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Optimization of IC Engine Valve for Stationary Engine on Fillet Basis

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Abstract— **Design of the valve depends on many parameters like behaviour of material at high temperature, vibrations, fluid dynamics of exhaust gas, oxidization characteristics of valve material and exhaust gas, fatigue strength of valve material, configuration of the cylinder head, coolant flow and the shape of the port. This project deals with the study of stress induced in a valve due to high pressure inside the combustion chamber, spring force and cam force at high temperature conditions. For modelling CATIA is to be used and to analyze the valve ANSYS will be used as the tool. Structural analyses are to be performed on the valve based on fillet radius and results are discussed in detail.**

Index Terms **: Intake Valve, Stress concentration, Optimization.**

I. Introduction

Internal combustion engine valves are precision engine components. The valve train system is one of the major parts of internal combustion engine, which controls the amount of air-fuel mixture to be drawn into the cylinder and exhaust gas to be discharged. The fresh charge (air - fuel mixture in Spark Ignition Engines and air alone in Compression Ignition Engines) is induced through inlet valves and the products of combustion get discharged to atmosphere through exhaust valves. This seals the working space inside the cylinder against the manifolds. So design of valve lift profiles and valve train components is most important for the engine performance. There are different types of valves used by the manufactures; some common types of valves being poppet valves, slide valves, rotary valves and sleeve valve.

A. Valve

There are different types of valves used by the manufactures; some common types of valves being poppet valves, slide valves, rotary valves and sleeve valve. The basic nomenclature used for valves is as shown in figure 2.

Any type of valve failure affects the engine performance thus making it mandatory to give due importance to failure analysis of internal combustion engine valves. Possible modes of valves failure are wear failure, valve face recession, fatigue failure,thermal fatigue, erosion / corrosion of valves, overheating of valves, carbon deposits on valves etc.

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In the operation thermal and mechanical stresses are imposed on inlet and exhaust valve because of high temperature and pressure in the cylinder. These thermal and mechanical stresses are prime sources of valve failures at sealing area. The movement of opening and closing also impart sliding friction on valve and valve seat sealing area which leads to valve and valve seat wear. Impact on valve closure may also cause plastic deformation of sealing faces and surrounding surface and formation of series of circumferential ridges. During engine operation sealing is most important factor to achieve perfect combustion of the injected fuel to get best performance and thermal efficiency from the engine. Sealing pressure must be around 550 to 600 bar. Inlet valve failures occurs due to reasons like wear, impurities in air in addition to this, exhaust valve are subjected to different stresses than inlet valve.

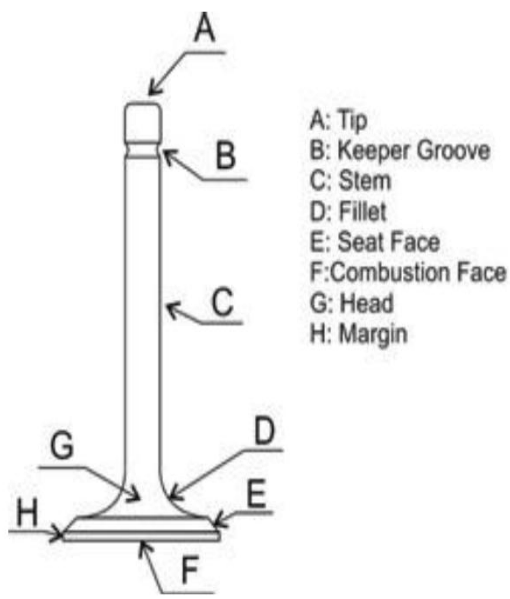


Fig 1: The basic nomenclature of engine valve [7]

The stem of the valve is under axial repeated loading, it can fail by axial Fatigue. The keeper groove area is subjected to tensile stresses and becomes a critical section due to geometric stress concentrations.

Exhaust valves are exposed to thermal stress more than intake valve because intake valve are virtually cooled by fresh air. However burnt gases have very high temperature in the range of 800 to1000^0C because of this frequency of failure of exhaust valve is higher than inlet valve. In turbocharged engines the cooling of inlet and exhaust valve is taken care by scavenging operation. Clean fresh air is cooled by intercooler and then pumped into the combustion chamber during the suction stroke and during the scavenging operation. This process receives adequate cooling of valve and valve seat surface and prevents from premature failure. Depositions building up on valve face and valve seats leads to poor sealing and seat can have an insulating effect which causes poor cooling and makes the valve run hot. If deposition is built up on valve face in the form of one spot, then poor sealing appears. This poor sealing leads to leaking of the combustion and creates hot spot on valve sealing face which in turn results in channelling effect.

