MAT
JOURNALS

Numerical Study of Heat Transfer through Fin by using ANSYS-Fluent Model

Basima S. Khalaf
Professor, Department of Mechanical Engineering,
Ministry of Higher Education and Scientific Research, Iraq
Al-Mustansiriyah University-Collage of Engineering, Baghdad, Iraq
Email: dr.basima2016@gmail.com
DOI: http://doi.org/10.5281/zenodo.3381857

Abstract
A mathematical model of the process occurring on fin at same height and different height with different heat flux (10000, 20000, 30000 w/m2) have been investigated. The model is developed using principles of heat transfer, fluid dynamics, and these values used for comparing with two height of fin which used in electronically device like computer. The distributions of velocity and temperature was found along flow path of fin cell using the software computer (ANSYS FLUENT 16.1), this software was developed to apply the theoretical model to simple three -dimensional geometry. Finally the optimal heat flux and temperature along fin has been obtained for five tests of fins, and a good agreement is found between theoretical results with previous works.

Keywords: Fins, natural convection, temperature distribution

INTRODUCTION

Extended surfaces, commonly known as fins, often offer an economical and trouble free solution in many situations demanding natural convection heat transfer. Heat sinks in the form of fin arrays on horizontal and vertical surfaces used in variety of engineering applications, studies of heat transfer and fluid flow associated with such arrays are of considerable engineering significance. The main controlling variable generally available to designer is geometry of fin arrays. The natural convection heat transfer from vertical rectangular fin arrays. The different geometrical shapes have also been analyzed for the purpose of comparison and optimization. A length of fin flat becomes ineffective due to the fact that, already heated air comes in its surface contact. In the present study, the fin flats are modified by removing the height fin portion by reduce the length. Passive techniques are treated and structured surfaces, rough surfaces, extended surfaces, displaced enhancement devices, swirl flow devices, additives for liquids and gases, etc.Extended surfaces are widely used passive techniques to enhance heat transfer.

LITERATURE REVIEW

The main objective of this section to review the work carried on fins, two and three dimension. P. Ramamurty Raju a, et al. [1] There study is concerned with generation for aluminum alloy (Al) and estimation of fatigue life under radial fatigue load. Tests are conducted on alloy wheels for fatigue life evaluation under radial loads. Finite element analysis (FEA) is carried out by simulating the test conditions to analyze stress distribution and fatigue life of the alloy wheels. It is observed from analysis that the prediction of fatigue life using FEA is found to be in

Page 27-35 © MAT Journals 2019. All Rights Reserved

close agreement with the corresponding experimental observations.

Trong Nhan et al., [2] used, theoretical expressions of the mean crushing force of the three different square multi-cell tubes were derived by applying the simplified super folding element (SSFE) theory. The profiles of three square multi-cell tubes were divided into several basic angle elements: right corner, T-shape, 3-panel, crass-cross, and 4-panel angle element. Numerical simulations and multi-objective crashworthiness optimization were also performed for the three tubes. B. Venkatesh, et al., [3] focus on reduction of weight and thereby reducing the unbalance forces setup in the system. The helical gear offers high contact and more friction which avoids slippage when compared to spur gear. The numerical solution is done by ANSYS, which is a finite element analysis package. The analytical investigation is based on Lewis stress formula. Deepanraj, et al. [4] proposed a various techniques for cooling of blades and one such technique is to have axial holes along the blade span. Finite element analysis is used to analyze thermal and structural performance due to the loading condition, with material properties of.

S.H. Barhatte1 et al. [5] investigated fin arrays with and without notch at the center experimentally and theoretically. The heat transfer and fluid flow associated with such arrays are of considerable engineering significance. The main controlling variable generally available to designer is geometry of fin arrays. Considering the above fact, natural convection heat transfer from vertical rectangular.

SCOPE OF WORK

The scope of activities included the following:

Background research and understanding of the field of extended surfaces.

