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Research Paper

STRUCTURAL AND THERMAL ANALYSIS OF SPRING LOADED SAFETY VALVE USING FEM

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This paper deals with the study of dynamic characteristics of spring loaded relief valve and by using ANSYS Workbench. Mesh deformation due to the fluid-solid interaction between the valve disc and the surrounding fluid, are used to account for the motion of the valve disc for different Materials. The initial boundary conditions are applied to check the failures and then different materials are used with same boundary condition for evaluating the best suitable material. The results of FEM analysis depicts that $La_2Zr_2O_7$ material is best suitable.

Keywords: FEM, Dynamic characteristics, Ansys, Relief valve

INTRODUCTION

Safety Valve is a one type of valve that automatically actuates when the pressure of inlet side of the valve increases to a predetermined pressure, to open the valve disc and discharge the fluid (steam or gas); and when the pressure decreases to the prescribed value, to close the valve disc again. The basic spring loaded pressure Relief Valve has been developed to meet the need for a simple, reliable, system actuated device to provide overpressure protection. The image on the right shows the construction of a spring loaded pressure Relief Valve.The Valve consists of a Valve inlet or nozzle mounted on the pressurized system, a disc held against the nozzle to prevent flow under normal system operating conditions, a spring to hold the disc closed, and a body/Bonnet to contain the operating elements. The spring load is adjustable to vary the pressure at which the Valve will open.

When a pressure Relief Valve begins to lift, the spring force increases. Thus system pressure must increase if lift is to continue. For this reason pressure Relief Valves are allowed an overpressure allowance to reach full lift. This allowable overpressure is generall y 10% for Valves on unfired systems. This margin is relatively small and some means must be provided to assist in the lift effort. Most pressure Relief Valves, therefore, have a secondary control chamber or huddling chamber to enhance lift. As the disc begins to lift, fluid

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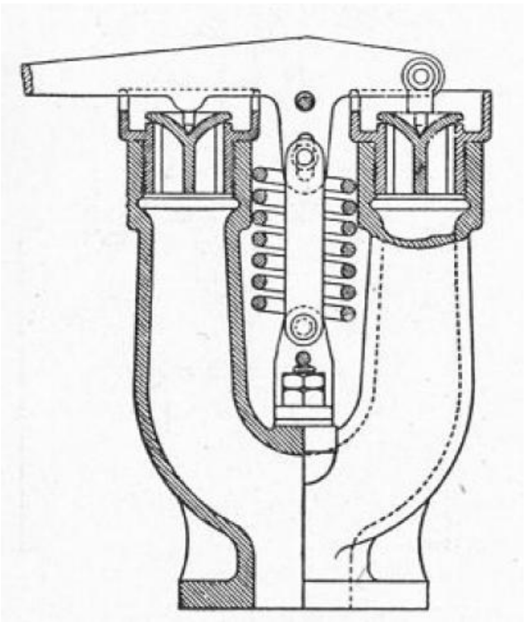
enters the control chamber exposing a larger area of the disc to system pressure.

This causes an incremental change in force which overcompensates for the increase in spring force and causes the Valve to open at a rapid rate. At the same time, the direction of the fluid flow is reversed and the momentum effect resulting from the change in flow direction further enhances lift. These effects combine to allow the Valve to achieve maximum lift and maximum flow within the allowable overpressure limits. Because of the larger disc area exposed to system pressure after the Valve achieves lift, the Valve will not close until system pressure has been reduced to some level below the set pressure. The design of the control chamber determines where the closing point will occur. The difference between the set pressure and the closing point pressure is called blow down and is usually expressed as a percentage of set pressure.

Figure 1: Spring Loaded Safety Valve



OBJECTIVES OF WORK

The following are the objectives of the study:

- To investigate the problems occurs in the Safety Valve.
- To prepare 3D CAD model of Safety Valve geometry (Data Available from earlier research).
- To perform Finite element analysis of Safety Valve geometry with natural boundary conditions.
- To suggests the remedial actions, new material, and different shapes for Safety Valve geometry to solve the failures.

PROBLEM STATEMENT

To design Pressure Relief Safety Valve which can regulate the pressure in the system within given specified limit with regards to an axial and bending load by the flowing liquid'. Multiple objectives include material finalization, thickness requirement for restrictor plate, and stiffness finalization for spring. The geometric dimension should be such that, self-weight should be the operational parameter for the valve. Further FEA techniques are used to test this design to study the stress patterns and to ensure a durable design. Key constraints in designing the valve are geometrical parameters as well as operating parameters such as pressure and temperature.

The Safety Valve used for the present work is Lever Operated Spring Safety Valve and Analysis done on it. The same type of analysis can also be done on the different other types of Safety Valve like Direct Operated Safety Valve, Pressure Relief Valve, etc. The design procedure of all types of valve if investigated first and the causes of failures are found out.

