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Design & Thermal Analysis of I.C. Engine Poppet Valves using Solidworks and FEA

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Abstract - *Intake and exhaust valves in I.C. engines are called as poppet valves. These valves are operated by valve mechanism. When these valves are exposed to the heat thermal stresses are developed so that thermal analysis is very important to predicting and preventing failures in valves. This paper aims to model and simulates the thermal analysis on poppet valves applications of 99.3cc. Modeling of the valves was done in the solidworks and thermal analysis was carried out in the ANSYS.* In thermal analysis determined directional heat flux, total heat flux and temperature. Here used three materials for each valves and suggested best material for each valves on basis of thermal point of view.

Keywords: **Inlet valve, Exhaust valve, Composite materials, Ceramics, Solidworks, and FEA.**

I. INTRODUCTION

The valves used in internal combustion engines are of the three types

1. Poppet or mushroom valve
2. Rotary valve
3. Sleeve valve

Out of these three valves, poppet valve is very frequently used. It possesses certain advantages over the other valve types because of which it is extensively used in the automotive engines. The advantages are;

1. Simplicity of construction
2. Self-centering.
3. Free to rotate about the stem to the new position.
4. Maintenance of sealing efficiency is relatively easier.

Sanoj.T et al (2014) analyzed the stress induced in a valve due to high thermal gradient and high pressure inside the combustion chamber. In the first stage of analysis the temperature distribution across the valve was determined. In the second stage found displacement [1].

Deepak Bhargav et al (2016) they evaluated for uncoated and coated engine valve with and without the application of bond coat. From the results decrease in heat flux, mechanical stress and total deformation the with coated engine valve with bond coat while increased in stress were observed. Bond coat gave better wear and corrosion resistance [2].

Sagar.S Deshpande, et al (2014) Analyzed the effect of varied materials and geometric parameters on mechanical properties of poppet engine valve to improve its performance over life and fatigue life using Ansys software [1].

B Seshagiri Rao et al (2014) they had designed the exhaust valve for four wheeler petrol engine using theoretical calculations. 3D model and transient thermal analysis is to be done on the exhaust valve when valve is open and closed. Study state condition is attained at 5000 cycles at the time of when valve is closed is 127.651 seconds valve is opened 127.659 seconds. The material was used for exhaust valve is EN52 steel [3].

Karan Soni et al (2015) they conclude valve design can be optimized to reduce its weight, without affecting permissible stress and deformation values. Due to reduction in strength improves the valve strength [4].

II. DESIGN CONSIDERATIONS

II.I Specifications

Engine specification:

1	Make	TVS
2	Model	Luna
3	Displacement	97.22 cc
4	Bore &stroke	50 x 49.5 mm
5	Compression ratio	8.8 : 1
6	Swept Volume	97193.02272 mm^3
7	Clearance Volume	12460.64394 mm^3
8	Theoretical Efficiency	58.1

Exhaust valve dimensions

Diameter of the valve= 10.4mm
Distance between the groove= 9.8mm
Base diameter= 23.2mm
Diameter above the base=9.8mm
Total length of the valve=66.4mm
Length of the stem=47.2mm
Thickness of valve disc=2.4mm

Inlet valve dimensions

Diameter of the valve= 10.2mm

Distance between the groove= 9.8mm
Base diameter= 20mm
Diameter above the base=9.6mm
Total length of the valve=67mm
Length of the stem=42mm
Thickness of valve disc=2mm

