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THERMAL ANTLYSIS OF PISTON

VIJAY POKHARKAR[1], SAURBH PALKHE[2], ADITYA PAWAR[3], AADITYA YADAV[4]

Abstract: The piston is the most important part of the engine, which is subjected to the thermal and mechanical stresses. The role of the piston is to guide the movement of the rod while transmitting the gases pressure forces, in order to make the volume variation inside the cylinder. Piston is a reciprocating part of engine which converts thermal energy into mechanical energy. There is thermo-mechanical load on the piston, there is fatigue failure due to cyclic thermal and mechanical loading. To increase the life of the piston, there has been more research going on in modifying the design of the piston, changing the material and also changing the method of the manufacturing. This uses standard procedure of obtaining critical dimensional values from empirical formulae and material constants resulted from previous experimental data. A three

Dimensional model can be made using solid modelling software's like CATIA and SOLIDWORKS and mesh can be generated. Further, a finite element model can be made and analysis can be carried out using software's like ANSYS. thermal flux and thermal temperature distribution is analysed by applying temperatures on the piston surface in thermal analysis

Introduction

Automobile components are in great demand these days because of increased use of automobiles. The increased demand is due to improved performance and reduced cost of these components. R&D and testing engineers should develop critical components in shortest possible time to minimize launch time for new products. The piston is a significant component of a cylindrical engine. It reciprocates inside the cylinder bore. The piston acts as a moveable end in the cylinder. The piston converts the energy of the expanding gases into mechanical energy. Pistons are commonly made of aluminium or cast-iron alloys. To avoid the combustion gases from bypassing the piton and to keep friction to a minimum, each piston has several metal rings around it.

Governing Equation

In an IC engine fuel is burnt out in combustion chamber, by the burning of air fuel mixture lots of energy is generated through it by converging chemical energy into heat and pressure energy. This heat can be further transfer from conduction, convection, radiation like. The heat transfer is can be calculated by the formula given below

$Q=hA\Delta t$

Here,

Q - Amount of heat can be transferred

H – Heat transfer coefficient

A – Area of heat transfer

Δt – Change in temperature

Literature Analysis

SR. NO	PAPER NAME	Publication, Year	AUTHOR'S NAME	DESCRIPTION
1	THERMAL ANALYSIS OF PISTON USING ANSYS.	Feb- 2019	Mr. Vinay D. Shinde1, Mr. Pratik P. Shinde2, Mr. Tanmay T. Revankar3, Prof. Rohit Bhandwale4	The thermal flux and thermal temperature distribution is analysed by applying temperatures on the piston surface in Thermal analysis of Cast iron, Aluminium Alloy A360 material, comparing results of both materials of above there is difference between temp. In one minute Aluminium is more heated as compared to Cast Iron. But Cast Iron is heavier in weight. So, for better performance we can combine both materials.
2	Thermal and Static Structural Analysis on Piston.	May- 2019	G.V.N. Kaushik	In this paper designing the 3D model of piston in solid works, structural and thermal analysis part will be done in ANSYS software by using 4 different materials and finding the best material for piston. conclusion while designing a piston 42CrMo must be used to make the piston top land because it is the surface of piston that directly comes in contact with combustion of fuel and high temperatures and Al-Si-C-12 must be used for piston skirt and rest of the piston.
3	DESIGN AND ANALYSIS OF FOUR STROKE PISTON FOR DIESEL ENGINE THERMAL AND STATIC ANALYSIS	Jan- 2018	1K.SIVARAMAKRISHNAN, 2A.RAJESH,3 S.SOMALINGAM, 4V.VENKATESH	ANSYS on aluminium and zirconium coated aluminium piston surfaces. With the advancement in material science, very light weight materials with good thermal and mechanical properties can be used for fail safe design of the I.C Engine. This will reduce the fuel consumption and protect the environment. Finally, we concluded that Al Alloy GHS1300 and Zirconium alloy material is best one when compared to Al alloy A2618
4	STRUCTURAL AND THERMAL ANALYSIS OF IC ENGINE PISTON HEAD WITH CONCAVE AND CONVEX SHAPES	Jul- 2017	D. MANI SAI KAMAL	In comparison between the two types of piston designs for which the analyses are carried out, the stresses and total deformations observed in concave shaped piston are larger than the convex shaped piston.
5	Thermal Analysis of Piston Using Convex and Concave Profile of Piston head	June-2018	Satish Sharma , P.S. Dhakar	Total heat flux found maximum 10.64 W/mm2 in aluminium alloy piston with concave shape and minimum temperature found on top surface of piston in concave shape i.e. 154.39 0C. so it is concluded that concave type piston shows better thermal properties in this analysis.