B. Modes of Valve Failures

1. Failure Due to Fatigue
2. Failure Due to High Temperature
3. Failure of Valve Due to Erosion-Corrosion
4. Failure of Valve Due to wear
5. Miscellaneous Considerations

C. Why Inlet Valve Fails and Need of Redesign

The manufactures and user is facing a problem with stationary engine valve which was continuously failing while working. Even though it is safe in design, it is observed that the intake valve fails while working. Hence it is decided to redesign the intake valve and test it using software to avoid future failures.

D. Fillet Radius Role in Valve Design

One of the main purpose of the valve is that it must streamline the gases and make it possible for them to move into and out of the combustion chamber as rapidly as possible, and, when the gases leave the combustion chamber, they must be so directed that they will not swirl or congest in a manner that will prevent the complete scavenging of the cylinder. The terrific pressure at which the gases pass through the exhaust manifold will normally create a vacuum in the cylinder, which in turn will assist in the complete scavenging of the cylinder.

The purpose of this fillet is to streamline the gases so they will pass freely out of the exhaust manifold. Most poppet valves are made at an angle of forty-five degrees, and being round they permit, (provided the valve is properly aligned), the exhaust gases to rush towards each other in a circle and under terrific pressure at an enormous velocity. This actually creates a vacuum that completely scavenges the cylinder. If the gases are not guided by the fillet under the valve, they collide and swirl, so to speak, which will cause congestion in the manifold. This congestion will work against the proper elimination of the gases.

