Analysis of Pressure Relief valve with Buffer Chamber using finite Element Analysis

Mr. Mahesh.B.Kulkarni [1], Mrs. Richa.S.Agrawal[2]
Department of Mechanical Engineering
[1] M.E.Student, Pillai Hoc College of Engg. and Technology, Rasayani
[2] Professor, PHCET, Panvel

Abstract- *Analysis of pressure relief valve is of utmost importance to provide safety, durability and serviceability to the system, which can range from boilers to air bottles. They are usually employed with pressure vessels, which handle varying degree of loads and pressure and to safeguard them from damage. To safeguard against such harm, a buffer chamber pressure relief valve is utilized, which channels the released toxic gases into a cylindrical container. This contained toxic gas can later be treated, with the help of filters, for safe release or directed to a secondary system, where it can be further utilized depending upon the need. This paper focus on design and analysis valve by using FEA.*

Keywords- Buffer chamber, Linear FEA, Ansys work bench

I. INTRODUCTION

Pressure relief valve is the key component in any system when pressure rise could be hazardous to safety of the people and plant. For any process operating under pressure, safety is important. Pressure relief valves are provided to protect the equipment against critical pressure.

The objective of high pressure handling can be successfully carried out by knowing the minimum requirements of the boiler and pressure vessel that can be design as per ASME standards.

The current design of pressure relief valve releases the gas to open air, which is not advisable for toxic gases. Hence a new design is proposed where in the relief will allow the gases to pass to a buffer container so that it gives sufficient warning. Below figure shows CAD model of pressure relief valve with buffer chamber.

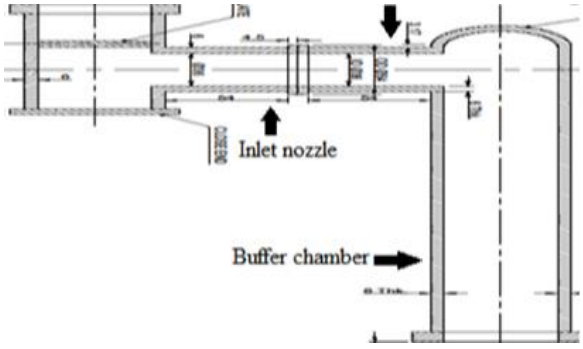

Figure. 1 CAD model of pressure relief valve with buffer chamber.

1.1 Objective

1. To study the current valve design and its performance.
2. Analysis of buffer chamber for two stage pressure relief valve.
3. Analyze the overall shell thickness of pressure relief valve with buffer chamber.

II. LITERATURE SURVEY

J. Ortega.et al [1] developed direct acting spring loaded pressure relief valve. 2D model was designed on the base of geometrical and constructive characteristics. A direct acting spring loaded pressure relief valve's computational model developed so as to overcome the lack of information regarding valve and transient behavior of flow.

R.G.Desavale[2] designed a gradual flow reducer valve with available data but found that the flow reduer valve was bulky. Hence they decided to do weigth optimization of flow meter.

In another study carried by C.Bazso [3], he showedin industry generally direct loaded spring relief valves are widely used against over pressure and this type of valve have a tendency to become self oscillated and unstable. Hence, experiment has been carried with poppet valve body behaviour on static and dynamic conditon.with a special emphasis on the parameters influencingthe valve instabiliy.

H.chattopadhyay [4] during investigation of flow through a valve, found different pressure drops at different openings.It was found that the flow in spool type valve had difference of pressure due to variation in opening the valve.This flow process inside the domain of interest was solved under the influence of compressible flow at increased turbulence.

N.Jadhav [5] carried out study on pressure valves and has described pressure valve as a critical components for handling toxic or flammable materials. They found that the pressure in the system is well regulated and there is minimum risk of system explosion or leak due to exssesive pressure. They have focused on design and optimization of the pressure vessel valve.

M.V.Awati [6] has focused on safety control in pressure relief valve. Design of mechanically operated emergency shut off valve is done through electronic operation. In this review, by using analytic approach design of emergency safety valve and analysis is easily possible. As the working environment is hazardous, focus on the design of this type of valve is necessary.

Jadhav.S.G [7] has specified pressure relief valve necessaryfor protection against high pressure of steam, gas, air, liquid lines & pressure vessel.An overpressure event refers to any condition which would cause pressure in a vessel or system to increase beyond the specified maximum allowable working pressure. This synopsis focus on the review design, analysis and weight optimization of pressure relief valve by usingFEA.