Research Gap

- Study on effects of thermal stress of piston with different materials.
- Study optimum types of material used in piston, how they deformed or changes accordingly in various parameters.

Problem Definition

- Existing piston and there material is superb but we have to study for better performance.
- Different surfaces of the piston undergoes different thermal load .the crown surface undergoes high temperature variation. Temperature variation along with the piston crown surface is observed.
- Observing if material change accordingly piston geometry also changed

Objectives

- The objective of the analysis is to obtain optimum thermal comfort, temperature range surrounding the piston
- Due to proper thermal comfort, it improves in low use of fuel, piston failure and etc.,

2.1 Piston

Methodology

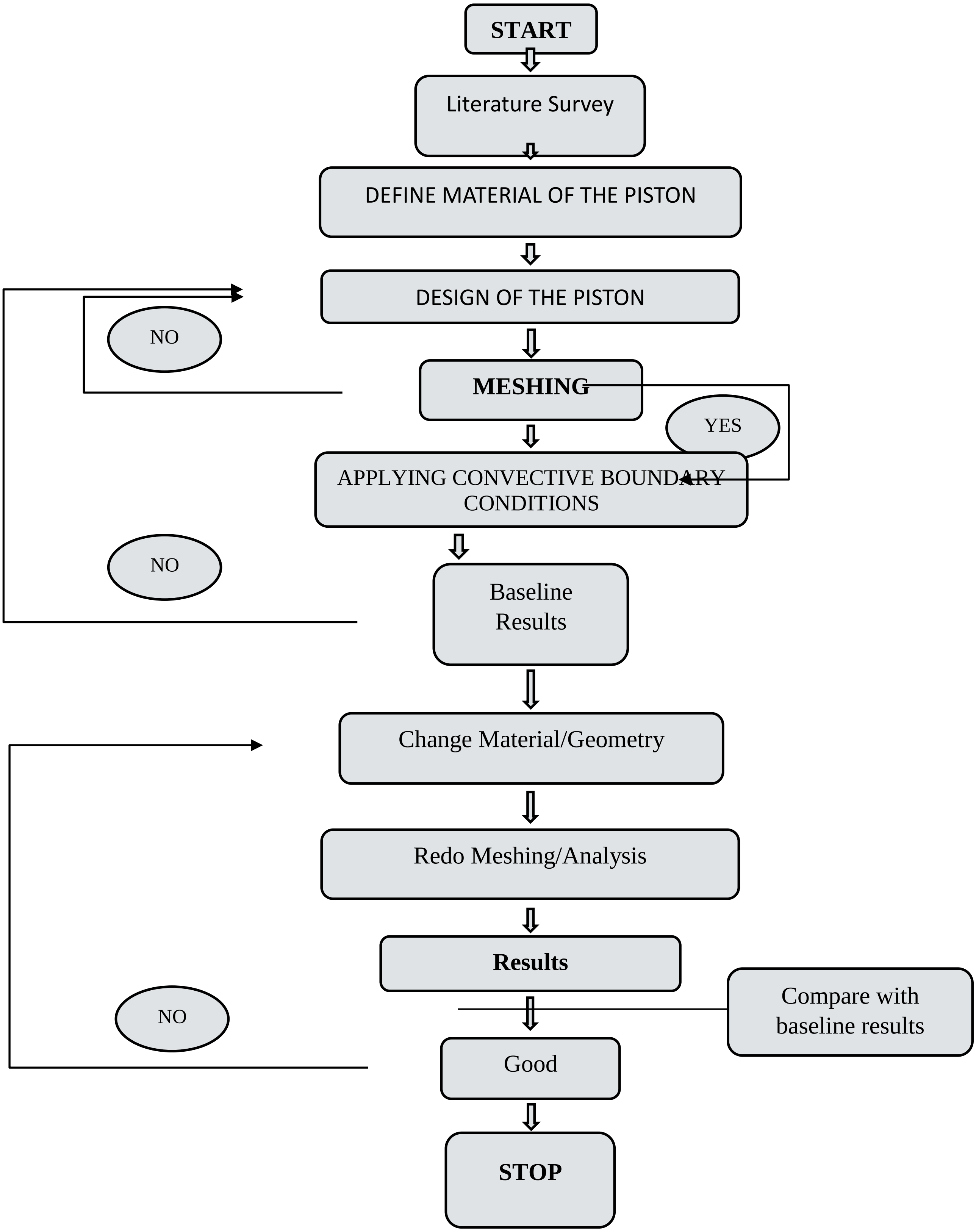


Fig. 3.1. Schematic flow of Project

Advantages

- We will get the complete and thoroughly knowledge about the piston, design of piston, physical changes of piston in various load condition
- We will give the better research and highly thermal, static load material for piston

Applications

If our selected material get better results in various tests then it will good selection of material rather than conventional material which will give a light weight and high thermal stress