II.2. 2D Model

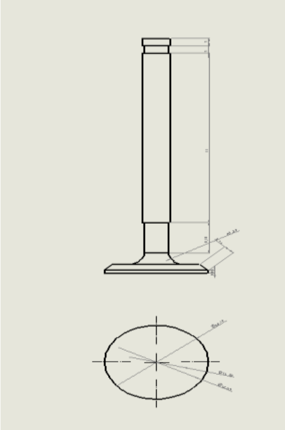


Fig.1. Inlet valve

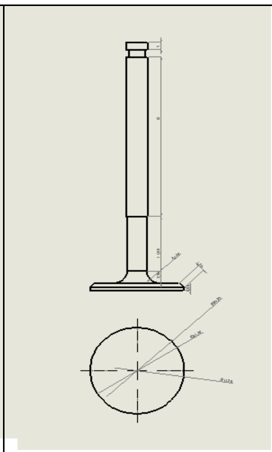


Fig.2. Exhaust valve

II.3. 3D model

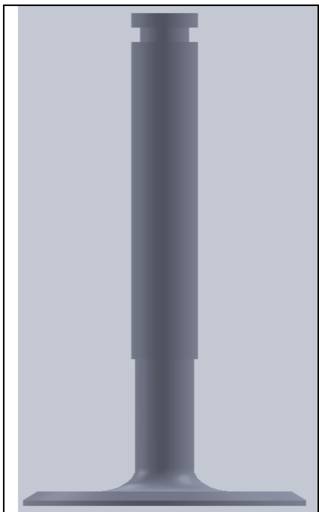


Fig.3. Inlet valve

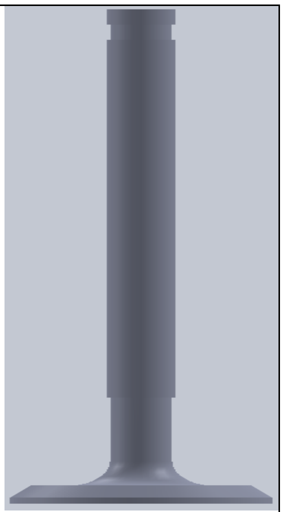


Fig.4. Exhaust valve

II.4. Methodology

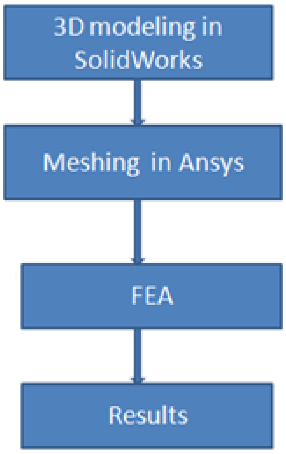


Fig. 5. Thermal analysis process flow chart for poppet valves

II.5. Modeling

The 3-D modeling was done by using Solidworks software.

II.6. Meshing

The components were meshed by using ANSYS software.

II.7. FEM analysis

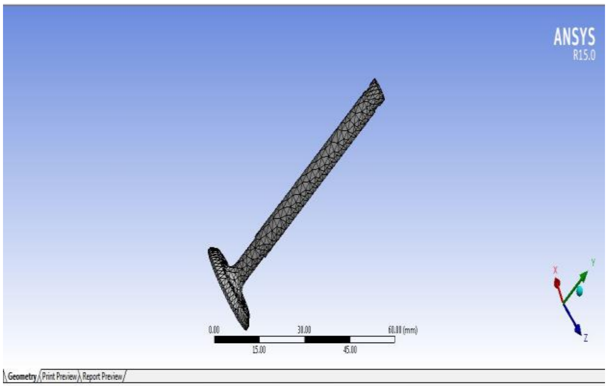


Fig.6. Proposed meshing (Tetrahedral element) of Inlet Valve

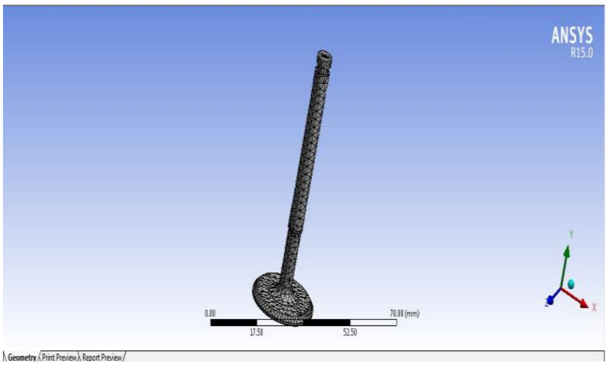


Fig.7. Proposed meshing (Tetrahedral element) of Exhaust Valve

The, temperature, total heat flux and directional heat flux are very important for poppet valve. To meet these requirements to perform thermal analysis on stainless steel and ceramic composite materials of poppet valves. The finite element analysis was carried out by using Ansys software. This thermal analysis was performed based on the following assumptions.

In thermal analysis the max temperature is 900°C and mini. Temperature is 300°C for exhaust valve and 60°C and 750°C mini and max temperatures for inlet valve respectively.

III. MATERIAL

III.1. Inlet valve

Steel

1	Density in (kg/cm^3)	7.6
2	Young's modulus in (GPa)	190
3	Poissons ratio	0.25
4	Thermal conductivity in (W/m- K)	12-45
5	Coefficient of linear expansion in (µm/m- °C)	11-12.5

Alumina

1	Density in (kg/cm^3)	3.7-3.97
2	Young's modulus in (GPa)	393
3	Poissons ratio	0.27
4	Thermal conductivity in (W/m- K)	35
5	Coefficient of linear expansion in (µm/m- °C)	8.4

Silicon

1	Density in (kg/cm^3)	2.3
2	Young's modulus in (GPa)	160
3	Poissons ratio	0.17
4	Thermal conductivity in (W/m- K)	149
5	Coefficient of linear expansion in (µm/m- °C)	2.6

