INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

A PATH FOR HORIZING YOUR INNOVATIVE WORK

# STRUCTURAL AND THERMAL ANALYSIS OF SAFETY VALVE

**PATERIYA A, KHAN M**

1. Department of Mechanical Engineering, Padm. Dr. V. B. Kolte college of Engineering Malkapur.
2. Student M.E CAD/CAM

**Accepted Date: 08/11/2014; Published Date: 01/12/2014**

**Abstract:** In presently used safety valve sizing standards the gas discharge capacity is based on a nozzle flow derived from ideal gas theory. At high pressures or low temperatures real-gas effects can no longer be neglected, so the discharge coefficient corrected for flow losses cannot be assumed constant anymore. Also the force balance and as a consequence the opening characteristics will be affected. In former studies valve capacities have been validated at pressures up to 35 bar without focusing on the opening characteristic. This paper presents a study of dynamic characteristics of spring loaded relief valve and the turbulent flow of water through it by using ANSYS in 2-Dimensions. 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 under different inlet pressure conditions. The velocity and pressure distribution through the valve at each time step are obtained. Especially, this simulation presents the different effects of the flowing fluid acting on different part of disc, and thus identifies the critical part/region, which has significant effect on the transient response of the system. The results provide a better understanding of motion and flow characteristics of a relief valve and thus are helpful to the relief valve design process

**Kevwords:** Structural Analvsis. Safetv Valve

**Corresponding Author: PROF. AJITABH PATERIYA**

**Access Online On:**

www.ijpret.com

**How to Cite This Article:**

Pateriya A, IJPRET, 2014; Volume 3 (4): 7-13

***PAPER-QR CODE***

**INTRODUCTION**

The spring loaded pressure relief valve (also called direct operated relief valve) is a type of pressure relief valve (PRV) used to control or limit the pressure in a system or vessel. It performs a critical function in preventing excessive pressure and protecting the system and mechanical equipment. Due to its simple configuration, spring loaded PRVs are widely used in lots of hydraulic systems. Hence, the detail study on such a valve is essential. There is a rich literature that describes their usage in hydraulic circuits and gives information on their design and application. In hydraulic circuits that are in steady operating conditions, and the constant flow rate input of the system is less than the delivered flow rate of the pump then the deference will flow through the by-pass line secured by a relief valve. Such situations arise when economic operation is not so important. The other case when relief valves interact in most of the hydraulic equipments is when transient phenomena occur (e.g. the scoop sticks in a rocky layer below the soil) and the pressure raises much above the tolerable limit. The relief valve has to intervene and limit the pressure so that other parts of the circuit are not damaged. These are the main reasons why designers of such systems have to insert pressure limiters into the circuit.

Till now, two approaches are usually adopted to study the Performance of a spring loaded PRV. One is the experimental study. Many researchers have experimented and analyzed spring loaded PRVs for the fluid characteristics, operating parameters, and the coefficients such as discharge coefficient and pressure loss coefficient. From the viewpoint of practical application, this method is more reliable and suitable, since the real situations are usually simulated in the experiments. But on the other hand, this method is very expensive in time, manpower and facilities. Hence, with the development of computer and numerical method, more and more researchers started to use computer simulation to investigate. In the computer simulation, most of them used the dynamic model to investigate the performances of various PRVs.

Figure 1 shows a so called Lever operated pressure relief valve. The simplest configuration of such a relief valve is when an orifice is closed by a poppet or similar element. The closing force can be adjusted by pre-stressing a spring that presses the poppet towards the valve seat. This force divided by the cross-sectional area of the orifice also represents the opening pressure, the threshold at which the safety valve will come into operation. There are numerous examples in industry where these kinds of valves can vibrate when their equilibrium loses stability and many researchers have been interested in the investigation of this phenomenon.

