Design and Analysis of Composite Poppet Valve with Catia and Ansys

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ABSTRACT

Poppet valve work well in engines because the pressure inside the combustion chamber pushes 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-stroke diesel engine by using fem analysis.

In poppet valve we have considered three different materials Al2O3, Carbon-epoxy, Carbon-carbon composite materials. 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 modified poppet valve design values are shown tremendous change in stress, strain and total deformation of the composite material.

1.INTRODUCTION

INTERNAL COMBUSTION ENGINE

An engine is a device which transforms one form of energy into another form. However, while transforming energy from one form to another, the efficiency of conversion plays an important role. Normally, most of the engines convert thermal energy into mechanical work and therefore they are called heat engines. Heat engine is a device which transforms the chemical energy of fuel into thermal energy and utilizes this thermal energy to perform useful work. A combustion engine is an engine which generates mechanical power by combustion of a fuel.
Generally combustion engines are two types:

- Internal combustion engine (ICE)
- External combustion engine (ECE).

External combustion type in which the working fluid is entirely separated from the fuel- air mixture (ECE), and the internal - combustion (ICE) type, in which the working fluid consists of the products of combustion of the fuel- air mixture itself.

Advantages of ICE over ECE

i.More mechanical simplicity and lower weight/power ratio.

ii.They do not need auxiliary equipment, such as boiler & condenser.

iii.They could be started and stopped in a short time.

iv.Their thermal efficiency is higher than other heat engines.

v.Their initial cost is low.

These advantages make ICE more suitable in the transport sector, motor cars, small ships, submarines, and small aircrafts

Types of ICE

i.I.C.E. can be divided into several groups according to different features as characteristics:
ii.Operating cycles

iii.Method of charging the cylinder

iii.Fuel used

General design (position and number of cylinders, method of ignition, rotating speed, etc.)
iv.Method of cooling the engine

2.IMPORTANT COMPONENTS OF AN IC ENGINE

Main parts of an internal combustion engine are cylinder, piston, crankcase, crankshaft, and intake exhaust valves, spark plug and fuel injector as shown in Fig: 1.1

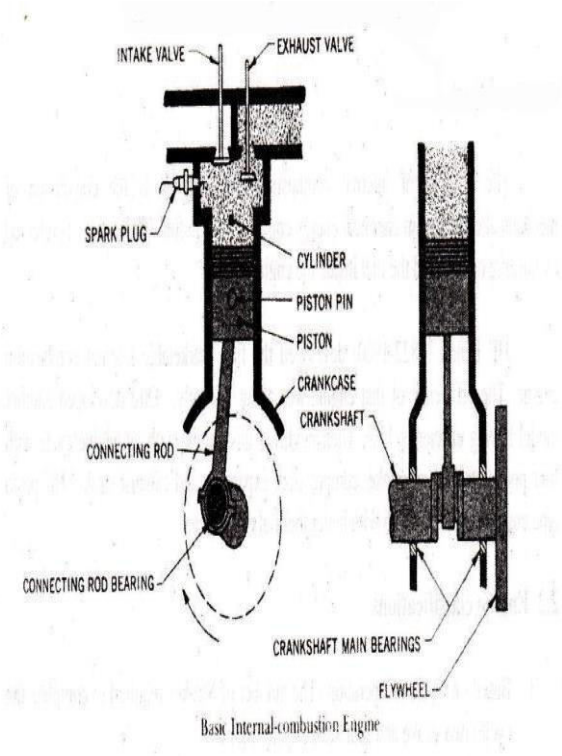


Fig: 1.1 Components of IC engine

Cylinder:

It is a cylindrical vessel or space in which the piston makes a reciprocating motion. The varying volume created in the cylinder during the operation of the engine is filled with the working fluid and subjected to different thermodynamic processes.

Piston:

It fits perfectly into the cylinder providing a gas tight space with the piston rings and the lubricant. It forms the link in transmitting the gas forces to the output shaft.

Crankshaft:

It converts the reciprocating motion of the piston into useful rotary motion of the output shaft.

Inlet and exhaust valves:

Valves are commonly mushroom shaped poppet type. They are provided either on the cylinder head or on the side of the cylinder for regulating the charge coming into the cylinder and for discharging the products of combustion from the cylinder.

Spark plug:

It is a component to initiate the combustion process in spark-ignition engines and is usually located on the cylinder head.

Fuel injector:

This is used in CI engines. By atomizing the fuel into very fine droplets, it increases the surface area of the fuel droplets resulting in better mixing and subsequent combustion.

3.Working procedure of four stroke IC engine:

In a four stroke engine, the cycle of operations is completed in four strokes of the piston or two revolution of the crankshaft. Each stroke consists of 180 deg. Of crankshaft rotation and hence a four stroke cycle is completed through 720 deg. of crank rotation. The cycle of operation for an ideal four stroke engine consists of the following four strokes:

1. Suction or intake stroke.
2. Compression stroke
3. Expansion or power stroke
4. Exhaust stroke

Intake stroke:

The first stroke of the internal combustion engine is also known as the suction stroke because the piston moves to the maximum volume position (downward direction in the cylinder). The inlet valve opens as a result of the cam lobe pressing down on the valve stem, and the vaporized fuel mixture enters the combustion chamber. The inlet valve closes at the end of this stroke.

Compression stroke:

In this stroke, both valves are closed and the piston starts its movement to the minimum volume position (upward direction in the cylinder) and compresses the fuel mixture. During the compression process, pressure, temperature and the density of the fuel mixture increases.

A Power stroke:

When the piston reaches a point just before top dead center, the spark plug ignites the fuel mixture. The point at which the fuel ignites varies by engine; typically it is about 10 degrees before top dead center. This expansion of gases caused by ignition of the fuel produces the power that is transmitted to the crank shaft mechanism.

Exhaust stroke:

In the end of the power stroke, the exhaust valve opens. During this stroke, the piston starts its movement in the maximum volume position. The open exhaust valve allows the exhaust gases to escape the cylinder. At the end of this stroke, the exhaust valve closes, the inlet valve opens, and the sequence repeats in the next cycle. Four-stroke engines require two revolutions.

When the four strokes of the engine are being performed individually, it is termed as "Four stroke engine" and when the actions of intake and compression and expansion and exhaust are performed together as a whole of two strokes is termed as "Two stroke engine".

4.Mechanisms

Mechanisms involved in an internal combustion engine are:

i.Valve mechanism

ii.Cam and follower mechanism

iii.Piston cylinder mechanism

Valve mechanism

To admit the air-fuel mixture in the engine cylinder and to force the exhaust gases out at correct timings, some control system is necessary, which is provided by the valves.

