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Design & Structural Analysis of Poppet Valves for TVS Luna Bike

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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 load stress and strains are developed so that Stress and strain analysis is very important to predicting and preventing failures in structures. This paper aims to model and simulate the stresses and strain analysis of poppet valves applications of 99.3cc. Modeling was done in the solidworks and structural was carried out in the ANSYS.*

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

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].

Sanoj.T, et. al.(2012) 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 [2].

B Seshagiri Rao, et al.(2014) They had designed the exhaust valve for a four wheeler petrol engine using theoretical calculations. Manufacturing process that is 2D drawings is drafted from the calculations and 3D model and transient thermal analysis is to be done on the exhaust valve when valve is open and closed. Analysis is done in ANSYS. Analysis will be conduct when the study state condition is attained. Study state condition is attained at 5000 cycles at the time of when valve is closed is 127.651 sec valve is opened 127.659 sec. The material 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	Displacement	97.22 cc
2	Bore &stroke	50 x 49.5 mm
3	Compression ratio	8.8 : 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

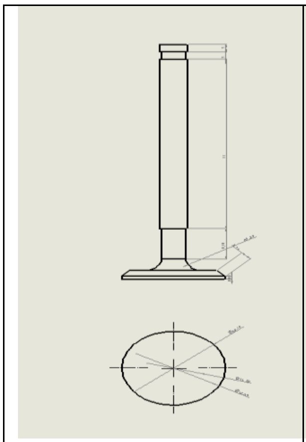


Fig.1. Inlet valve

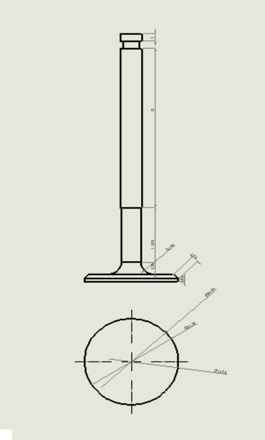


Fig.2. Exhaust valve

II.3. 3D model

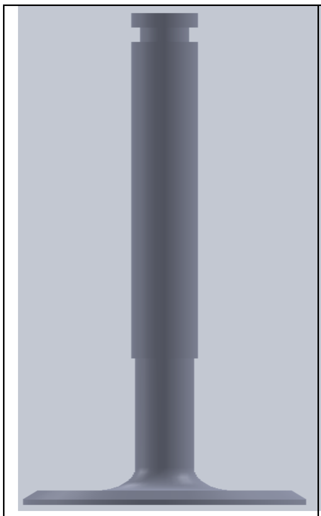


Fig.3. Inlet valve

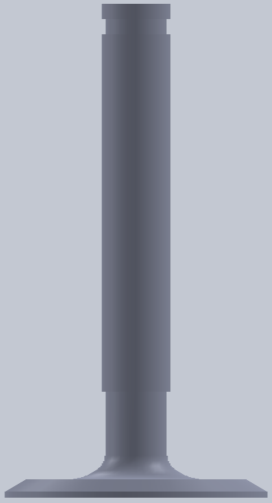


Fig.4. Exhaust valve

II.4. Methodology

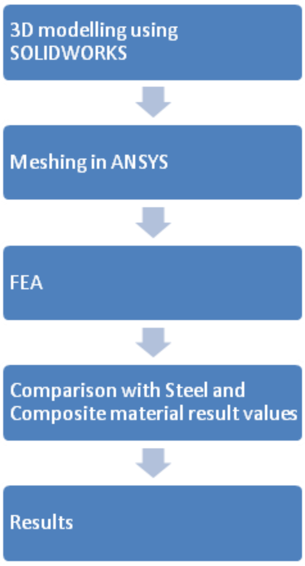


Fig. 5. Process flow chart for poppet valves

II.5. Modeling

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

II.6. Meshing

The all the components was meshed by using ANSYS software.

II.7. FEM analysis

The deformation, equivalent elastic strain, equivalent stress, strain energy and shear stress are very important for poppet valve. To meet these requirements to perform structural analysis on stainless steel and ceramic composite materials of poppet valves. The finite element analysis was carried out by using Ansys software. This analysis was performed based on the following assumptions.

The maximum load for stainless steel and ceramic composite poppet valve during applications 7312.84N and minimum load is 314.37N, this data is related in structural analysis for both the valves.