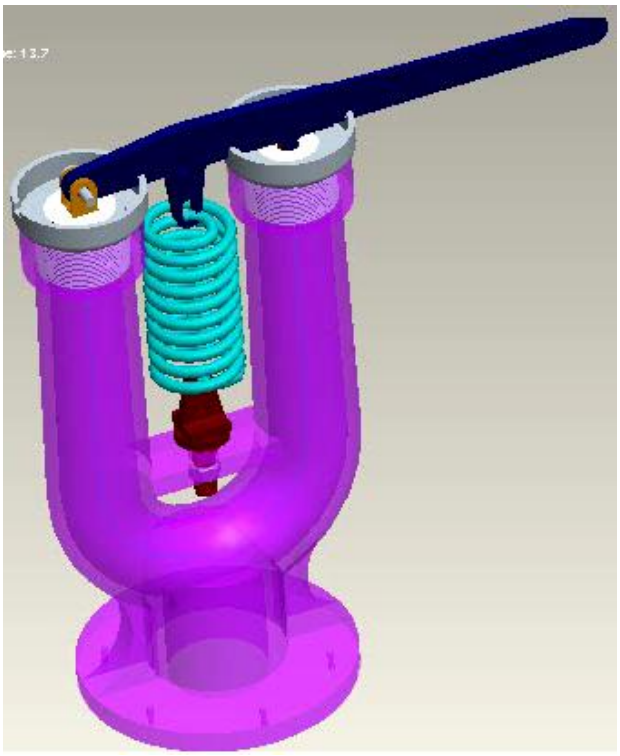

**Fig. 1 Lever Operated Pressure Safety Valv**

OBJECTIVES OF WORK

The following are the objectives of the study:

- To study basic principle of working of Safety Valve.
- 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

2.1. Software used to Study the Project:

- PRO-E:
- To prepare 3D CAD model of Safety Valve
- Ansys:
- To perform Finite element analysis of Safety Valve

2.2. Scope of the Study

The Safety Valve used for the present work is Lever Operated 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.

**LITERATURE REVIEW**

Greg Ritchie (1989) optimized the Pressure Relief valve for Minizing the seat leakage. The Optimization is done by forming the Mathematical model of component. The goal of his project is to evaluate the effect of misapplied loading of valve seat leakage and develop the component design which minimizes the leakage problem

Gábor Licskó,Alan Champneys,Csaba(2009) Has Studied the " Nonlinear Analysis of a Single Stage Pressure Relief Valve" for behavior that can occur when the valve poppet impacts with its seat. He derives a mathematical model that describes the dynamics of a single stage relief valve embedded within a simple hydraulic circuit. The aim is to capture the mechanisms of instability of such valves, taking into account both fluid compressibility and the chattering behavior that can occur when the valve poppet impacts with its seat.

Xue Guan Song, Lin Wang, Young Chul Park (2010) has studied the "Transient analysis of spring loaded Pressure relief valve using CFD" A 3D transient flow field through a spring-loaded pressure safety valve was analyzed numerically using the CFD software. By combining unsteady analysis, the moving mesh technique, and a 1D dynamics equation, the flow characteristics through a safety valve and the dynamic behavior of the valve, which are difficult to observe experimentally or with steady CFD analysis, were obtained

K. Klarecki Studied the "Analysis of Innovative type Direct operated Low pressure relief valve" On the basis of his idea was created a mathematical model of the valve and next, a computer Simulation in MATLAB/SIMULINK environment. The results of the simulation indication that new type of the low pressure relief valve characterized: almost stable operating pressure in flow-function, short setting times, acceptable pressure overshoot..

Xue Guan Song,Ji Hoon Jung, Hyeong Seok Lee, Dong Kwan Kim, Young Chul Park, Studied the 2 D analysis of Pressure relief valve by CFD. They studied the dynamic characteristics of spring loaded relief valve and the turbulent flow of water through it by using CFD in 2-Dimensions.The results provide a better understanding of motion and flow characteristics of a relief valve and thus are helpful to the relief valve design process.

Mehul S Rajapati and Dr.D.N.Raut (2010) analyzed the Pressure Relief valve using MATLAB. The goal of his Study is to investigate the principal and practical Mechanics involved in the design of hydraulic valve, using a computational software package MATLAB.

In the Study of "Arend Beune(2009)" investigated a numerical tool of sufficient predictive capability that allows the calculation of mass flow capacities and opening characteristics of spring-loaded safety valves at operating pressures up to 3600 bar. For the mass flow capacity calculation the standardized sizing method based on nozzle flow of a perfect gas needs to be evaluated. Possibly this model has to be extended to account for flow at high pressures with real-gas effects. Besides the mass flow capacity, for predicting the opening characteristics CFD is used to obtain the complex flow phenomena.

Mr. V. D. Rathod, Prof. G. A. Kada, Mr. V. G. Patil (2014) has Design ,Analyzed and Optimized pressure vessel safety release valve, which save bursting the pressure vessel. For doing this FEA is used. The majority vessel. Have their protection system designs based on spring type pressure relief valves. In simple terms, these valves have a plate which is pressed by a spring against the inlet pressure of the pipes; vessels etc. & hold this plate with help of clip ON.. In this case plate is subjected to two forces, at one side a spring force & at other side is vessel pressure force. For design of a pressure safety release valve, the most important component is the plate

and the clip ON design that will actually restrict the fluid flow in the safety line. The plate will be subjected to a bending load as well as axial load and shearing load. The basic design problem of a safety release valve, which is set to close at a particular pressure.