The engine valves may be broadly divided into 3 main categories:

i.Poppet valve

ii.Sleeve valve

iii.Rotary valve

Out of these three, poppet valve is the one which is being universally used for automobile engines.

The conventional automotive engine is fitted with mechanically operated poppet valves for both inlet and exhaust. A poppet valve consists of a disc of metal with a coaxial stem on one side which closes a circular opening in a wall separating two chambers, against which wall it is drawn by a spring. To open the valve, a force must be applied to it in, a direction contrary to that of the spring pressure. Poppet valves are lifted from their seats by means of cams, and are closed by springs. The rate at which the valve is opened and closed depends on the cam outline and on the type and size of cam follower employed. From the standpoint of gas flow it is, of course, desirable that the valve should open and close very quickly, and remain fully open for the greatest possible length of time. The heads of the valves are subjected to the high temperature of the burning gases,and it is essential that they should not warp under the influence of the heat, and that their seats should not scale or corrode, as in either case they would become leaky. Exhaust valves may reach a temperature of 1475 F.

In four stroke internal combustion engine, the "Poppet Valve" performs the opening of the cylinder to inlet or exhaust manifold at the correct moment. Generally the face of valve is ground at 45 degree but in some cases it is ground at 30 degree also. It is not important to have a same angle of face in inlet and exhaust valve of same engines.

To make it in right order, the valve may be reground after some use. There is some margin provided to avoid sharp edges. The groove, retain the valve spring which aids in keeping the valve pressed against the seat when closed and thus seal the combustion space tightly. In close position, the valve face fits the accurately matched ground seat in the cylinder block. Generally replaceable ring inserts are used for exhaust valve seat. The inlet valves are made from plain nickel, nickel chrome or chrome molybdenum. Whereas exhaust valves are made from nickel chrome, silicon chrome steel, high speed steel, stainless steel, high nickel chrome, tungsten steel and cobalt chrome steel. Poppet valve has following main parts, Cam Shaft, Cam, Cam Follower, Tappet, Adjusting Screw, Washer, Valve Spring, Valve Stem, Guide valve face. With the help of these parts, valve performs its operation very accurately in internal combustion engine.

The cam actuates the movement of the valve through the tappet. The replaceable valve stem moves up and down in the valve stem guide. This movement is obtained by rotation of camshaft and cam, which generally runs at the half the engine speed.

The valve spring, keeps the valve pressed against its seat and ensures a leakage proof operation and also brings back the valve very quickly during its closing. When the engine is started, it gets heated up gradually there by causing the valve stem to expand. A valve tappetclearance is always provided to allow the expansion of valve stem and other parts. This clearance value depends upon the length of the valve, its material and the operating temperature of the engine. The tappet valve clearance can be adjusted by rotating theadjusting screw. Where adjusting screw is not provided to vary the clearance, it can be increased by grinding the bottom of the valve stem and face or by using longer valve. Due care must be taken because even a slightly insufficient clearance may lead to the valve not properly resting against its seat as the engine gets heated causing increased noise level and loss of power. The clearance provided in exhaust valve is slightly more than that of inlet valve. This is due to slightly more expansion in exhaust valve because of higher temperature of hot exhaust gases produced during combustion.

5.IDEA DEVELOPMENT

PROBLEMS WITH AVAILABLE ENGINE:

A poppet valve used in a valve operating system of a usual internal combustion engine is currently employed in most of internal combustion engines because of its good sealing property. When an improvement in performance of the internal combustion engine is intended to be provided, however, the use of the poppet valve is accompanied by the various disadvantages:

i.The presence of a valve stems and valve head in a passage results in a resistance to the passing of a gas to cause degradation in intake and exhaust efficiencies.

ii.Because of the poppet valve have the valve stem and the valve head, intake and exhaust passages are curved in the

vicinity of the valve, resulting in degradation in intake and exhaust efficiencies.

iii.Because of the valve is reciprocally moved by the valve stem, a space elongated in the direction of such reciprocal movement is required, resulting in a large sized engine.

iv.Because the opening and closing of the valve are conducted by the reciprocal movement of the valve stem, a shock noise is generated during closing of the valve.

v.Frictional losses are also present due to more number of mating parts in valve mechanism. Due to more components material cost and manufacturing cost of material is increased. And lubricating losses are also increased.

6.NEW MECHANISM

To overcome the disadvantages found in the use of the poppet valve, an oscillatory valve is proposed. Oscillatory valve is proposed to avoid the reciprocal movement of the valve. Due to the oscillatory motion of a valve, intake and exhaust gas are passed out. An effective opening time cannot be precisely provided, and to provide such an effective opening time precisely, it is necessary to ensure a more precise timing in opening of a valve bore and to increase the opened area of the valve bore. The present invention has been accomplished with the foregoing in view and aims at providing an increment in opened area per unit time during opening of a valve, an improvement in sealing property during explosion and a reduction in friction, as well as a compact construction of engine and an improvement in performance of assembling a valve operating mechanism.

According to the present invention, there is provided a valve operating system for an internal combustion engine, which consists of a single oscillatory valve inside the combustion chamber in an internal combustion engine. By oscillatory valve operating system we can increase the opening time of inlet manifold, and we can achieve the stoichiometric air fuel ratio (14.7: 1). When the air fuel ratio is nearer to the stoichiometric ratio, perfect combustion is possible in an internal combustion engine and production of CO gases is minimized. Comparing with poppet valve operating system, oscillatory valve operating system consists of less number of mating parts by this we can minimize the frictional losses, lubricating losses. By decreasing the mating parts, complexity in valve operating system is reduced.

When we use two valves we require more number of mating parts which are used to transmit motion from the cam shaft, due to more number of components transmission of motion from camshaft to valve is delayed.

IMPORTANT PARTS :

Oscillatory valve mechanism consists of five important parts. Name of parts and quantity of parts are:

I

i.Cam

ii.Follower

iii.Pushrod

iv.Connecting rod

v.Oscillatory Valve

Available motion is rotatory which is from crankshaft of an internal combustion engine, but to control an oscillatory valve we should convert rotary motion into oscillatory motion. For that follower and two connecting rods are used in oscillatory valve system.