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

Boundary Conditions

The boundary conditions were considered under the head, just above the head and at the neck portion of the both the valves in structural. The boundary conditions are shown in the respective figures.

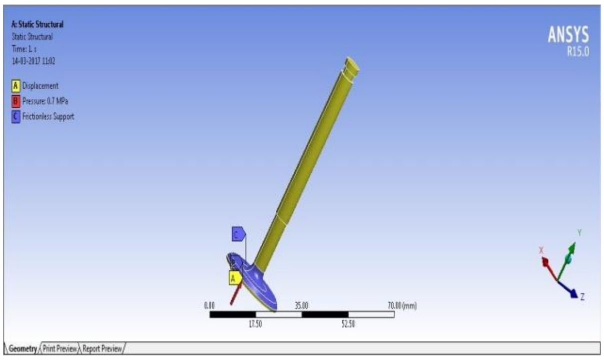
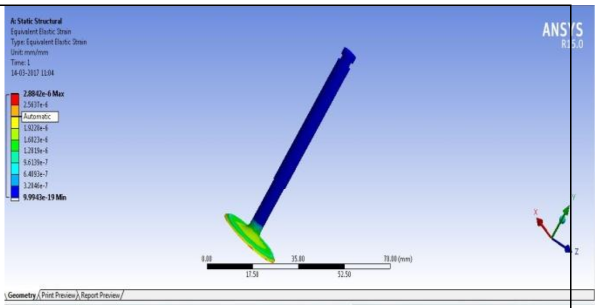
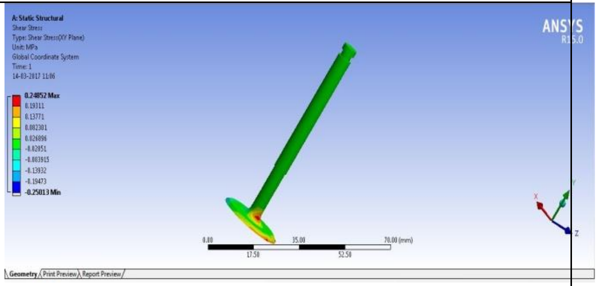
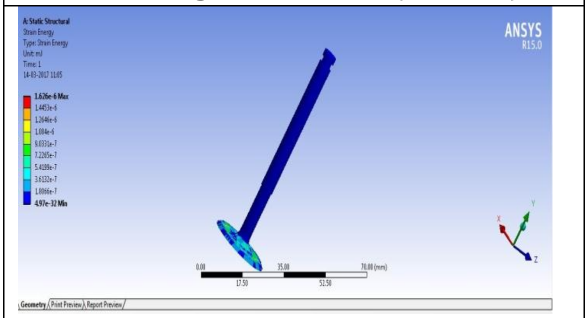


Fig.6. Boundary conditions

IV. Results and Discussion

Structural analysis of exhaust valve

Alumi num Nitride	 **Fig.7. Equivalent elastic strain**
	 **Fig.8. Shear Stress(XY Plane)**
	 **Fig.9. Strain energy**

