



FAILURE ANALYSIS OF INTERNAL COMBUSTION ENGINE VALVES BY USING ANSYS

Goli Udaya Kumar¹, Venkata Ramesh Mamilla²

¹M.Tech. Student, ²Associate Professor, Department of Mechanical Engineering
QIS College of Engineering & Technology, Ongole – 523272, Andhra Pradesh, INDIA.

Abstract: Intake and exhaust valves are very important engine components that are used to control the flow of intake and exhaust Gases in internal combustion engines. They are used to seal the working space inside the cylinder against the manifolds; and are opened and closed by means of what is known as the valve train mechanism.. These valves are loaded by spring forces and subjected to thermal loading due to high temperature and pressure inside the cylinder. The present study is forced on different failure modes of internal combustion engine valves. Failures due to fatigue, high temperature effects, and Failures due to impact load that depends on load and time. For the study of fatigue life, a combined S-N (max. stress v/s number of cycles) curve is prepared. Such a curve helps in comparing the fatigue failure for different materials at different high temperatures and may also assist the researchers in developing the valve materials with a prolonged life. For achieving above said goals couple –field, fatigue and transient analysis will be done on valves to determine structural and thermal behavior in working condition.

Keywords: Failure, Internal Combustion Engine Valves, High Temperature, Fatigue, Wear.

I. INTRODUCTION

Internal combustion four-stroke engine consists of two valves known as inlet and exhaust valve. The inlet valve allows the air or air-fuel mixture into the chamber. The exhaust valve forces out the exhaust gases. Many things can make a valve fail. The usual causes are thermal and mechanical overstresses, longitudinal cyclic stress, and creep conditions, forging defects etc. these leads to many troubles. The valve troubles include valve breakage; valve face wear. Steam and guide wear, necking of valve stem and other valve problems. “VALVE” is a component used to open or close a passage. To admit the-fuel mixture I the engine cylinder and to force the exhaust gases out at correct timing. Some control system is necessary, which is provided by the valve. In motor vehicle engines, tow valves are used for each cylinder an intake valve and an exhaust valve. The inlet valve is located at the junction of cylinder and intake port and the exhaust valve is located the junction of exhaust port and the cylinder. Generally inlet valve are larger than exhaust valves, because speed of incoming air-fuel mixture is less than the velocity of exhaust gases which leave under pressure. Further because of pressure, the density of exhaust gases is also comparatively high. Moreover, smaller exhaust valve is also preferred because of shorter path of heat flow in this case and consequent reduced thermal loading. Generally inlet valves and exhaust valves are 45% and 38% of the cylinder bore respectively.

II. PURPOSE OF VALVES

The purpose of the valve in the cylinder of the engine is to admit the air-fuel mixture and to force out the exhaust gases. The inlet valve also known as intake valve admits the charge into the cylinder and exhaust valves are used to send the exhaust gases out of the cylinder. In a 4-stroke engine the inlet valve and exhaust valve operate once in two revolution of the crankshaft. Each of the valves must operate once in one turn and this is done by a camshaft, which turns at half speed of the crankshaft. The firing order of cylinder establishes the sequence in which the valves opening and closing. The main components of the mechanism are valves, rocker arm, valve spring, push rod, cam and camshaft .The fuel is admitted to the engine by the inlet valve and the burnt gases are escaped through the exhaust valve. The cam moving on the rotating cam shaft pushes the cam follower and push rod up wards, there by transmitting the cam action to rocker arm. When one end of the rocker arm is pushed up by the push rod, the other end moves downwards. This pushes down the valve stem causing the valve to move down, there by opening the port. When the cam follower moves over the circular portion of the cam, the pushing action of the rocker arm on the valve is released and the valve returns to its seat and closes it by the action of valve spring.

III. VALVES MATERIALS

The materials used for inlet and exhaust valves are generally different because of the different operating conditions to which these are subjected. The material for exhaust valve must the following mechanical properties which to operate in more severe conditions.