Follower which is converts the rotary motion into reciprocal motion, and connecting rods are used to convert reciprocal motion into oscillatory motion. Assembly of these parts is shown below in Fig:4.1

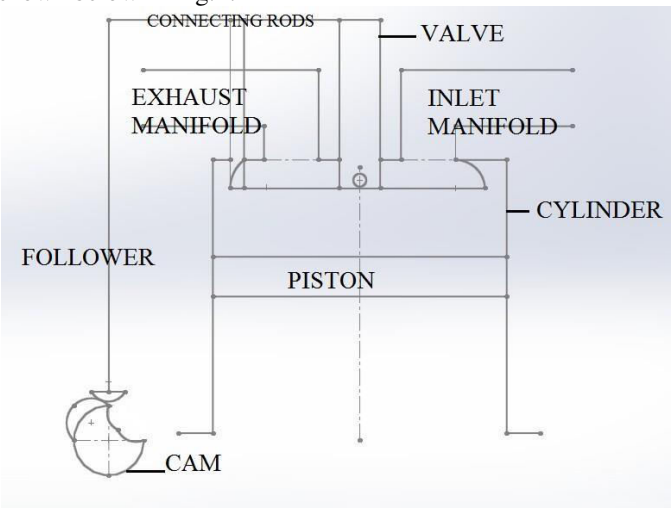


Fig: 4.1 Assembly of new engine

This shows the complete oscillatory valve system arrangement. Basic rotary motion is from cam. Follower is used to converts rotary motion of cam into reciprocal motion. Follower one end is on the surface of cam and another end is connected to the connecting rod of oscillatory valve system. When the connecting rod receives the reciprocal motion from follower and converts it into oscillatory motion by the help of another connecting rod which is connected to oscillatory valve. Oscillatory valve is controls the inlet and exhaust gases by utilizing oscillatory motion which is given by two connecting rods.

7.CATIA DRAWINGS

By using CATIA V5 mechanical design software we designed new oscillatory valve mechanism system parts. Dimensions are approximately same to the present single cylinder internal combustion engine. How we designed is shown in below.

VALVE HEAD

Valve head material is same as the oscillatory valve material i.e. NIMONIC 80A. Valve head is used to control the oscillatory motion of valve. Half of part is inside the combustion chamber and another half is outside of combustion chamber. Valve head having a 3mm diameter hole which is used to fix the oscillatory valve inside the

combustion chamber. Valve head is fixed to the cylinder head by a fixed joint. Valve head must contain these properties hot strength, high corrosive resistance, high thermal conductivity. Isometric view of valve head is shown in Fig: 4.12

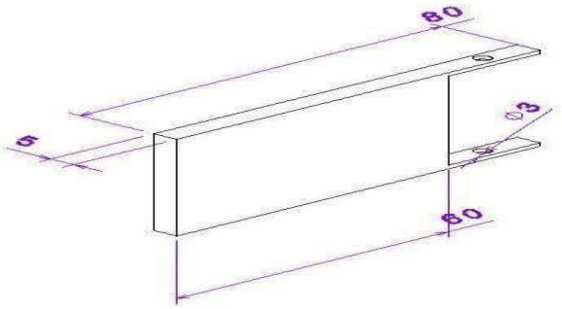


Fig: 4.12 Valve head with dimensions Actual

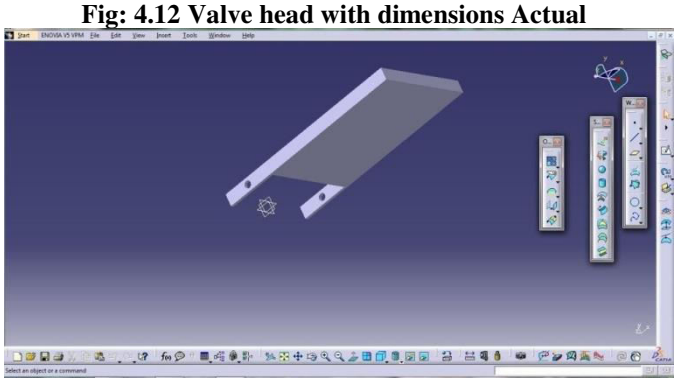


Fig: 4.13 CATIA drawing of valve head

CYLINDER HEAD

Cylinder head design is completely different from the present IC engine cylinder head.

Cylinder head having two manifolds which are inlet and exhaust manifolds. And one rectangle slot is used to insert valve head into the combustion chamber. One 3mm diameter hole is used to join connecting rod and oscillatory valve end. Gray cast iron is
used to manufacture cylinder head. Isometric view of cylinder head shown in Fig:4.14

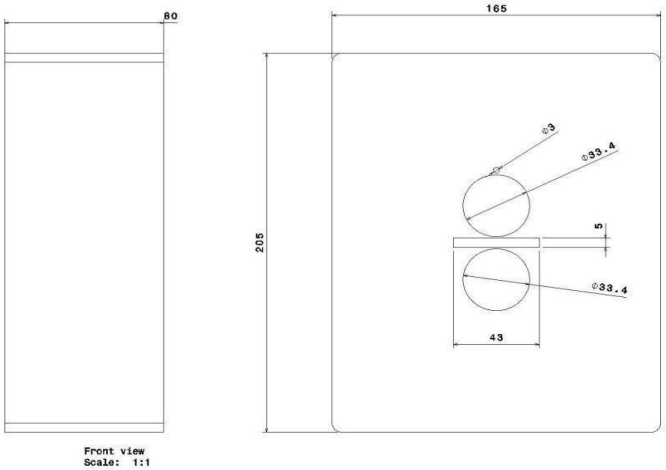
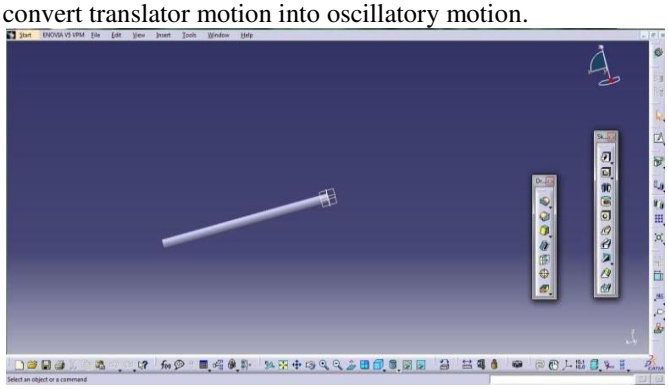


Fig: 4.14 Cylinder head with dimensions

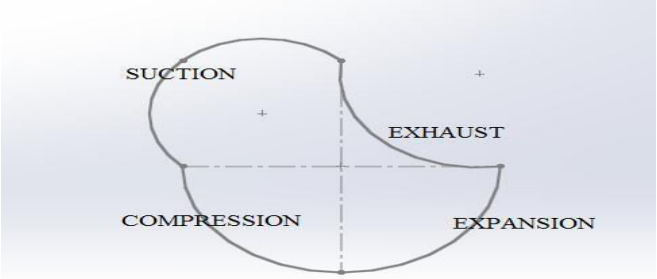
CONNECTING RODS:

In this oscillatory valve mechanism two connecting rods are used to transform the motion from follower to engine valve. Two fulcrums, valve heads and valve springs are replaced by two connecting rods only. Connecting rods arrangement is to convert translator motion into oscillatory motion.



