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A Study Review on Computer Aided Design and Experimental Analysis of Self Regulated Pressure Valve

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Abstract:

In chemical processing industry the pressure inside the vessel is increase due to many reasons. An important responsibility of a chemical plant designer is to make sure that a plant under design, can be operated safely, it is provided with primary, secondary safety arrangement. One of the dangerous situations that can be arises during operation inability of a system to a pressure higher than that for which it was designed. With designing pressure safety release valve for inside vessel pressure, should be giving priority to mechanical systems to release inside pressure. The reasons are many for increase/exceed inside pressure. Most flow applications require regulating the flow of liquid, and usually the parameter of concern is the pressure. This paper focuses on the review on design of self regulating pressure valve by using transient finite element analysis. There are many authors work on this pressure valve. This paper includes study of various papers related to self regulating pressure valve. In this project focus on exchange of liquid between two chambers, where in it is required that flow be shut off when a certain pressure is reached .Electronic valves are available, however the intent of this design project is have a total mechanical system, which has an in built response mechanism.

Keywords — **Pressure Valve Design, FEA, Combined Bending and Axial loads.**

1. INTRODUCTION

Valves are mechanical devices specifically designed to direct, start, stop, mix, or regulate the flow, pressure, or temperature of a process fluid. Valves can be designed to handle either liquid or gas applications. Self regulating valve are using the output feedback signal valve to pass through the signal tube to the valve actuator drive change in the valve opening to adjust the pressure, flow, temperature. Self regulating valve are new type of regulating valve compared to manual control valve, it has the advantages is the ability to automatically adjust, relative to the electric control valve, which has advantages of no external power.

Classification of self –regulating valves

Direct action type valves

Direct Action Valve is also known as spring –loaded type valve, elastic element within its structure: such as springs, bellows, bellows-type bulb etc, using elastic force and the principle of balance.

Indirect action control valves

Indirect-acting valves, the addition of a command and control(pilot valve) it played the role of the feedback signal is amplified and then through the implementing agencies, driving the main valve disc movement to change the valve opening purpose.

2. CRITICAL ASPECT OF DESIGN

Concept of design team has come up with two generic designs

A) The gradual flow reducing valve
B) Snap shut valve

A) The gradual flow reducing valve

1. In this valve, a spring loaded obstruction will be used.
2. It will be so calibrated that it will connected to the vessel where pressure is to be regulated.
3. The pressure P, inside the vessel will push the obstruction against the spring load.

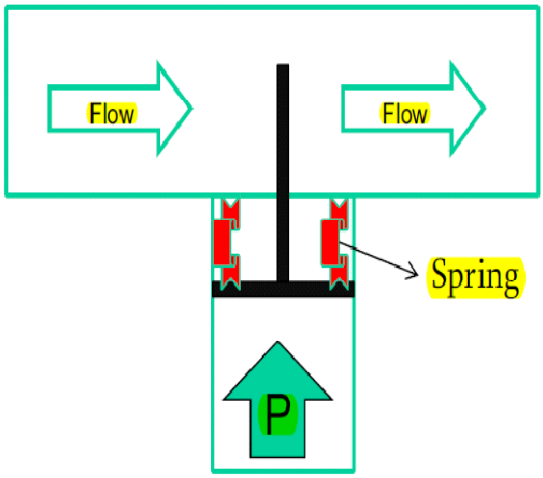

Figure: 1 the gradual flow reducing valve

B) Snap shut valve:

1. Snap shut shall consist of a mechanism that will hold the flow obstructer against compressed springs.
2. The mechanism rod will rotate under action of pressure.
3. Once it reache0s a critical pressure, the control will be free and the spring will snap shut the flow.

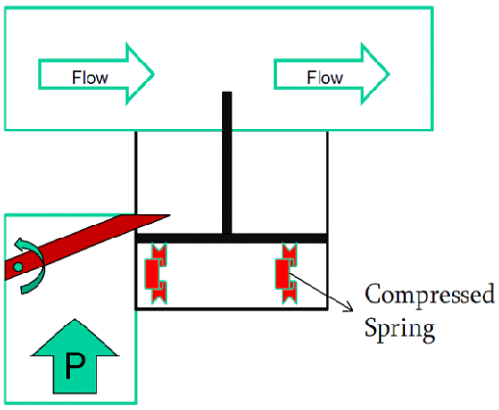

Figure: 2 Snap shut valve

3. LITERATURE REVIEW

There are many authors' works on self regulating pressure valve using finite element analysis. This papers include review of some selected papers related to self regulating pressure valve. A lot of work done in design of pressure valve but very little work is done in design of self regulating pressure valve. A brief review of some selected references on the design of pressure valve.