E. Objectives

- To find optimized fillet radius for the inlet valve

II. 3D Model in CATIA based on Design

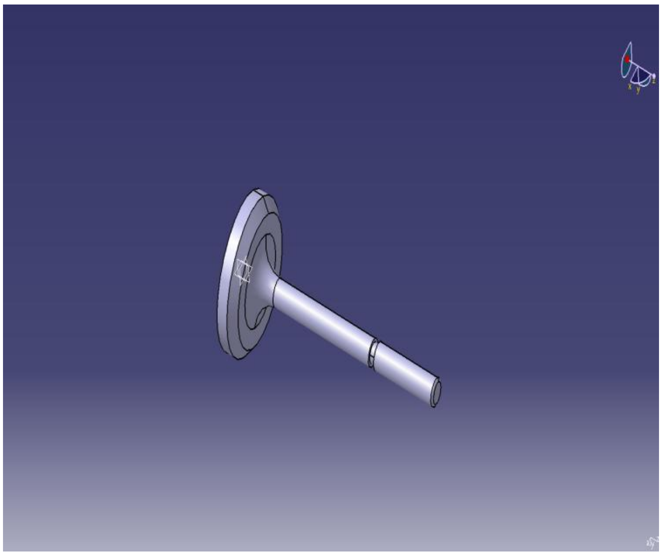


Fig 2: Valve Model based on design

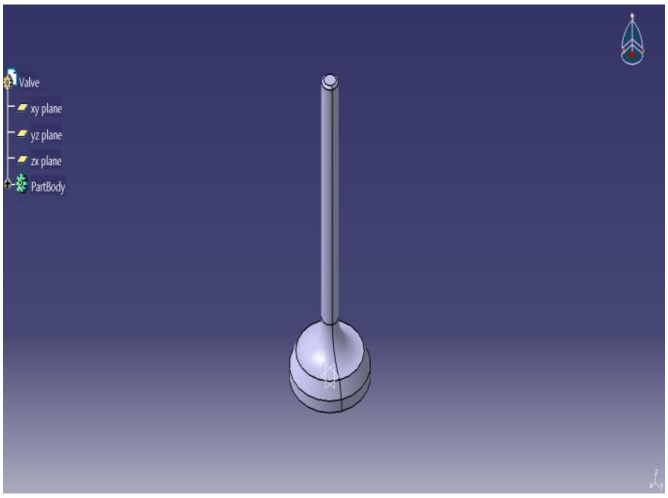


Fig 3: Valve Model Based On Design

A. Analysis Results for Existing Valve:

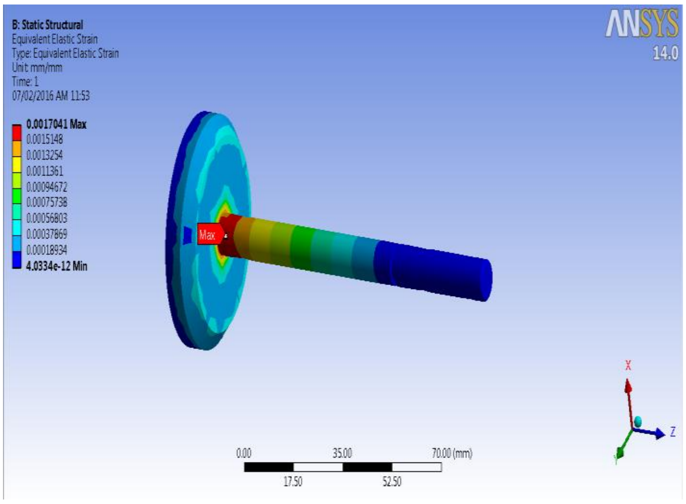


Fig 4: Elastic Strain

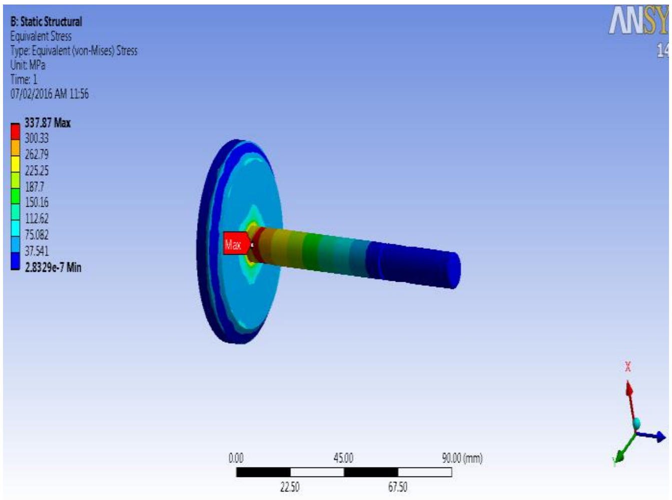
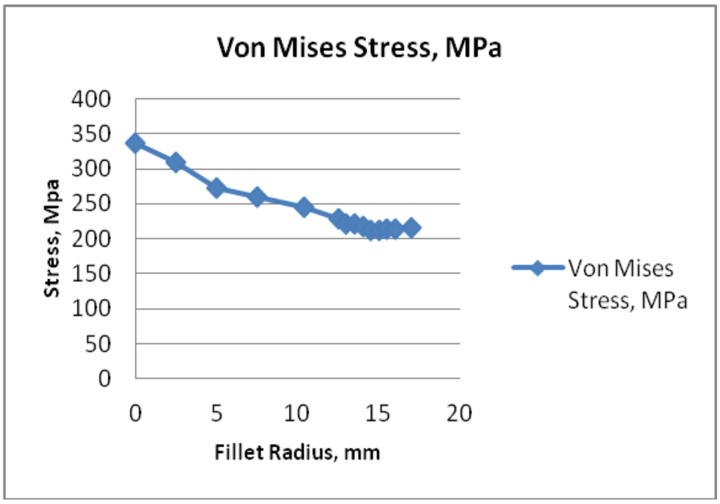


Fig 5: Von-Mises Stress



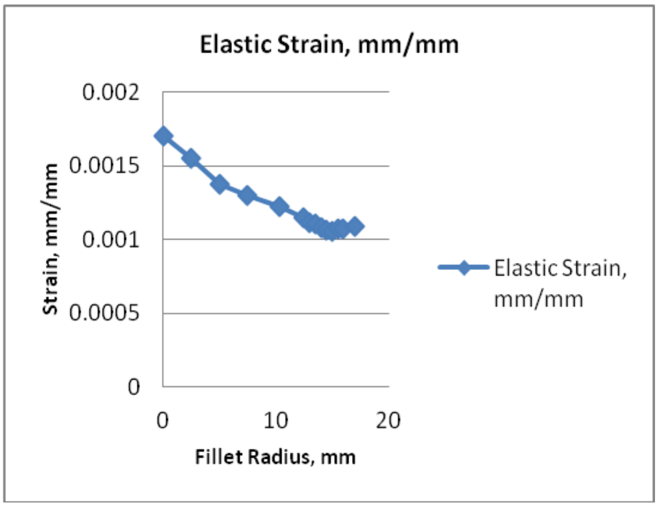
Graph 2: Fillet radius Vs Stress

B. Similarly analysis is done for various fillets and results are tabulated as below,

Table 1: Results based on Valve fillet Radius

Trial	Radius, mm	Elastic Strain, mm/mm	Von Mises Stress, MPa
0	0	0.0017041	337.3
1	2.5	0.0015502	309.3
2	5.0	0.0013725	272.82
3	7.5	0.0012995	259.51
4	10.35	0.0012233	244.55
5	12.5	0.0011452	228.79
6	13.0	0.0011121	222.23
7	13.5	0.0011032	220.51
8	14.0	0.0010853	216.91
9	14.5	0.0010658	213.01
10	15.0	0.0010593	211.68

Allowable Stress = S_{yt} / FOS = 350/1.5 = 233.33 MPa
Allowable Stress is 233.33MPa (Carbon Steel)
Due to valve seat arrangement and size restriction, maximum radius we can afford to select is 14.0 mm, and hence fillet radius for further work is 14.0 mm.