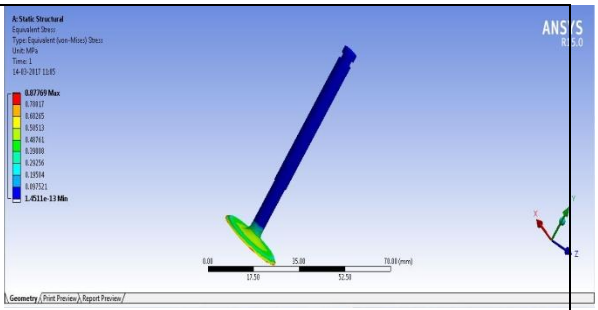


Fig.10. Equivalent (von-Misses) stress

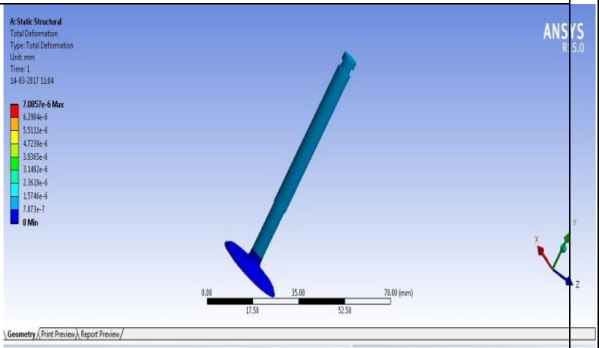


Fig.11. Total Deformation

SILICON NITRIDE

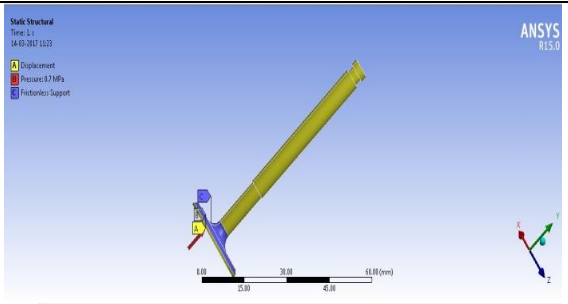


Fig.12. Boundary Conditions

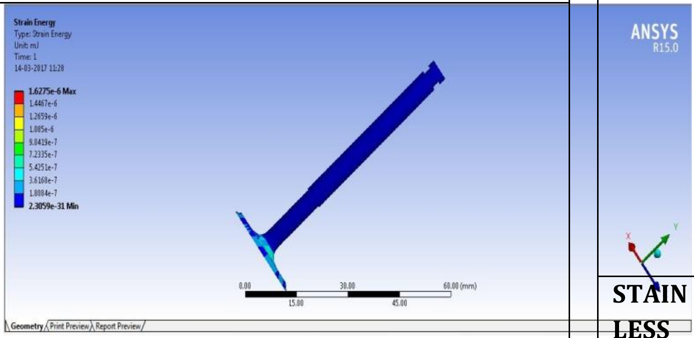


Fig.13. Strain Energy

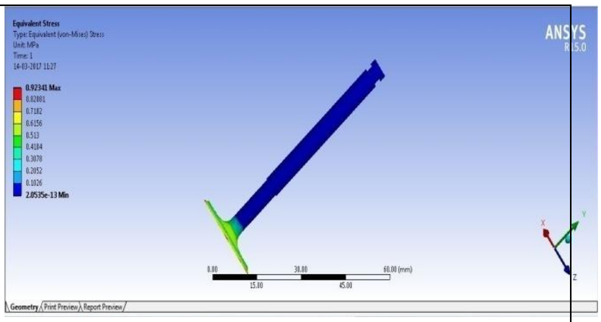


Fig.14.Equivalent (von- misses)Stress

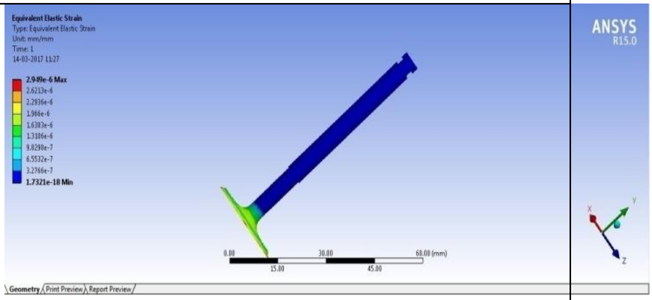


Fig.15. Equivalent Elastic

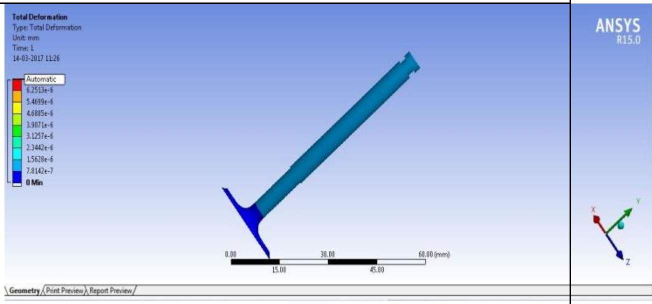


Fig.16. Total Deformation

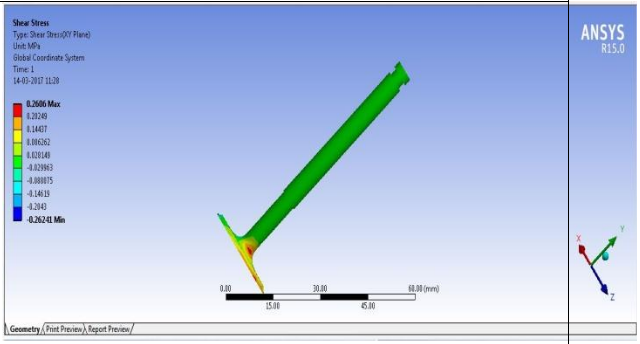


Fig.17. Shear Stress(XY Plane)