Analysis of heat transfer in steel structures by use of 3-D finite element software TAS. (Thermal Analysis Software)

Sensitivity analysis of the parameters that play an important role in heat transfer mechanism towards the assemblies in the form of convection and radiation and within the assemblies in the form of conductivity.

Investigation of the different types of multi-geometry during various temperature.

PROBLEM DESCRIPTION

Extended surfaces or fins are commonly used in engineering applications to dissipate heat. The figure below shows the 3-D geometry of an aluminum heat sink designed for cooling a micro-processor. The thermal conductivity of aluminum is $k = 170$ W m^{-1} K^{-1}. The initial temperature of the heat sink is 293 K. When the microprocessor is operating, the bottom surface of the heat sink is exposed to a constant heat flux of $q = 1000$ W m^{-2}. Forced air flow from a cooling fan over the developed surface maintains the surrounding surface at 323 K. The convective heat transfer coefficient between the fin and the ambient surrounding is at $h = 80$ W m^{-2} K^{-1}. Formulate a transient 3-D FE model to predict (i) the time needed for the heat sink to achieve steady-state conditions, as shown in Fig. 1, and (ii) the temperature distribution within the developed surfaces as shown in Fig. 2.
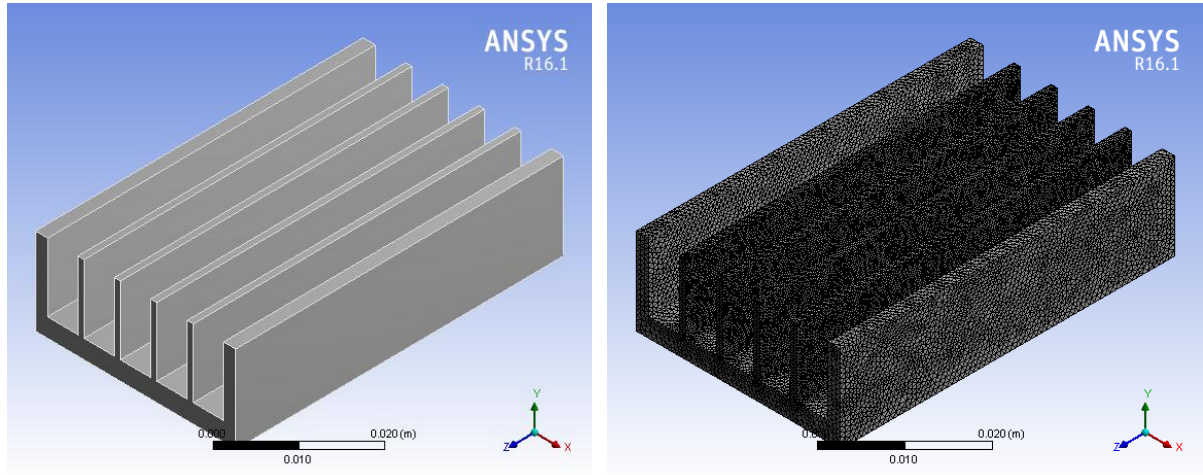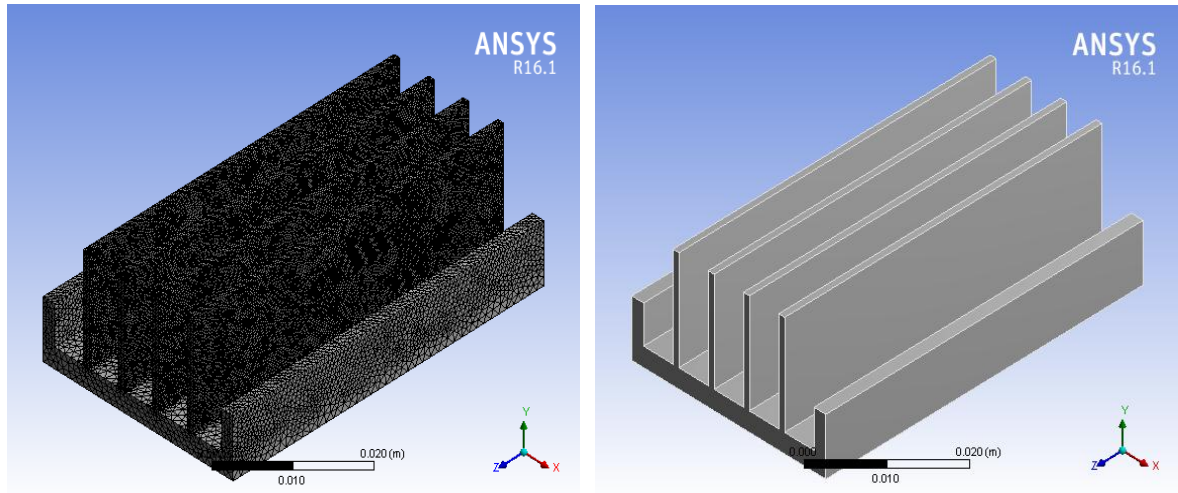
Figure 1: Fin geometry at same height.

