International Journal of Scientific and Innovative Research 2017; 5(2) : 104 - 112
P-ISSN 2347-2189, E- ISSN 2347-4971

TRANSIENT THERMAL ANALYSIS OF DISC BRAKE 105 - 113 ROTOR GRAY CAST IRON F12801

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ABSTRACT

Transient analysis is most important to collect the information about nonlinear behaviour of the component or product. In the present the study, we collected different response for the loading condition on disc rotor and its stability in critical condition. The transient simulation calculates the response on arbitrary excitations. Substantial for the transient analysis is the consideration of energy storing in the components. In the study, we saw the transient behaviour in thermal condition as well as in structural condition. From CREO-Parametric for the CAD modelling of the disc rotor and Ansys 14.0 workbench for transient analysis of the disc rotor, from the thermal transient analysis we get the information regarding heat flux, heat formation during braking, heat dispassion through the convection and from the structural transient analysis we got the information regarding mechanical deformation and some mechanical behaviour of the rotor

Keywords: Disc rotor; Transient; Response; Structural; Analysis; CREO-parametric; Ansys workbench

INTRODUCTION

A transient analysis, by definition, involves loads that are a function of time. In the Mechanical application, we can perform a transient analysis on either a flexible structure or a rigid assembly. For a flexible structure, the Mechanical application can use the ANSYS Mechanical APDL, Samcef or ABAQUS solver to solve a Transient Structural analysis. We can perform a transient structural analysis (also called time-history analysis) in the Mechanical application using the transient structural analysis that specifically uses the ANSYS Mechanical APDL solver. This type of analysis is used to determine the dynamic response of a structure under the action of any general time-dependent loads. We can use it to determine the time-varying displacements, strains, stresses, and forces in a structure as it responds to any transient loads. The time scale of the loading is such that the inertia or damping effects are considered to be important. If the inertia and damping effects are not important, we might be able to use a static analysis instead.

A transient structural analysis can be either linear or nonlinear. All types of nonlinearities are allowed - large deformations, plasticity, contact, hyper elasticity, and so on. ANSYS Workbench offers an additional solution method of Mode-Superposition to perform linear transient structural analysis. In the Mode-Superposition method, the transient response to a given loading condition is obtained by calculating the necessary linear combinations of the eigenvectors obtained in a modal analysis. Transient Structural Analysis Using Linked Modal Analysis System is more useful. The Mode Superposition method is not available to the Samcef or ABAQUS solver. The ANSYS/Multiphysics, ANSYS/Mechanical, ANSYS/FLOTRAN, and ANSYS/Thermal products support steady-state thermal analysis. A steady-state thermal analysis calculates the effects of steady thermal loads on a system or component. Engineer/analysts often perform a steady-state analysis before doing a transient thermal analysis, to help establish initial conditions. A steady-state analysis also can be the last step of a transient thermal analysis; performed after all transient effects have diminished. From the transient analysis of the rotor we clearly able to understand following information about the disc rotor

1. Understand how nonlinearities (if you are including them) affect the structure's response by doing a static analysis first. In some cases, nonlinearities need not be included in the dynamic analysis. Including nonlinear effects can be expensive in terms of solution time.
2. Understand the thermal deformation in the rotor during the high temperature produced while braking. And information regarding heat input and heat releases for the better stability of the brake rotor.
3. Analyse a simpler model rotor which can provide good insight into the problem at minimal cost. This simpler model may be all you need to determine the dynamic response of the structure.

MECHANICAL AND THERMAL PROPERTIES OF THE MATERIAL F12801

Table1 contains the mechanical properties of the material and table 2 contains the thermal properties of the material

Table-1 Mechanical properties of (F12801)

Properties	Quantity
Brinell Hardness	230
Compressive(crushing) strength (MPa)	970
Young's modulus (Gpa)	180
Elongation at break	.52%
Fatigue strength (MPa)	130
Pission's Ratio	0.29
Shear modulus(GPa)	69
Shear Strength (MPa)	390
Tensile strength : Ultimate (UTS) (MPa)	310
Tensile strength :yield (proof) (MPa)	200

Table 2: Thermal properties of (F12801)

Properties	Quantity
Melting completion (^{o}C)	1380
Melting completion (^{o}C)	1180
Specific heat capacity (J/kg-K)	490
Thermal Conductivity W/m-K	46
Thermal expansion (µm/m - K)	11