CAM

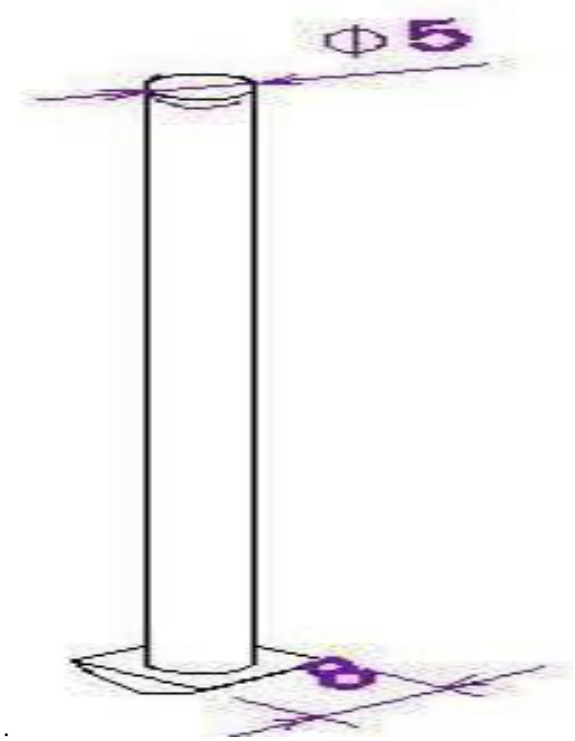
Cam is very important part in oscillatory valve system because it is completely different from the present engine cams, present engine cams are only used to provide upward lift, but this new designed cam gives both upward and downward motions to the follower. Cam is manufactured itself on the camshaft of engine. Valve opening and closing is completely depends on cam design. If cam inlet portion is more, then inlet manifold opening is more, else opening is less, same way exhaust manifold opening and closing is also depending on cam design. Present engine cam design is shown in below Fig: 4.17



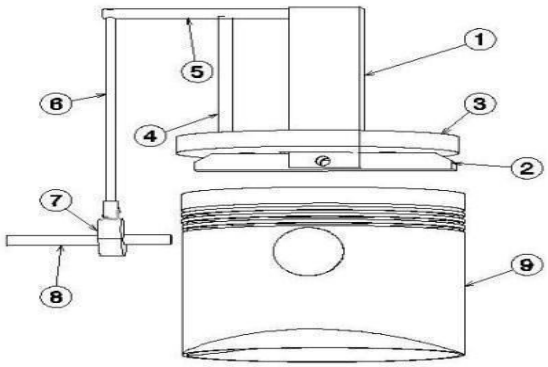
FOLLOWER

Follower which is used in oscillatory valve system is different from the present valve system. Mush room type gravity loaded follower is used. Gravity loaded follower is required to obtain exhaust stroke. Slipping chances are reduced by the use of mush room type follower. Follower is mainly used to convert rotary motion to reciprocal motion.

Follower used to transform the motion from cam to connecting rods. When the follower touches nose edge of the cam then inlet stroke is occurred. When the follower moves down then exhaust stroke is occurred. Oscillatory valve system follower is shown in below



Complete assembly of new oscillatory valve mechanism

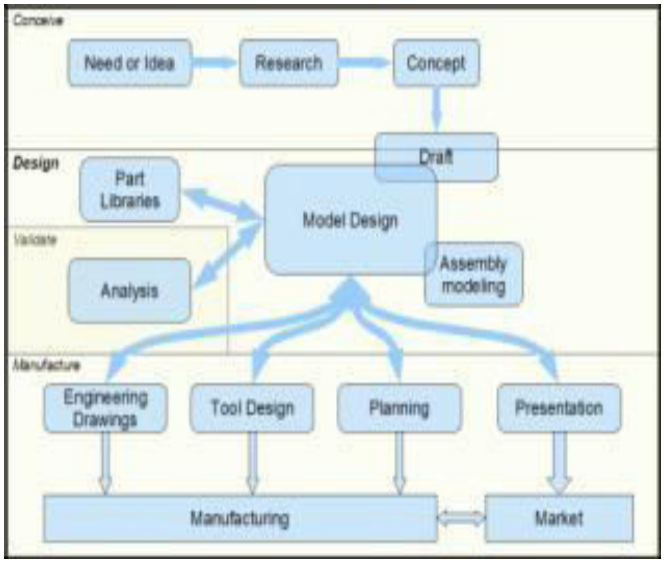


- Valve head
- Oscillatory valve
- Cylinder head
- Connecting rod1
- Connecting rod2
- Follower
- Cam
- Camshaft
- Piston.

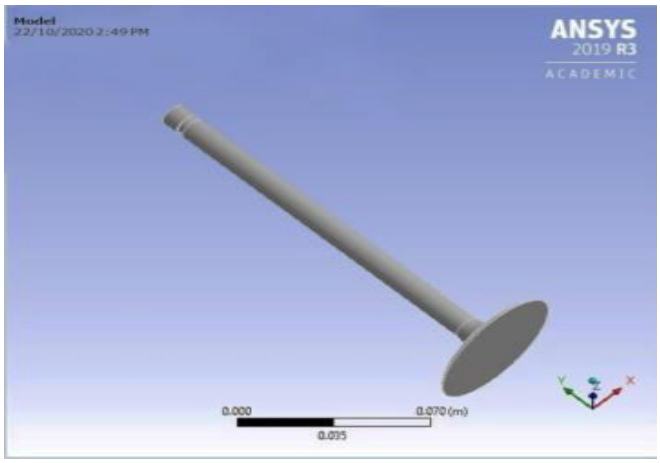
8.CAD (Computer Aided Designing)