Design Calculation of Piston

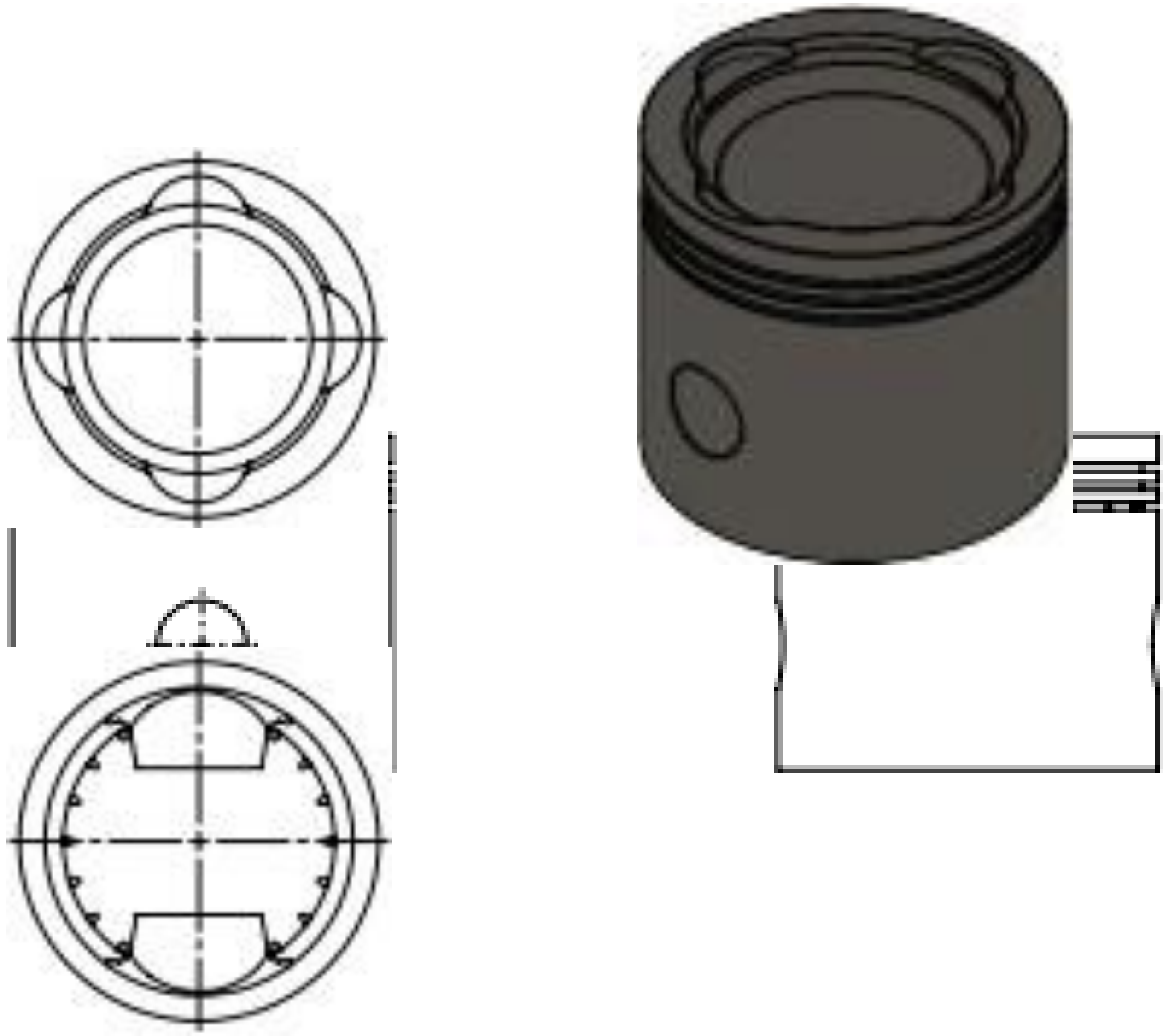
Engines Specification

PARAMETER	VALUE
ENGINE TYPE	4- STOKE PETROL ENGINE
BORE	67MM
STOKE	62.4MM
MAXIMUM POWER	15.5KW AT 8500RPM
MAXIMUM TORQUE	19.12NM AT 7000RPM

Design parameters of piston

Parameter	Value	Unit
Piston length	62	mm
Radial Thickness	2	mm
Axial Thickness	2	mm
Thickness of piston head	6	mm
Diameter of piston head	19	mm
Thickness of barrel	8.5	mm

Modelling Of Piston



Material selection for piston

The material selection for piston is based on the criteria of weight reduction for which composite plays a better role. Materials are chosen in such a way that the reliability of the component is not affected