Table-3 Unclassified Properties of F1201

Properties	**Quantity**
Density (g/cm^3)	7.5
Embodied carbon kg (CO_2/kg)	1.5
Embodied energy (MJ/kg)	21
Embodied Water	44

Table : 4 Alloy Composition

Alloys	**Percentage of composition**
Iron(Fe)	92.1-93.9
Carbon(C)	3.1-3.4
Silicon (Si)	2.5-2.8
Manganese (Mn)	0.05-0.07
Phosphorus (P)	0-0.9
Sulfur (S)	0-0.15

Table-3 shows the unclassified properties of the material and table- 4 shows the alloys composition of the material. These alloys composition give the material suitable compressive strength and hardness for braking application.

CAD MODELLING OF DISC ROTOR

For the CAD modelling CREO-Parametric 1.0 is used, rotor model made in part modelling section of CREO-Parametric after that model save ".igs" file format for importing in ANSYS for further analysis of the component. Figure 1 shows the wireframe model of the disc rotor and figure 2 shows the solid part model of the rotor which is used in transient thermal analysis and figure 3 shows the assembly of block A and block and rotor for transient structural analysis of the rotor.

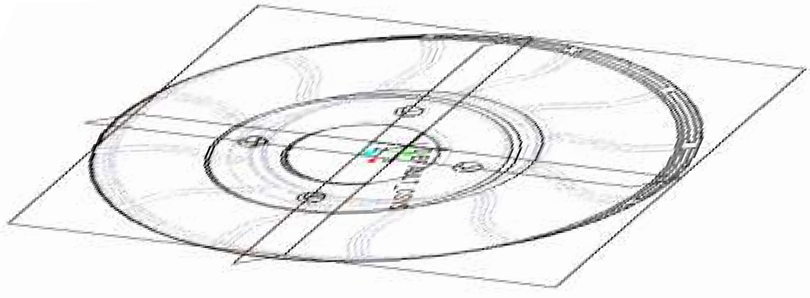

Fig1: Wireframe model of the disc rotor

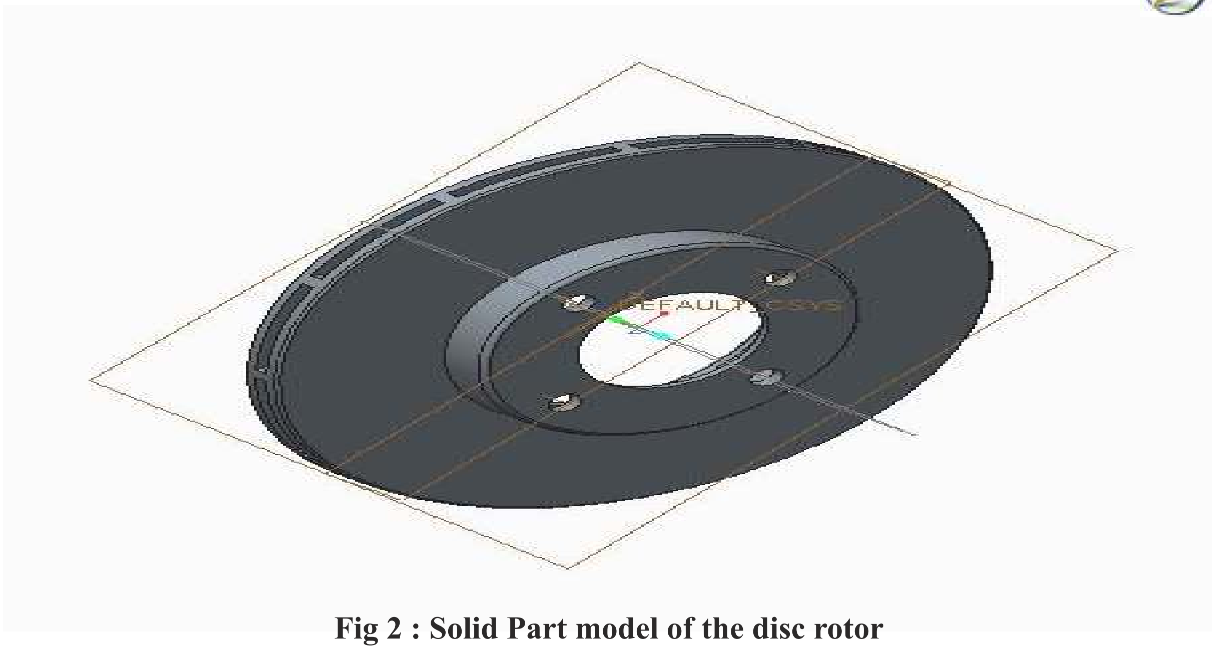

Fig 2 : Solid Part model of the disc rotor

TRANSIENT THERMAL ANALYSIS IN ANSYS WORKBENCH