COMPUTER AIDED MODEL DESIGN OF SAFETY VALVES

CAD/CAE Software's used for design and analysis

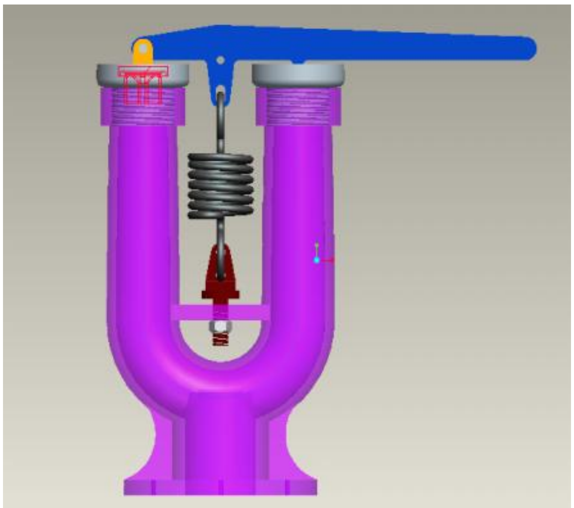
- PRO/E – For 3D Component Design
- Pro/Assembly – For Assembling Components
- ANSYS Workbench – For CAE/FEM analysis

3D Modeling

The essential difference between Pro/ENGINEER and traditional CAD systems is that models created in Pro/ENGINEER exist as three-dimensional solids. Other 3D modelers represent only the surface boundaries of the model. Pro/ENGINEER models the complete solid. This not only facilitates the creation of realistic geometry but also allows for accurate model calculations such as those for mass properties.

Figure 2: Parts of Spring Operated Relief Valve

Figure 3: Complete Assembly Drawing of Spring Operated Relief Valve



FINITE ELEMENT ANALYSIS OF SAFETY VALVES

Using Existing Material

Structural steel/Alloy steel are used as an existing materials. By using the existing

Figure 4: Ansys Result for the Existing Material

Young's Modulus (MPa)	200000
Poisson's Ratio	0.3
Density (kg/mm3)	7.85E-06

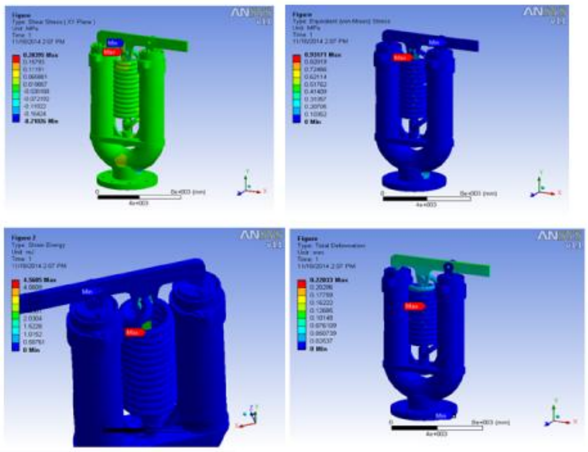
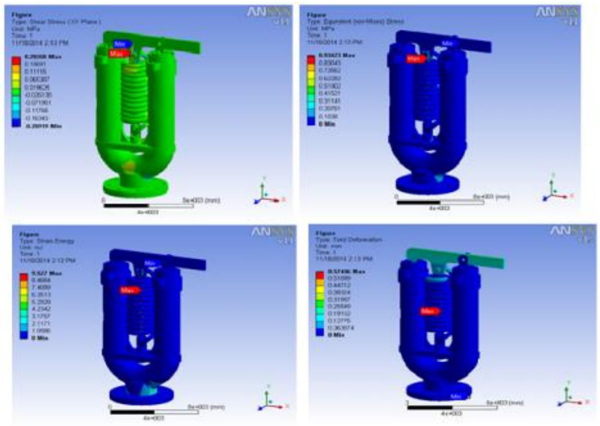


Figure 5: Ansys Result for the Aluminum Alloy Material

Young's Modulus (MPa)	96000
Poisson's Ratio	0.36
Density (kg/mm3)	4.62E-06



CONCLUSION

From above Study it is conclude that for spring loaded safety valve and marine feed check valve Aluminum alloy is best material than existing material as per the Ansys result obtained. In order to examine the performance characteristics of the safety valve of high-pressure, Structural and thermal analysis were conducted. The following conclusion was obtained.

For spring loaded safety valve the maximum shear stress that produce for existing material is 0.20395 Mpa which is greater than the for Aluminum alloy, i.e., 0.20268 Mpa. Also as per the weight and cost comparison the Aluminum alloy material is preferred.

Table 1: Results

	Structural Steel/ Alloy Steel	Aluminum Silicate Alloy	Steel and Magnesium Alloy	Titanium Alloy	La2Zr2O7
Total Deformation	2.2833 mm	2.6244 mm	2.4542 mm	0.57486 mm	1.1582e-002 mm
Equivalent Stress	0.93171 MPa	0.93171 MPa	0.9333 MPa	0.93423 MPa	0.93366 MPa
Shear Stress	0.20395 MPa	0.20395 MPa	0.2029 MPa	0.20268 MPa	0.20498 MPa
Strain Energy Lost Due to Heat	4.5685 mJ	10.152 mJ	20.328 mJ	9.527 mJ	0.52017 mJ

material the analysis is performed in Ansys. Material Property of Structural steel are:

Using Titanium Alloy Material

Second Material used for the analysis of safety valve is Titanium Alloy. The Material Properties are as follow

Similar Analysis can be done by using the following material and compared with existing material.

RESULT

Result obtained after the analysis of spring loaded safety valve

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