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# Fin Efficiency Analysis In Electronic Devices Considering Temperature, Heat Transfer, Coefficient, Fin Length

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Abstract—**Research work has proposed the Fin Efficiency Analysis in Electronic Devices. When the fin is infinitely long then the temperature at the tip of the fin are essentially that of the fluid. The fin tip is insulated when Conduction heat transfer at x = L is equal to zero. Fin efficiency has been defined as the ratio related to actual heat transfer. It has been done to the maximum heat transfer withinfin. It is done in the situation of whole fin area is situated at temperature which is basic. It has been analyzed that the perforation related to fin makes increment in heat dissipation rate. At this time, it makes decrement in the expenditure related to fin material. Comparative analysis has been proposed related to cases when heat transfer, length and temperature are varied. If temperature has been increased then heat transfer got increased but the efficiency and effectiveness is not affected In Simulation related to finarray has been made on MATLAB platform consider influencing factors such Temperature (Temp) (Tb), Straight rectangular fins (W/m.K), Heat transfer coefficient (W/m.K), Ambient air condition (T∞), Fin Length (L) in meter, Fin thickness (t) in meter, Fin Width(w) in meter.. The present work would be able to optimize the problem related to natural convection heat transfer. The variation related to effectiveness with respect to base temperature. There would be decrement in the effectiveness related to rectangular and triangular at the time of the increment of base temperature.**

**Keywords— Heat Transfer, Coefficient, Fin Length, Baffle, Surface Roughness, Plate Fins, Offset Strip Fins, Matlab Script**

## I. INTRODUCTION

Heat transfer by convection between a surface and the fluid surrounding can be increased by attaching to the surface is called as fins [25].A fin has been considered as thesurface. Ithas been extended from an object. It has been done in order to increase the rate related to heat transfer. This heat transfer may be to the environment with the increment of the convection. For the principle related to conduction, convectionradiation related to pin configuration determines the amount related to heat it transfers. In order to increase the temperature variation between fin configurations and varies as per the environment, slightly increasing the convection coefficient of the heat transfer. [21].

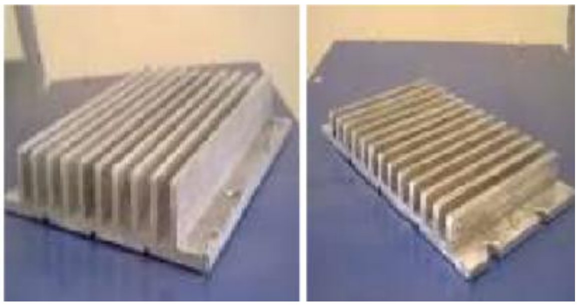

Figure 1 Fin Array or Extended Surface (Source: [62])

Extension on the finned surfaces has been applied in orderto increase the surface area. This area is related to fin in contact within fluid flowing that is situated around it. Therefore, as the surface area more fluid contact to increase the rate related toheat transfer related to extension provided on fin such as (a) Rectangular extensions, (b) Trapezium extensions, (c) Triangular extension, and (d) Circular Segmental extension [22].

## II. HEAT TRANSFER ENHANCEMENT

Heat transfer enhancement can be referred as the heat transfer intensification. It plays an important part in the appsof thermal systems. Here are the chances of overheating side effect on the components related to architecture. In that situation, transfer intensification methods have been used in apps applicable in industrial [23]. To avoid such issues, these techniques are applicable. Three mechanisms are discussed here which are used to enhance the heat transfer enhancement.

Active method – In this method, some external power source is required to increase the heat transfer e.g. induction pulsating related to cam and reciprocating plunger, use related to magnetic field to disturb particles related to flowing fluid[23].

Passive method-For augmentation, there is lack of external power is used. For example the treating surface, roughness surface etc. are considered here. [23].

Compound method- Compound method is related to the combination that has been made between the active and passive techniques [23].

Method to Increase the Heat transfer

Surface Roughness: using therough surfaces, the heat transfer has been increased. Four shapes are used for the investigation of the heat transfer enhancement. These shapes aresemicircle,

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sine wave, trapezoid, and arc. Here using such shapes, the friction factor on rectangular duct is also used. [30].