Conventional Material for piston: Al alloy

Composite Material for piston: Al 4032, ALSI 4340, Titanium Ti-6AL-4V

Table 3 Properties of Al Alloy

PROPERTY	SYMBOL	VALUE	UNITS
YOUNGS MODULUS OF ELASTICITY	E	71000	Mpa
POISSON'S RATIO	μ	0.33	
DENSITY	P	2700	Kg/ m^3
TENSILE YEILD STRENGTH	σ_t	280	Mpa

Table 4 Properties of Al alloy 4032

PROPERTY	SYMBOL	VALUE	UNITS
YOUNGS MODULUS OF ELASTICITY	E	79000	Mpa
POISSON'S RATIO	µ	0.35	
DENSITY	P	2680	Kg/ m^3
TENSILE YEILD STRENGTH	σ_t	315	Mpa

Table 5 Properties of ALSI 4340

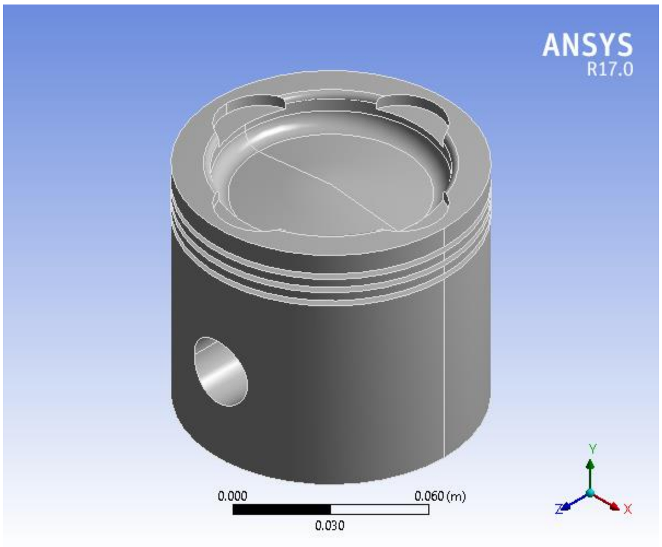
PROPERTY	SYMBOL	VALUE	UNITS
YOUNGS MODULUS OF ELASTICITY	E	210000	Mpa
POISSON'S RATIO	µ		
DENSITY	P	7800	Kg/m^3
TENSILE YEILD STRENGTH	σ_t	745	Mpa

