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"Design and Analysis of Composite Material Poppet Valve"

Hajgude Vishal V.[1], Bhavar Pratik A.[2], Birari Prathmesh M.[3], Ahirrao Ankit K.[4], Raut Mahesh B.[5]

Department of Mechanical Engineering, Savitribai Phule Pune University

[1]hajgudevishal16@gmail.com
[2]pratikabhavar72@gmail.com
[3]biraripm2017@gmail.com
[4]morahirrao90@gmail.com

Abstract- *'Poppet valves' is a precision engine component which is well known as Intake & Exhaust valves. Poppet valves work well in engines combustion chamber, it prevents the leaks during the engine cycles. But during that cycles poppet valves exposed to high temperature & pressure, which will affect the life & performance of engine. The aim of project is to design am exhaust valve with a suitable composite material for a 4-stroke engine by using FEA analysis & Simulation by using 'ANSYS' software. & to ratify the 'ANSYS' the result values FEA analytical method used. In poppet valve we have considered 5 different materials St. Steel, Carbon Epoxy, Silicon Chromium, Cobalt Chromium, Molybdenum composite material. In this we observe the results of original poppet valve as stress, strain and total deformation. These values are compared with the modified poppet valve design. The comparison of 'ANSYS' values & also the analytical values. The modified poppet valve design values are shown tremendous change in stress, strain and total deformation of the composite material.*

Index Terms- *Poppet valve, Composite Materials, CATIA, ANSYS.*

1. Introduction

In a four stroke IC Engine, inlet and exhaust valve are used to open and close the inlet and exhaust port. Inlet and Exhaust valve is called as a poppet valve. The major function of these valves is to seal the combustion chamber and control the flow of fluid in the combustion chamber. Poppet valve are subjected to very high pressure and temperature which will affect the life and performance due to which thermal and mechanical stresses are imposed on inlet as well on exhaust valve.

Four Strokes of IC Engine

In a four stroke, our strokes are completed in a two revolution of a crankshaft and each stroke is completed in a 180 degree of crank rotation and hence four strokes are completed in a 720 degree of crank rotation.

Suction Stroke: - The first stroke in a IC engine is called as a suction stroke. During a suction stroke Inlet valve is opened and Exhaust valve is closed and mixture of air and fuel is drawn into the combustion chamber. During this piston moves from top dead center to bottom dead center.

Compression Stroke: - During compression stroke Inlet valve and Exhaust valve are closed. During this cycle charged is compressed up to the clearance volume and at the same time due to compression pressure and temperature increases. During this stroke piston moves from bottom dead center to top dead center. At the end of compression stroke mixture is ignited.

Expansion/Power Stroke: - When the piston reaches the top dead center spark plug ignites the fuel mixture and generated high pressure and temperature gases push the piston to create motive force. During this Inlet and Exhaust are closed and piston moves from top dead center to bottom dead center.

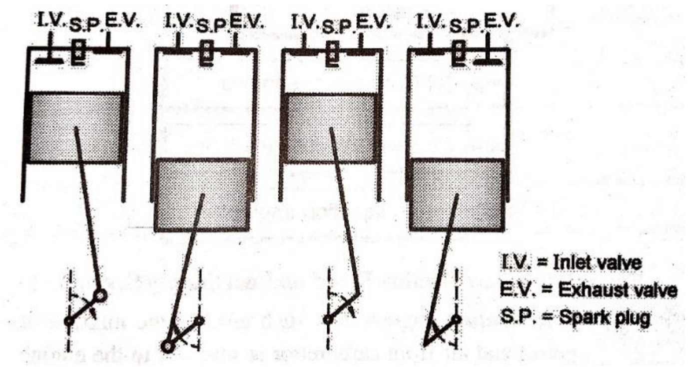

Fig. 1

Exhaust Stroke:- During the exhaust stroke piston moves from bottom dead center to top dead center and inlet valve is closed and exhaust is opend. In this stroke the burned gases are escape from the cylinder.

1.1 Objectives of project:-

1.The main objective of the project is to find out the sutiable material for poppet valve.

2.To determined better performance, efficiency with low cost materials.

3.To improve strength of valve according to need.

2. Poppet Valve

A poppet valve is important engine component which control the exchange of gases and air fuel mixture in a engine. The working end of the poppet valve, valve face which is typically at 45-degree bevel to the seal. A pressure differential on either side of poppet valve can impair its performance. Higher pressure against the valve helps to seal the chamber and lower pressure will helps to open the chamber. To open the valve pressure must be applied in a direction of a spring pressure.