- Sufficient strength and hardness to resist tensile forces and wear
- Adequate fatigue strength
- High creep strength
- Resistance to corrosion
- Resistance to oxidation at the high operating temperatures
- Small coefficient of thermal expansion to avoid excessive thermal stresses
- High thermal conductivity for good heat dissipation

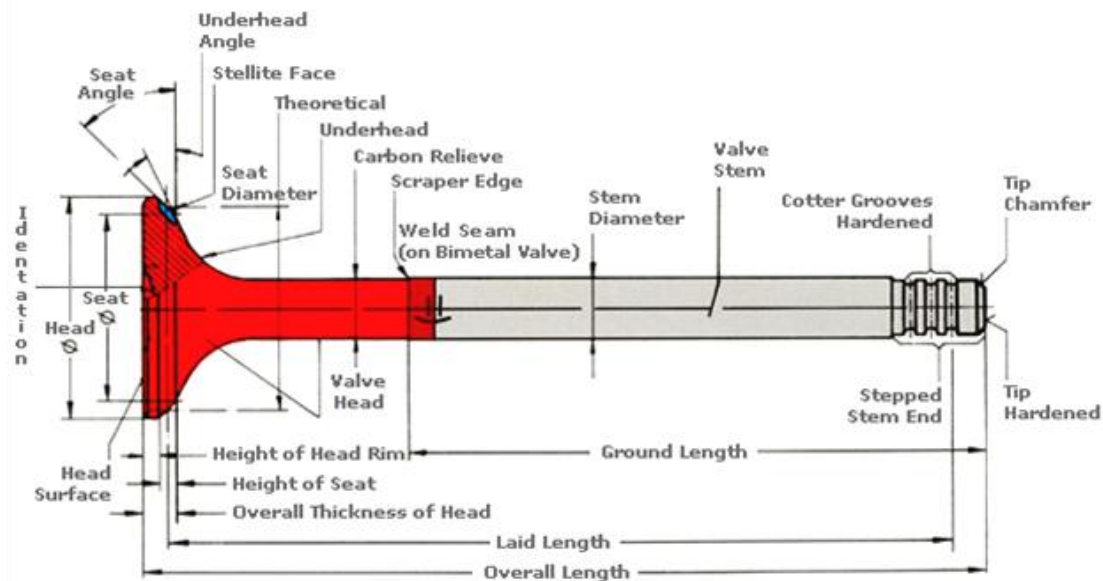


Figure 1: Valve dimensions

IV. FAILURE ANALYSIS

Failure analysis is a systematic examination of failed devices to determine the root cause of failure and to use such information to eventually improve the product reliability. The material engineers and failure analysts generally provide the expert opinions regarding materials for future analysis. The analyst approach is to examine or test materials to evaluate the cause of product failure. The failure analyst must also have a procedure or precisely a method for evaluation when a failure occurs. A method of evaluation that is logical and well planned will enable the analyst to prevent future failure by suggesting corrective measures or by selecting the appropriate material for application.

V. STRUCTURAL, THERMAL AND TRANSIENT STRUCTURAL ANALYSIS

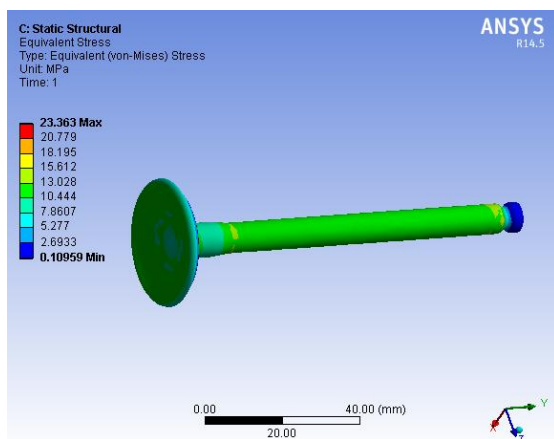


Figure 2: Above image is showing stress range with the help of colour bar. This value is obtained at atatic condition.

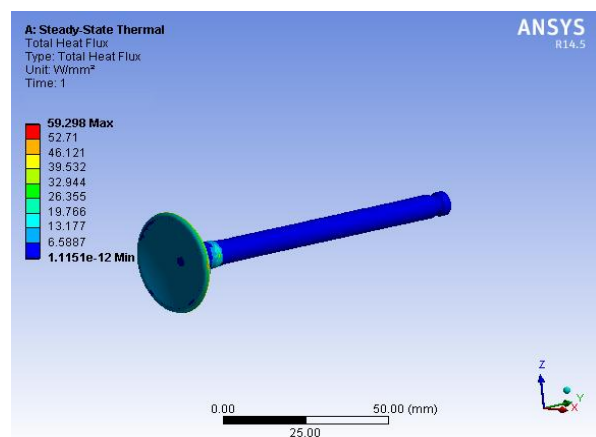


Figure 3: Above image is showing flux range with the help of colour bar. This value is obtained at a static condition.