Baffle:In complicated component, the turbulent flow is able to increase the heat transfer. As the example the design related to nuclear reactors, exchangers of the heat,machine used for cooling etc can be discussed [31]. Baffles are able to enhance the pressure losses and the heat transfer coefficients. [23].

Perforated baffle: The heat transfer and friction in an asymmetrical rectangular duct with some solid and perforated baffles with relative roughness. It has been seen that the friction factor has been achieved between 9.6-11.1 times as compare to smooth duct. It is able to make in perforated baffle. The open area baffle provides the highest [32].

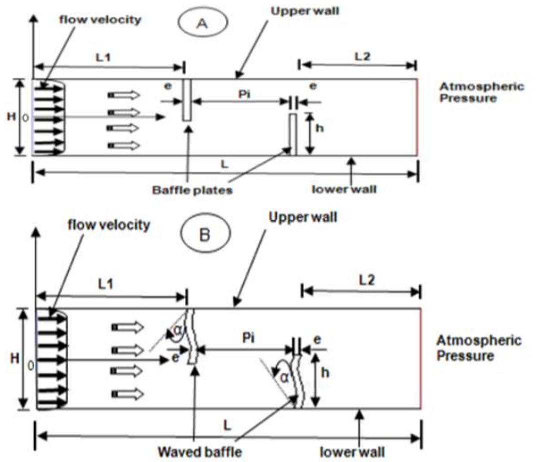



Figure 2: The Geometry Related to the System Under Investigation (A) Plate Baffles (B) Waved Baffles(Source:[31]

Inclined baffle: the effect related to local heat transfer and friction factor in a rectangular pipe with inclined and perforated baffles. Two baffles were applied in this experiment, one was mounted at the top and another one varied to identify optimum configuration for enhancement related to heat transfer [33].

## III. OBJECTIVE OF THE RESEARCH WORK

The research work has considered the following objectives:

1. To propose simulation for fin array considering thickness, length and width related to fin in order to resolve the issues related to heat in nano technology [1,4,7,9,13,14,20,22,25,55,58,59].
2. Calculation fin efficiency by modification the value related to temperature, fin length, fin heat coefficient [1,4,7,9,13,14,20,22,25,55,58,59]
3. Calculation fin effectiveness by modification the value related to temperature, fin length, fin heat coefficient [1,4,7,9,13,14,20,22,25,55,58,59]
4. Calculation heat transfer by modification the value related to temperature, fin length, fin heat coefficient [1,4,7,9,13,14,20,22,25,55,58,59].

## IV. PROPOSED WORK

Convection heat transfer between a hot solid surface and the surrounding colder fluid is governed by the Newton's cooling law which states that "the rate of convection heat transfer is directly proportional to the temperature difference between the hot surface and the surrounding fluid and is also directly proportional to the area of contact or exposure between them". Newton's law of cooling can be expressed as

$$Q_{conv} = hA(T_S - T_\infty) \tag{4.1}$$

Where, h = convection heat transfer coefficient

$T_S$ =Hot surface temperature

$T_\infty$ =Fluid temperature

A=area of contact or exposure

Therefore, convection heat transfer can be increased by either of the following ways-

1. Increasing the temperature difference ( $T_S - T_\infty$ )between the surface and the fluid.
2. Increasing the convection heat transfer coefficient by enhancing the fluid flow or flow velocity over the body.
3. Increasing the area of contact or exposure between the surface and the fluid.

## V. RESULT AND DISCUSSION

It has been analyzed that the perforation related to fin makes increment in heat dissipation rate. At this time, it makes decrement in the expenditure related to fin material [4].

In Simulation related to finarray has been done on MATLAB platform consider influencing factors such Temperature (Temp) ($T_b$),

Straight rectangular fins (W/m.K),

Heat transfer coefficient (W/m.K),

Ambient air condition ($T_\infty$),

Fin Length (L) in meter,

Fin thickness (t) in meter

Fin Width(w) in meter.