The poppet valve has following parts: - Cam Shaft, Cam, Follower, Washer, Valve steam, Adjusting screw, Tappet, valve spring, Valve guide face. The cam actuates the moment of the valve through tappet. This moment is obtained by a rotation of a camshaft and cam and which runs at high of engine speed. The poppet valve is subjected to a high temperature due to which it gets heated up and gradually valve parts are expand for this a clearance must be provided on a poppet valve. The clearance depends upon temperature, material and length. The tappet clearance can be adjusted by adjusting by screw and when the adjusting screw is not provided to vary the clearance it can be increased by grinding at the bottom of the valve steam and face.

3. Literature Review

Manasi Jayant Neve et al.

They analysed an exhaust valve with a suitable composite material (Al2O3, Carbon-epoxy, Technetium) for a four-stroke diesel engine. In this they observe the result of original poppet valve as stress, strain & total deformation, then these values are compared with modified poppet valve. They seen that modified poppet valve design values are shows change in stress, strain & total deformation. Finally, concluded that Technetium material is suitable for poppet valve.

Awanish Kumar Singh et al.

They had designed an intake and exhaust valve of IC Engine. 3D model and transient thermal analysis is to be done on the poppet valve by using different composite materials (SUH1 Steel, Alumina, Carbon composite, Silicon Carbide composite). They observed the thermal & structural analysis of material behaviour of inlet and exhaust valves in internal combustion engine, then they had suggested that Carbon/SiC is better material for inlet valve & SUH1 Steel for exhaust valve.

Ch. Mani Kumar et al.

They aimed to modelling & simulates the thermal analysis on poppet valves applications of 99.3cc. In thermal analysis determined directional heat flux, total heat flux and temperature. They used three different materials (Stainless Steel, Silican Nitride, Aluminium Nitride) for thermal analysis. In this study found out, in thermal analysis maximum heat flux was observed in steel (0.48813 W/mm2) for inlet valve and for exhaust valve stainless steel (0.64196 W/mm2).

Nayudu et al.

In this paper, biofuels blended in different percentages vary from 0, 5, 10 and 20%. Here the effect diesel blended fuels on the valve is studied by mathematical correlations applying thermal loads produced during combustion. Finally concluded that, silichrome steel have minimum thermal gradient and thermal flux with 0% blended fuels as compared to silichrome steel and nimonica 942 with 5, 10 and 20% blended fuels. They suggested that we can use bio-diesel blends with regular diesel engines without any effect on engine material, lifetime and heat dissipation.

Snehal Gawale et al.

In this paper, engine valve is designed to reduce the stress concentration by selecting suitable fillet radius with secondary objective is to increase the working life of exhaust valve by recommending the best alternative material. They findout results experimentally over an Universal Testing Machine for compressive loading.finally concluded that valve with fillet radius 14.0 mm shows safe results and is selected for further work.

4. Selection of Materials

Material selection for poppet valve should have the following requirements :-

• High tensile strength and hardness to resist tensile loads and stem wear.

• High fatigue and creep resistance.

• Adequate corrosion resistance & less brittle.

• Least coefficient of thermal expansion to avoid excessive thermal stresses in the head.

• High thermal conductivity for better heat dissipation.

• The material available at cheap rate.

5. Calculation for forces acting on poppet engine Valve

a) Force required to open the valve

Fopen = Fi + Fl + Fg --------------(1)

Where,

Fi = Initial spring force

Fl= Force required to lift the valve

Fg= Gas force

Mathematically,

Fi =Dv^2*Ps ------------------(2)

=(31)^2*(0.002)

=1.5095 N

Where,

Ps = Suction pressure

= 0.002 to 0.004 N/mm2

Fl = k*hmax -----------------(3)

= 10*10 = 100 N

Where K= spring stiffness

= 10 N/ mm

Fg =Dv^2*Pg ------------------(4)

= (31)^2*0.35

= 264.1686 N

Where,

Pg = gas pressure

= 0.35 to 0.45 N/mm2

Substituting equation (2),(3) and (4) in equation (1)