STAINLESS STEEL

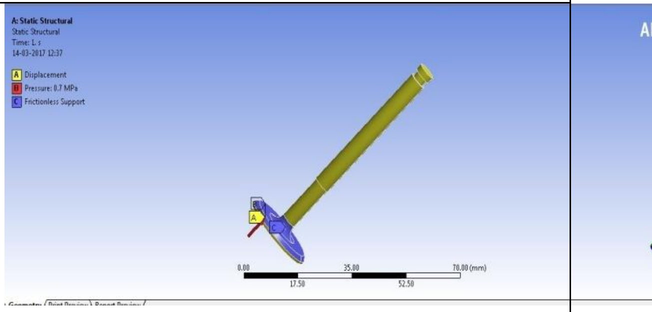


Fig.18. Boundary Conditions

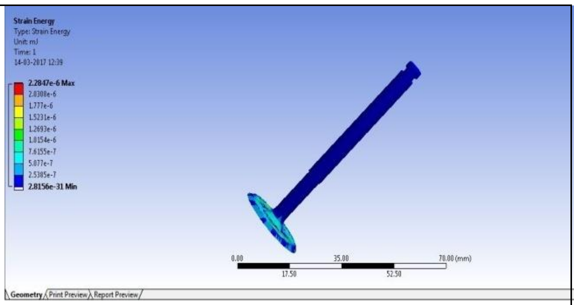


Fig.19. Strain Energy

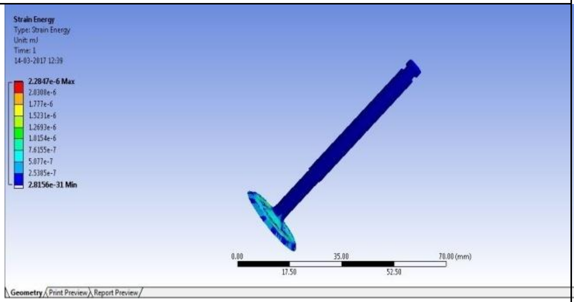


Fig.20.Strain Energy

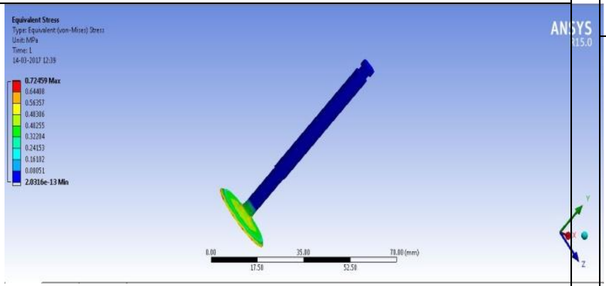


Fig.21. Equivalent (von-Mises) Stress

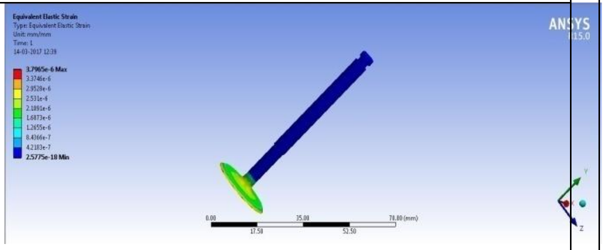


Fig.22. Equivalent Elastic Strain

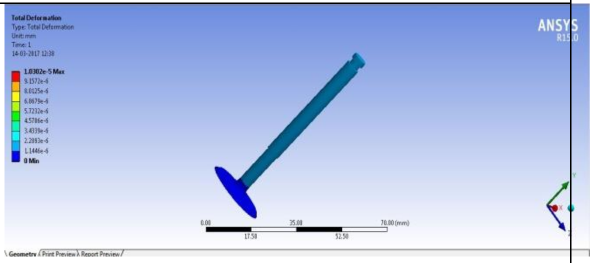


Fig. 23.Total Deformation

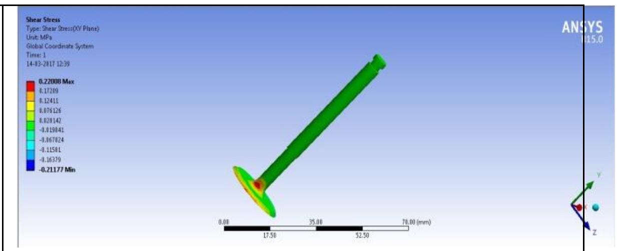


Fig. 24.Shear Stress(XY Plane)

