following observations were made from the graphs shown in figure 3.2 (a) to figure 3.2 (d) are given below

(i) If taken given radius ratio (R_e / R_b) above the data, the length of the fin isdirectly proportional to the base radius. If the base radius is increases then the length of fin and their corresponding temperature gradient of the fin are also increases. So that the efficiency of the both fins such as without coating and with coating fin is decreases, but the efficiency ratio is increases.

(ii) When the heat transfer coefficient is 50 W/m^{2}K, the increase efficiency ratio is 10.46 - 28.02% for Zinc coated fin from the journal [1], but it has been found that the increase efficiency ratio is 9.3 - 25.54% for zinc coated fin by using MATLAB.

(iii) If the convective heat transfer coefficient is increase 25 to 50 W/m^{2}K, it has been found that the efficiency ratio is increase, but after that increase the convective heat transfer coefficient 75 to 100 W/m^{2}K the efficiency ratio is decreases.

Increasing in efficiency ratio of the zinc and zinc alloy coating by the variation of heat transfer coefficient and changes in radius ratio of the fin are given on table no. 3.1 and then compare with the journal result and MATLAB result at heat transfer coefficient is 50 W/m^{2}K are given below

Heat transfer coefficient (W/m^{2}K)	Increasing efficiency ratio of zinc	Increasing efficiency ratio of Zinc alloy	Journal result of efficiency ratio in zinc and zinc alloy
25	8.2-21.19%	8.36-21.49%	
50	**9.3-25.54%**	**9.48-25.96%**	**10.46-28.02%, 10.63-28.34%**
75	9.2-25.47%	9.35-25.93%	
100	8.75-25.43%	8.92-25.9%	

Table no. 3.1

III.3.Variation efficiency ratio with respect to the thickness of base material

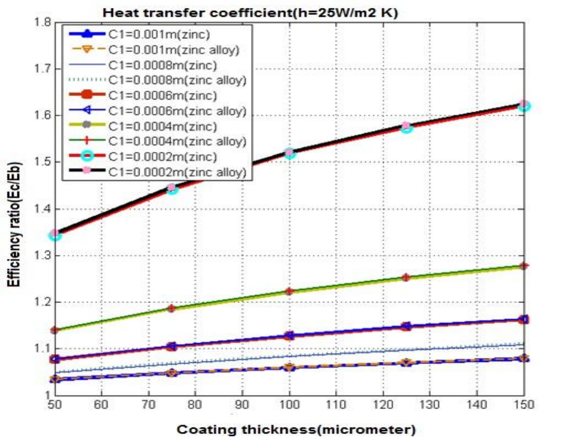

Figure 3.3 (a) Comparison of efficiency ratio against coating thickness at h=25W/m^{2}K for variation of the thickness of base material using zinc& zinc alloy coating

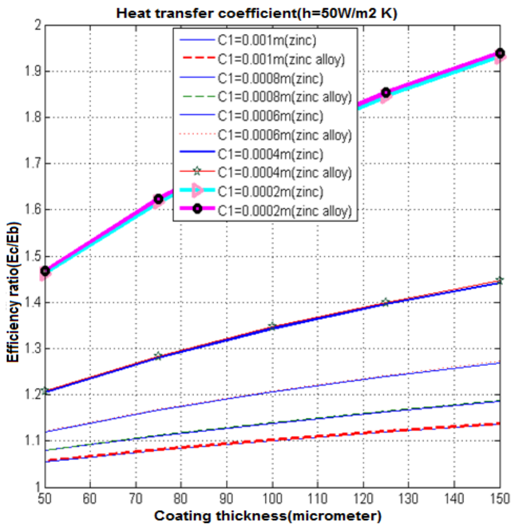

Figure 3.3 (b) Comparison of efficiency ratio against coating thickness at h=50W/m^{2}K for variation of the thickness of base material using zinc & zinc alloy coating

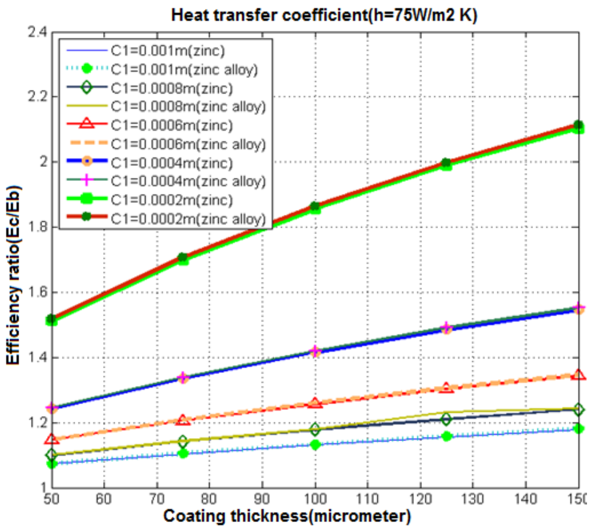

Figure 3.3 (c) Comparison of efficiency ratio against coating thickness at h=75W/m^{2}K for variation of the thickness of base material using zinc & zinc alloy coating