Table 6 Properties of Titanium Ti-6AL-4V

PROPERTY	SYMBOL	VALUE	UNITS
YOUNGS MODULUS OF ELASTICITY	E	113800	Mpa
POISSON'S RATIO	µ	0.342	
DENSITY	P	443	Kg/m^3
TENSILE YEILD STRENGTH	σ_t	880	Mpa

Thermal Anlysis Using Ansys software

Project



Units

TABLE 1

Unit System	Metric (m, kg, N, s, V, A) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

TABLE 9

Model (A4) > Transient Thermal (A5) > Loads

Object Name	Temperature	Convection
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	20 Faces	15 Faces
Definition		
Type	Temperature	Convection
Magnitude	Tabular Data	
Suppressed	No	
Film Coefficient		1200. W/m²·°C (step applied)
Coefficient Type		Bulk Temperature
Ambient Temperature		22. °C (step applied)
Convection Matrix		Program Controlled
Tabular Data		
Independent Variable	Time	

TABLE 10

Model (A4) > Transient Thermal (A5) > Temperature

Steps	Time [s]	Temperature [°C]
1	0.	25.
	1.	2000.

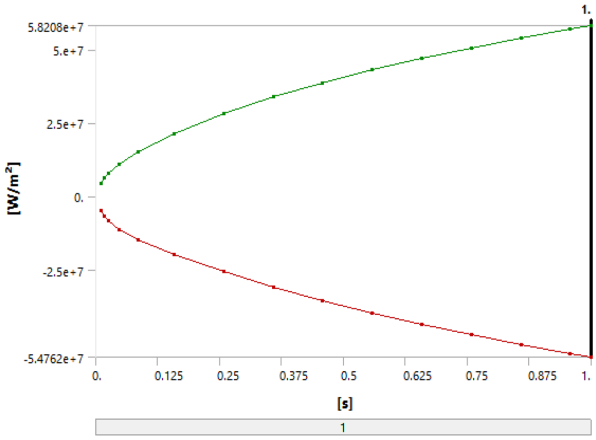


FIGURE 2

Model (A4) > Transient Thermal (A5) > Convection

TABLE 11

Model (A4) > Transient Thermal (A5) > Convection

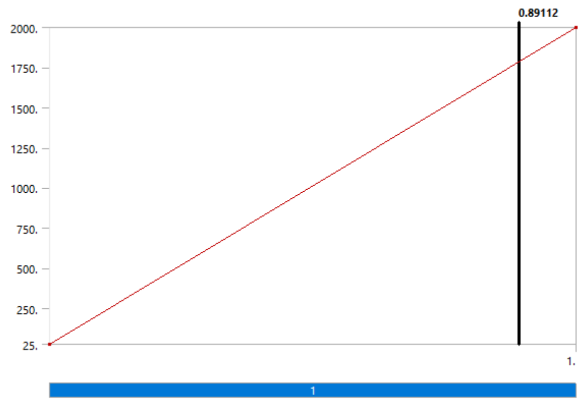
Temperature [°C]	Convection Coefficient [W/m²·°C]
21.	1200.

