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Structure Analysis of IC Engine Exhaust Valve by ANSYS

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Abstract

Design of a valve is depending upon the various parameters such as material strength, behavior of material at elevated temperature, concentration of charge, fluid dynamic, coolant flow, axial forces, spring and inertia forces, oxidation properties of a material and operating condition of engine. The most crucial parameter which affects the valve is the exhaust temperature and stress. In this paper we are selecting the five types of material and one reference material over which we are analysis our result with the help of ANSYS. Materials are **Nickel, Austentic steel, Titenium, Beryllium, Silicon nitride,** and **Alluminum Nitride**.

Keywords: *Exhaust Valve, Combustion, Steady State Thermal, ANSYS, Total Heat Flux.*

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1. Introduction

Exhaust valve is one of the most critical components of internal combustion engine. It controls the intake air-gas mixture supply into the combustion chamber for the combustion and makes the path for the exhaust gases for exit. Failure due to Fatigue it means that "to tire" which is the Latin word "Fatigue". There are two types of fatigue failure I) Mechanical failure due to fluctuating stress due to cyclic load at high temperature II) Thermal fatigue due to cyclic changes in component material temperature.

Failure of Valve Due to Erosion –Corrosion is the scale formations are on the valve which corrodes the surface of the valve operate at very high temperature. The erosion –corrosion of exhaust valve is an important cause of failure of internal combustion engine. In this paper we deal with the analysis of valve considering different material with the help of ANSYS. Engine valve are classified into following type.

Dimension of Valve: -

Port Diameter	d_1	43.42 mm
Valve lift	h	15.35 mm

Thickness of valve disc	t	5.89 mm
Width of seating	b	4.14 mm
Valve head Diameter	d_2	51.74 mm
Diameter of valve stem	d_o	9.42 mm

Save this model in the .stp file, for the steady state thermal analysis in the ANSYS software.

2. LITERATURE REVIEW

Snehal S.Gawale, Dr.S.N.Shelke proposed the radius and minimum stress in the exhaust valve in his paper "Diesel engine Exhaust Valve Design and Optimization". Objective of this paper is to find the suitable radius in which the maximum stress induced is Minimum, for the safe design. In this paper taking three different metals (AISI 1541 Carbon steel, Austenitic steel-23-8N, Supper Alloy 21-2N) for the analysis in ANSYS.

G.Ragul, Samrat Majumdar, S.Sankar, Prakash, Dehesinghraja J proposed the materials behaviour under the high thermal gradient and high pressure inside the combustion chamber in his paper "Thermo Mechanical Analysis of Engine Valve and Valve Seat". Objective of this paper is to analysis the valve by thermal analysis through ANSYS as a tool with three materials (21-4N, Nimonic 80A, Nimonic 105), Fourier's Law is used to relate the heat flux vector to the thermal gradient.

Sanoj.T, S.Balamurugan proposed the stress induced in a valve due to high thermal gradient and high pressure inside the combustion chamber in his paper "Thermo Mechanical Analysis of engine valve" by taking two material (Nimonic 80A, Nimonic 105) and suggested that Nimonic 105A is the best material for valve.

J.Sumathi MLR.Chaitanya Lahari, Dr.PHV Sesha Talpa sai, Nandkishore Singh Thakur proposed the 21-4N is the best material for steady state thermal and static structure because it have the maximum heat flux and highest equivalent stress. This paper takes two materials (21-4N, Nimonic 80A) and 21-4N is the suggested material.

3. MATERIAL SELECTION

Material selection based on following properties.

- Low Density
- High Temperature strength
- Excellent wear resistance
- Good corrosion resistance at elevated temperature

4. MATERIAL PROPERTIES

BERYLLIUM

MECHANICAL PROPERTIES	
Young modulus	303 GPa

Ultimate Tensile Strength	827 MPa
Poission ratio	0.180

NICKEL

MECHANICAL PROPERTIES	
Young modulus	1310 GPa
Tensile yield Strength	2379 MPa
Poission ratio	0.305

SILICON NITRIDE

MECHANICAL PROPERTIES	
Young modulus	310 GPa
Compressive Strength	2950 MPa
Poission ratio	0.27

AUSTENITIC STEEL

MECHANICAL PROPERTIES	
Young modulus	193 GPa
Tensile Yield Strength	550 MPa
Poission ratio	0.3

TITANIUM

MECHANICAL PROPERTIES	
Young modulus	115 GPa
Ultimate Tensile Strength	220 MPa
Poission ratio	0.34

ALLUMINIUM NITRIDE

MECHANICAL PROPERTIES	
Young modulus	302 GPa
Tensile Yield Strength	197 MPa
Poission ratio	0.23