Figure 2: Fin geometry at different height.

Governing Equations

The case was mathematically handled by assuming that the flow is a three dimensional, steady state, incompressible flow.

Continuity Equation

$$\frac{\partial}{\partial x}\rho u + \frac{\partial}{\partial y}\rho v + \frac{\partial}{\partial z}\rho w = 0 \tag{3-1}$$

Conservation of Momentum

$$\frac{\partial}{\partial x}\rho u^2 + \frac{\partial}{\partial y}\rho uv + \frac{\partial}{\partial z}\rho uw = -\frac{\partial p}{\partial x} + \frac{\partial}{\partial x}\mu_e\frac{\partial u}{\partial x} + \frac{\partial}{\partial y}\mu_e\frac{\partial u}{\partial y} + \frac{\partial}{\partial z}\mu_e\frac{\partial u}{\partial z} + Sx \tag{3-2}$$

$$\frac{\partial}{\partial x}\rho vu + \frac{\partial}{\partial y}\rho v^2 + \frac{\partial}{\partial z}\rho vw = -\frac{\partial p}{\partial y} + \frac{\partial}{\partial x}\mu_e\frac{\partial v}{\partial x} + \frac{\partial}{\partial y}\mu_e\frac{\partial v}{\partial y} + \frac{\partial}{\partial z}\mu_e\frac{\partial v}{\partial z} + Sy \tag{3-3}$$

$$\frac{\partial}{\partial x}\rho wu + \frac{\partial}{\partial y}\rho wv + \frac{\partial}{\partial z}\rho w^2 = -\frac{\partial p}{\partial z} + \frac{\partial}{\partial x}\mu_e\frac{\partial w}{\partial x} + \frac{\partial}{\partial y}\mu_e\frac{\partial w}{\partial y} + \frac{\partial}{\partial z}\mu_e\frac{\partial w}{\partial z} + Sz \tag{3-4}$$

Where S_x, S_y and S_z are source terms due to body force, and they are equal zero for the case under consideration.

Conservation of Energy

$$\frac{\partial}{\partial x}\rho uT + \frac{\partial}{\partial y}\rho vT + \frac{\partial}{\partial z}\rho wT = \frac{\partial}{\partial x}(\rho\Gamma_e\frac{\partial T}{\partial x}) + \frac{\partial}{\partial y}(\rho\Gamma_e\frac{\partial T}{\partial y}) + \frac{\partial}{\partial z}(\rho\Gamma_e\frac{\partial T}{\partial z}) \qquad (3\text{-}5)$$

Where: $\Gamma_e = \Gamma_l + \Gamma_t$ and $\Gamma_1 = \dfrac{\mu_1}{Pr_l}$; $\Gamma_t = \dfrac{\mu_t}{Pr_t}$

Solver
Choosing of the Solver Formulation
The coupled solver is the solution algorithm using the governing equations of continuity, momentum and energy that are solved simultaneously (i.e., coupled together). Several iterations of the solution loop must be performed before a converged solution is obtained in both solvers. Coupled solver is divided into implicit and explicit.