The ANSYS/Multiphysics, ANSYS/Mechanical, ANSYS/Thermal, and ANSYS/FLOTRAN products support transient thermal analysis. Transient thermal analysis determines temperatures and other thermal quantities that vary over time. Engineers commonly use temperatures that a transient thermal analysis calculates as input to structural analyses for thermal stress evaluations. Many heat transfer applications-heat treatment problems, nozzles, engine blocks, piping systems, pressure vessels, etc. involve transient thermal analyses.

A transient thermal analysis follows basically the same procedures as a steady-state thermal analysis. The main difference is that most applied loads in a transient analysis are functions of time. To specify time-dependent loads, we first divide the load-versus-time curve into load steps. Each "corner" on the load-time curve can be one load step, as shown in the following sketches. For the transient thermal analysis of the rotor disc first of all the imports the CAD model of the rotor from CREO-Parametric which save as ".igs" file format. Figure-3 shows the imported model of the disc rotor.

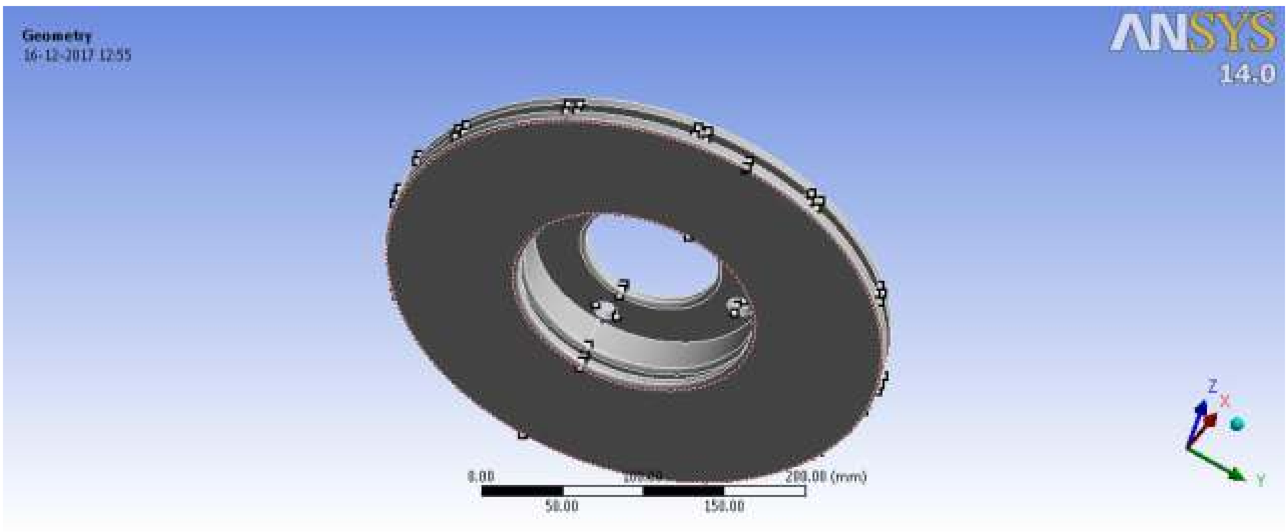

Fig .3 : Imported model of rotor

After import the rotor model in Ansys workbench we go for the meshing of the model in suitable number of elements with specific size for better result. Figure- 4 shows the meshed model of the rotor