Solution (A6)

TABLE 12

Model (A4) > Transient Thermal (A5) > Solution

Object Name	Solution (A6)



Material Data

Aluminum

TABLE 19

Aluminum > Constants

Thermal Conductivity	237.5 W m^-1 C^-1
Density	2689 kg m^-3
Specific Heat	951 J kg^-1 C^-1

TABLE 20

Aluminum > Color

Red	**Green**	**Blue**
235	209	184

TABLE 9 – TITANIUM

Model (A4) > Transient Thermal (A5) > Load

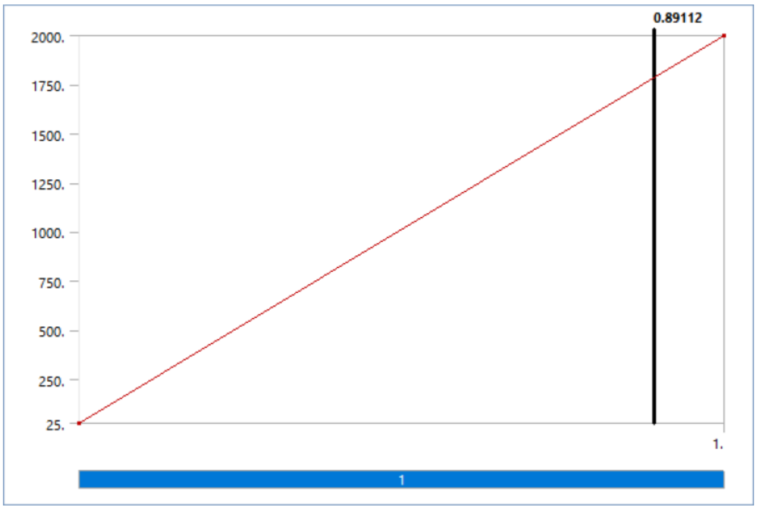
Object Name	*Temperature*	*Convection*
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	20 Faces	15 Faces
Definition		
Type	Temperature	Convection
Magnitude	Tabular Data	
Suppressed	No	
Film Coefficient		1200. W/m²·°C (step applied)

Coefficient Type		Bulk Temperature
Ambient Temperature		22. °C (step applied)

Convection Matrix		Program Controlled
Tabular Data		
Independent Variable	Time	

FIGURE 1

Model (A4) > Transient Thermal (A5) > Temperature



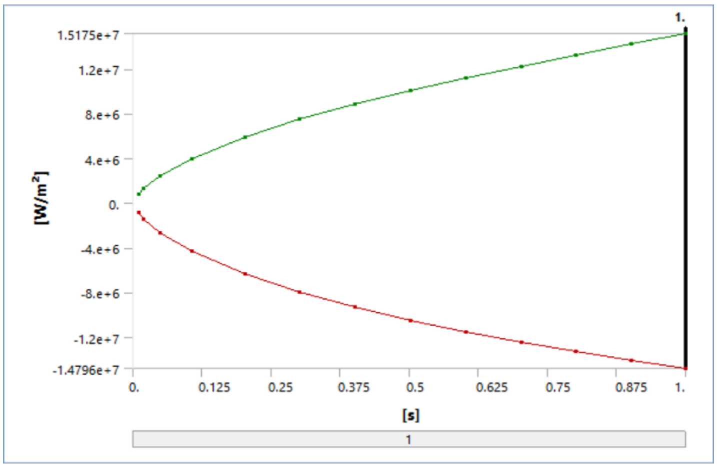


TABLE 10

Model (A4) > Transient Thermal (A5) > Temperature

Steps	Time [s]	Temperature [°C]

Material Data

Titanium

TABLE 19

Titanium > Constants

Thermal Conductivity	**21 W m^-1 C^-1**
Density	**4500 kg m^-3**
Specific Heat	**522 J kg^-1 C^-1**

BLE 20

Titanium > Color

Red	**Green**	**Blue**
234	**247**	**209**

Cost Estimation

- As this is a research-based analysis project and we are using student versions of the software hence there is no cost except for making black book which will be around Rs 2000.

Conclusion

We concluded that we will get complete knowledge of piston and stress applied on it, various deformation of piston. We are trying to study the thermal stress applied on piston by using various metals and alloys like Al alloy 4032, Al Alloy, ALSI 4340, Ti-6AL-4V.

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