ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Finite Element Analysis of Al – Si Metal Matrix Composite for Engine Valves

Sivaramanjaiah Sagi
M.Tech (Machine Design),
Malla Reddy College of Engineering and Technology,
JNTU, Hyderabad, Telangana, India.

Dr. P.H.V Sesha Talpa Sai (Ph.D)
Professor,
Malla Reddy College of Engineering and Technology,
JNTU, Hyderabad, Telangana, India.

ABSTRACT

In this thesis, comparative analysis is performed using Al-Sic composites with other alternatively materials for the engine valve guides. Al – Si composites are taken by varying Silicon percentages (10%, 15%, 20% & 25%).

Thermal, Static and Modal analysis is performed on the engine valve using different materials Steel, Titanium alloy, Nickel alloy, Aluminum Bronze alloy and Al-Si composites.3D model of the engine valve is done in Creo 2.0 and finite element analysis is done in Ansys 14.5.

INTRODUCTION

All four-stroke internal combustion engines employ valves to control the admittance of fuel and air into the combustion chamber. Two-stroke engines use ports in the cylinder bore, covered and uncovered by the piston, though there have been variations such as exhaust valves.

In piston engines, the valves are grouped into 'inlet valves' which admit the entrance of fuel and air and 'outlet valves' which allow the exhaust gases to escape. Each valve opens once per cycle and the ones that are subject to extreme accelerations are held closed by springs that are typically opened by rods running on a camshaft rotating with the engines' crankshaft.

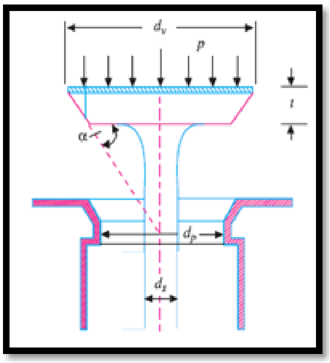

Fig: Engine Valve

LITERATURE SURVEY

In the work done by S.K. Rajesh Kanna, etal[1], valve performance has been improved by coating Al-Si alloy on the surface of mating zone of engine valve. Al-Si alloy coated valve had tested and the comparative results proved that the mechanical characteristics increased without affecting the functionality. The Al-Si coating was done on the engine valve by physical vapor deposition method in a controlled environment.

As the analysis results are satisfactory, the same coating can be extended to other parts of the engines to improve the overall effectiveness of the engine. In the work done by B Seshagiri Rao, etal[2], design an exhaust valve for a four wheeler petrol engine using theoretical calculations. Manufacturing process that is 2D drawings is drafted from the calculations and 3D model and transient thermal analysis is to be done on the exhaust valve when valve is open and closed. Analysis is done in ANSYS. Analysis will be conduct when the study state condition is attained.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Study state condition is attained at 5000 cycles at the time of when valve is closed is 127.651 sec valve is opened 127.659 sec. The material used for exhaust valve isEN52 steel. We are doing material optimization bydoing analysis on both materials EN52 andEN59.Static Modal analysis the exhaust valve to determine mode shapes of the valve for number of modes.

3D MODELING OF VALVE

The reference paper considered for modeling is "Petrol engine exhaust valve design, analysis and manufacturing processes", by B Seshagiri Rao and D Gopi Chandu, ISSN 2278 – 0149, Vol. 3, No. 4, October, 2014, IJMERR specified as [2] in References chapter. The dimensions are taken from above journal paper

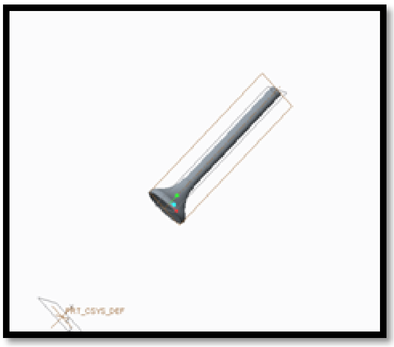

Fig: 3D model of valve

ANALYSIS OF ENGINE VALVE

The reference paper considered for modeling is "Performance evaluation using FEA on Al-Si coated engine valve by S.K. Rajesh Kanna, R. Ragu, P.S. Rajeswaran and Muthuvignesh, ISSN: 2347-3215 Volume 3 Number 8 (August-2015) pp. 67-72, International Journal of Current Research and Academic Review. Specified as [1] in References chapter. The boundary conditions and material properties are taken from above journal.