III.2. Exhaust valve

Stainless steel

1	Density in (kg/cm^3)	7.6
2	Young's modulus in (GPa)	190
	Poissons ratio	0.25
3	Thermal conductivity in (W/m- K)	12-45
4	Coefficient of linear expansion in (µm/m- °C)	11-12.5

Silicon Nitride

1	Density in (kg/cm^3)	3.31
2	Young's modulus in (GPa)	317
3	Poissons ratio	0.23
4	Thermal conductivity in (W/m- K)	27
5	Coefficient of linear expansion in (µm/m- °C)	3.4

Aluminum nitride

1	Density in (kg/cm^3)	3.25
2	Young's modulus in (GPa)	308
3	Poissons ratio	0.25
4	Thermal conductivity in (W/m- K)	82.3 - 170
5	Coefficient of linear expansion in (µm/m- °C)	4.6- 5.7

II.8. Boundary Conditions

The boundary conditions were considered under the head and at the neck (tappets located area) portion of the both the valves in thermal. The boundary conditions are shown in the respective figures.

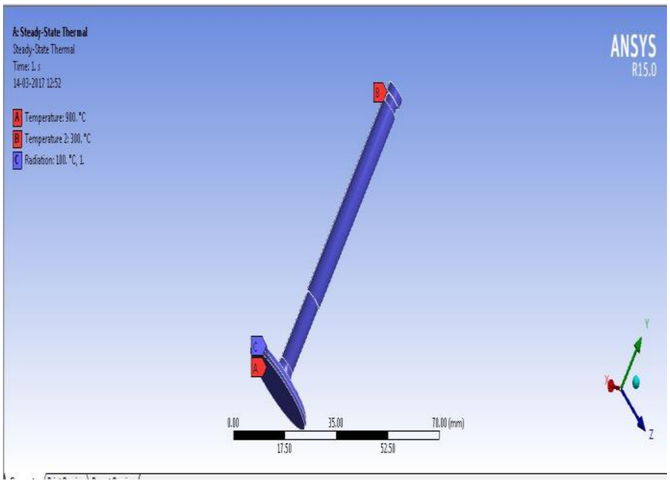


Fig.8. Boundary conditions

IV. Results and Discussion

Fig10, 14 and 22 shows the total heat flux rate of three materials for exhaust valve as well as fig 26, 30 and 34 shows the amount total heat flux rate of three materials for inlet valve. The maximum heat flux of Aluminum Nitride for exhaust valve is 2.511 W/mm^2 and the maximum heat flux of Silicon Nitride for inlet valve is 3.3878 W/mm^2

Thermal Analysis of Exhaust Valve

ALUMINIUM NITRIDE

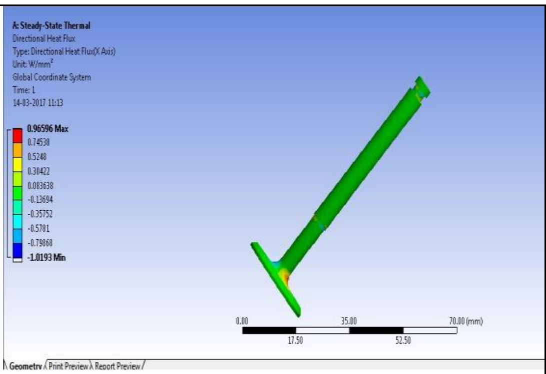


Fig.9. Directional heat flux(X axis)