Commuter Aided Manufacturing Procedure

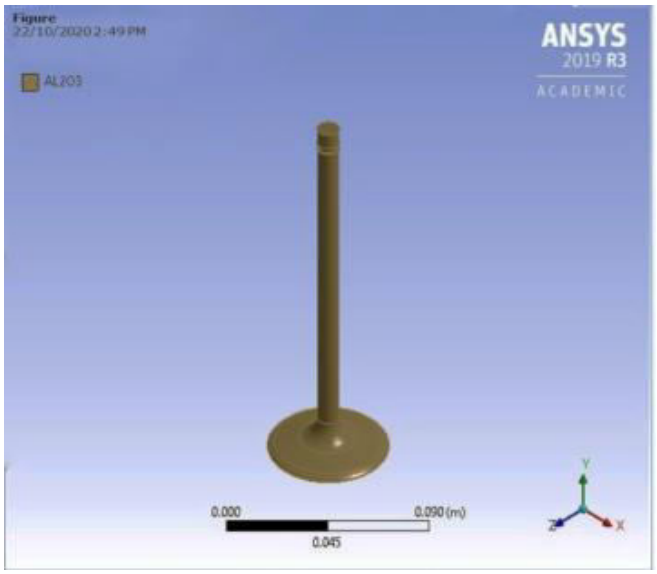
Computer-aided design (CAD) is the use of computer systems to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. Each stage requires specific knowledge and skills and often requires the use of specific software