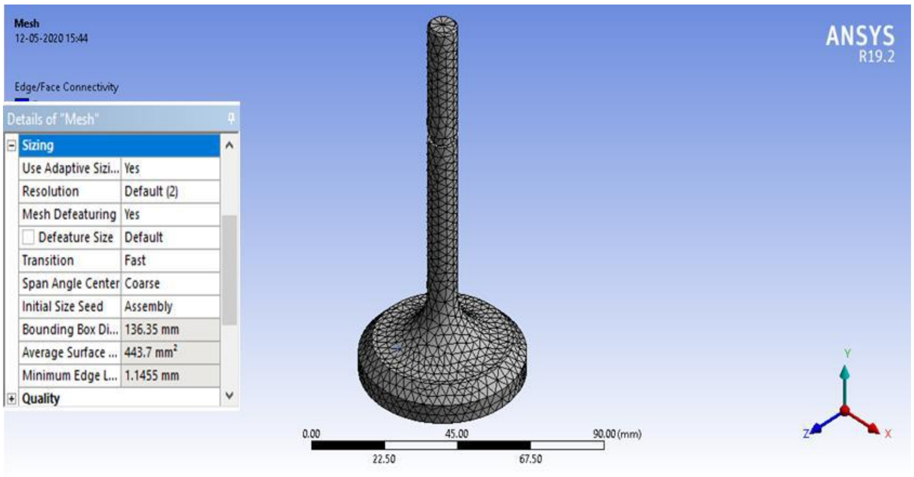

Figure 1. Meshing

5. ANSYS ANALYSIS

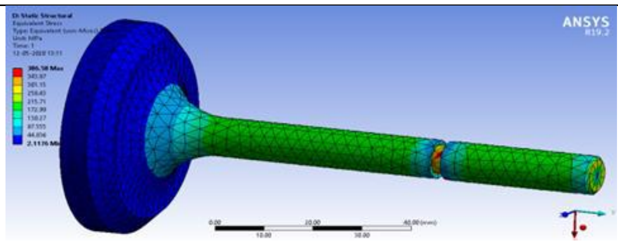

Figure 2. Equivalent Von-Mises Stress in Nickel

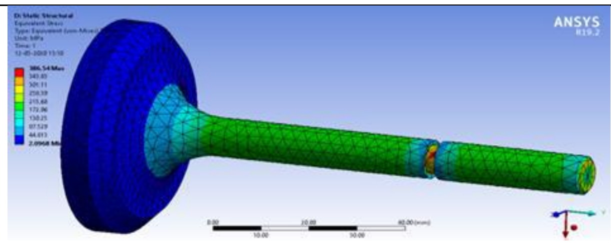

Figure 3. Equivalent Von-Mises Stress in steel

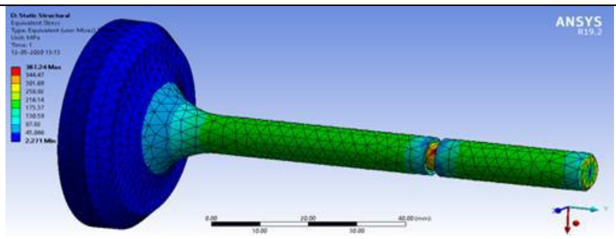

Figure 4. Equivalent Von-Mises Stress in Titanium

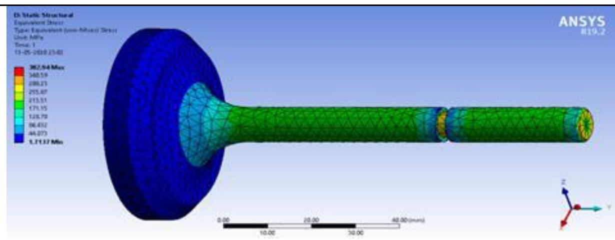

Figure 5. Equivalent Von-Mises Stress in Beryllium

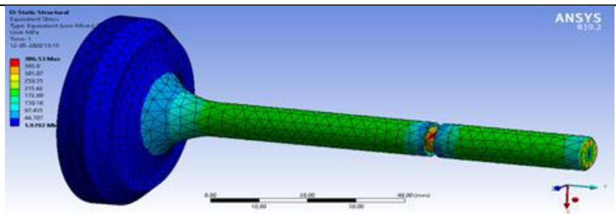

Figure 6. Equivalent Von-Mises Stress in Silicon Nitride

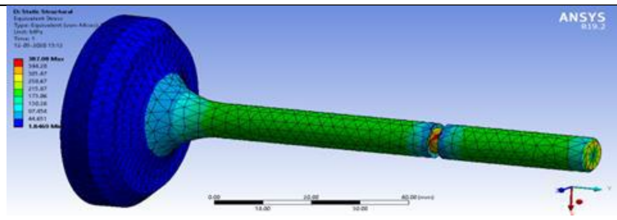

Figure 7. Equivalent Von-Mises Stress in Alluminum Nitride

6. VON-MISES STRESS

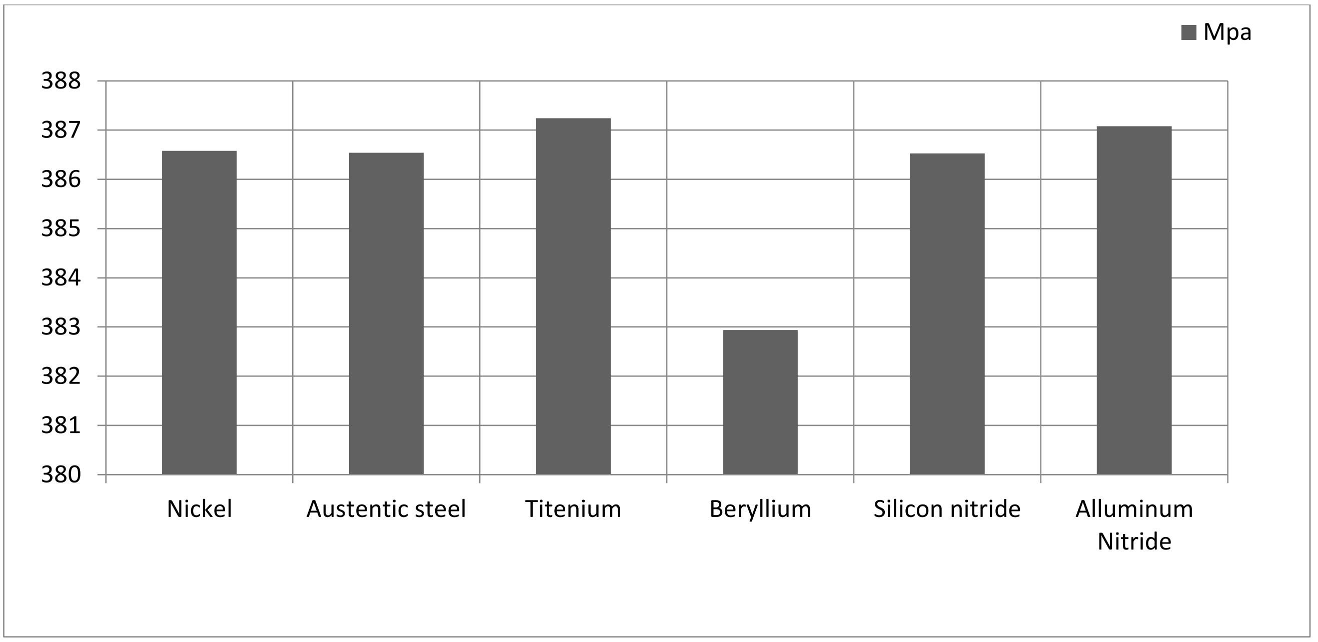

Figure 8. Graphical representation of VON-MISE Stress

Table 1: Maximum and Minimum VON-MISES stress of different material

S.N	MATERIAL	MAXIMUM VON-MISES STRESS (MPa)	MINIMUM VON-MISES STRESS (MPa)
1	**Nickel**	386.58	2.117
2	**Austentic steel**	386.54	2.098
3	**Titenium**	387.24	2.271
4	**Beryllium**	382.94	1.713
5	**Silicon nitride**	386.53	1.979
6	**Alluminum Nitride**	387.08	1.846

7. RESULTS

We seen that in the solution of, Maximum VON-MISES Stress is minimum in among all exhaust valve material i.e Nickel ,Austenic steel,Beryllium,Silicon nitride,alluminum nitride. is found to have least stress of 382.94 MPa in comparison with remaining materials including the present material.

8. CONCLUSION

- Model is created in three dimensional of exhaust valve with the help of CREO parametric 2.0 software.
- The model is meshed in ANSYS in ANSYS workbench.
- The analysis of a model is done in ANSYS, Steady state thermal analysis was successfully carried out to determine the total heat flux, directional heat flux.

- Exhaust valve is assigned with different material and analyzed. Compared with the other paper suggested material and suggested a best new material for the exhaust valve.
- By the analysis we conclude that the minimum stress that is the von- mises stress is 382.94 MPa. As the stress is minimum, we concluded beryllium is beast material among all.

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