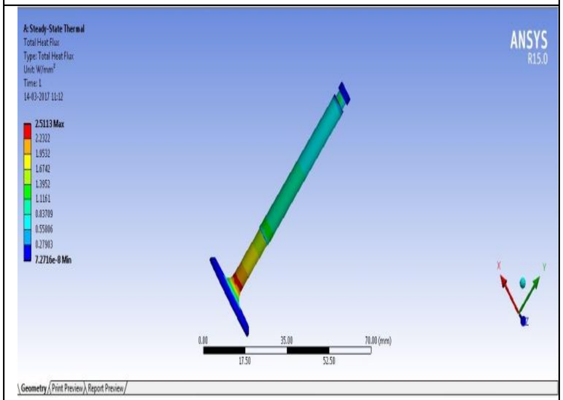


Fig.10. Total Heat Flux

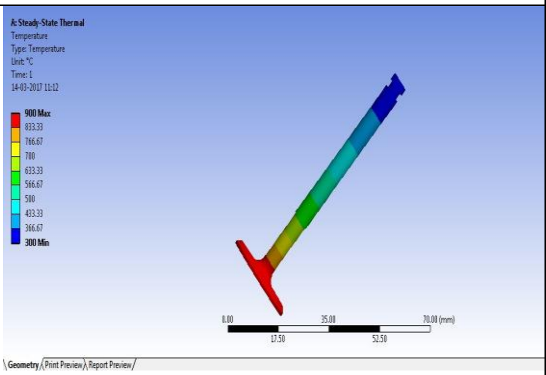


Fig.11. Temperature

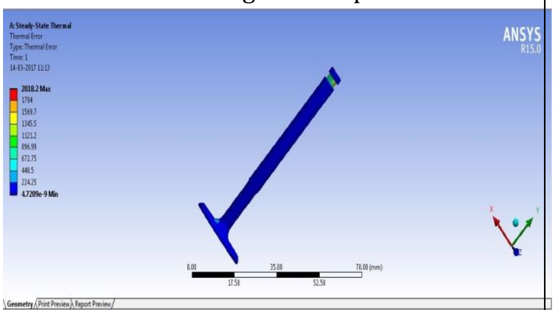
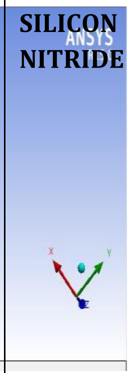


Fig.12.Thermal Error

SILICON NITRIDE



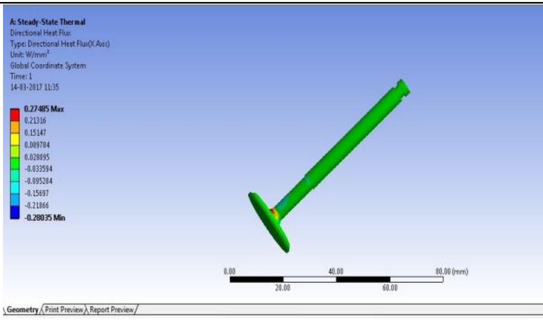


Fig.13. Directional heat flux(X Axis)

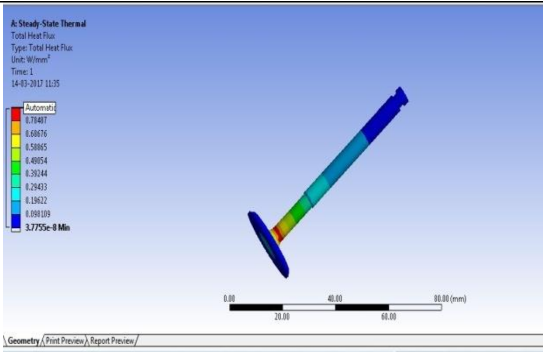
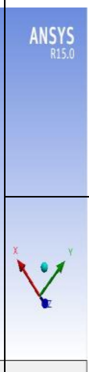


