DESIGN AND THERMAL ANALYSIS OF COMPOSITE POPPET VALVE

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***Abstract*— A poppet valve is a valve typically used to control the timing used to control the timing and quantity of gas or vapour flow into an engine. Poppet valves have a round head that blocks a Hole, the port, the stem attached to the back of this valve head pushes the valve up and away from the port, allowing air or fuel to flow through the gap between the valve head and valve seat and into the combustion chamber. Poppet valves work well in engines because the pressure inside the combustion chamber pushes the valve against the seat, sealing the chamber and preventing leaks during this cycle poppet valves are exposed to high temperature and pressure which will affect the life and performance of the engine. The aim of the project is to design an exhaust valve with a suitable material for a four wheeler diesel engine using FEA. 2D drawings are drafted from the calculations and 3D model is done in CATIA and Analysis is done in ANSYS. Thermal and structural analysis is to be done on the poppet valve when valve is closed. Analysis will be conducted when the study state condition is attained at 5000 cycles using different ceramic composite materials.**

***Keywords* — Poppet Valve, Thermal Analysis, CATIA and ANSYS.**

I. INTRODUCTION

Safety valves, which are usually of the poppet type, open at a predetermined pressure. The movable element may be kept on its seat by a weighted lever or a spring strong enough to hold the valve closed until the pressure is reached at which safe operation requires opening. On gasoline engines, poppet valves are used to control the admission and rejection of the intake and exhaust gases to the cylinders. The valve, which consists of a disk with a tapered edge attached to a shank, is held against the tapered seat by a compressed spring. The valve is raised from its seat by the action of a rotating cam that pushes on the bottom of the shank, permitting gas flow between a region, which leads to the intake or exhaust pipes, and to region, which leads to the cylinder.

II. POPPET VALVE WEAR

In the early days of engine building, the poppet valve was a major problem. Metallurgy was not what it is today, and the rapid opening and closing of the valves against the cylinder heads led to rapid wear. They would need to be re-ground every two years or so by a process known as a valve job. Adding tetraethyl lead to the petrol reduced this problem to some degree, as the lead would coat the valve seats, in effect lubricating the metal. In more modern vehicles and properly machined older engines, valve seats may be made of improved alloys such as satellite and the valves themselves may be made of stainless steel. These improvements have generally made this problem disappear completely and made leaded fuel unnecessary. Valve burn is another major problem. It causes excessive valve wear and defective sealing, as well as engine knocking. It can be solved by valve cooling systems that use water or oil as a coolant. In high performance engines sometimes sodium-cooled valve stems are used. These hollow valve stems are partially filled with sodium and act as a heat pipe. A major cause of burnt valves is a lack of valve clearance at the tappet, meaning the valve cannot completely close. This removes its ability to conduct heat to the cylinder head via the seat, and also forces extremely hot Combustion gases between the valve and the seat.

III. MATERIAL PROPERTIES

TABLE 1. MATERIAL PROPERTIES OF SUH 1 STEEL

S.No.	Properties	Value
1	Density(g/cc)	7.7
2	Young's modulus (GPa)	200
3	Poisson's ratio	0.265
4	Specific heat(J/kg-k)	502.416
5	Thermal conductivity (W/m-k)	23
6	Coefficient of thermal expansion (m/m-k)	$1.20x10^{-9}$

TABLE 2. MATERIAL PROPERTIES OF AL_2O_3/ AL_2O_3 COMPOSITE

S.No.	Properties	Value
1	Density (g/cc)	3.69
2	Young's modulus (GPa)	215
3	Poisson's ratio	0.21
4	Specific heat(J/kg-k)	880
5	Thermal conductivity (W/m-k)	18
6	Coefficient of thermal expansion (m/m-k)	$8.1\ 0\ x10^{-10}$

TABLE 3. MATERIAL PROPERTIES OF C/C COMPOSITE

S.No.	Properties	Value
1	Density (g/cc)	2.9
2	Young's modulus (GPa)	64.5
3	Poisson's ratio	0.22
4	Specific heat(J/kg-k)	800
5	Thermal conductivity (W/m-k)	20
6	Coefficient of thermal expansion (m/m-k)	$6.00\ x10^{-10}$

TABLE 4. MATERIAL PROPERTIS OF C/SIC COMPOSITE

S.No.	Properties	Value
1	Density (g/cc)	2.4
2	Young's modulus (GPa)	150
3	Poisson's ratio	0.4
4	Specific heat (J/kg-k)	750
5	Thermal conductivity (W/m-k)	120
6	Coefficient of thermal expansion (m/m-k)	$2.50\ x10^{-10}$