Specify Material Properties
In FLUENT, many solid/fluid materials and their physical properties (thermal conductivity, specific heat, density, etc.) are specified, if these properties vary with flow, it can specify the appropriate new properties []. Air is a default fluid material in FLUENT, and it's the working fluid in the present study.

Specify the Boundary Conditions
Basic boundary types are specified in pre-processor, and then the case considered is exported to FLUENT. These boundary types take certain values. Walls or interior boundaries take the values of physical properties related in magnitude and direction.

Setting Under-Relaxation Factors
The segregated solver uses under-relaxation to control the update of computed variables at each applicable iteration. In FLUENT, the default under-relaxation parameters for all variables are set to values that are near optimal for the largest possible number of cases [14]. These values are suitable for many problems. It is good practice to begin a calculation using the default under-relaxation factors. If the residuals continue to increase after the first 4 or 5 iterations, it should reduce the under-relaxation factors.

RESULT AND DISCUSSION
In this section, the following results are presented, the effect of the companied used same height fin on the heat transfer enhancement for electronica parts. The numerical results will be discussed, also the comparison between the fin at same height and fin at different height for both heat flux (10000, 20000, 30000 w/m2) will be achieved.

Discussions
Compression Tests Results
Fig. 3 show the variation of the inlet and outlet temperature for air flow through outer same hight fin surface for heat flux (10000 w/m2). It is clear from this figure that the heat flux increase with increasing distance rate. It is found that heat flux increases continuously until steady state occurs.

Fig. 4 shows the variation of temperature along same height fin where the variation of the inlet and outlet temperature for air flow through outer surface fin at tepmerature (39.09°C). It's clear from this figure that the temperature increase with increasing distance rate. It is found that temperature increases continuously until steady state occurs. It shows the relationship between heat transfer and samples. It is observed that for all cases, nusselt number increases with increasing Reynolds number. As expected, heat transfer rates are higher than those from

the plain tube fitted without twisted tape due to increase in turbulent intensity and flow length across the range of Reynolds number.

Fig. 5 shows the variation of the inlet and outlet temperature for air flow through outer same hight fin surface for heat flux (20000 w/m2). It is clear from this figure that the Heat flux increase with increasing distance rate. It is found that heat flux increases continuously until steady state occurs.

Fig. 6 shows the variation of temperature along same height fin where the variation of the inlet and outlet temperature for air flow through outer surface fin at tepmerature (51.13°C). It's clear from this figure that the temperature increase with increasing distance rate. It is found that temperature increases continuously until steady state occurs.

Fig. 7 shows the variation of the inlet and outlet temperature for air flow through outer same hight fin surface for heat flux (30000 w/m2). It is clear from this figure that the Heat flux increase with increasing distance rate. It is found that heat flux

increases continuously until steady state occurs.

Fig. 8 shows the variation of temperature along same height fin where the variation of the inlet and outlet temperature for air flow through outer surface fin at tepmerature (63.29 C). It's clear from this figure that the temperature increase with increasing distance rate. It is found that temperature increases continuously until steady state occurs.

Fig. 9 shows the variation of the inlet and outlet temperature for air flow through outer different hight fin surface for heat flux (10000 w/m2). It is clear from this figure that the heat flux increase with increasing distance rate. It is found that heat flux increases continuously until steady state occurs.