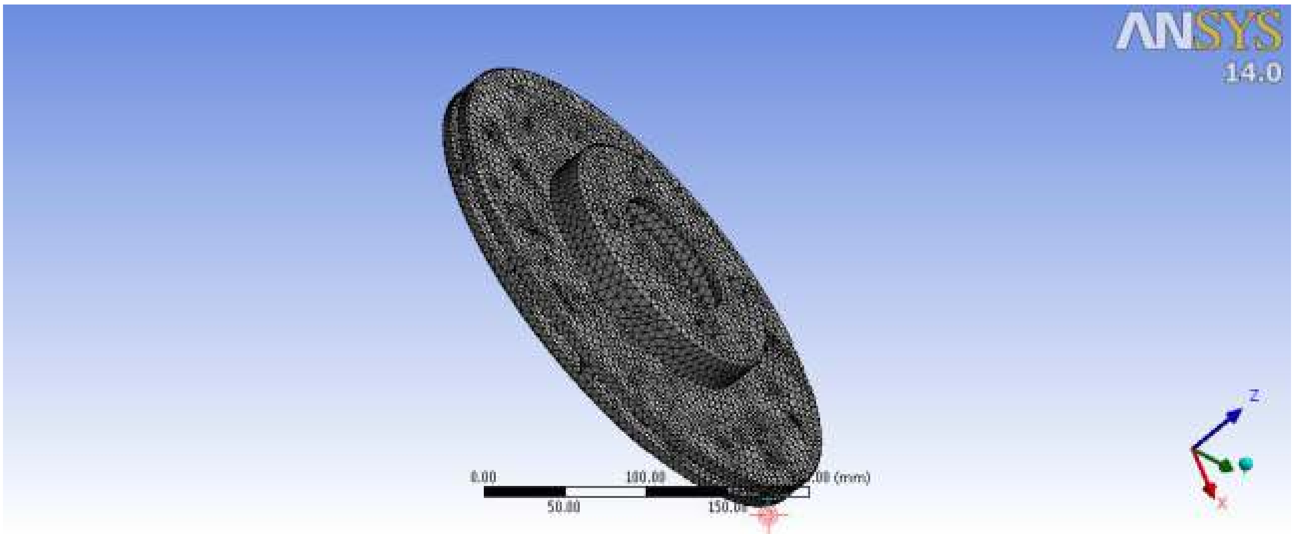

Fig4 : Meshed model of rotor

From the meshed model of the rotor we see that the number of node I the components are 75831 and the number of elements are 42318.