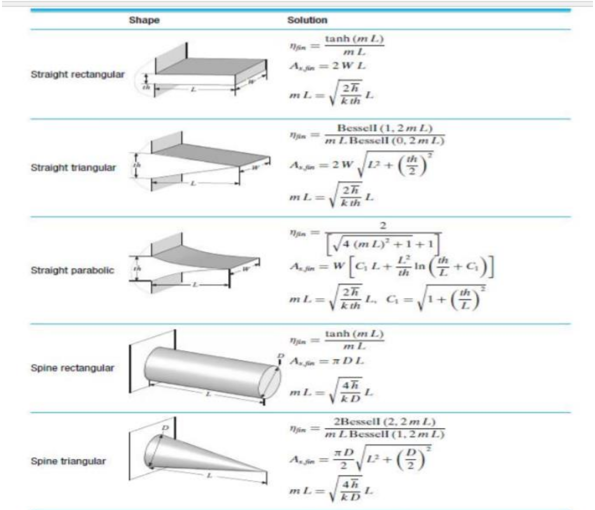



Figure 3 Solutions For a Uniform and Non-uniform Cross-Section Area Fin(Source:[57])

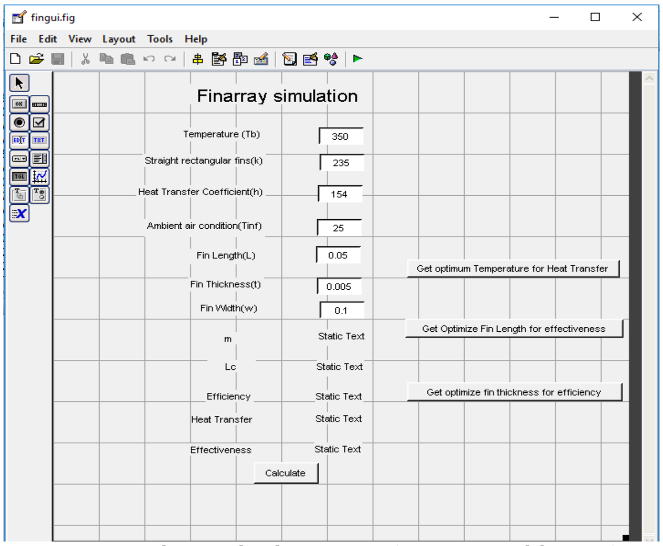



Figure 4 Simulation Related to Fin Array(Source: Own elaboration)

**Efficiency related to fin (η):**

The fin efficiency is defined as the ratio related to the actual heat transfer to the maximum heat transfer by the fin, if the entire fin area is at base temperature [26].

$\eta$ =actual heat transfer rate from the fin/heat dissipated if the whole surface of fin were maintained at the base temperature

$$\eta_{th} = \frac{\operatorname{Tanh} mL}{mL}$$

**Effectiveness related to the fin** (ϵ)**:**

Effectiveness related to the fin is the fin heat transfer rate (heat dissipation with a fin) to the heat transfer rate that would exist without a fin [26].

The equation to determine the effectiveness related to fin (ϵ) is as follows

$$\varepsilon = \frac{Q_a}{Q_b} = \frac{\int_a^b Ph(T - T_a)}{A_C h(T_b - T_a)} = G\int_a^b u dx$$

$$\varepsilon = \frac{Q_{withfin}}{Q_{withoutfin}}$$

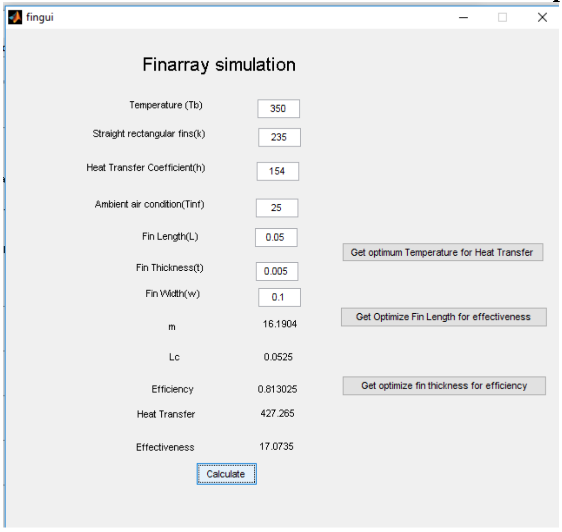
$$\varepsilon = \frac{Q_{withfin}}{Q_{withoutfin}} = \frac{(T_b - T_\infty)\sqrt{A_C hPk}}{hwt(T_b - T_\infty)}$$