MATERIAL - AL+SI (10%)

STATIC ANALYSIS

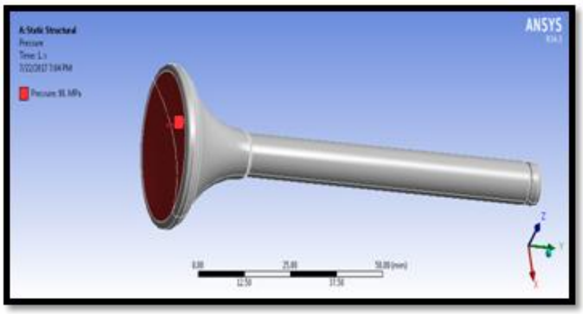

Fig: Pressure applied on the valve seat

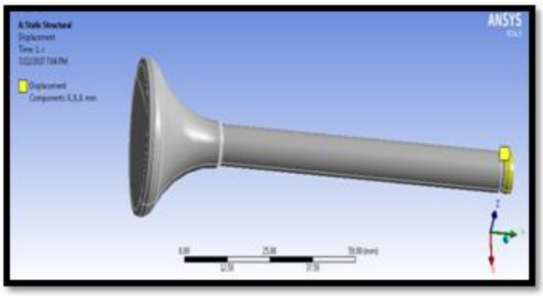

Fig: Displacement is applied on the valve top

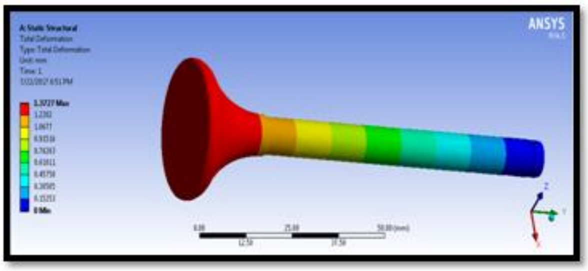

Fig: total deformation of al+si (10%)

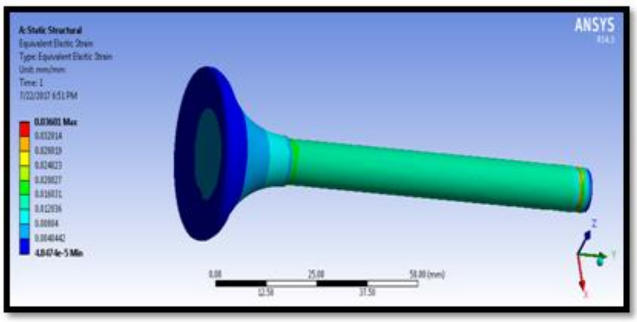

Fig: strain ofal+si (10%)

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

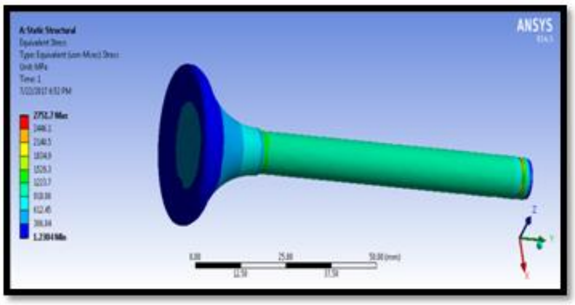

Fig: stressof al+si (10%)

MODAL ANALYSIS

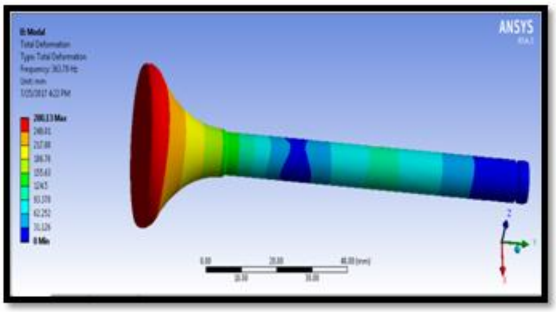

Fig: Total deformation-1 of al+si (10%)

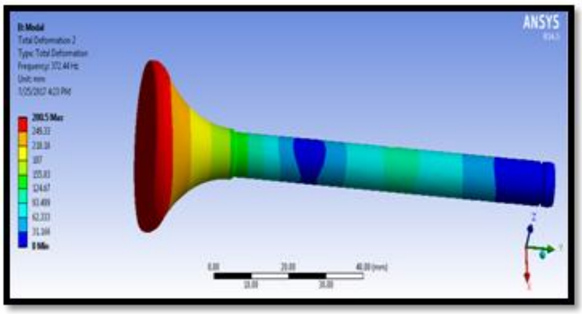

Fig: total deformation -2 of al+si (10%)