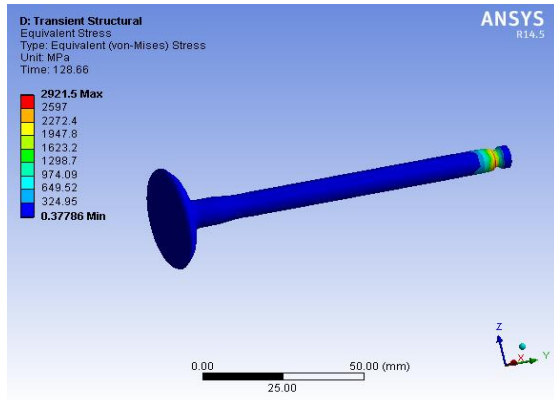


Figure 4: Above image is showing stress range with the help of colour bar. This value is obtained with the variation of time(cycles 5000 open and closed position).

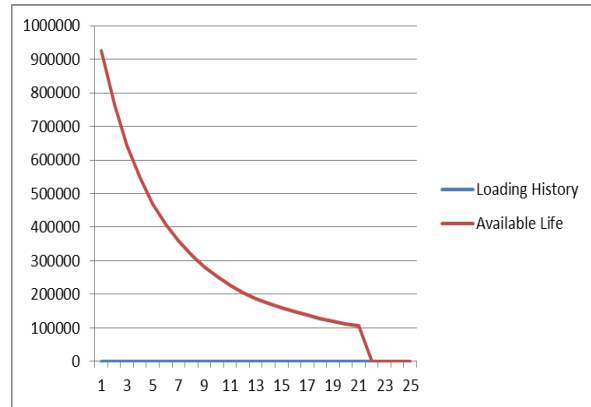


Figure 5: Each loading history value refers to 5000×10^7 cycles

VI. ANALYSIS WITH FIN BODY SEGMENT (ALUMINUM AS FIN MATERIAL)

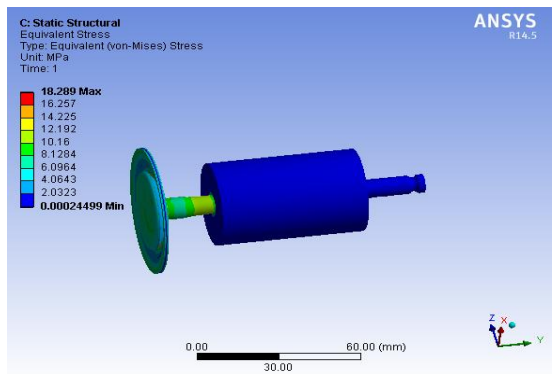


Figure 5: Above image is showing stress range with the help of colour bar. This value is obtained at atatic condition.

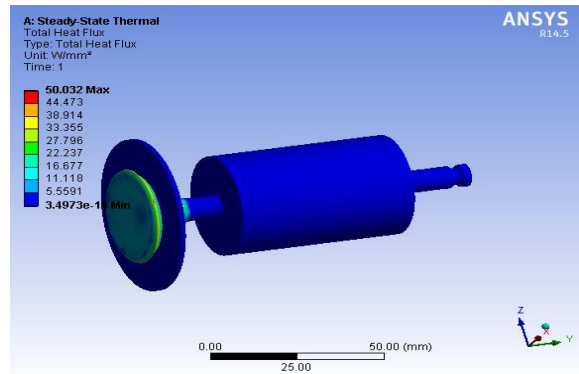


Figure 6: Above image is showing flux range with the help of colour bar. This value is obtained at atatic condition.

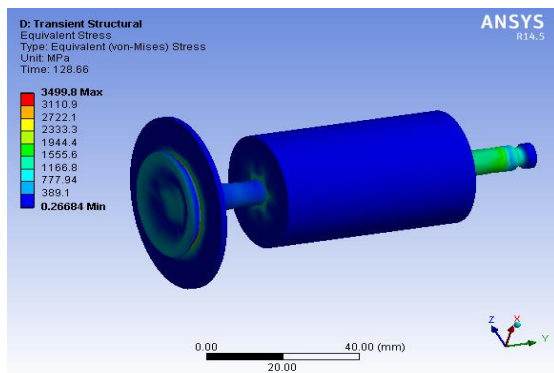


Figure 7: Above image is showing stress range with the help of colour bar. This value is obtained with the variation of time(cycles 5000 open and closed position).