Boundary condition for the analysis is shown in figure-5

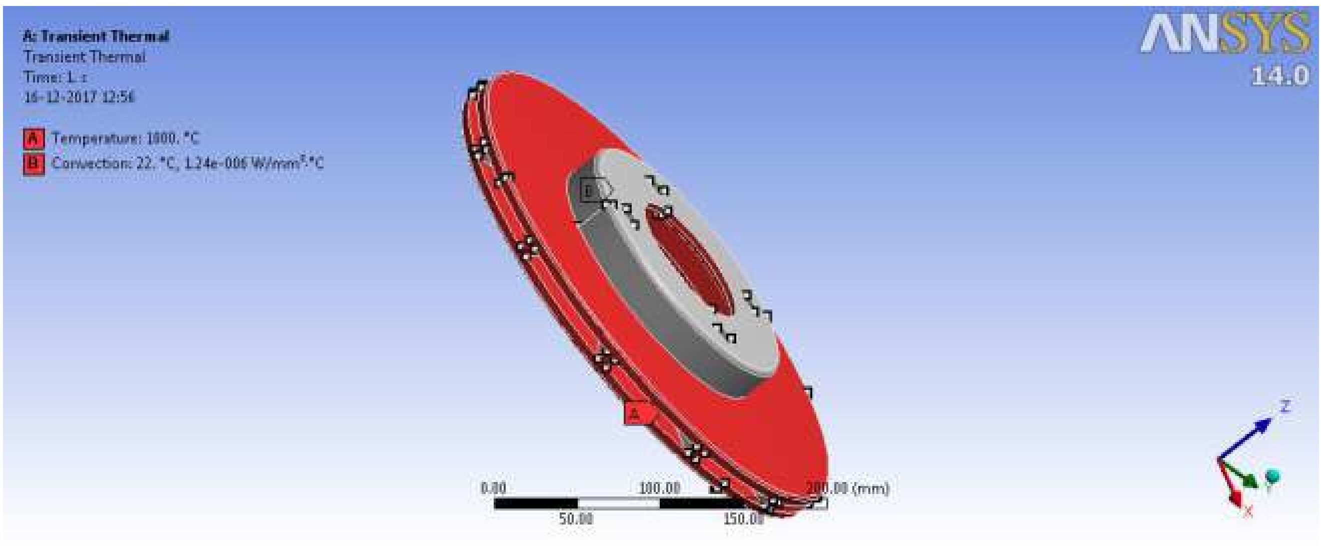

Fig. 5 : Boundary condition for transient thermal analysis of rotor

International Journal of Scientific and Innovative Research 2017; 5(2) : 104 - 112
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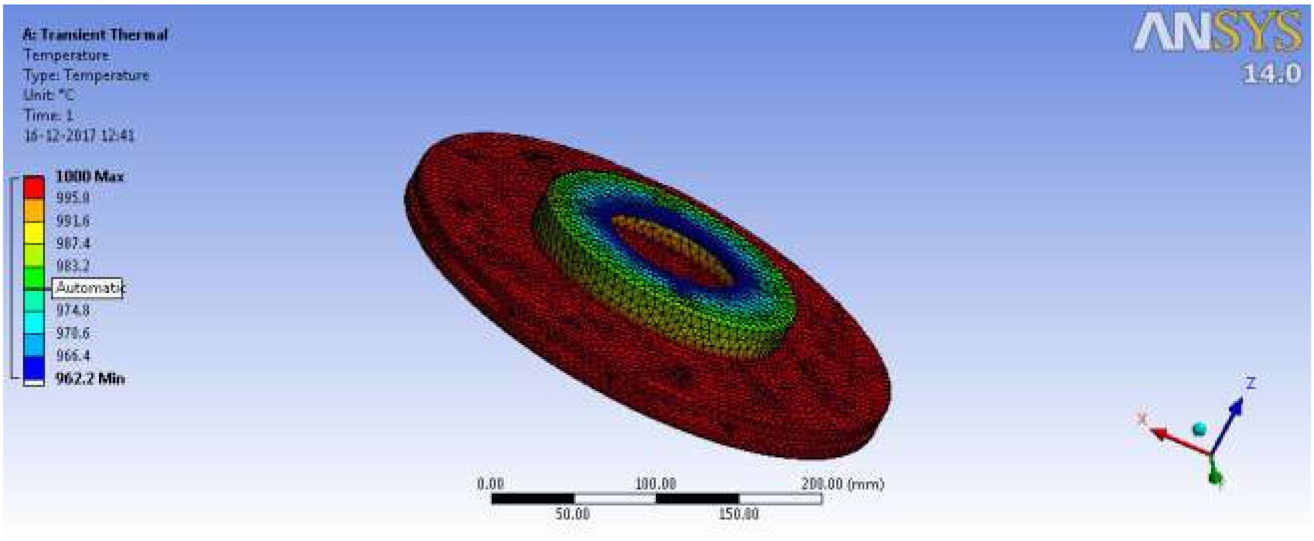