Fig.14. Total heat flux



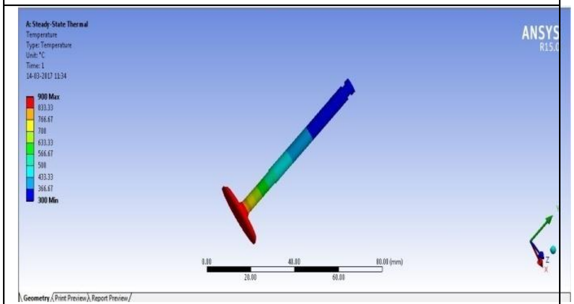


Fig.15.Temperature

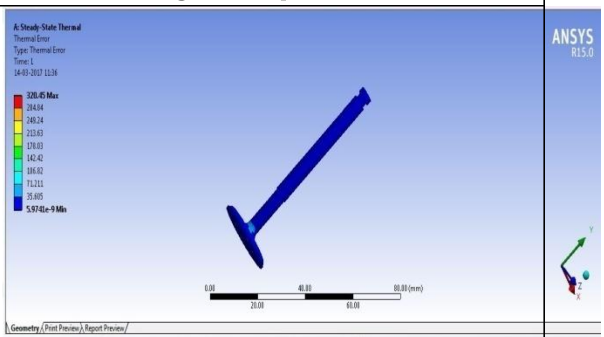
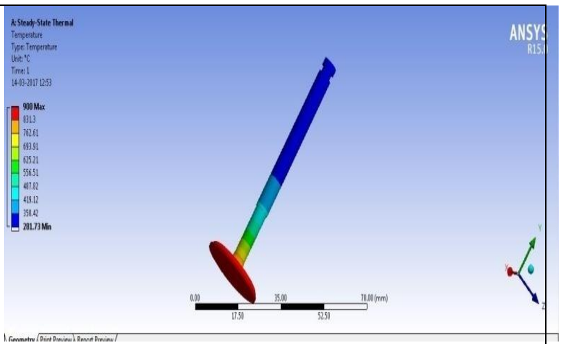
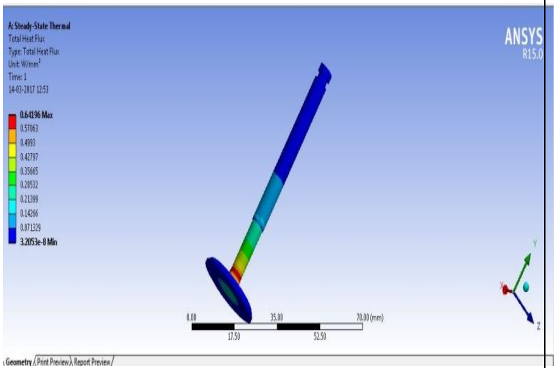
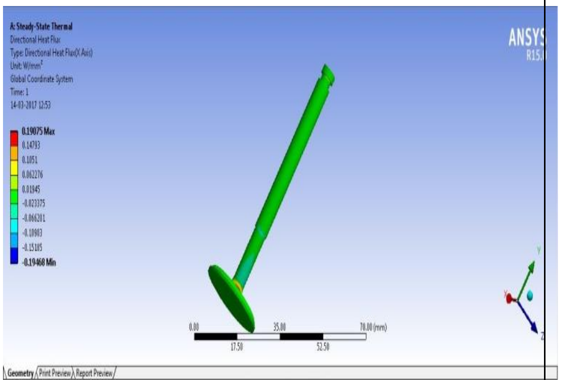
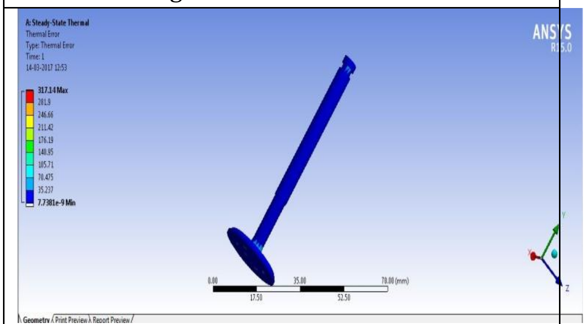
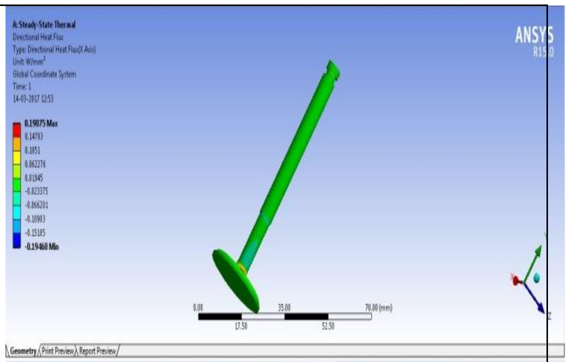
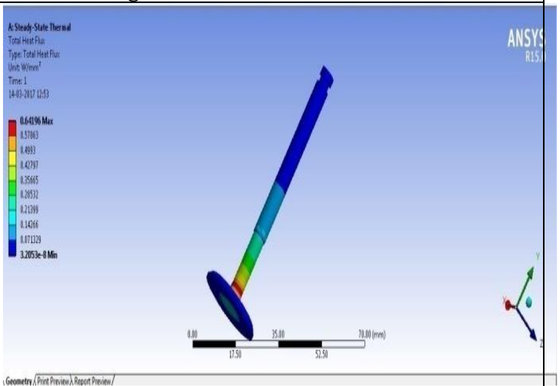
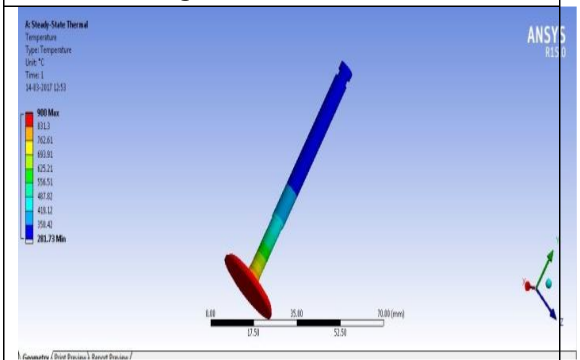
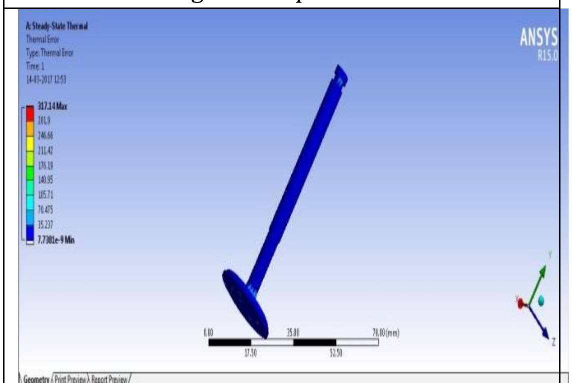