David Kazmer & Mahesh Munavalli [1] has predicted that design and performance analysis of a self regulating melt pressure valve. A design for a self-regulating pressure valve is analyzed using a 3D flow analysis that utilizes independent shear and elongation viscosities for the polymer. The regulator is derived from a low force valve design that enables the outlet pressure to be directly regulated by a provided force on a valve pin without need for pressure sensors or a closed loop control system. Analytical and experimental results indicate an excellent level of response and consistency given the simplicity of the design. If dynamic control of the polymer melt is to become common, it is necessary to design more compact valves that have improved dynamic response with lower actuation forces. Other essential objectives include ease of use, ease of maintenance, and positive shut-off of the molten plastic at the gate as in a conventional valve gated hot runner system. As per standard valve pin design, the valve pin is designed such that the polymer melts flows around the circumference of the pin to avoid lateral loading and bending of the pin. However, the valve pin design includes a flow port in which the axial forces due to shear. Stress and pressure drop are negligible.

Instead, the pressure drop for the valve is governed by the juncture loss between the valve choke and the drop bore, which imparts negligible forces on the valve pin. While this design could be used to produce a melt valve with very low forces, the design provided allows the melt pressure to act on the end of the pin to produce a force that is proportional to the melt pressure. If a control force is applied to the top of the pin, then a resultant force will act on the valve pin to move the valve pin to a different position such that the force due to the melt pressure equals the control force. In this way, the pressure valve is "self-regulating". Since the dynamic repositioning of the pin is accomplished through Newton's second law of motion ($F=ma$) and no external feedback control is necessary. In the current design, the control force is provided through a pneumatic actuator with regulated air pressure. Similar to the melt pressure on a hydraulic molding machine, the melt pressure downstream of the valve is governed by an intensification ratio relating the size of the pressure valve to the size of the pneumatic cylinder:

$$I = A(cylinder)/A(annulus = R^2(cylinder)/R^2(annulus) \approx 100$$

Finally this paper concludes that the melt flow in the self-regulating melt pressure valve has been analyzed with respect to steady state behavior, dynamic behavior, and steady state error.

Tang Pengxiang [2] has predicted design of system pressure valve of 8-speed automatic transmission. System pressure valve is very essential for the performance of 8-speed automatic transmission (8A T). The new system pressure valve of 8AT in front-wheel drive (FWD) is designed and simulated by ITI-Simulation X, its performance such as pressure and flow of system pressure valve were analyzed and optimized in a whole power train

system including hydraulic system, mechanical system and control system. Because the model includes the interaction of all components from the various physical domains in whole power transmission system, this is very helpful for the performance optimization of system pressure valve in real application of 8- speed automatic transmission.

The new SYSPV is designed in this paper. The dynamic simulation model of hydraulic system of AT is established. Based on the simulation model, the simulation results of pressure and flow of system pressure valve are analyzed. The results show that the dynamic simulation method would be very very helpful for analyzing the performance of SYSPV and optimizing its design under interaction of all components form the different physical domains in whole power transmission system.

Richard E. Clark, Geraint W. Jewell, Stephen J. Forrest, Jan Rens, and Christophe Maerky [3] have suggested design features for enhancing the performance of electromagnetic valve actuation systems. The paper describes a type of variable air-gap reluctance actuator that offers potential for enhancing the dynamic performance of electromagnetic valve actuation systems for internal combustion engines. In both the stator and armature, the actuator incorporates design features that allow the force-displacement characteristic to be tailored to meet operational requirements. The paper demonstrates the considerable scope for varying actuator characteristics by means of detailed two- and three-dimensional finite-element modeling. The key findings from the finite-element modeling are validated by experimental measurements on a proto- type actuator.

In this paper model is drawn by using design software ANSYS .Three dimensional finite element modeling shown in fig.3.Experimental validation done for getting result. This paper has described the design and experimental characterization of a class of variable air-gap reluctance actuators that offers the scope to tailor force-displacement characteristics to meet application specific requirements, in this particular case electromagnetic valve actuation. Although practical difficulties were encountered in terms of counteracting rotational forces, the utility of this modified E-core structure has been demonstrated.