Fig .6 : Result of Appling initial temperature and final temperature in rotor

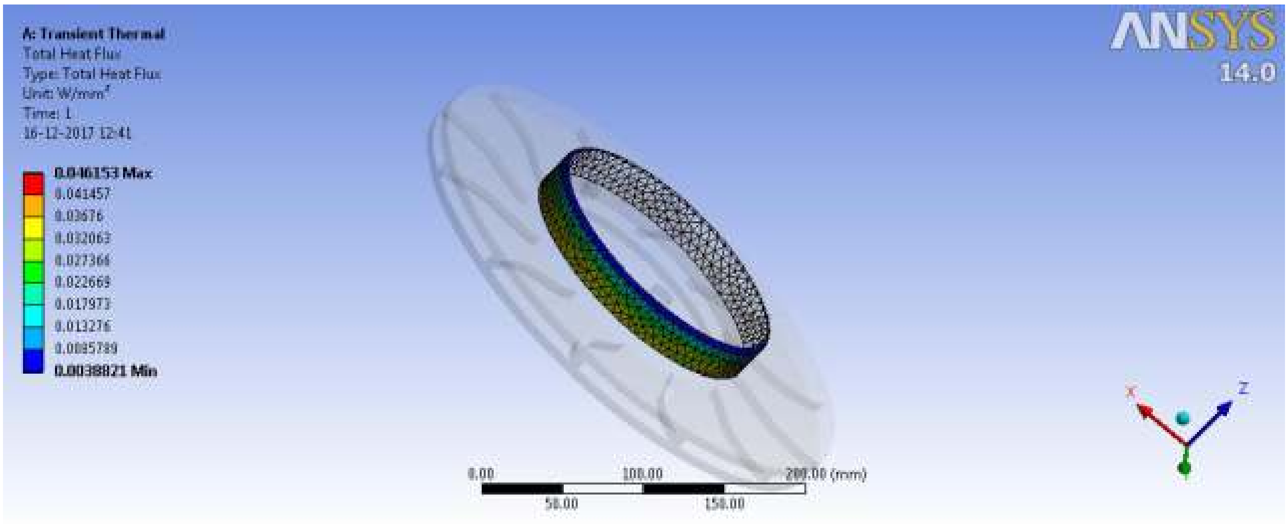

Fig. 7: Result of Appling heat flux in rotor

The **figure-6 and figure-7** show the result for the transient thermal analysis for the application of initial temperature 22 0C and final temperature 1000 0C and heat flux result for the convection of the heat.

Table 5: Effect of temperature increment on convection coefficient. shows the result for change in convection coefficient variation thought the temperature increment in rotor

Temperature [^{0}C]	Convection Coefficient [W/mm^2·°C]
1	1.24e-006
10	2.67e-006
100	5.76e-006
200	7.25e-006
300	8.3e-006
500	9.84e-006
700	1.101e-005
1000	1.24e-005

Figure- 8 shows the application of the braking system through the time and its respective temperature increment

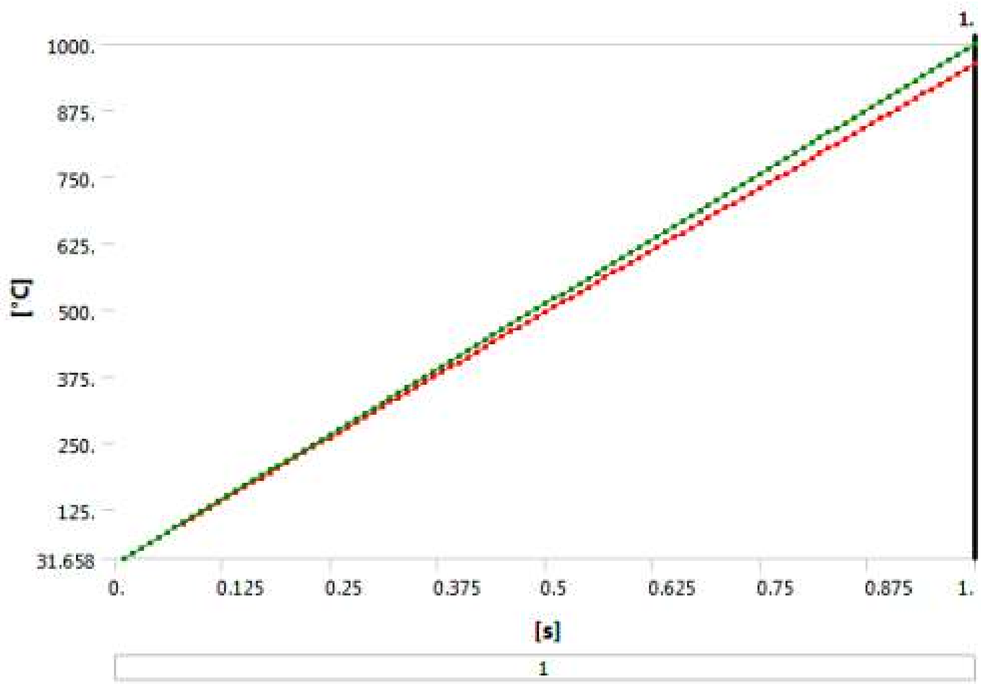

Fig. 8 : Effect of temperature in time difference

Figure-8 shows the two graphs between time (sec) and temperature (0C) red curve and the green curve. The red curve shows the maximum global condition and green curve shows the minimum global condition.