**Heat transfer**($\mathbf{Q_{fin}}$)

Heat transfer calculated by using the heat transfer governing differential equation for the fin related to finite length and loses heat by convection [58].

$$Q_{fin} = -kA_C\left(\frac{dT}{dx}\right)_{x=0} = \sqrt{hPkA_C}\,\theta_0 \operatorname{Tanh} mL$$

**Case1: Standard input**




Figur 5 Simulation Related to Fin Array For Standard Input(Case1) (Source: Own elaboration)

**Case2: Decrease the heat transfer coefficient (h)**

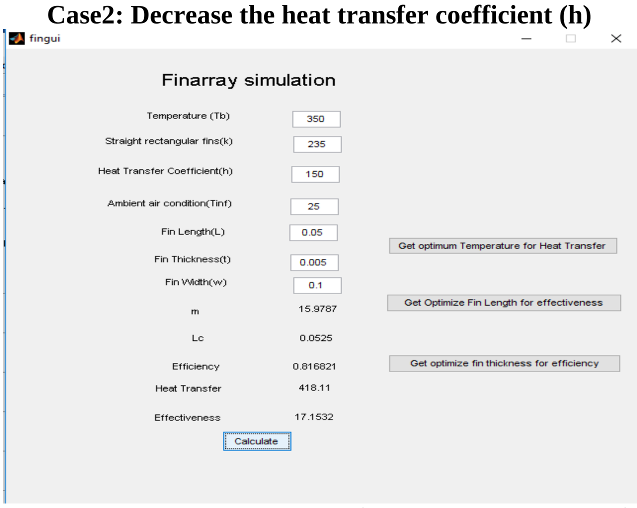



Figure 6 SimulationRelated to Fin Array after Decreasing the Heat Transfer Coefficient (h) (Case2) (Source: Own elaboration)

**Table 1 Comparative Analysis When Heat Transfer Coefficient (h)is Decrease**

| | |
|---|---|
| Heat transfer coefficient 154 | Heat transfer coefficient 150 |
| m = 16.1904 | m = 15.9787 |

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| | |
|---|---|
| $L_C$ = 0.0525 | $L_C$= 0.0525 |
| x =0.8500 | x = 0.8389 |
| afin = 0.0105 | afin = 0.0105 |
| efficiency($\eta_{th}$) = 0.8130 | efficiency($\eta_{th}$) = 0.8168 |
| heattransfer( $Q_{fin}$ )=427.2650 | heattransfer( $Q_{fin}$ )=418.1102 |
| qwithoutfin ($Q_{without\ fin}$) = 25.0250 | qwithoutfin ($Q_{without\ fin}$) = 24.3750 |
| effectiveness( $\varepsilon$ )= 17.0735 | effectiveness( $\varepsilon$ ) = 17.1532 |

From table 4.2 it conclude that after decreasing the value related to heat transfer coefficient
1. Heat transfer ($Q_{fin}$) decrease
2. Fin efficiency($\eta_{th}$) increase
3. Effectiveness ( $\varepsilon$ ) increase

**Case 3: Effect related to increasing Fin Length Input:**

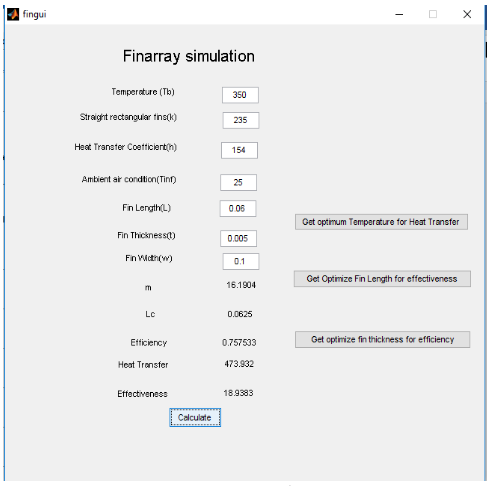


Figure 7 Simulation Related to Fin Array After Increasing The Fin Length(L) (Case 3)(Source: Own elaboration)