IV. ANALYSIS

A. SUH1 STEEL

Total deformation

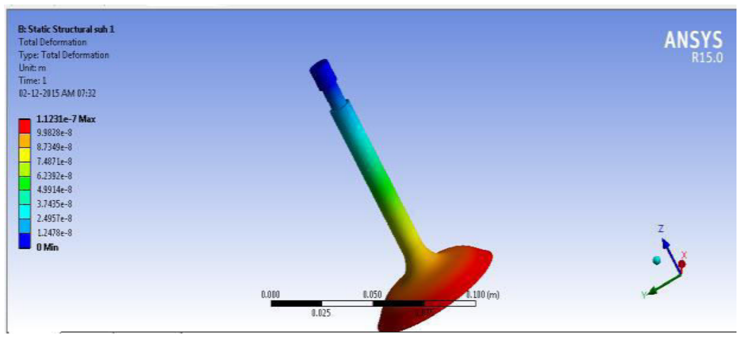

Fig. 1. Total deformation of poppet valve of SUH1 steel

von-Misses stress

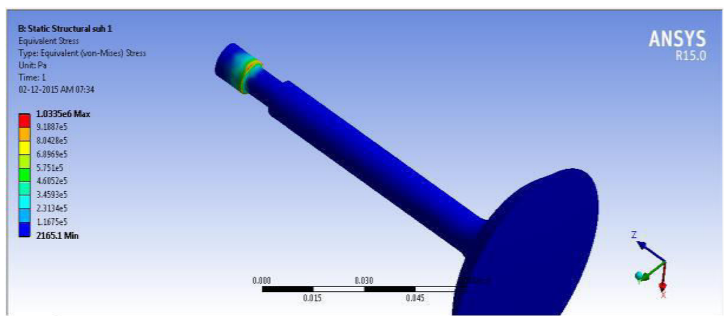

Fig. 2. von-Misses stresses of poppet valve of SUH1 steel

Strain

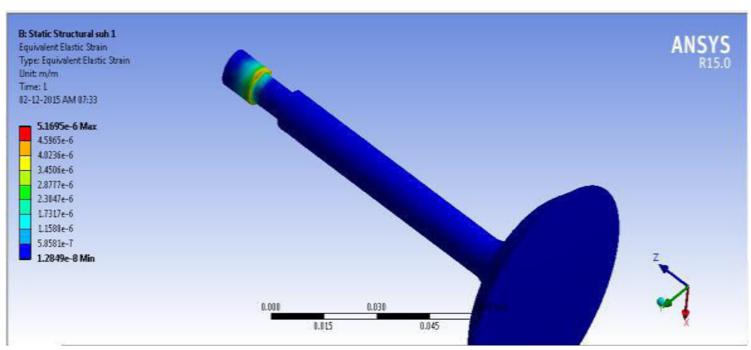

Fig. 3. Strains of poppet valve of SUH1 steel

Temperature Variations

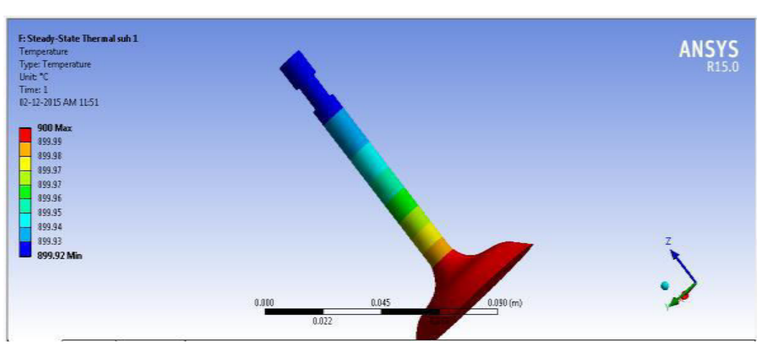

Fig. 4. Temperature of poppet valve of SUH1 steel

B. AL_2O_3 / Al_2O_3 COMPOSITE

Total Deformation

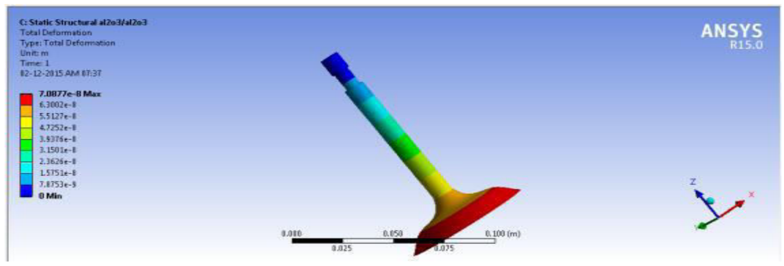

Fig. 5. Total deformation of Al_2O_3/Al_2O_3 Composite

von- Misses Stress

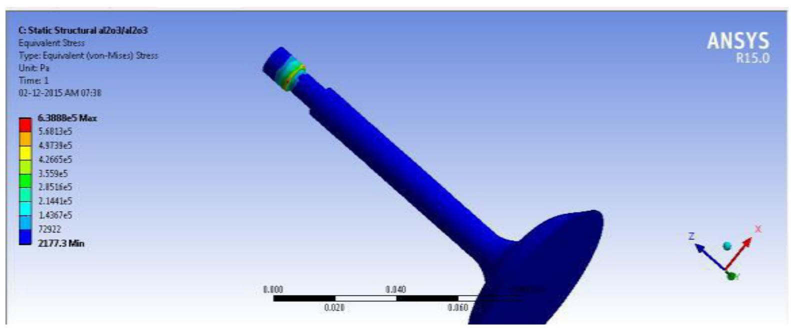

Fig. 6. von-Misses Stresses of Al_2O_3/Al_2O_3 Composite

Strain

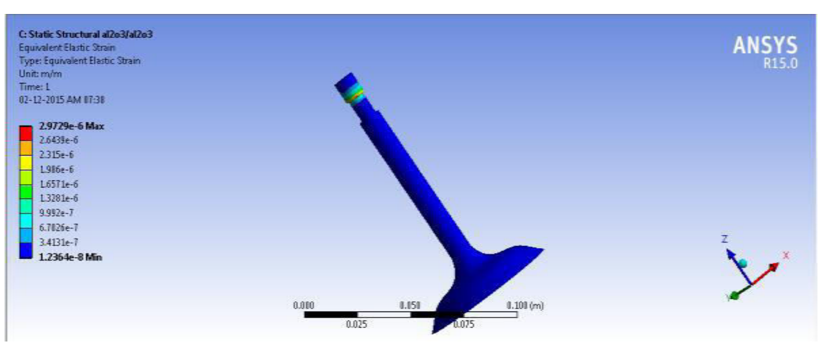

Fig. 7. Strains of Al_2O_3/Al_2O_3 Composite

Temperature variations

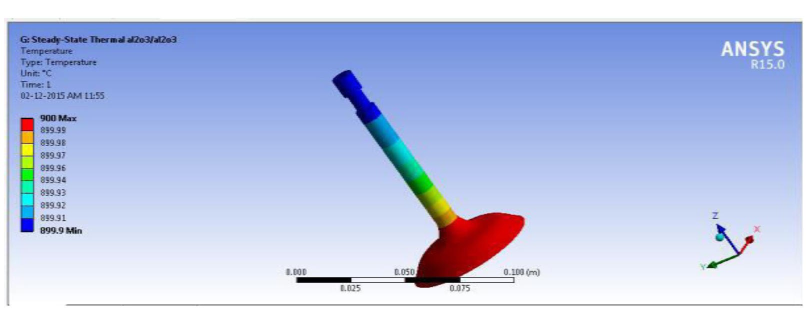

Fig. 8. Temperature of Al_2O_3/Al_2O_3 Composite