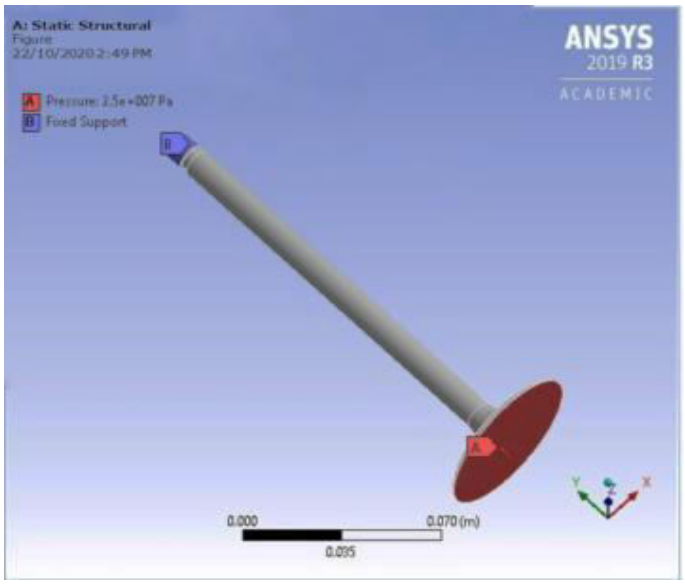


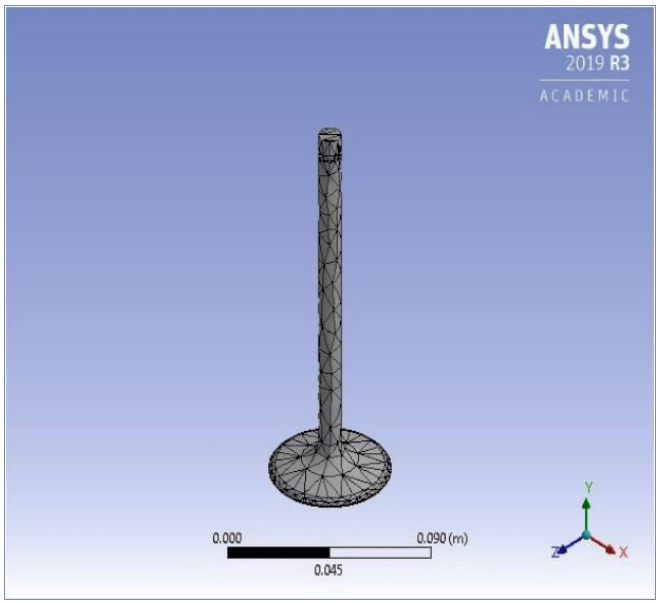
9.FINITE ELEMENTANALYSIS



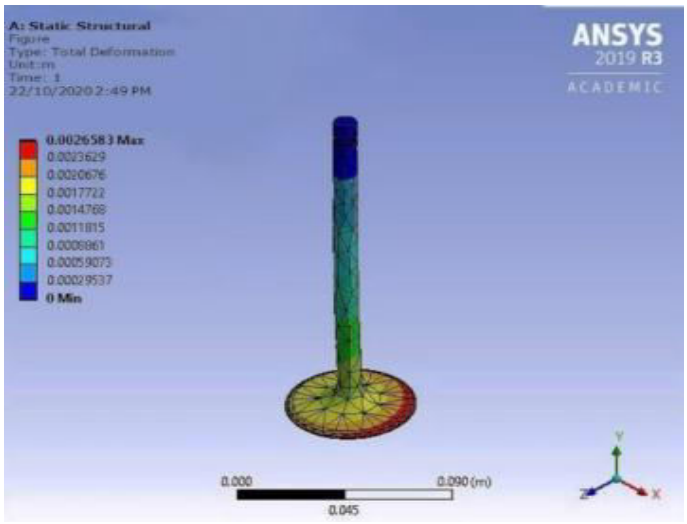
I.Al2O3





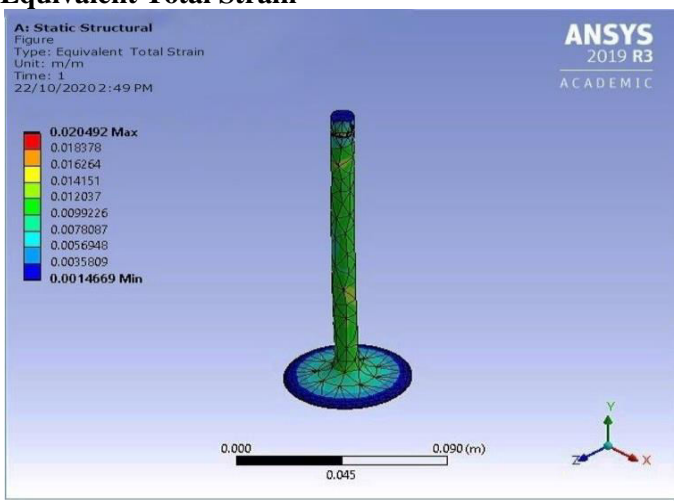


Total Deformation



Time [s]	Minimum [m]	Maximum [m]	Average [m]
1.	0.	2.6583e-003	1.7552e-003

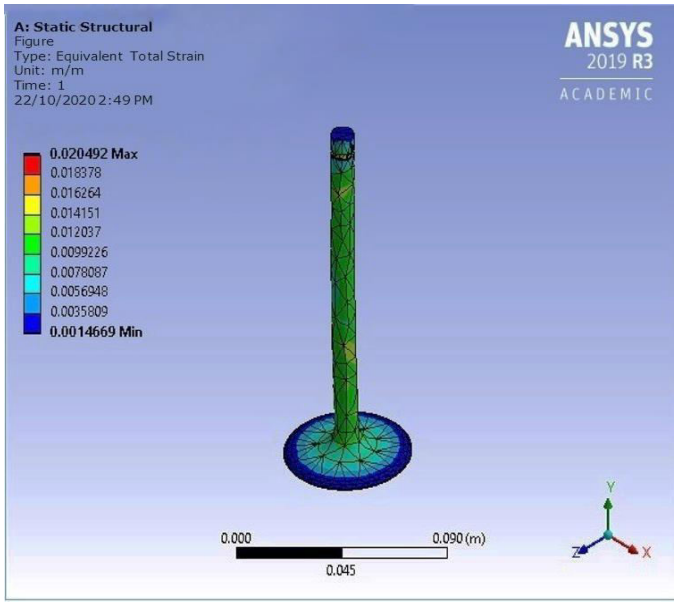
Equivalent Total Strain

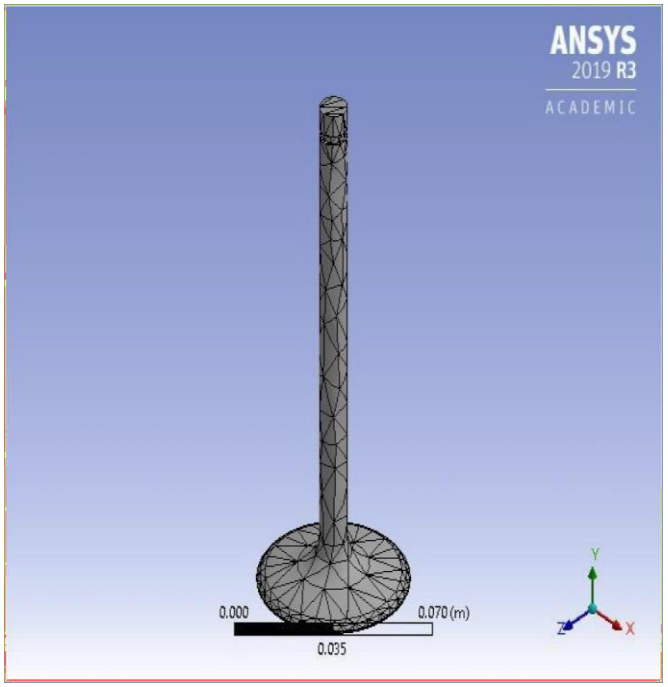


Time [s]	Minimum [m/m]	Maximum [m/m]	Average [m/m]
1.	1.4669e-003	2.0492e-002	6.0934e-003