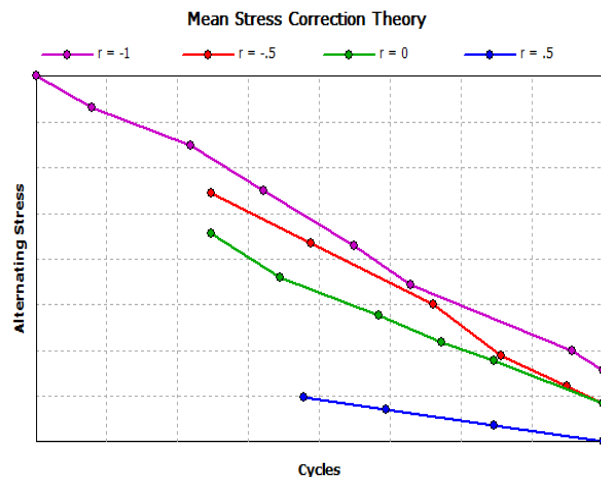


Figure: 8

VII. RESULTS AND DISCUSSION

STATIC STRUCTURAL		
	Deformation	Equivalent stress
vavle	0.0085947	23.363
WITH alu	0.0024984	18.289
WITH mag	0.0003903	11.804

The above table compares the stress and deformation in static conditions for the three conditions.

STEADY STATE THERMAL			
	TEMPERATURE	TOTAL HEAT FLUX	THERMAL ERROR
vavle	1000	59.298	6.9169e6
WITH alu	1000	50.032	8.0943e6
WITH mag	1000	35.99	6.9235e6

The above table compares the temperature, heat flux and thermal error in static conditions for the three conditions.

TRANSIENT STRUCTURAL				
	DEFORMATION	Equivalent Elastic strain	Equivalent stress	Structural error
vavle	0.60219	0.015715	2921.5	93.67
WITH alu	0.15358	0.017501	3499.8	87.442
WITH mag	0.91751	0.014527	2902.2	101.84

The above table compares the stress and deformation at 5000cycles conditions for the three conditions.

TRANSIENT THERMAL			
	TEMPERATURE	TOTAL HEAT FLEX	DIRECTION HEAT FLEX
vavle	600	18.494	15.473
WITH alu	600	12.758	10.29
WITH mag	600	12.821	10.29

The above table compares the temperature, heat flux and thermal error at 5000cycles conditions for the three conditions.

COUPLE FIELD			
	TOTAL DEFORMATION	Equivalent elastic strain	Equivalent stress
vavle	0.21878	0.0037337	734.52
WITH alu	0.0603	0.01575	3149.8
WITH mag	0.066731	0.025387	2263

The above table compares the stress and deformation at 5000cycles conditions using both thermal and structural loads for the three conditions.

FATIGUE		
	LIFE	SAFETY FACTOR
Maximum	1e10	15
WITH alu	1e10	15
WITH mag	1e12	15

The above table compares the life and safety factors for the three conditions.

Static and transient analysis for both structural and thermal conditions coupled field and fatigue analysis is also completed for direct valve and including fin and seat segments. Coupled field analysis has different values due combine lodes of static and thermal.

VIII. CONCLUSION

Static analysis is done on valve, valve with seat and fin segments by varying two materials. Study-state thermal analysis is done on valve, valve with seat and fin segments by varying two materials. Transient structural

analysis is done on valve, valve with seat and fin segments by varying two materials @5000 cycles. Transient thermal analysis is done on valve, valve with seat and fin segments by varying two materials @5000 cycles. Coupled field analysis (combined analysis of static and thermal) is done on valve, valve with seat and fin segments by varying two materials. Fatigue analysis is done on valve, valve with seat and fin segments by varying two materials. As per the analytical results valve with meg alloy fin is the right choice for maximum life.