Fig.16. Thermal error

	 Fig.17.Temperature
	 Fig. 18.Total Heat Flux
	 Fig.19. Directional Heat
	 Fig. 20.Thermal Error

Stainless Steel	 Fig.21. Directional Heat Flux
	 Fig.22 Total Heat Flux
	 Fig.23.Temperature
	 Fig. 24.Thermal Error

Thermal Analysis of Inlet Valve

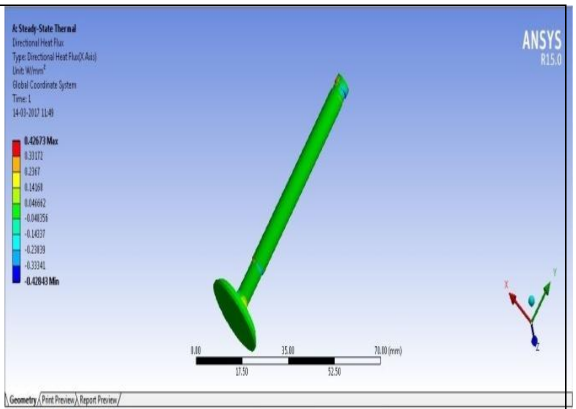
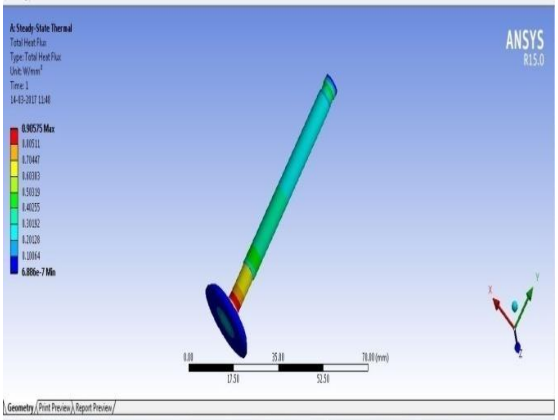
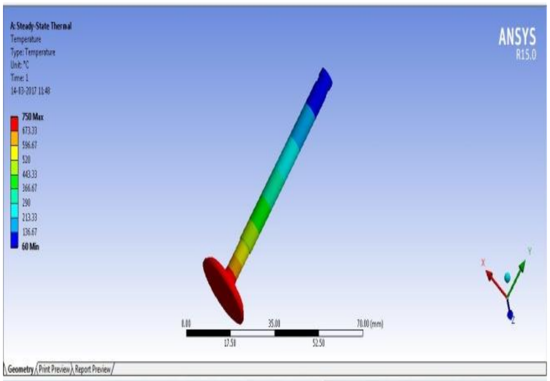
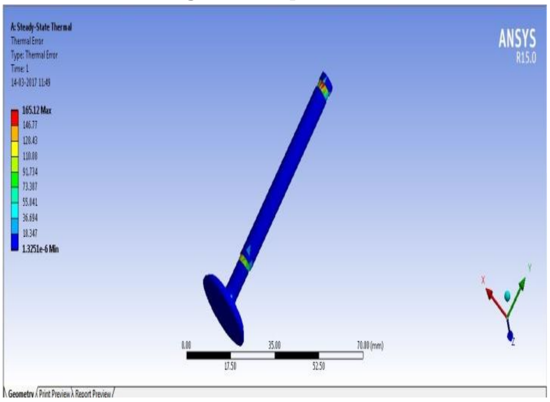
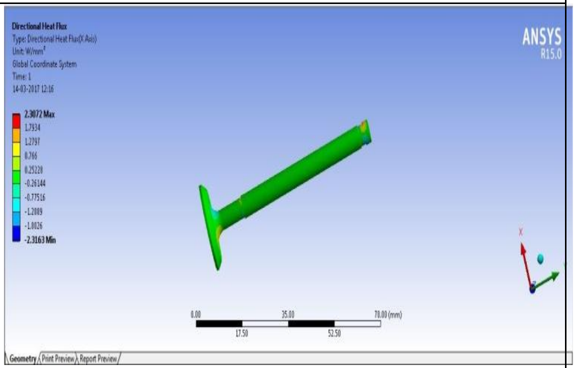
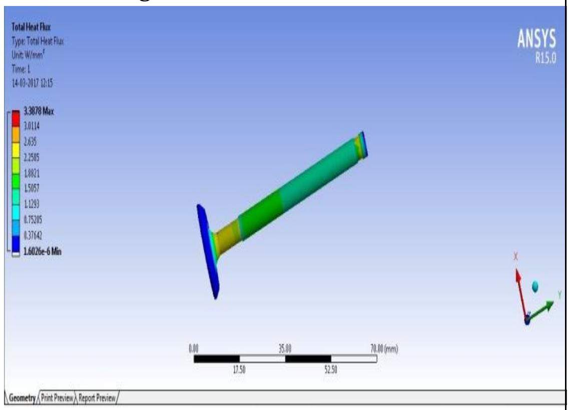
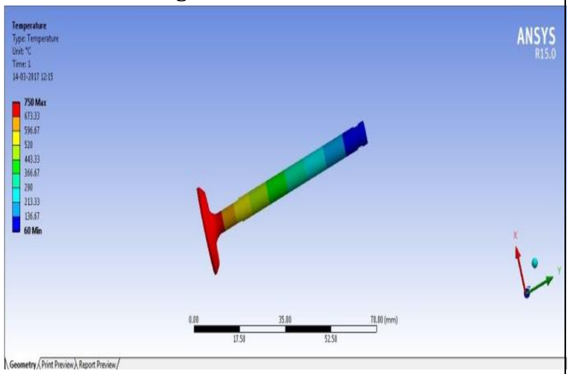
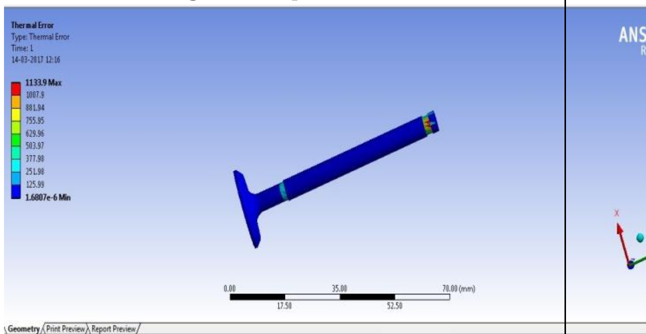
ALUMINA	 Fig. 25.Directional Heat Flux(X Axis)  Fig.26. Total Heat Flux  Fig.27.Temperature 