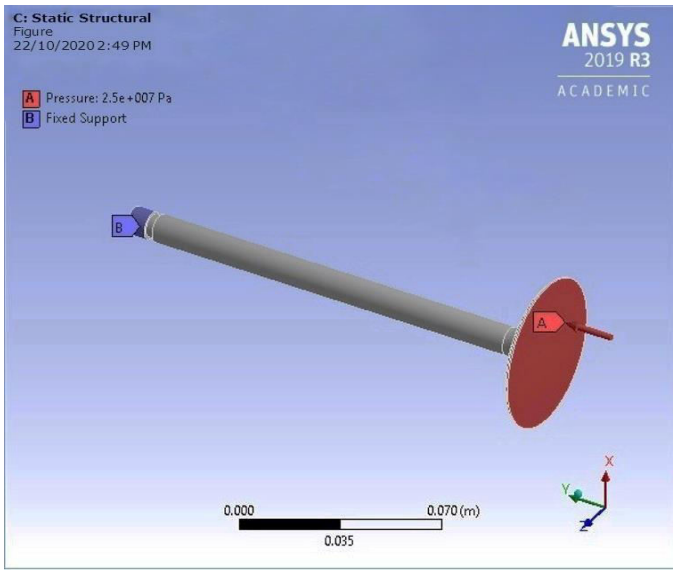
Epoxy Carbon

Equivalent Stress

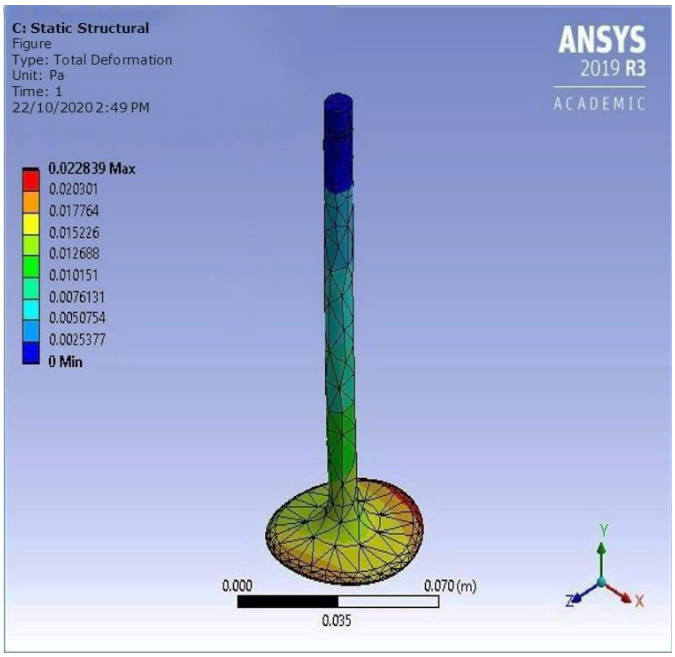




Time [s]	Minimum [m/m]	Maximum [m/m]	Average [m/m]
1.	0.0014669	0.020492	0.0109

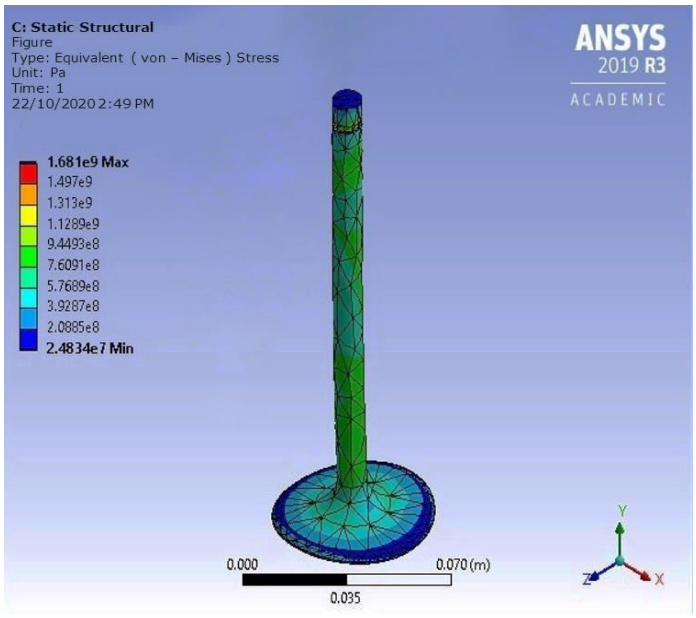


Total Deformation



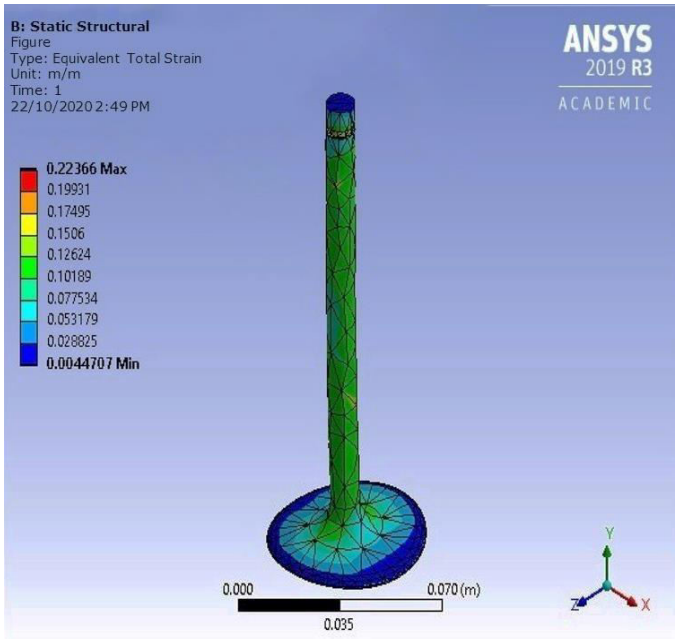
Time [s]	Minimum [m]	Maximum [m]	Average [m]
1.	0.	2.2839e-002	1.3879e-002

Equivalent Stress

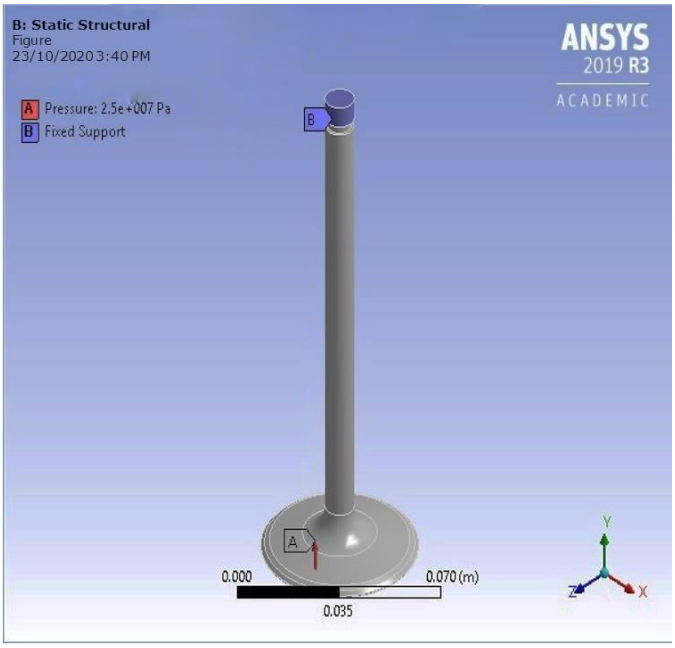


Time [s]	Minimum [Pa]	Maximum [Pa]	Average [Pa]
1.	2.4834e+007	1.681e+009	4.3546e+008

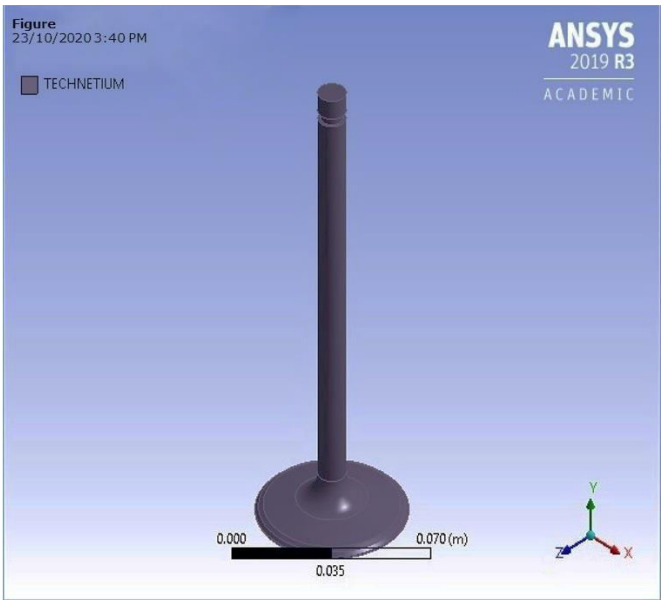
Equivalent Total Strain

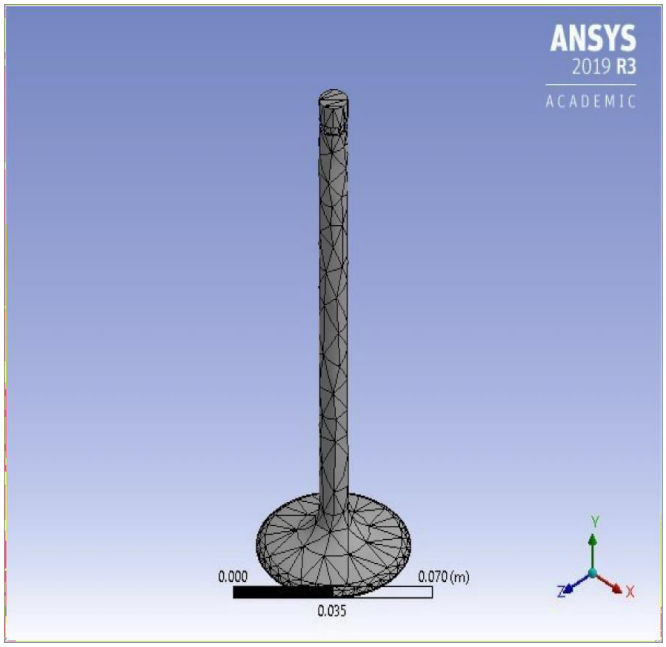


Time [s]	Minimum [m/m]	Maximum [m/m]	Average [m/m]
1.	4.4707e-003	0.22366	5.8575e-002