Meiqiu LI [4] has shown that Visual Design System Development of Wellhead's High Pressure Valve. The article introduces the advantages and the application of the visual design, analyzes the tendency and shortage of product development about high pressure valve used in wellhead. Combining the visual design method with collaborative design idea, a visual design system is designed for high pressure valve used in wellhead, which includes three modules. The development process and function of the system is described in detail. Based on a great deal database and modularized collaborative design, basic geometric design, three-dimensional modelling, virtual assembly and finite element analysis (FEA) on chief parts are finished successfully. Practice indicated that the visual design system was an effective measure to improve efficiency of design, meet the demand of the development of product serialization, and reduce the cycle of development of product, reduce the cost.

Figure: 3 the system main interface

Geometric Design shown in above Fig. 3 illustrates the function of the visual system. In general, it consists of four parts: Design Content: gate valve, check valve, relief valve, throttles valve and globe valve. Database: material, standard component, drawing and geometric parameter. Three-dimensional Modeling and Virtual Assembly having all components of the object have been finished and the results have been issued, a user can view three aspects of an augmented product model in this system by the Inventor interface, namely, a consistent 3D model, the highlighted features being discussed. Parametric Finite Element Analysis using the ANSYS Parametric Design Language (APDL) to establish 3D entity of some main components and forming a corresponding finite element model to carry out the finite analysis. The system keeps interaction between geometric parameter and finite model by the ANSYS interface.

In this paper, a visual design system for high pressure valve used in wellhead through collaborative design condition has been proposed and developed. This system can provide consistent geometric design, three dimensional modeling, virtual assembly and finite element analysis by the application interface (API). The system can be used among a group of users in different places, enterprises and departments which want to achieve a same project based on the support of the computer supported cooperative work (CSCW) by a local area network (LAN) or internet. It will shorten the time of design, reduce the cost and enhance the work efficiency. Practice indicates the cost has been decreased about 13%-30% and the design period has been shortened about 60%-80% by the system. In future, the system functions can be enhanced through adding CAPP. In addition, with the database continually extension, the accuracy and efficiency of design can be enhance, and more intuitive and natural 3D interaction techniques can be developed by using hardware and software.

N.N. Manchekar and V. Murali Mohan [5] has shown that design of gradual flow reducing valve by finite element analysis. In modern industries like chemical,

petroleum, nuclear and oil gas, involves so many processes deals with high temperature and high pressure fluid flow. To control this fluid flow electronically actuated valves are generally used. Also there is a need of mechanical actuated valve by considering the safety and reliability. The secondary objective is to maintain pressure inside the pressure vessel at specific level to avoid bursting of pressure vessel. At present this is achieved by incorporating electronic pressure control valves, which regulates pressure in the system and avoid failure of system, but these valves are failed due to electronic malfunction and high operating temperature. This paper work presents to fulfill these objectives by employing a 'Gradual Flow Reducing Valve' controlled by using purely mechanical actuation thus serving primary purpose of self-actuation. However key constraints in designing the valve are geometrical parameters as well as operating parameters. These parameters are analyzed by FEA Restrictor plate thickness is finalized with Design by Analysis approach such that it can well account for the Bending as well as Axial loading. In theoretical design the spring stiffness were designed based on the sliding distance calculations, however while designing the spring following parameters are ignored. The friction in between sliding plate and jacket wall. The Bending pressure exerted on the valve also reduces the sliding distance of valve.

The Transient solution was extremely useful in order to know the effects of the above two parameters, and enabled us to finalize the spring stiffness, saving on crucial prototype and testing costs. In order to observe performance characteristics of the valve transient structural analysis is done over valve assembly. This analysis shows maximum stress developed is 62.5 Mpa which is within the permissible safety limit. By introducing non linearity (geometric) more realistic simulations were achieved. More ever these simulations gave complete idea about the operation of the valve enabling us to predict any parameters that might not have been considered during the theoretical design. The dimensions of the constituent parts of the gradual flow reducing valve were finalized. In this paper transient structural analysis has been introduced in order to finalize the geometrical parameter of gradual flow reducing valve.

4. CONCLUSION

It conclude that all above review of papers used for the design of self regulating pressure valve by using finite element analysis which is very useful for designing .For geometrical modeling of self regulating pressure valve ANSYS software can be used. In this paper transient structural analysis has been introduced in order to finalize the geometrical parameter of gradual flow reducing valve.
The Transient solution was extremely useful in order to know the effects of friction and bending pressure parameters, and enabled us to finalize the spring stiffness, saving on crucial prototype and testing costs. According to reference of all above papers dimensions of the gradual flow reducing valve can be finalized. But operating conditions such as high temperature is not considered. Due to high temperature working environment, thermal stresses are generated in the valve model. It is necessary to account for thermal stresses in the analysis.

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