Figure 9 shows the changes in heat flux in time duration for both maximum global condition (red curve) and minimum global (green curve).

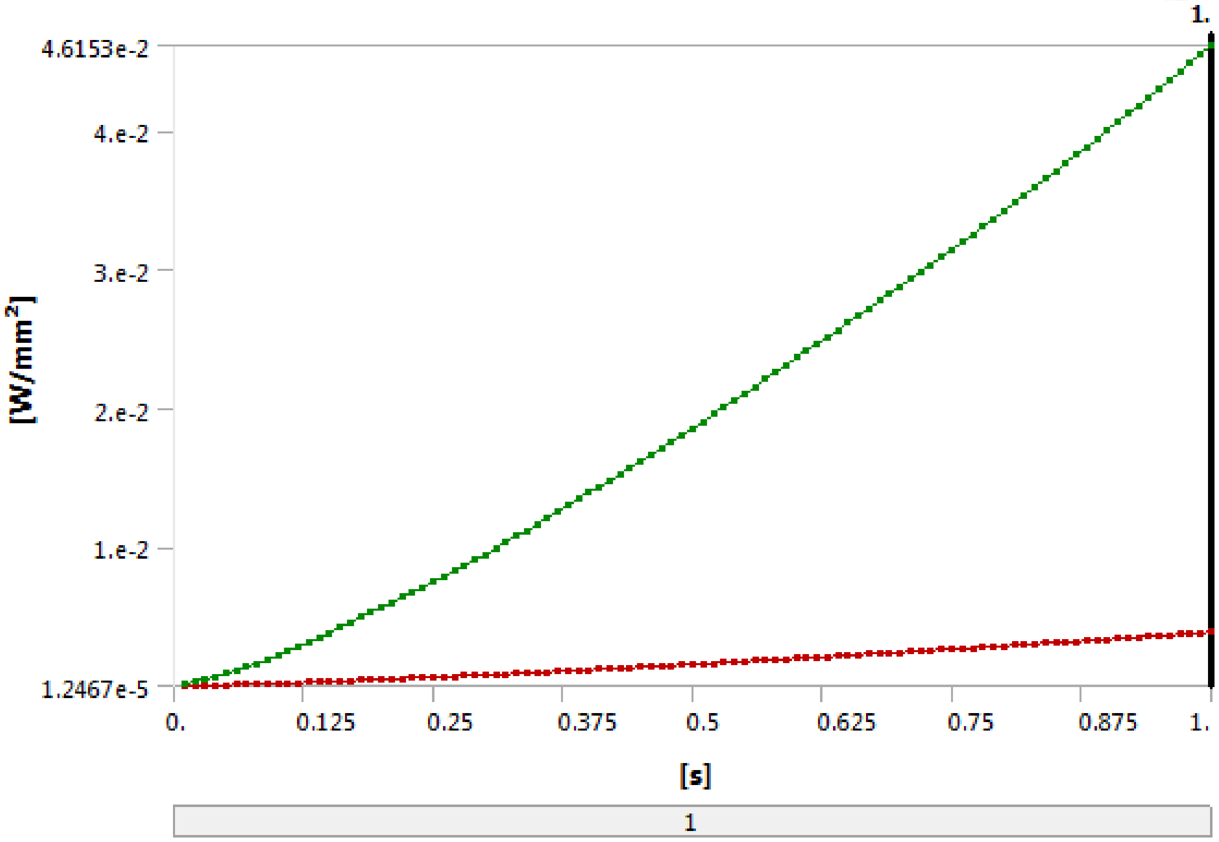

Fig .9 : Effect of total heat flux in time difference

RESULTS AND DISCUSSION

For the input data of the material thermal conductivity 46 4.6e-002 W mm^-1 C^-1 and specific heat 4.9e+005 MJ kg^-1 C^-1, the results show that during the time difference the convection coefficient and total heat flux increase if the time of braking is more so in the place of continuous apply the brake, it is applied in rapid to minimise the effect of the temperature on the rotor.

CONCLUSION

The transient thermal analysis of the disc rotor states that if the time of applying brake force is increased it means the duration of the contact time of the rotor and the pad then more heat will be produced and the probability of the plastic deformation also increases so we have to use that material which convection coefficient increases with the like F12801. The material F12801 is suitable for disc rotor.

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