Fopen = 365.67 N

Fl = 1.508 N

6. Design of Poppet Valve Using CATIA

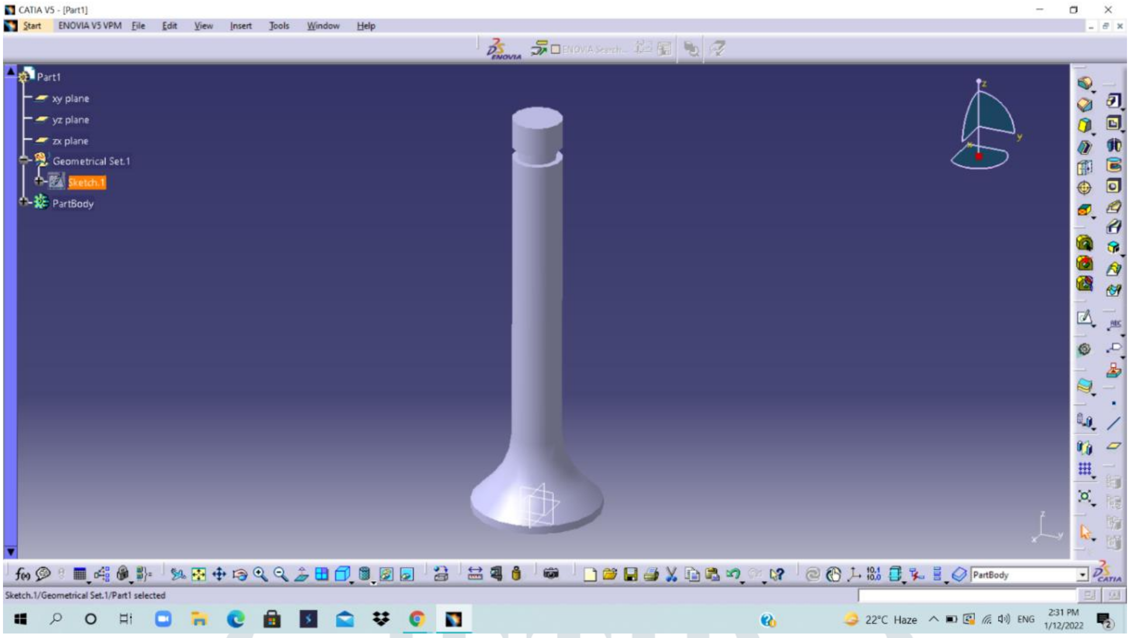

Fig.2

7. Analysis of Poppet Valve Using ANSYS

1) St. Steel

A) Deformation:

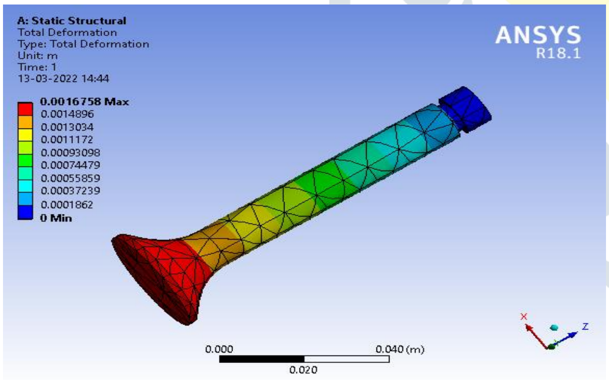

Fig.3

B) Strain:

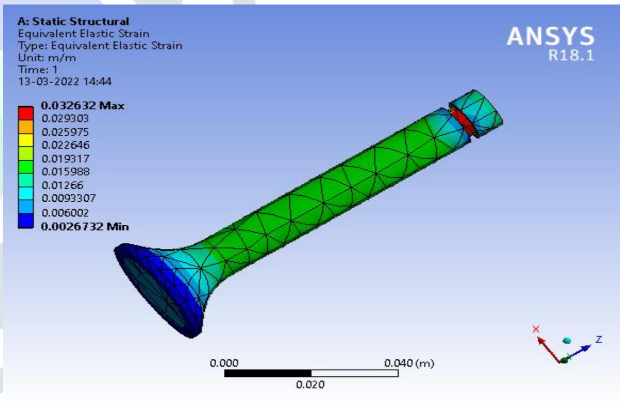

Fig.4

C) Stress:

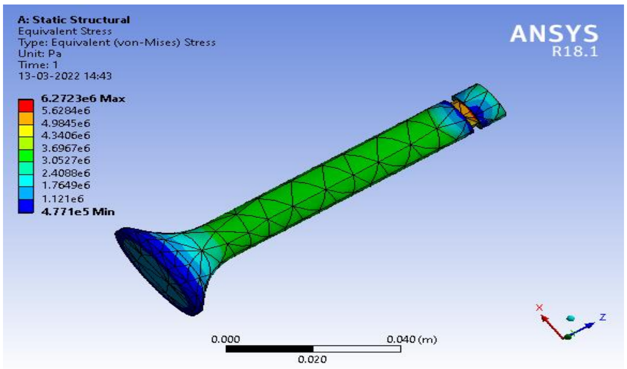

Fig.5

2) Carbon Epoxy

A) Deformation

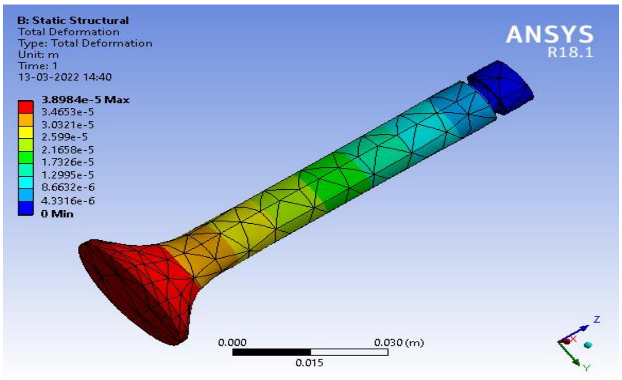

Fig.6

B) Strain

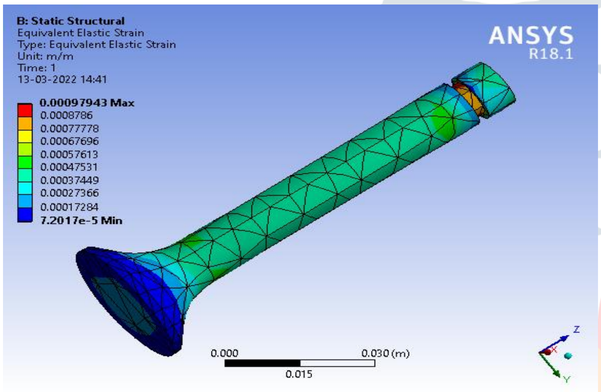

Fig.7

C) Stress

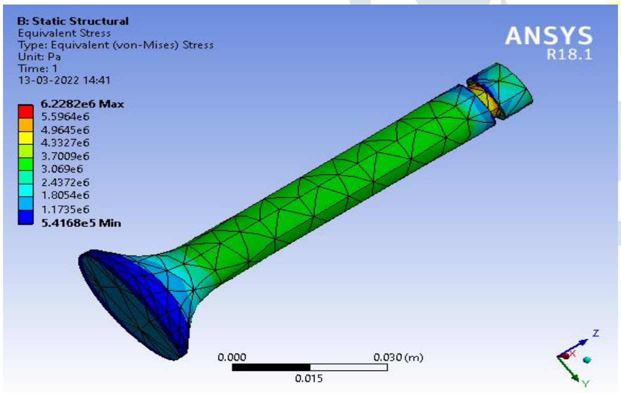

Fig.8

3) SiCr

A) Deformation

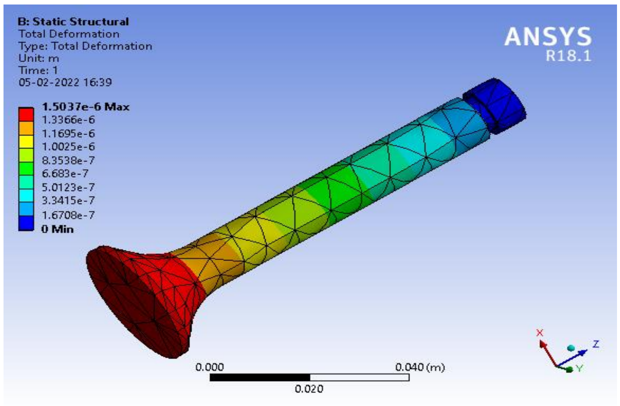

Fig.9

B) Strain

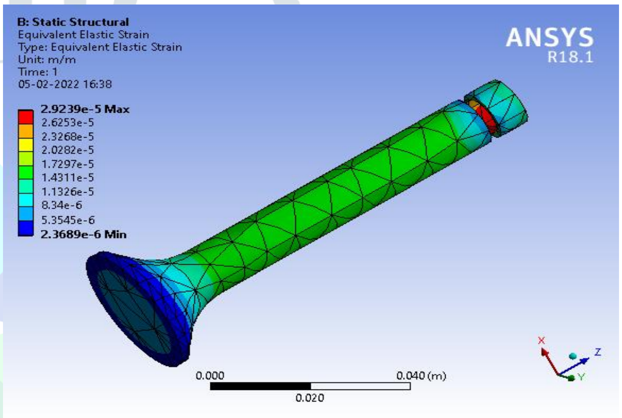

Fig.10

C) Stress

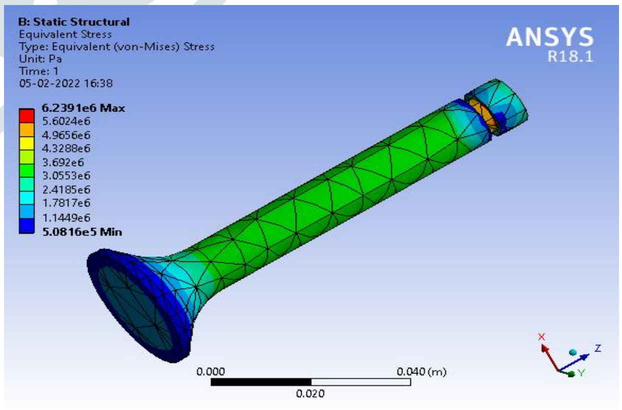

Fig.11

4) CoCr

A) Deformation

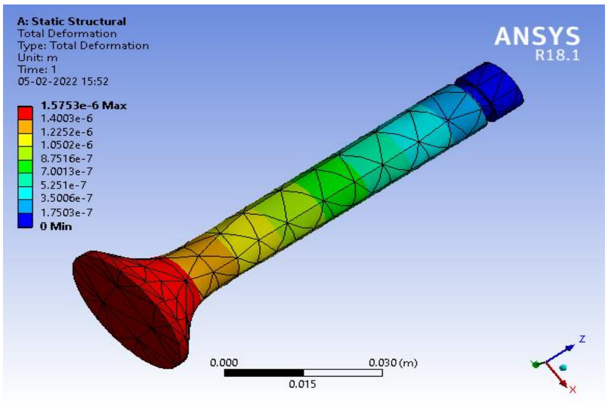

Fig.12

B) Strain

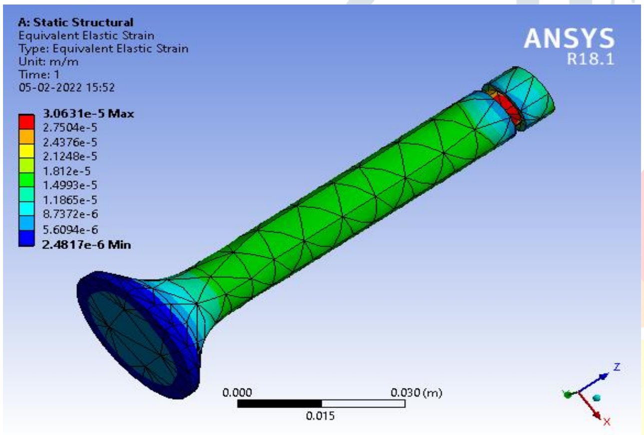

Fig.13

C) Stress

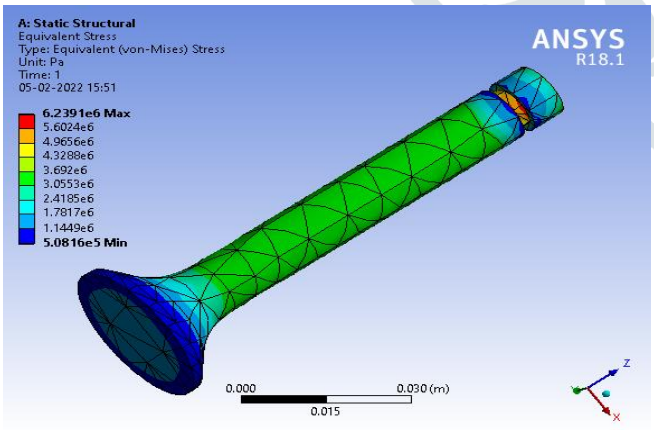

Fig.14

5) Molybdenum

A) Deformation

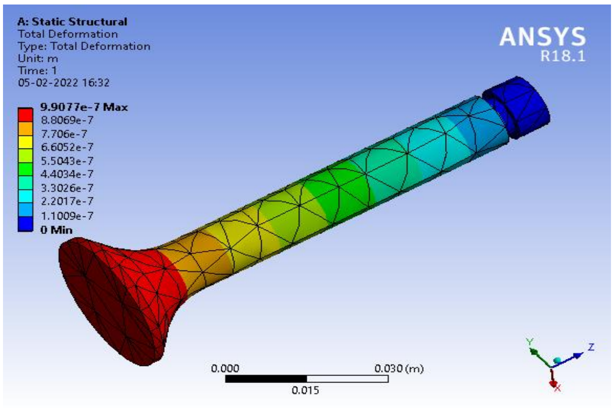

Fig.15

B) Strain

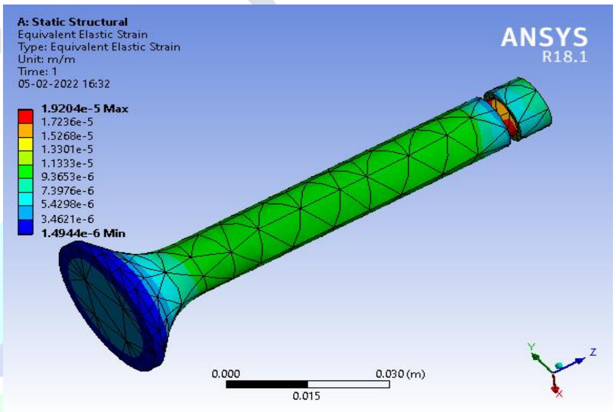

Fig. 16

C) Stress

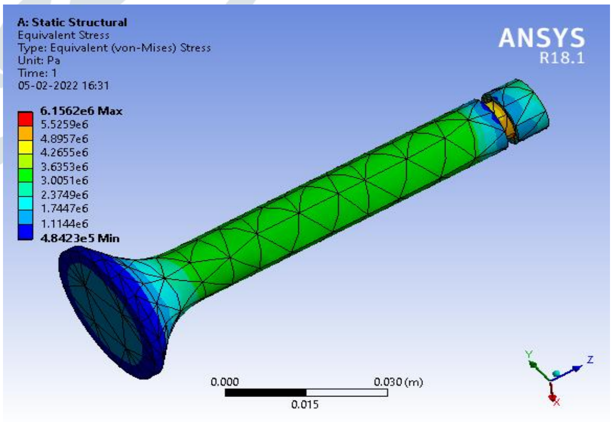

Fig.17

8. Result Tables

1) Showing structural analysis results of valve:

Table No. 1

	Stress		Strain		Total Deformation