Table 2 Comparative Analysis When the Fin Length(L)Related to Modified

| Fin Length 0.05m | Fin Length 0.06m |
|---|---|
| m = 16.1904 | m = 16.1904 |
| $L_C$ = 0.0525 | $L_C$ = 0.0625 |
| x =0.8500 | x = 1.0119 |
| afin = 0.0105 | afin = 0.0125 |
| efficiency ($\eta_{th}$) = 0.8130 | efficiency ($\eta_{th}$) = 0.7575 |
| heattransfer ( $Q_{fin}$ ) = 427.2650 | heattransfer( $Q_{fin}$ ) =473.9316 |
| qwithoutfin($Q_{without\ fin}$)= 25.0250 | qwithoutfin($Q_{without\ fin}$)= 25.0250 |

| | |
|---|---|
| effectiveness( $\varepsilon$ )= 17.0735 | effectiveness ( $\varepsilon$ )= 18.9383 |

From table 5.3 it conclude that after increasing the value related to fin length (L)
1. Heat transfer ( $Q_{fin}$ ) increase
2. Fin efficiency($\eta_{th}$)decrease
3. Effectiveness increase

**Case 4: Effect related to increase in Temperature** ($T_b$)

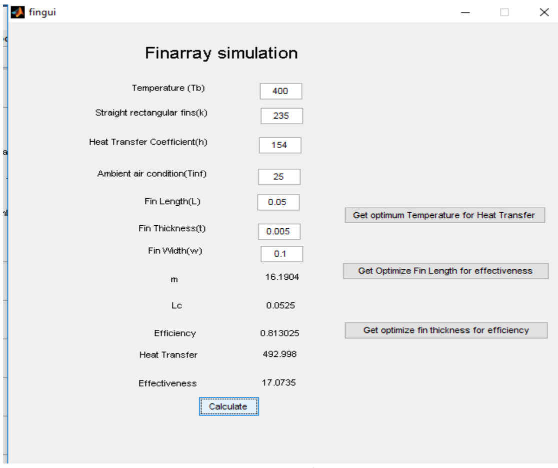


Figure 8 Simulation Related to Fin Array after Increasing the Temperature ($T_b$) (Case 4) (Source: Own elaboration)

Table 3 Comparative Analysis Temperature is Related to modified

| Temperature 350 degree | Temperature 400 degree |
|---|---|
| m = 16.1904 | m = 16.1904 |
| $L_C$ = 0.0525 | $L_C$ = 0.0525 |
| x =0.8500 | x = 0.8500 |
| afin = 0.0105 | afin = 0.0105 |
| efficiency ($\eta_{th}$)= 0.8130 | efficiency ($\eta_{th}$)= 0.8130 |
| heattransfer ( $Q_{fin}$ ) = 427.2650 | heattransfer( $Q_{fin}$ ) = 492.9981 |
| qwithoutfin( $Q_{withoutfin}$ )= 25.0250 | qwithoutfin( $Q_{withoutfin}$ )= 28.8750 |
| effectiveness( $\varepsilon$ )= 17.0735 | effectiveness ( $\varepsilon$ )= 17.0735 |

From table 5.4 it concludes that after increasing the value related to Temperature ($T_b$)
1. Heat transfer ( $Q_{fin}$ ) increase
2. Fin efficiency($\eta_{th}$) remain same
3. Effectiveness remain same

In following Simulation the Optimization related to fin length to get particular effectiveness has been made

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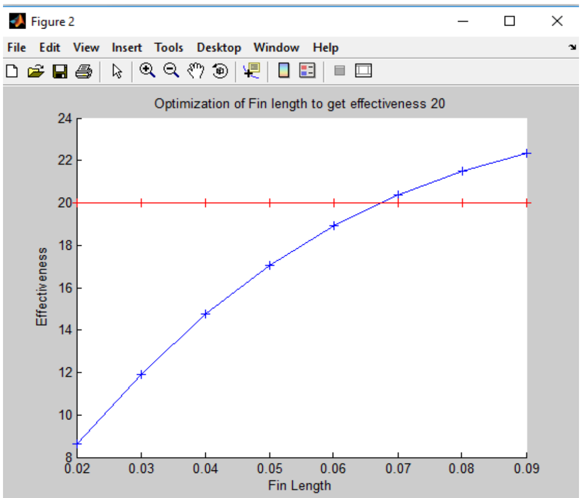