Structural analysis of inlet valve

ALUMINA

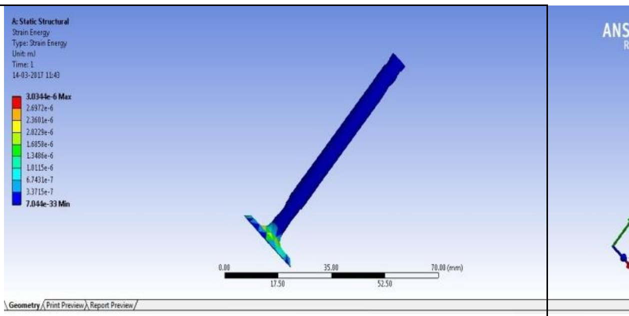


Fig.25. Strain energy

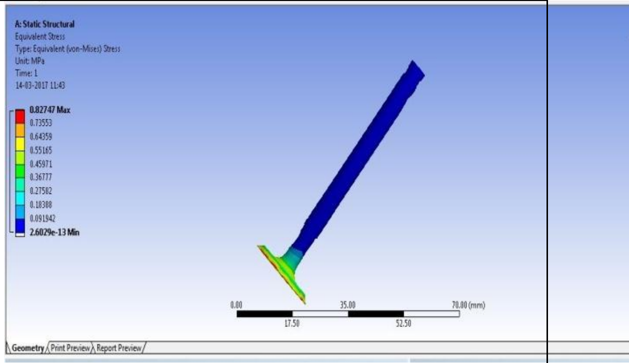


Fig.26.Equivalent (von-mises)Stress

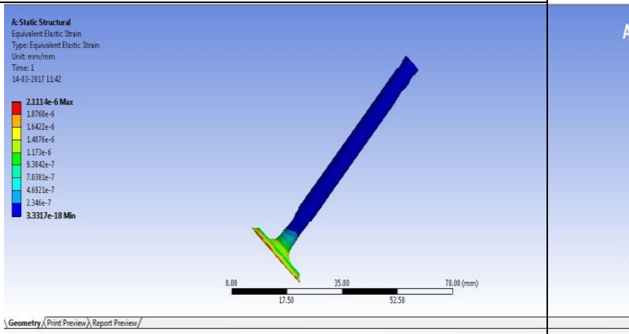


Fig.27. Equivalent Elastic Strain

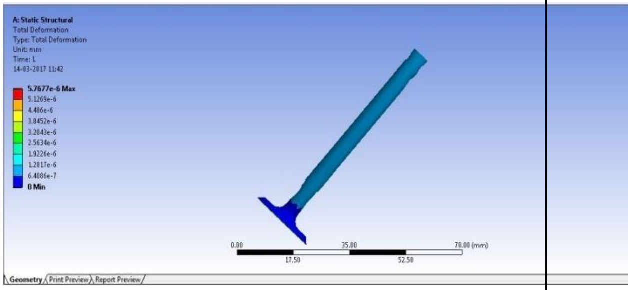
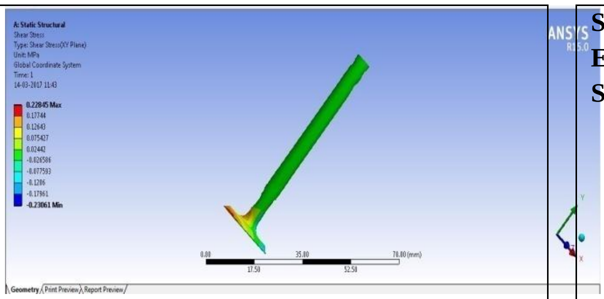