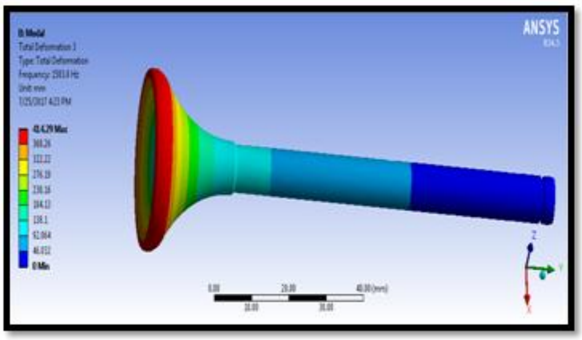

Fig: total deformation-3 ofal+si (10%)

THERMAL ANALYSIS

The reference paper considered for modeling is “Performance evaluation using FEA on Al-Si coated engine valve by S.K. Rajesh Kanna, R. Ragu, P.S. Rajeswaran and Muthuvignesh, ISSN: 2347-3215 Volume 3 Number 8 (August-2015) pp. 67-72, International Journal of Current Research and Academic Review. Specified as [1] in References chapter. The boundary conditions and material properties are taken from above journal.

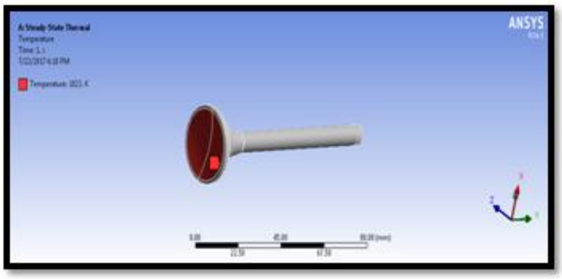

Fig – Temperature applied on the valve

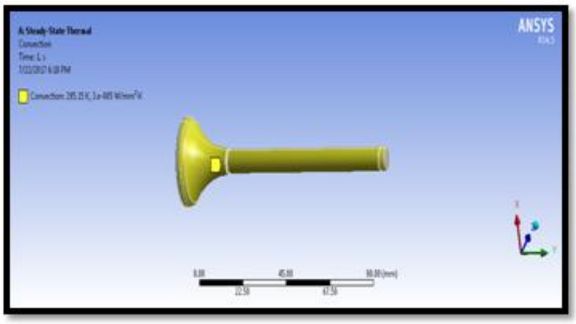

Fig – Convection applied on the outer surface

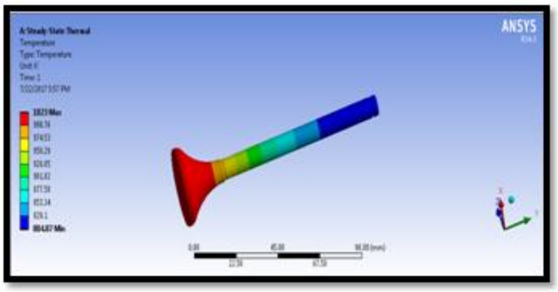

Fig – Temperature for al+si(10%)

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

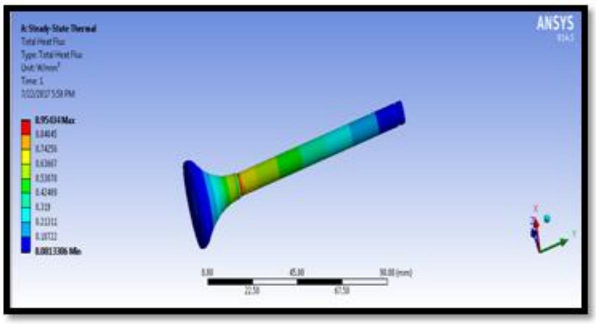

Fig - Heat flux for al+si(10%)

RESULTS TABLE

STATIC ANALYSIS

MATERIALS	DEFORMATION (mm)	STRAIN	STRESS (MPa)
AL+SI (10%)	1.3727	0.03601	2751.7
AL+SI (15%)	1.2964	0.034065	2759.2
AL+SI (20%)	1.2367	0.032549	2766.5
AL+SI (25%)	1.1956	0.031516	2773.6
ALUMINIUM BRONZE ALLOY	0.88799	0.023509	2793.7
NICKEL ALLOY	5.143	0.13577	2780.5
AL6061	1.5421	0.040453	2751.7
TITANIUM ALLOY	1.1032	0.028595	2700.5