	Fig. 28.Thermal Error
SILICON	 Fig. 29.Directional Heat Flux  Fig.30.Total Heat Flux  Fig.31.Temperature  Fig. 32.Thermal Error

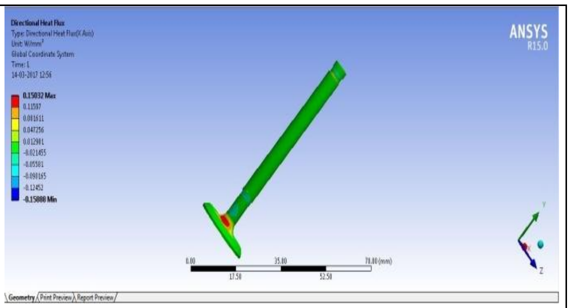
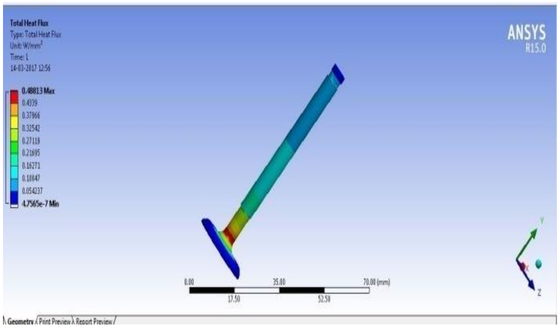
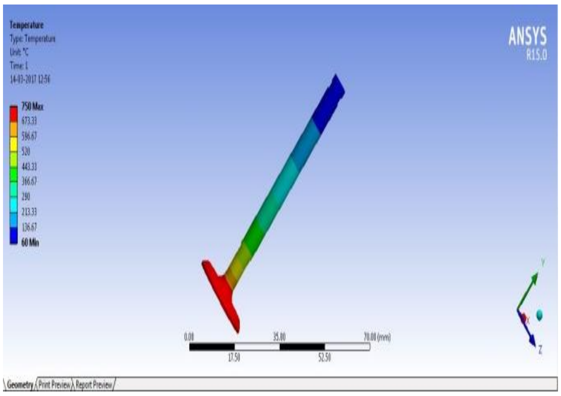
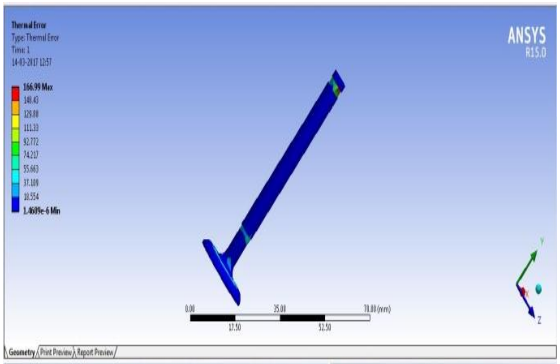
STEEL	 Fig.33. Directional Heat Flux(X Axis)  Fig.34. Total Heat Flux  Fig.35.Temperature  Fig. 36.Thermal Error