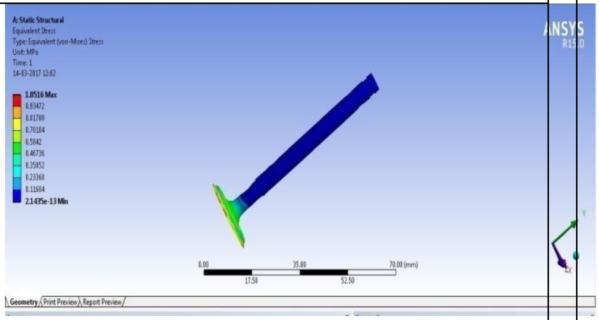
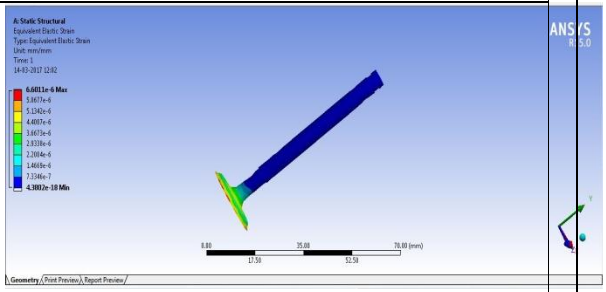
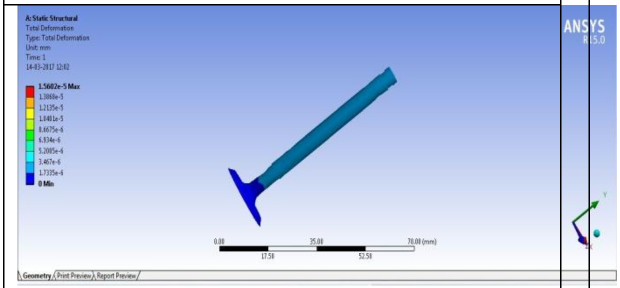
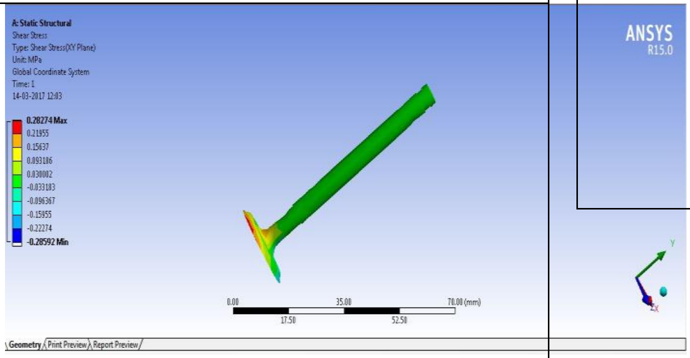


Fig.28.Total Deformation

	 Fig.29.Shear Stress(XY Plane)
SILICON	 Fig.30. Equivalent(von-Mises)Stress
	 Fig.31.Equivalent Elastic Strain
	 Fig.32. Total Deformation
	 Fig.33. Shear Stress(XY Plane)