III. DESIGN PROCEDURE

Valve Body design by using ASME code. The material selected is Sa 516 Gr 70 for the component as internal pressure acting on the system is applicable rather than external pressure. The design of all components of the relief valve are done for the design parameters mentioned in Table 1 as per ASME codes, IS codes and design procedures. It consist of Main shell, Circular plate, Nozzle, Flange, Buffer chamber.

Table 1: Input condition of valve

Sr.No	Parameter	Intensity
1	Pressure	0.14 Mpa
2	Inlet diameter of Valve	50mm
3	Nozzle diameter	36mm
4	Spring	01
5	Operating temperature	70^0c

A. Design of Valve Body

Design of main shell

According to ASME Section-VIII, Division-I, UG27, Thickness of main shell for internal Pressure (tr):

tr= P.R/(S.E-0.6P)+ Corrosion Allowance

tr= 0.14 x 25/ [(138.023 x 1)-(0.6 x 0.14)]+3

tr= 0.0253+3

tr= 3.0253 mm

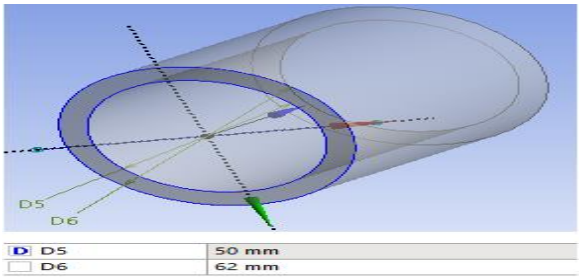

Figure. 2 Main Shell

B. Design of plate

For design of circular plate, ASME code is used to determine the thickness of the plate Referring ASME section VIII, div-I, Calculate thickness of circular plate

$$T1 = d\sqrt{\frac{C.P}{S.E}}$$

$$T1 = 50 \times \sqrt{\frac{0.2 \times 0.14}{138.023 \times 1}}$$

T1= 50 x 0.0142

T1= 0.7121 mm

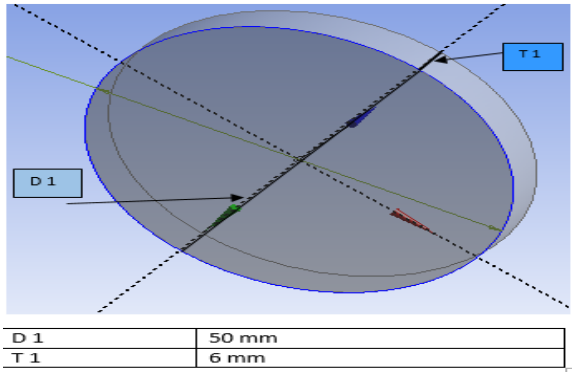

Figure. 3 Design of circular Plate

C. Design Inlet and Outlet nozzle with Flanges

Flange outer Diameter = 1.5 x D_N = 1.5 x 36 = 54 mm

Flange inner Diameter = D_N = 36

Thickness of flange = t = 4.5mm.

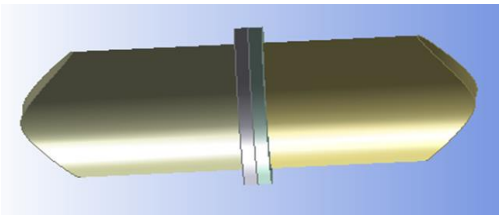

Figure. 4 Design of Inlet nozzle and Outlet nozzle with Flanges

D. Buffer Chamber

Vs = (NTD)*(pi*R*R)

NTD = Vs/ (pi*R*R)

= 100/ [0.14x (2x0.025) x (2x0.025) x 10^6

= 0.285m

= 285.71mm

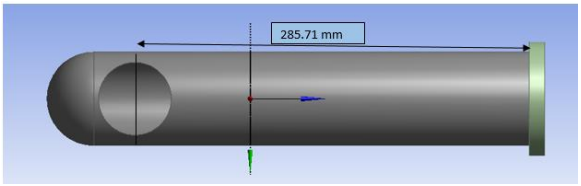

Figure. 5 Design of Buffer Chamber

IV. LINEAR ANALYSIS

A. Model

Geometry of pressure relief with buffer chamber is done by ANSYS workbench 15.

B. Meshing

Meshing is done by Hex dominated method. Figure 5 shows Meshed model of valve.

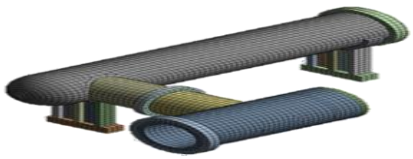

Figure. 6 Meshed model of valve

C. Boundary conditions

Boundary conditions are applied in 3 directions with respect to time variation for different pressure.