Figure 9 Optimization Related to Fin Length to Get Effectiveness 20 (Source: Own elaboration)

As it could been seen the fin length should be approximately 0.07m to get effectiveness related to 20

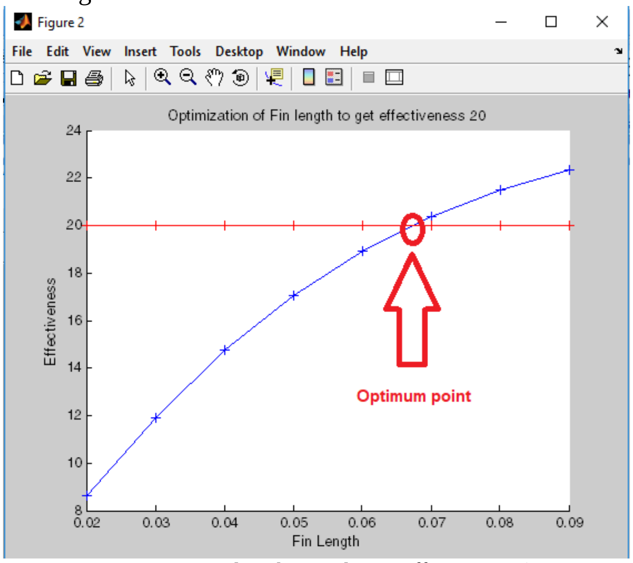


Figure 10 Getting Optimum length according to effectiveness (Source: Own elaboration)

Optimization of Temperature to get Particular Heat Transfer has been shown here as below

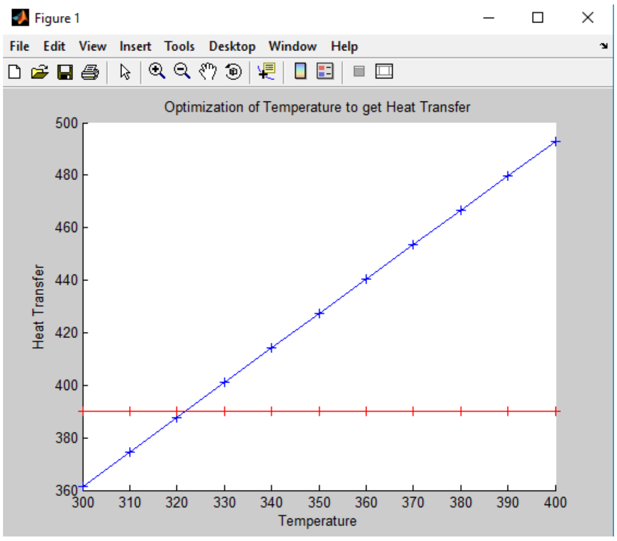


Figure 11 Optimization Related to Temperature to Get Heat Transfer to 390(Source: Own elaboration)

From figure 11, As it could been seen the temperature should be Approximately 320 to get heat transfer related to 390

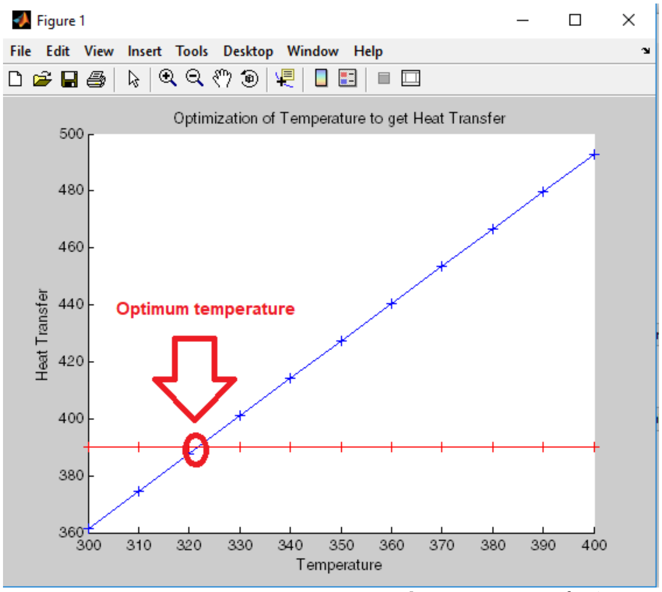


Figure 12 Getting Optimum Temperature According to Heat Transfer (Source: Own elaboration)