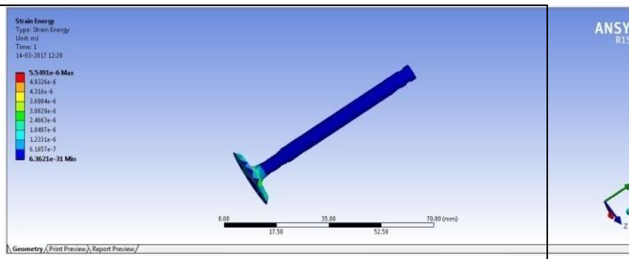
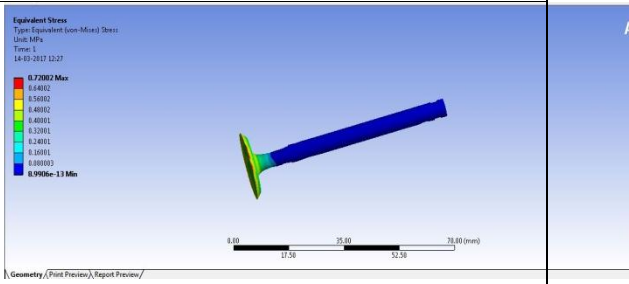
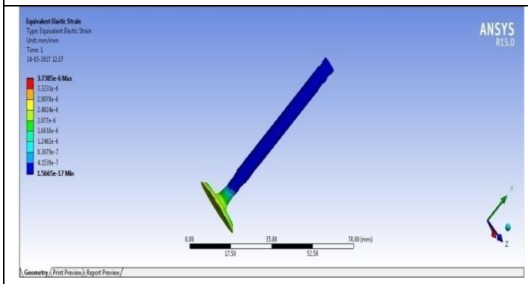
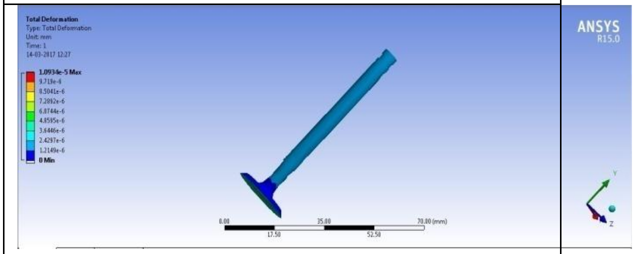
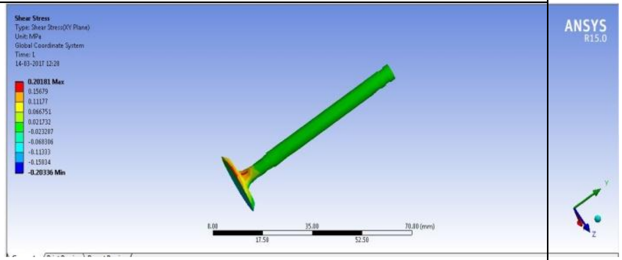
STAINLESS STEEL	 Fig. 34.Strain Energy
	 Fig. 35.Equivalent(von-Mises) Stress
	 Fig. 36.Equivalent Elastic Strain
	 Fig.37. Total Deformation
	 Fig. Shear Stress(XY Plane)

Table.1. Structural Analysis of Inlet valve

S. No	**Material**	**Total Deformation in (mm)**		**Equivalent Elastic Strain in (mm/min)**		**Equivalent Stress in (MPa)**		**Strain Energy in (mJ)**		**Shear Stress in (MPa)**	
		Mini	Max	Mini	Max	Mini	Max	Mini	Max	Mini	Max
1.	Alumina	0	5.7677e -006	3.3317e -018	2.1114e -006	2.6029e -013	0.82747	7.044e -033	3.0344e -006	-0.23061	0.22845
2.	Silicon	0	1.5602e -005	4.3802e -18	6.6011e -18	2.1435e -013	1.0516	2.1147e 032	8.86893e -006	-0.28592	0.28274
3.	Stainless Steel	0	1.0934e -005	1.5665e -17	3.7385e -6	8.9906e -013	0.72002	6.3621e -031	5.5491e -006	-0.20336	0.20181

Table.2. Structural Analysis of Exhaust valve

S. No	**Material**	**Total Deformation in (mm)**		**Equivalent Elastic Strain in (mm/min)**		**Equivalent Stress in (MPa)**		**Strain Energy in (mJ)**		**Shear Stress in (MPa)**	
		Mini	Max	Mini	Max	Mini	Max	Mini	Max	Mini	Max
1.	Aluminium Nitride	0	7.0857e -006	9.9943e -019	2.8842e -006	1.4511e -013	0.87769	4.97e -032	1.626e -006	-0.25013	0.24852
2.	Silicon Nitride	0	7.0327e -006	1.7321e -18	2.949e -006	2.0535e -013	0.92341	2.3059e 031	1.6275e -006	-0.26241	0.2606
3.	Stainless Steel	0	1.0302e -005	2.5775e -18	3.7965e -006	2.0316e -013	0.72459	2.8156e -031	2.2847e -006	-0.21177	0.22008

VI. CONCLUSION

- In this paper the 3D model of poppet valve was designed by using Solidworks software. The model meshing was done by using ANSYS. The FEA was done by ANSYS.
- The structural analysis was successfully carried out to determine stresses 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 structural analysis maximum von-Mises stress was observed high in silicon (1.0516MPa) for inlet valve whereas silicon

nitride (0.92341MPa) for exhaust valve. From the above results it was observed that the silicon is the best material for inlet valve and for exhaust valve aluminum nitride.

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