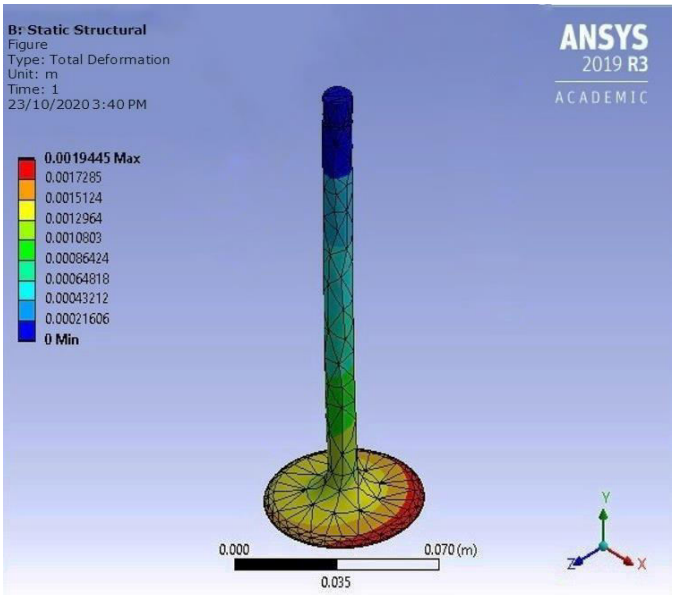


Technetium



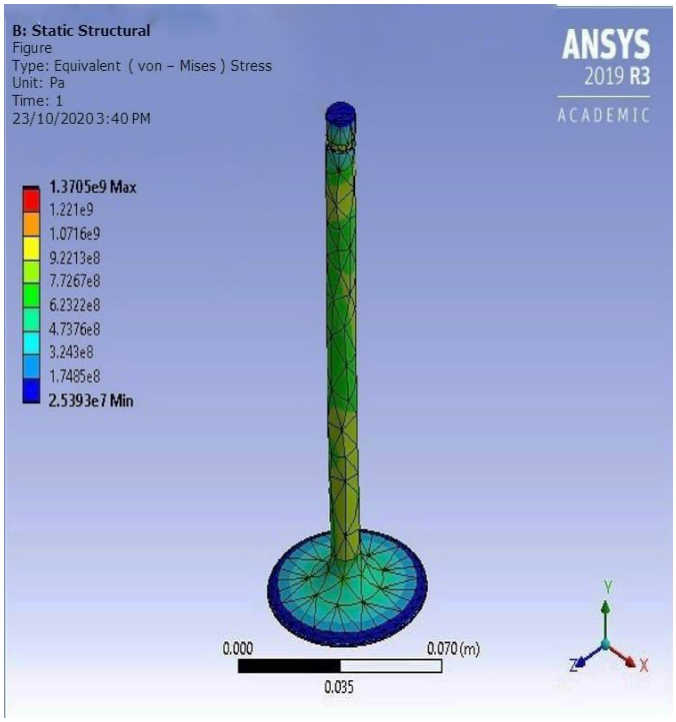


Total Deformation



Time [s]	Minimum [m]	Maximum [m]	Average [m]
1.	0.	1.9445e-003	1.2867e-003

Equivalent Stress



Time [s]	Minimum [Pa]	Maximum [Pa]	Average [Pa]
1.	2.5593e7	1.3705e5	1.2865025e7

10.Result Comparison

	Equivalent STRESS		Equivalent STRAIN		TOTAL DEFORMATION
	MI N	MAX	MIN	MA X	
AL2O3	2.1191e+007 Pa	1.4088e+009 Pa	1.4669e-003	2.0492e-002	1.7552e-003
CARBON EPOXY	2.4834e+007 Pa	1.681e+009 Pa	4.4707e-003	0.22366	1.3879e-002
TECHNETIUM	2.5393e+007 Pa	1.3705e+009 Pa	1.0577e-003	1.4796e-002	1.2867e-003

11.CONCLUSIONS

In this thesis, we have taken a poppet valve and even we have modified the design of the poppet valve and in this project we have considered the design in Catia v5 software and analysis work is carried out in Ansys software. As here we have considered 3 materials al2o3, carbon epoxy, and technetium materials for analysis. As if we observe in the analysis all the results obtained are plotted in to tables and graphs, as if we compare the results obtained in the original model, we can conclude that stress (6.69E+10), strain (0.20893) and total deformation (0.013013) is having the lesser values. These results are obtained for the material technetium material. So here we can conclude that this material is the best material for the better output and life of the original model. As if we observe in the modified model in analysis all the results obtained are plotted in to tables and graphs, as if we compare the results obtained in the original model, we can conclude that stress (1.40E+11), strain (0.44848) and total deformation (0.023374) is having the lesser values. These results are obtained for the material technetium material. So here we can conclude that this material is the best material for the better output and life of the original model.So from all the results obtained, here we can conclude that the modified model with technetium material can withstand for long life and for better life output and better life efficiency.

REFERENCES

1.Internal combustion engines by V.GANESAN

2.Ch.Venkata Rajam, P.V.K.Murthy, M.V.Murali - Design Analysis and Optimization of Piston using CATIA and ANSYS- International Journal of Innovative Research in Engineering & Science

3.K. Thriveni1 Dr.B.JayaChandraiah- Modeling and Analysis of the Crankshaft Using Ansys Software- International Journal of Computational Engineering Research

4.B. Anusha, Dr.C.Vijaya Bhaskar Reddy- Comparision Of Materials For Two- Wheeler Connecting Rod Using Ansys- International Journal of Engineering Trends and Technology

5.Effect of temperature on mechanical properties and type of fracture ofnimonic superalloys

6.A. S. More, S P. Deshmukh-Analysis of Valve Mechanism – A Review- IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)

7.Hermes Fernandez-Development of Continuously Variable Valve Lift Mechanism for Improved Fuel Economy- SAE International

8.Osama H. M. Ghazal, Mohamad S. H. Dado-Gear Drive Mechanism for Continuous Variable Valve Timing of IC Engines

9.R. Mikalsen, A.P. Roskilly -A review of free-piston engine history and applications.

10.Shivakumar, Srinivas Pai P-performance and emission characteristics of a4 stroke CI engine operated on honge methyl Ester using artificial neural network