Fig. 10 shows the variation of temperature along different height fin where the variation of the inlet and outlet temperature for air flow through outer surface fin at tepmerature (38.9°C). It's clear from this figure that the temperature increase with increasing distance rate. It is found that temperature increases continuously until steady state occurs.
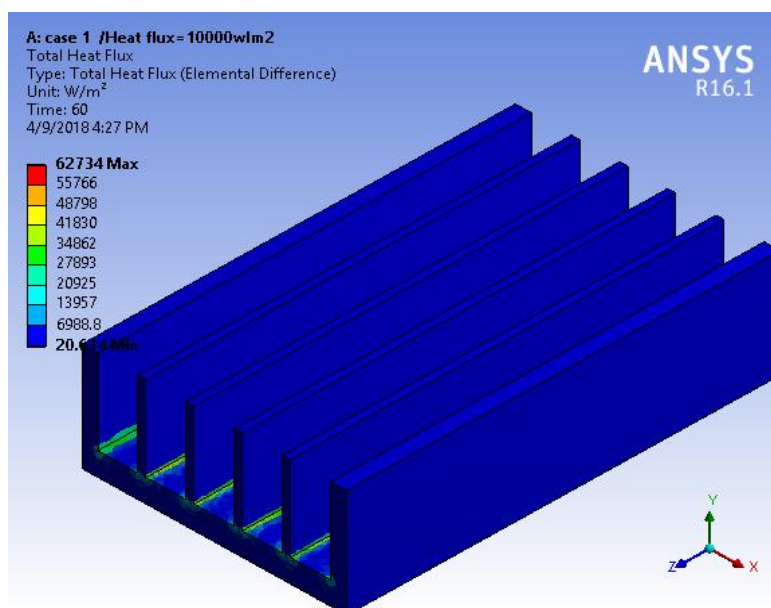
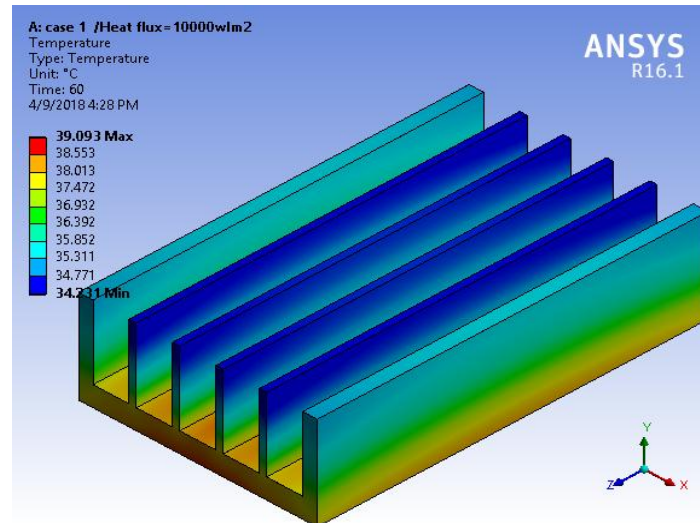*Figure 3: The heat flux of results on model test (10000w/m2).*

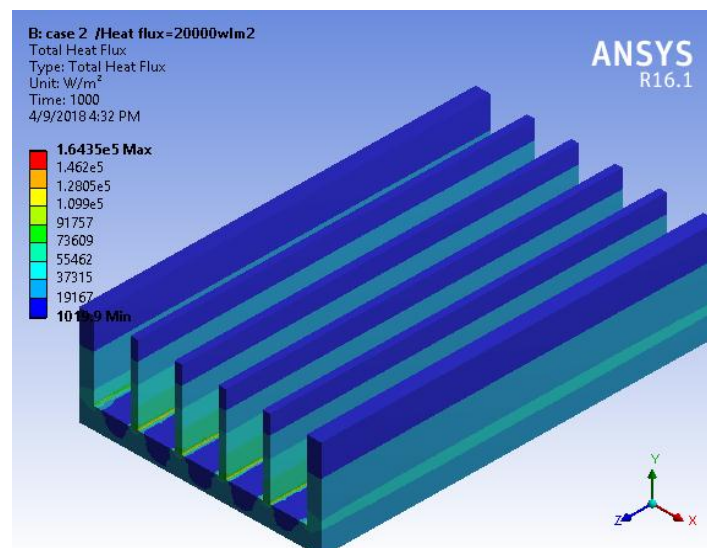**Figure 4:** *The relationship between heat transfers at same height fin thickness (10000w/m2).*