MODAL ANALYSIS

MATERIALS	DEFORMATION-1 (mm)	DEFORMATION-2 (mm)	DEFORMATION-3 (mm)
AL+SI (10%)	280.13	280.5	414.29
AL+SI (15%)	285.07	285.43	412.64
AL+SI (20%)	288.83	289.21	411.01
AL+SI (25%)	291.11	291.5	409.28
ALUMINIUM BRONZE ALLOY	181.57	181.69	232.67
NICKEL ALLOY	231.33	189.45	190.13
AL6061	417.65	395.95	395.66
TITANIUM ALLOY	233.49	233.8	319.29

MATERIALS	FREQUENCY-1 (Hz)	FREQUENCY-2 (Hz)	FREQUENCY-3 (Hz)
AL+SI (10%)	363.79	372.44	1583.8
AL+SI (15%)	482.57	489.12	1627.7
AL+SI (20%)	559.51	1565.35	1664.1
AL+SI (25%)	608.11	613.71	1689.5
ALUMINIUM BRONZE ALLOY	602.6	607.18	1124
NICKEL ALLOY	449.36	621.88	628.66
AL6061	1504.8	4011.6	4028.8
TITANIUM ALLOY	560.28	564.65	1346.5

THERMAL ANALYSIS

MATERIALS	TEMPERATURE (K)	HEAT FLUX (W/mm^2)
AL+SI (10%)	1023	0.95434
AL+SI (15%)	1023	0.95069
AL+SI (20%)	1023	0.94819
AL+SI (25%)	1023	0.94565
ALUMINIUM BRONZE ALLOY	1023	0.7505
NICKEL ALLOY	1023	0.68667
AL6061	1023	0.95434
TITANIUM ALLOY	1023	0.40451

CONCLUSION

By observing static analysis results, the stresses are increasing when the Silicon percentage in the Al-Si composite is increasing but the deformations are decreasing. The stresses are increasing by about 2.71% for Al-Si (15%), by about 5.3% for Al-Si (20%), by about 7.89% for Al-Si (25%) when compared with that of Al-Si (10%). The stresses are less when Titanium alloy is used.By observing modal analysis results, the frequencies are increasing when the Silicon percentage in the Al-Si composite is increasing thereby increasing the vibrations. The frequencies are increasing by about 2.69% for Al-Si (15%), by about 4.8% for Al-Si (20%), by about 6.25% for Al-Si (25%) when compared with that of Al-Si (10%). The stresses are less when Nickel alloy is used.By observing thermal analysis results, the heat flux values are decreasing when the Silicon percentage in the Al-Si composite is increasing. That is the heat transfer rates are decreasing.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

The heat flux values are decreasing by about 0.38% for Al-Si (15%), by about 0.644% for Al-Si (20%), by about 0.911% for Al-Si (25%) when compared with that of Al-Si (10%). The heat transfer reduction results in reduced coefficient of friction and in turn increases in wear rate. Thus the deviation/delay occurs in valve opening and closing and leads to reduction in engine performance.

REFERENCES

[1] S.K. Rajesh Kanna, R. Ragu, P.S. Rajeswaran and Muthuvignesh, Performance evaluation using FEA on Al-Si coated engine valve.

[2] Seshagiri Rao, etal, design an exhaust valve for a four wheeler petrol engine using theoretical calculations.

[3] Hemendra Kumar Srivastva, Arurendra Singh Chauhan, Manmohan Kushwaha, Amaan Raza, Prashantkr Bhardwaj, Vaibhav Raj, Comparative Study of Different Materials with Al-Sic for Engine Valve Guide by Using FEM.

[4] Vinay V. Kuppast, Vijay Kumar N. Chalwa, S. N. Kurbet, Aravind M. Yadawad, Finite Element Analysis Of Aluminium Alloys For Their Vibration Characteristics.

[5] Rohit T. Londhe, J.M. Kshirsagar, Experimental Analysis of Valve and Valve Seats Wear in Gases (CNG) Fuelled Engine.

[6] Naresh Kr. Raghuwanshi , Ajay Pandey , R. K. Mandloi, Failure Analysis of Internal Combustion Engine Valves.

[7] Nilamkumar S. Patel Dr A. D. Patel,Studies on Properties of Composite Material (AlSic MMC) for Valve Development of Light Vehicle Petrol Engine - A Technical Research.

[8] G.Sekhar, B.Baloji, Design and Analysis of the Al-Sic Composite Materials of Engine Valve Guide.

[9] Nilam kumar S. Patel Dr A. D. Patel Studies on Properties of Al-Sic MMCs for Making Valves for Automobile Components - A Technical Review.

[10] Naresh Kr. Raghuwanshi , Ajay Pandey , R. K. Mandloi, Failure Analysis of Internal Combustion Engine Valves: A Review.