Optimization related to fin thickness to get particular Efficiency has been shown here as below:

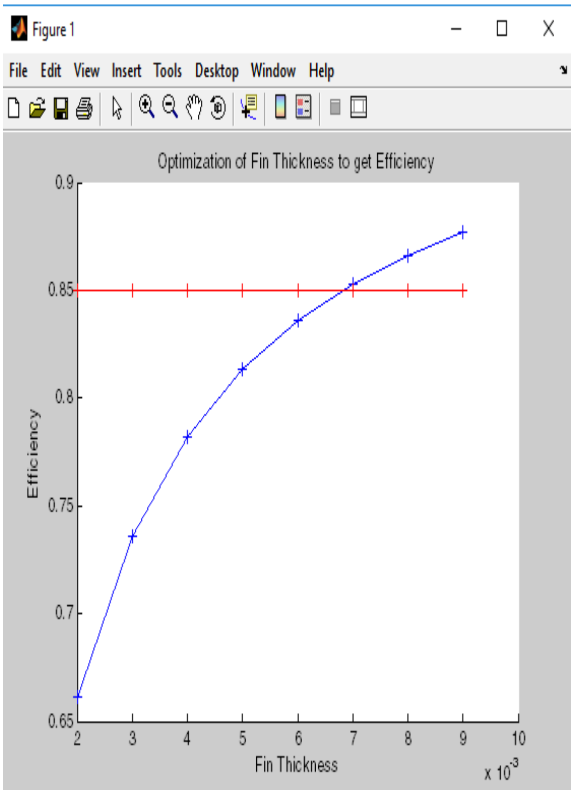


Figure 13 Optimization related to Fin Thickness to get efficiency related to 0.85 (Source: Own elaboration)

As it could been seen the fine thickness should be approximately 0.007 to get heat efficiency related to 0.85

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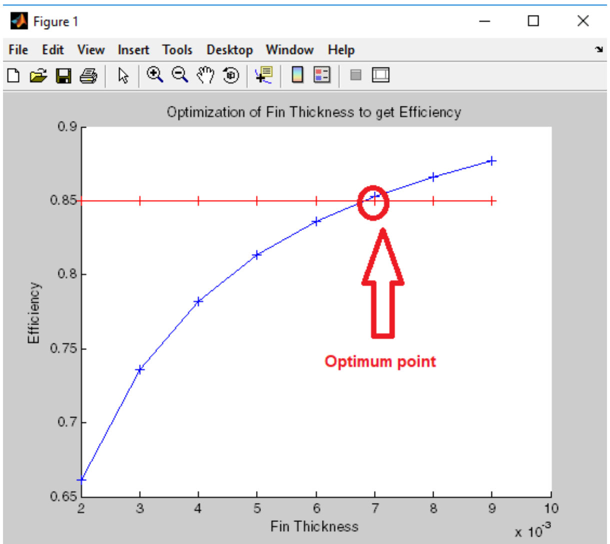


Figure 14 Getting Optimum Efficiency according to Fin Thickness (Source: Own elaboration)

## VI. Conclusion

In this research work, simulation of fin array is done by using MATLAB GUI system. Results for increasing and decreasing of various factors are calculated. Comparative analysis has been proposed related to cases when heat transfer, length and temperature are varied. If the heat transfer coefficient has been reduced then efficiency and effectiveness got increased but the Heat transfer got reduced. If length has been increased then heat transfer and effectiveness got increased but the efficiency got reduced.If temperature has been increased then heat transfer got increased but the efficiency and effectiveness is not affected.

## VII. FUTURE SCOPE

The present work would be able to optimize the problem related to natural convection heat transfer.

The various factors which are considered in the research work would solve the problem related to heating in nanodevice. The variation related to effectiveness with respect to base temperature. There would be decrement in the effectiveness related to rectangular and triangular at the time of the increment of base temperature. The rectangular fin would exhibit with more effectiveness.

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