C. CARBON / CARBON COMPOSITE

Total Deformation

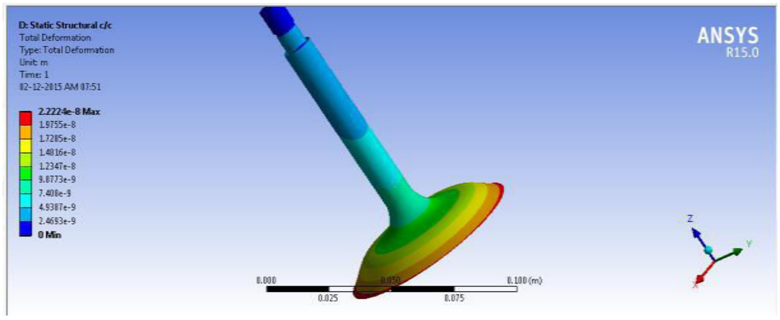

Fig. 9. Total Deformation of C/C Composite

von-Misses Stress

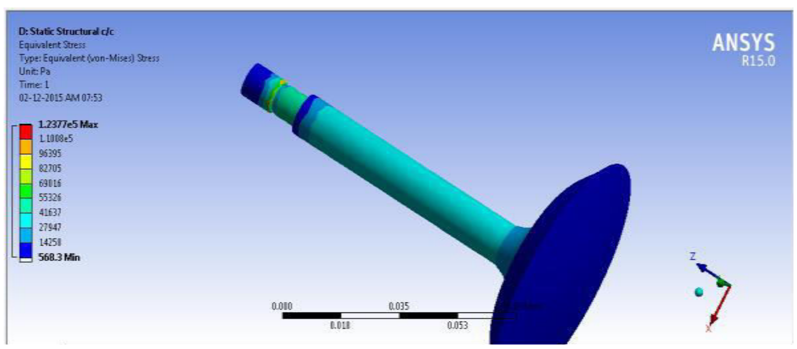

Fig. 10. von Misses Stress of C/C Composite

Strain

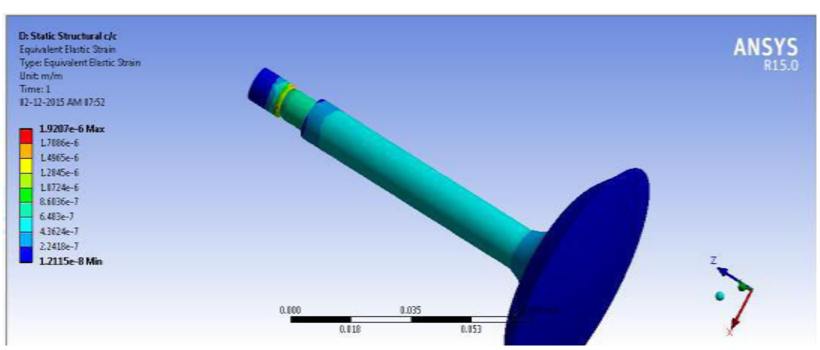

Fig. 11. Strains of C/C composite

Temperature Variations

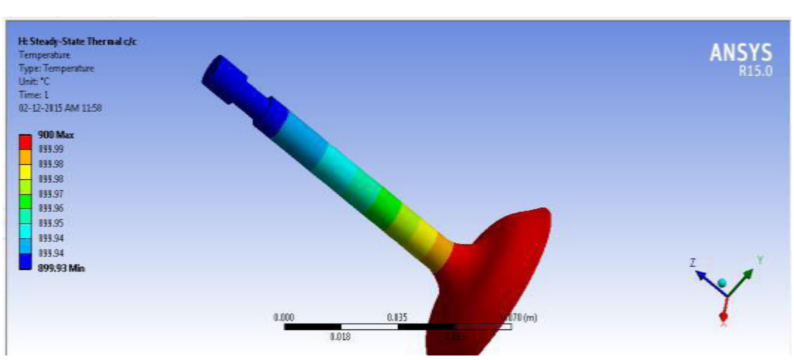

Fig. 12. Temperature of C/C Composite

V. RESULTS

TABLE 5. TABLE OF STRUCTURAL ANALYSIS RESULTS OF A POPPET VALVE

	DEFORMATION(m)		THERMAL STRESS(Pa)		STRAIN	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
SUH 1	0	1.12 $X10^{-7}$	2165.1	1.03 $X10^{6}$	1.28 $X10^{-8}$	5.17 $X10^{-6}$
Al_2O_3/Al_2O_3	0	7.09 $X10^{-8}$	21773	6.39 $X10^{5}$	1.24 $X10^{-8}$	2.97 $X10^{-6}$
C/C	0	2.22 $X10^{-8}$	568.3	1.24 $X10^{5}$	1.21 $X10^{-8}$	1.92 $X10^{-6}$
C/SIC	0	2.22 $X10^{-8}$	2140.5	2.76 $X10^{5}$	1.57 $X10^{-8}$	1.84$X10^{-6}$

VI. CONCLUSIONS

Here, we conducted structural analysis with 900ºC temperature and 800 Pa pressure as boundary conditions, and thermal analysis is done at 900ºC. Both structural and thermal analysis are conducted with SUH 1 steel, Al_2O_3/Al_2O_3 composite, CARBON-CARBON composite and CARBON-SILICON CARBIDE composite and the results are discussed below. In structure analysis we concentrated on deformations, thermal stress and strains. From the results we observed that least deformation and strains are in C/SiC poppet valve, but least strains are recorded in carbon-carbon composite. Coming to thermal analysis there is no much variations in the temperature, but maximum fluxes are recorded in C/SiC composite followed by carbon-carbon composite. Finally we conclude that carbon-carbon composite is better material for a poppet valve with moderate deformations, and least stress, and moderate thermal fluxes when compared with the remaining three materials.

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