IX. REFERENCES

1. Naresh Kr. Raghuwanshi, Ajay Pandey, R. K. Mandloi, International Journal of Innovative Research in Science, Engineering and Technology Vol. 1, Issue 2, December 2012.
2. Combating Automotive Engine Valve Recession By Roger Lewis and Rob S.Dwyer-Joyce University of Sheffield Dept. of Mechanical Engineering Sheffield, United Kingdom Engine valve recession 9/11/03 Tribology & Lubrication Technology
3. Investigation of Exhaust Valve Failure in Heavy – duty Diesel Engine Nurten VARDAR¹, Ahmet EKERİM² Gazi University Journal of Science GU J Sci 23(4):493-499 (2010).
4. Modelling of the heat loads of the engine valves and the accuracy of calculations P. Gustof, A. Hornik Faculty of Transport, Department of Vehicle Service, Silesian University of Technology, ul. Krasińskiego 8, 40-019 Katowice, Poland Received 03.04.2007; published in revised form 01.08.2007 Journal of Achievements in Materials and Manufacturing Engineering.
5. Modelling and analysis of radial thermal stresses and temperature field in diesel engine valves with and without air cavity Subodh Kumar Sharma, P. K. Saini, N. K. Samria.
6. Failure Analysis Of Exhaust Valve Spring Of C.I.Engine Patel Sujal V., Pawar Shrikant G., Research Scholar, Department of Automobile Engineering, RIT Sakharale 415414, Sangli, Maharashtra, India), Associate Professor, Department of Automobile Engineering, RIT Sakharale 415414, Sangli, Maharashtra, India) International Journal of Engineering Research & Technology (IJERT) Vol. 2 Issue 3, March - 2013 ISSN: 2278-0181.
7. Engine Cylinder Head Thermal and Structural Stress Analysis Ing. Radek Tichánek, Ing. Miroslav Španiel, CSc. Czech Technical University in Prague Technická 4, Prague 6 CZ-166 07, Czech Republic.
8. Computational Visualization and Simulation of Diesel Engines Valve Lift Performance Using CFD Semin, Rosli Abu Bakar and Abdul Rahim Ismail , Automotive Focus Group, Faculty of Mechanical Engineering, University Malaysia Pahang, Locked Bag 12, 25000 Kuantan, Pahang, Malaysia American Journal of Applied Sciences 5 (5): 532-539, 2008 ISSN 1546-9239.
9. M. I. Karamangil A. Avci and H. Bilal, Investigation of the effect of different carbon film thickness on the exhaust valve. Heat Mass Transfer 44 (2008) 587–598
10. H. J. C. Voorwalda, R. C. Coisse, and M. O. H.Cioffi. Fatigue Strength of X45CrSi93 stainless steel applied as internal combustion engine valves. Procedia Engineering 10 (2011) 1256–1261.
11. V.Kazymyrovych, Very high cycle fatigue of engineering materials. Karlstad University Studies 2009:22. ISSN 1403-8099, ISBN 978-91-7063-246-4.
12. Dowling, Norman E.: Mechanical Behavior of Materials, Engineering Methods for Deformation, Fracture and Fatigue. Prentice-Hall.
13. D. J. Benac and R. A. Page, Integrating Design, Maintenance, and Failure Analysis to Increase Structural Valve Integrity. ASM International 3 (2001) 31- 43.
14. Y.B. Liu, Y.D. Li, S.X. Li, Z.G. Yang,S.M. Chen, W.J. Hui, and Y.Q. Weng , Prediction of the S–N curves of high-strength steels in the very high cycle fatigue regim. International Journal of Fatigue 32 (2010) 1351–1357.
15. Oh Geon Kwon and Moon Sik Han, Failure analysis of the exhaust valve stem from a Waukesha P9390 GSI gas engine. Engineering Failure Analysis 11 (2004) 439-447.
16. Z.W. Yu and X.L. Xu, Failure analysis and metallurgical investigation of diesel engine exhaust valves. Engineering Failure Analysis 13 (2006) 673–682.
17. Alan V. Levy, Solid particle erosion and erosion-corrosion of materials. Copyright 1995 by ASM International.
18. C.G. Scott, A.T. Riga and H. Hong. The erosion-corrosion of nickel-base diesel engine exhaust valves. Wear 181-183 (1995) 485-494.
19. ZHAO Yun-cai and YAN Hang-zhi, Experimental study on wear failure course of gas-valve/valve-seat in engine. J. Cent. South University. Technology 12 (2005) 243-246.
20. P. Forsberg, P. Hollman, and S. Jacobson, Wear mechanism study of exhaust valve system in modern heavy duty combustion engines. Wear 271 (2011) 2477– 2484.
21. Keyoung Jin Chun, Jae Hak Kim, and Jae Soo Hong, A study of exhaust valve and seat insert wear depending on cycle numbers. Wear 263 (2007) 1147– 1157.