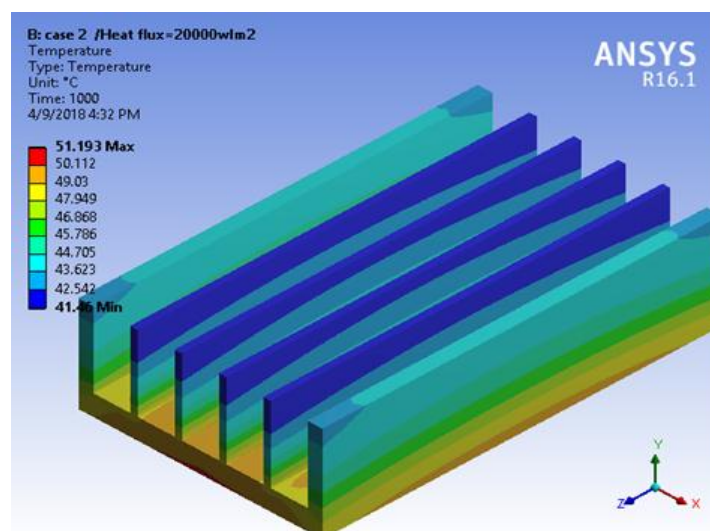**Figure 5:** *The heat flux of results on model test at (20000w/m2).*

Figure 6: *The relationship between heat transfers at same height fin thickness (20000w/m2).*
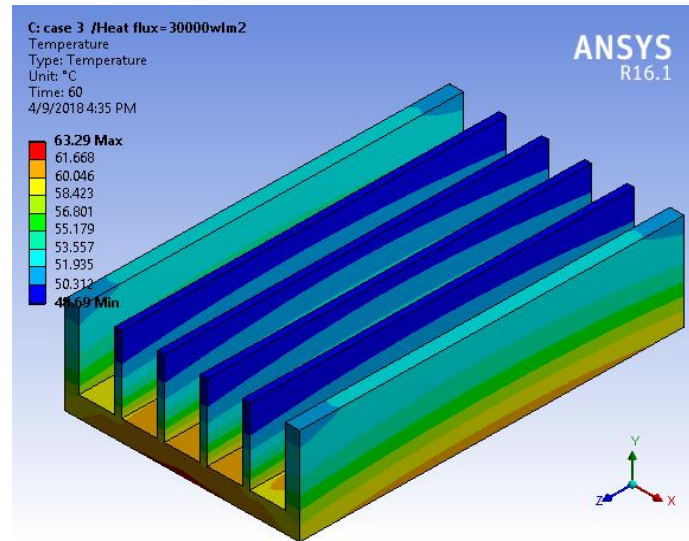
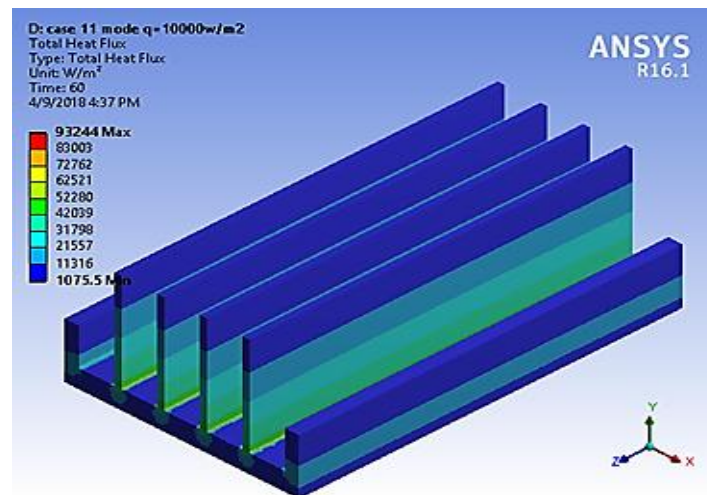**Figure 7:** *The relationship between heat transfers at same height fin thickness (30000w/m2).*