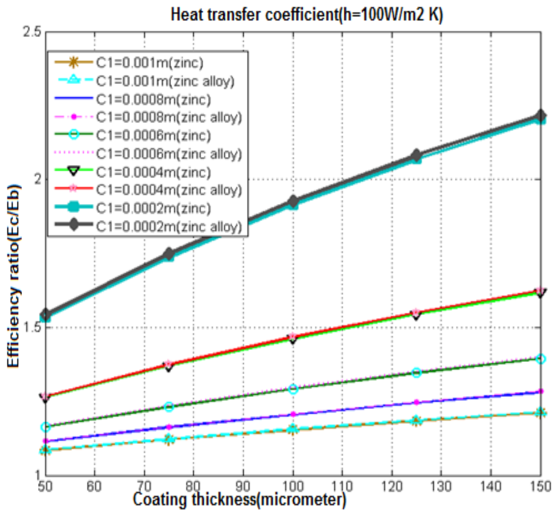

Figure 3.3 (d) Comparison of efficiency ratio against coating thickness at h=100W/m^{2}K for variation of the thickness of base material using zinc & zinc alloy coating

Effects of change in thickness of base material on the variation of heat transfer coefficient. The graphs were drawn against the efficiency ratio vs. coating thickness as shown in fig.3.3 (a) to fig.3.3 (d), but the base fin radius (R_b) and outer fin radius (R_e) both are keeping constant. The other parameters are changes like thickness of base material and coating thickness. Then the following observations were made from the graphs shown in figure 3.3 (a) to figure 3.3 (d) are given below.

(i) From the journal [1] has been taken the gain efficiency ratio of the thicker base fin (d=0.001m) is 11.72 % and the thinner base fin (d=0.0002m) is 33.57 % for Zinc coating, but the gain efficiency ratio in thicker base fin (d=0.001m) is 7.45% and the thinner base fin (d=0.0002m) is 32.14% for zinc coating by using the MATLAB. The both results have been compared at heat transfer coefficient is 50 W/m^{2}K.

(ii) The gain efficiency ratio of the thicker base fin (d=0.001m) is 11.92 %, and the thinner base fin (d=0.0002m) is 33.61% for coating with Zinc alloy from the journal [1], but the gain efficiency ratio of the thicker base fin (d=0.001m) is 7.51% and the thinner base fin (d=0.0002m) is 32.15% for zinc alloy coating by using the MATLAB. The both results have been compared at heat transfer coefficient is 50 W/m^{2}K.

(iii) It has been found that the efficiency ratio of the fin is decreases if increasing the base material thickness.

(iv) It has found that the increasing heat transfer coefficient the efficiency ratio is increasing and vice versa.

Table no. 3.2

H.T.C (h) (W/m^2K)	Efficiency ratio of zinc		Efficiency ratio of zinc alloy		Journal result of efficiency ratio in zinc and zinc alloy	
	d= 0.001 (m)	d=0.0002 (m)	d=0.001 (m)	d=0.002 (m)	d=0.001, 0.0002(m)	d=0.001, 0.0002 (m)
25	4.29%	19.13%	4.33%	20.59%		
50	**7.45%**	**32.10%**	**7.51%**	**32.22%**	**11.72%, 33.57%**	**11.92%, 33.6%**
75	9.84%	39.12%	9.93%	39.22%		
100	11.69%	43.55%	18.11%	43.7%		

IV. CONCLUSION

In this project report, study or focus on the efficiency ratio of a radial composite fin by the variation of heat transfer coefficient and other geometrical parameter of the fin. When coating likes zinc and zinc alloy materials over the base fin (steel) metal under the 2-D steady state condition.

The following conclusions were drawn is given below

1. If the fin radius is increased from (R_b= 0.01to 0.05m) at heat transfer coefficient 50W/m^2K and coating thickness at 50µm, the efficiency of the base fin is reduces by (η_b=0.9145 to 0.3507) and efficiency of zinc coating fin is reduces by (η_z=0.9288 to 0.3888) but the efficiency ratio is increased 9.3% as compare the base efficiency.
2. Increasing the base thickness from (d=C1=0.0002 to 0.001m) at heat transfer coefficient 50W/m2K and coating thickness at 50µm, the efficiency of the base fin is increases by (ηb=0.3435 to 0.6934) and efficiency of zinc coating fin isincrease by (ηz=0.5020 to 0.7327) but the efficiency ratio is increases 7.45% as compare the base efficiency.
3. Coating is more efficient for the thinner fin.
4. Increase the heat transfer through the fin with increase the heat transfer coefficient
5. If surface temperature is increase then the efficiency of the fins is decrease.

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