Graph 1: Fillet radius Vs Strain

C. Thermal analysis is done on final selection (14.0 mm fillet)

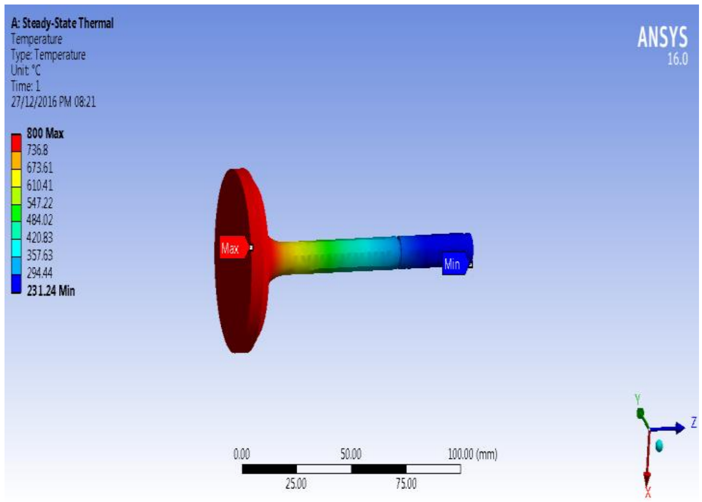


Fig 6: Temperature Distribution (Fig shows temperature distribution along the valve length due to application of temperature of 800^0C at the bottom face of valve)

III. Conclusions

- Valve basics and materials and its operating are studied in detail which will be useful in further part of work.
- Design of valve is done based on given specifications with study of valves and its failure modes.
- Model of valve is done using CATIA 3-D Modeling Software.

IV. Acknowledgment

Every orientation work has imprint of many people and this work is not different. This work gives me an opportunity to express deep gratitude for the same.

While preparing paper, I have received endless help from number of people. This paper would be incomplete if I don't convey my sincere thanks to all those who were involved.

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REFERENCES

[1] Jerzy Jaskolski & Rudolf Krzyzak (2007) "The Temperature - and Stress Fields of Valves of IC Engine" at Journal of KONES Power train and Transport, Vol.14, No. 3.

[2] S. M. Jafari, et.al. (2014) "Valve Fault Diagnosis in Internal Combustion Engines Using Acoustic Emission and Artificial Neural Network" Hindawi Publishing Corporation Shock and Vibration Volume 2014, Article ID 823514,

[3] B. E. Gajbhiye, et.al. (2014)"Vibration Testing and Performance Analysis of IC Exhaust Valve Using Finite Element Technique" at International Journal of Research in dvent Technology, E-ISSN: 2321-9637Vol.2, No.2

[4] A. S. More & S P. Deshmukh "Analysis of Valve Mechanism – A Review" at International Journal IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) ISSN (e): 2278 1684, ISSN (p): 2320–334X, PP: 06-09.

[5] Sanoj. T & S. Balamurugan (2014) "Thermo Mechanical Analysis of Engine Valve" at International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064, Volume 3 Issue 5,

[6] Yuvraj K Lavhale & Prof. Jeevan Salunke (2014) "Overview of Failure Trend of Inlet & Exhaust Valve" at International Journal of Mechanical Engineering and Technology (IJMET), ISSN 0976 – 6340(Print), ISSN 0976 – 6359(Online), Volume 5, Issue 3, pp. 104-113.

[7] GoliUdaya Kumar & Venkata Ramesh Mamilla (2013) "Failure Analysis of Internal Combustion Engine Valves by using ANSYS" at American International Journal of Research in Science, Technology, Engineering & Mathematics, volume(2), pp. 169-173.

[8] Naresh Kr. Raghuwanshi et.al. (2012) "Failure Analysis of Internal Combustion Engine Valves: A Review" by International Journal of Innovative Research in Science, Engineering and Technology ISSN: 2319 – 8753 Vol. 1, Issue 2.

[9] Kum-Chul,Oh et.al. (2014) "A Study of Durability Analysis Methodology for Engine Valve Considering Head Thermal Deformation and Dynamic Behaviour" of R&D Center, Hyundai Motor Company, at 2014 SIMULIA Community Conference.