	Max.	Min.	Max.	Min.	
St. Steel	6.2723e+6	4.7712e+5	3.2632e-4	2.6732e-3	1.6758e-3
Carbon Epoxy	6.2282e+6	5.4168e+5	9.7943e-4	7.2017e-5	3.8964e-5
SiCr	6.2391e+6	5.816e+5	2.9239e-5	2.3689e-6	1.5037e-6
Molybdenum	6.1562e+6	4.8423e+5	1.9204e-5	1.4944e-6	9.9077e-7
CoCr	6.2391e+6	5.081e+5	3.063e-5	2.481e-6	1.5753e-6

2) Showing theoretical analysis results of valve:

Table No. 2

	Stress		Strain		Total Deformation
	Max.	Min.	Max.	Min.	
St. Steel	38.32e+6	0.48e+6	1.92e-4	2.50e-6	1.34e-3
Carbon Epoxy	35.05e+6	0.48e+6	2.29e-4	5.59e-6	1.60e-3
SiCr	36.77e+6	0.47e+6	1.67e-4	2.13e-6	1.17e-3
Molybdenum	33.47e+6	0.46e+6	1.124e-4	1.45e-6	7.10e-4
CoCr	35.02e+6	0.48e+6	1.67e-4	2.302e-6	1.15e-3

9. Conclusion

In this thesis, a poppet valve and even in modified design of the poppet valve considering design (3D modelling) in CATIA V5 software and FEA analysis work is carried out in ANSYS software. Three materials are selected for calculation/observation. They are Stainless Steel, Molybdenum, carbon epoxy, Cobalt Chromium, Silicon Chromium.As per observation all the results obtained are plotted into tables and graphs, conclude that stress (6.1562e6), strain (1.9204e-5) and total deformation (9.9077e-7) is having the lesser values. These results are obtained for the molybdenum material. So here is the conclusion that this material is the best material with adequate strength and life of the valve.

10. Future Scope

1.In sport or racing cars there is number of engine cycles done within a minute so, there is a high temperature & pressure is generates, then they cam affects the life & performance of poppet valve. By the implementation of composite materialed poppet valve design, improves the life & performance of poppet valve.

2. By giving some amount of concave shape to the bottom side of valve head, to escape the exhaust gases in combustion chamber like a 'scavenging'.

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