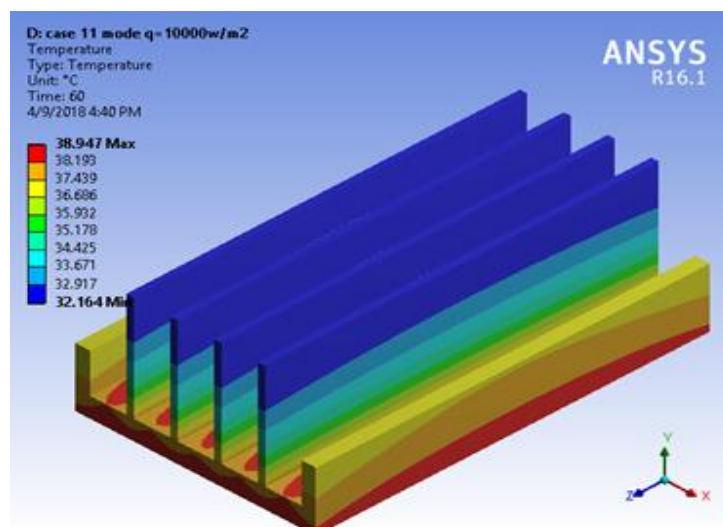**Figure 8:** *The heat flux of results on model test at different height fin thickness (10000w/m2).*

Figure 9: *The relationship between heat transfers at different height fin thickness (10000w/m2).*

A	(Surface area of the duct, (m2)
AC	Cross sectional area of the duct, (
Cp	Specific heat (J/kg. K),
Dh	Hydraulic diameter of ducts,(m)
h	Convection heat transfer coefficient, (W/m^2. K)
K	Thermal conductivity, (W/rn. K)
Lt	Test section length, (m)
m	Mass flow rate, (kg/s)
Nu	Nusselt number for duct
P	Wetted perimeter, (m)
Q	Rate of heat transfer (Watt)
Re	Reynolds number duct = u. d_h / v_u
T	Temperature (°C)
u	Free flow velocity, (m/s)

REFERENCES

1. Deepener et al. (July 2011), "Theoretical analysis of gas turbine blade by finite element Method", *Scientific World,* Volume, Issue 9.
2. SH Barhattcl et al. (January−March 2011) "Experimental and computational analysis and optimization of heat through Fig with different types of Notch", Volume 2, Issue 1, pp. 133−138. E-Issn0976-7916. JERS/.
3. Throng Nuan et al., "Crushing analysis and numerical optimization of angle element structures unser axial impact loading".
4. Bvenkatesh, V Kamalam, AMK Prasad (2010), "Modeling and analysis of aluminum A360 Alloy italic gear for Marine Applications", Volume 1, Issue 2, ISSN-0976-3259.
5. P Ramamurthy Raju A et al. (2007), "Evaluation of Fatigued life of aluminum alloy wheels under radial loads", *Engineering Failure Analysis,* Volume 14, pp. 791−800.
6. N Satya Narayana, P Ch Sambals (2012), "Fatigue analysis of Aluminum

alloy wheel under Radial Load", Volume 2, Issue 1, ISSN- NO. 2231-46779.

7. J Jonardhan, V Ravikumar, R Lili tha, Narayang (2014), "Radial fatigue analysis of anally wheel", *Decomposer,* Volume 4, Issue 2, Part 6, pp. 253−258. ISSN-2248-96229.

8. H Hosseini- Toudeshky, B Mohammedia, G Sidechain, HR Dag hyena (2007), "Numerical and experimental Fatigue Crack growth analysis in mode- I for repaved aluminum panels using composite material", *Composites,* Part A, Volume 38, pp. 1141−1148.

9. Kant ha K, Rao Jaya Hertha, K Rao (July 2015), "Heal insulation analysis of an aluminum honeycomb Sandwich structure", *Journal of Thermal Engineering Yildiz Technical university Press,* Volume 1, Issue 3, pp. 201−220, Research Article- JTEN-2014- 15. Astute bull, Turkey.

10. Ganesh Raut, Anil Manjra, P Bhaskar (Dec 2013), "Analysis of multidisc cutch using FEA", *International Journal of Engineering Treads and Technology (IJETT),* Volume 6, Issue 1, ISSN: 2231-5381.