Table: 1. Thermal Analysis of Inlet valve for three materials

S. No	Material	Temperature in (°C)		Total Heat Flux in (W/mm^2)		Directional Heat Flux in (W/mm^2)		Thermal Error	
		Mini	Max	Mini	Max	Mini	Max	Mini	Max
1.	Alumina	60	750	6.886e -007	0.90575	-0.42843	0.42673	1.3251e - 006	165.12
2.	Silicon	60	750	1.6026e -006	3.3878	-2.3163	2.3072	1.6807e - 006	1133.9
3.	Steel	60	750	4.7565e -007	0.48813	-0.15888	0.1502	1.4689e – 006	166.99

Table: 2. Thermal Analysis of exhaust valve for three materials

S. No	Material	Temperature in (°C)		Total Heat Flux in (W/mm^2)		Directional Heat Flux in (W/mm^2)		Thermal Error	
		Mini	Max	Mini	Max	Mini	Max	Mini	Max
1.	Aluminum Nitride	300	900	7.2716e -008	2.5113	-1.0193	0.96596	4.7209e -009	2018.2
2.	Silicon Nitride	300	900	3.7755e -008	0.88298	-0.28035	0.27485	5.9741e -009	320.45
3.	Stainless Steel	281	900	3.2053e -008	0.64196	-0.19468	0.19075	7.7381e –009	317.14

VI. CONCLUSION

- In this paper the 3D model of poppet valve were designed by using Solidworks software. The model is meshed by using ANSYS. The FEA was done by ANSYS.
- The thermal analysis was successfully carried out to determine the total heat flux, directional heat flux and temperature distribution on the valves. Both the valves were analyzed with different materials.
- Compared and suggested best material for both the valves.
- In this study found out, in thermal analysis maximum heat flux was observed in steel (0.48813 W/mm^2) for inlet valve and for exhaust valve stainless steel (0.64196 W/mm^2).From the above results it was observed that the steel is the best material for inlet valve and for exhaust valve stainless steel.

REFERENCES

[1] Sanoj. T1 , S. Balamurugan "Thermo Mechanical Analysis of Engine Valve" International Journal of Science and Research Volume 3 Issue 5, May 2014

[2] Deepak Bhargav1, Anurag Singh Rana1, Chirag Narayana1, Nikhil Sharma1 and Amit Sethi 2Design and Performance Evaluation of Thermal Barrier Coated Engine Valve Using Finite Element AnalysisInternational Journal of Innovative Research in Science,Engineering and Technology Vol. 5, Issue 5, May 2016

[3] Sagar.S Deshpande , Vidyadhar. C. Kale , K.V. Chandratre "Analysis Of Stress Concentration Factor For Engine Valve Designs For Improved Fatigue Strength "

International Journal of Modern Trends in Engineering and Research, Volume 2, Issue 7, [July - 2015] Special Issue of ICRTET'2015

[4] Snehal S.Gawale , Dr.S.N.Shelke, Prof.M.A.Ahire "Design Of Stationary Ic Engine's Exhaust Valve and Optimization Based on Finite Element Analysis" Volume 3, Issue 4, [April 2016] Special Issue of ICRTET'2016 International Journal of Modern Trends in Engineering and Research

[5] B Seshagiri Rao* and D Gopi Chandu "PETROL ENGINE EXHAUST VALVE DESIGN, ANALYSIS AND MANUFACTURING PROCESSES "International journal of Mechanical and Robotics Researchh, Vol. 3, No. 4, October, 2014 © 2014 IJMERR.

[6] Karan Soni* , S. M. Bhatt**, Ravi Dayatar***, Kashyap Vyas* "Optimizing IC Engine Exhaust Valve Design Using Finite Element Analysis" International Journal Of Modern Engineering Research (IJMER), IJMER | ISSN: 2249–6645| Vol. 5 | Iss. 5 | May 2015 | 55 |