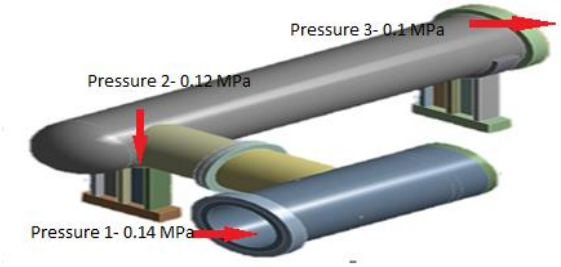

Figure. 7 Pressure relief valve with boundary condition

D. Solution Information

In analysis total deformation, total equivalent stress, equivalent stress at inlet and outlet nozzle are checked. It all values within limit.

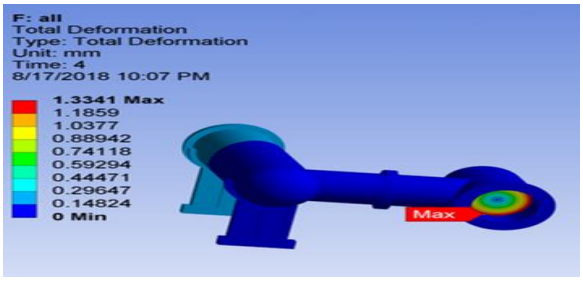

Figure. 8 Total Deformation of Valve Body

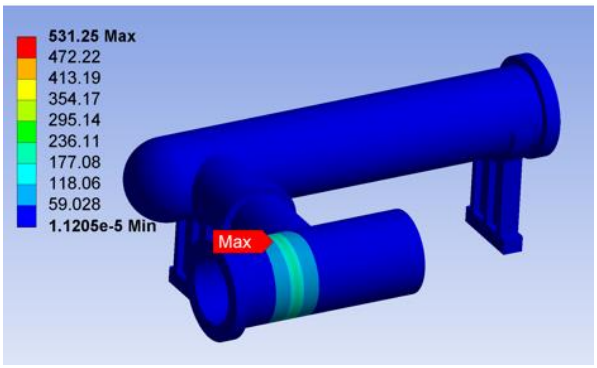

Figure. 9 Total Equivalent stress in valve body

E. Experimental validation

Following results are obtained from the test.

Trial no	Opening Pressure	Opening Time
1	0.138	0.41
2	0.133	0.43
3	o.1337	0.45

V. CONCLUSION

Buffer chamber has been design for the pressure relief valve for safely store of toxic gases. All stresses and deformation are within permissible values.

REFERENCES

[1] Kukade Vaibhav, Jadhav S.G, Patil V.G, May 2015, "Literature Review on Weight Optimization of Pressure Relief Valve for Emergency Relief Operation", International Journal on Recent Technologies in Mechanical and Electrical Engineering (IJRMEE) Volume: 2, pp. 090 – 092.

[2] Aniket A. Kulkarni, Keshav H. Jatkar, Jun 2014, "A Review on Optimization of Finite Element Modelling for Structural Analysis of Pressure Vessel", International Journal of Engineering Trends and Technology (IJETT) – Volume 12 Number 1, PP. 20-22.

[3] C.J. Hos, A.R. Champneys, K. Paul, M. McNeely, (2014), "Dynamic Behavior of Direct Spring Loaded Pressure Relief Valves in Gas Service: Model Development, Measurements and Instability Mechanisms", Journal

[4] Prof. Vishal V. Saidpatil,Prof. Arun S. Thakare, June 2014, "Design & Weight Optimization of Pressure Vessel Due to Thickness Using Finite Element Analysis", International Journal of Emerging Engineering Research and Technology Volume 2, Issue 3, PP. 1-8.

[5] Mr. M. V. Awati, Prof. S. G. Jadhav,Vinay G. Patil, 2014, "Analysis of Pressure Safety Relief Valve using Finite Element Analysis", International Journal of Engineering Development and Research, Volume 2, pp. 2968-2973.

[6] Sushant M. Patil, Ramchandra G. Desavale, Imran M. Jamadar, 2013, "Conceptual Structure Design Through Thickness Optimization Of High Pressure And High Temperature Self Regulated Pressure Valve Using Non-Linear Transient Finite Element Method", International Journal of Engineering Research & Technology, Vol. 2, pp. 2043-2049.

[7] C. Bazso, C.J.Hos, 2013, "An Experimental Study on the Stability of a Direct Spring Loaded Poppet Relief Valve", Journal of Fluids and Structures 42, pp. 456–465. Himadri Chattopadhyay, Arindam Kundu, Binod K. Saha, Tapas Gangopadhyay, 2012, "Analysis of Flow Structure Inside a Spool Type Pressure Regulating Valve", Energy Conversion and Management 53 pp. 196–204.