Kishan Patel (2014) has done the CFD analysis of a weir type diaphragm valve. When diaphragm is stretched up to weir, the flow stops. However, even in open condition, the weir obstructs the flow. That is why if design is not proper, drastic pressure drop can occur. These make to use CFD analysis to find values of various flow parameters and simulate flow in weir type diaphragm valve which helps to improvise flow Characteristics of the valve.

A. Beune, J.G.M. Kuerten, M.P.C. van Heumen (2012) has done the CFD analysis with fluid–structure interaction of opening high-pressure safety valves CFD result for the flow force are used to model the movement of the valve. In incompressible transient flow simulations a large force rise and collapse is caused by a redirection of the bulk flow. This flow-history effect cannot be incorporated in a quasi-steady approach. For real-gases at a set pressure of 40 bar oscillations have been observed during closing of the valve. They are caused by the interaction between the flow in the cavity of the valve disk and the flow towards the valve outlet. At a higher set pressure the flow force continually decreases, which indicates that only a sufficiently fast inlet pressure rise forces the valve to open. With this tool the operation characteristics of safety valves can be assessed to optimize the valve design.

V. Dossena, F. Marinoni, F. Bassi, N. Franchina, M. Savini (2013) has studied the Numerical and experimental investigation on the performance of safety valves operating with different gases . A detailed analysis of the effect related to the expansion of different gases throughout safety relief valves is carried out both numerically and experimentally. They considered gases are air, argon and ethylene, representative of a wide range of specific heat ratios.

William Dempster, Wael Elmayyah (2013) Studied the Two phase discharge flow prediction in safety valves. CFD based two phase mixture model to predict the critical flows of air and water through a safety valve is examined. An industrial refrigeration safety relief valve of ¼ inlet bore size has been tested experimentally over a pressure range of 6e15 barg and air mass qualities from 0.1 to 1 when discharging to near atmospheric conditions for a fully open condition. A two-dimensional mixture model consisting of mixture mass, momentum, and energy equations, combined with a liquid mass equation and the standard kee turbulence model for mixture turbulent transport has been used to predict the two phase flows through the valve. The mixture model results have been compared with the Homogenous Equilibrium Model (HEM)

commonly used for in valve sizing in non flashing two phase flow conditions. The accuracy of the models over the two phase flow range are quantified and discussed

**REFERENCES**

1. Gabor Licsko,Alan Champneys,Csaba Hose " Nonlinear Analysis of a Single Stage Pressure Relief Valve" International Journal of Applied Mathematics, November 2009, IJAM_39_4_12

2. Xue Guan Song, Lin Wang, Young Chul Park "Transient analysis of spring loaded Pressure relief valve using CFD" Journal of Pressure Vessel Technology OCTOBER 2010, Vol. 132 / 054501-1

3. Xue Guan Song,Ji Hoon Jung, Hyeong Seok Lee, Dong Kwan Kim, Young Chul Park, "2 D analysis of Pressure relief valve by CFD" 9th WSEAS Int. Conference on APPLIED COMPUTER and APPLIED COMPUTATIONAL SCIENCE, ISSN: 1790-5117 ISBN: 978-960-474-173-1

4. Mehul S Rajapati and Dr.D.N.Raut "Analysis of Pressure Relief Valve Using Matlab Simulink" 37th National & 4th International Conference on Fluid Mechanics and Fluid Power December 2010, IIT Madras, Chennai, India. FMFP10 - FP – 01

5. Arend Beune "Analysis of high-pressure safety valves" A catalogue record is available from the Eindhoven University of Technology Library ISBN: 978-90-386-2006-0

6. Mr.V.D.Rathod, Prof.G.A.Kada,Mr.V. G. Patil "Design and Analysis of Pressure Safety Releas Valve by using Finite Element Analysis" International Journal of Engineering Trends and Technology (IJETT) – Volume 13 Number 1 – Jul 2014, ISSN: 2231-5381

7. Kishan Patel "CFD Analysis of A Pressure Relief Valve" International Journal for Scientific Research & Development| Vol. 2, Issue 04, 2014 | ISSN : 2321-0613

8. A. Beune, J.G.M. Kuerten, M.P.C. van Heumen "CFD analysis with fluid–structure interaction of opening high-pressure safety valves" Journal of Science Direct Computers & Fluids 64 (2012) 108–116.

9. V. Dossena, F. Marinoni, F. Bassi, N. Franchina, M. Savini "Numerical and experimental investigation on the performance of safety valves operating with different gases" International Journal of Pressure Vessels and Piping 104 (2013) 21-29

10. William Dempster, Wael Elmayyah "Two phase discharge flow prediction in safety valves" International Journal of Pressure Vessels and Piping 110 (2013) 61-65