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Qualitative Study to Check Feasibility of Knife Gate Valves for High Working and Testing Pressures

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ABSTRACT

In the current industrial scenario, emphasis is being laid on cost cutting and induction of versatility in the offerings of a particular company. Satisfaction of the customer is indeed of paramount importance but while doing so, it is necessary to provide technically feasible solutions so that the right product is chosen for the right application. This paper shall study and check the feasibility of offering Knife Gate Valves for high working and testing pressures. Being a member of the family of Block valves used for enabling and disabling the flow, Knife Gate Valves serve the best in demanding applications that include handling of thick and abrasive media which needs to be cut through during operation. However, there are certain applications which include working pressures in the range of 10 bar. In such case, it is necessary to check the feasibility of employing a Knife Gate Valve based on the design and overall valve structure. In order to do the same, this paper shall consider various aspects like applications, purpose of use, suitability of flow media, working parameters and design for various profiles. A conclusion shall be drawn dictating the technical feasibility of employing Knife Gate Valves for high working and testing pressure requirements.

KEYWORDS: *Valve, Pressure, Flat, Round, Design*

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INTRODUCTION

A Valve is equipment used to govern the flow in a pipeline. The word govern is used in a global sense which encompasses three main types of valves viz. On-off valves, flow control valves and non return type check valves. Each type of valve has its own area of applications and it would be highly unintelligible to employ one type of valve in the application of another. However, in the recent times as a result of cost competitiveness, there is a hike in the overall expectations of the users as a result of which, there are such similar demands which need to be met by the route of technical feasibility study.

Knife Gate Valves can be offered with a number of versatile features like variations in seat material, variations in actuation and so on thereby making it as a most sought after product. On account of a compact design, the weight is also lesser than its counterparts with a similar flow bore. Additionally, there is ease of design for larger bore ranging 1000 mm to 1200 mm without any special modifications in the overall design. The overall effect of this is that considering the cost component, a knife gate valve with any selected actuation method is economical compared to other valves. This has led to expectations which require knife gate valves to function in conditions similar to those required for other conventional valves. For example, in case of water application and dead end service, Gate Valves with a tapered wedge or Butterfly valves would be ideal but on observations, it was found that knife gate valves are employed in these applications. This shows the need to enhance technical knowhow of selecting the right valve for the right application.

A. Types of Knife Gate Valves

As stated earlier, knife gate valve are highly versatile and can be manufactured as desired. It can be called as a customer's valve in true sense. In the following sections, for the sake of acquaintance, types of knife gate valves based on various parameters shall be discussed so as to improve the comprehension to enable adequate grasp of further contents. Based on the direction of flow, the valves can be classified as unidirectional and bidirectional knife gate valves. As the name indicates, these valves can be accordingly used in the required applications. While unidirectional knife gate valves are generally cast in a single piece body if not fabricated, bidirectional valves are made by fastening two machined body faces with the seat sandwiched between them. There are certain packing and bag filling operations for which unidirectional valves are ideal if the flow is under gravity while in certain other applications where flow reversals may be involved based on the requirements, a bidirectional valve can be most suitable.

Based on the type of actuation, there are a number of options like manual operation, pneumatic actuation, geared actuation and electrical motorized actuation. Manual operation involves opening and closing the flow by means of a hand wheel by applying manual effort. Pneumatic actuated valves employ a pneumatic cylinder which can ease the manual

effort by enabling easy operation using pressurized air. Pneumatic actuation can be automated by employing SCADA systems and certain other accessories like flow control valves as found appropriate. Although pneumatic actuated valves are easy to operate and are nearly automated, the cost component may not be that agreeable which leads to modified manual actuation like geared actuation. Geared valves need lesser effort compared to manually operated hand wheel valves. There is another type of actuation wherein electrical motorized actuators can be employed. With these, there can be an established control over the actuation time.

The most important part of any valve is the seating area. In knife gate valves, this can either metal integral to the body or of any other soft materials for applications demanding zero leakage and a tighter shutoff. The soft seat materials may be Teflon or a variety of rubber as suitable for the application. It is necessary to select the right seat material to ensure a trouble free operation in the pipeline.

By this, it must have been quite clear that due to the versatility of knife gate valves; there exists suitability for almost all types of on-off applications. This has resulted into use of knife gate valves in applications where they are not technically appropriate which includes flow control of water, handling of liquids using metal seated valves and so on. The next section shall throw some light on the applications of knife gate valves.

B. Applications of Knife Gate Valves

Knife Gate Valves are mainly employed in areas where the working fluid which is also known as flow media has certain peculiar characteristics like viscosity greater than that of water, abrasiveness, powdery composition, semi solid substances, pulpy composition and so on. The flow media may have any one or a combination of any of these characteristics. Likewise, the applications of knife gate valve involve Petroleum Industry, Waste water treatment plants, corrosive media and acids, Mining slurry, Abrasive slurry, Cement handling lines, Pulp and paper industry, Husk handling and so on. As it can be understood from the names of these applications themselves, each demands for operating conditions which would require a working pressure nearer to the ambient pressure.

Flow media can be broadly categorized into two types; one being free flowing and the other being pressurized flow. In case of free flowing media, the valve is installed in order to allow the passage of the media in the required direction without hindrance wherein the flow is mainly due to gravity. In such flows, the pipeline is mounted vertically or at an inclination to the horizontal. Free flowing media is seldom subjected to pressure as gravity is the only means by which the flow can take place. When it comes to pressurized flow, the pipeline may be placed either vertically, horizontally or at any inclination which practically matters only while designing the pump system to pressurize the media. This requires the system to be designed in such a way that the pressure containing parts are designed to take the maximum rated pressure.

The next section shall cover the purpose of using a knife gate valve and the operational parameters to be considered during the same.

C. Purpose of using a Knife Gate Valve

Flow media which has solid particles or is highly viscous needs a strong and stiff mechanism to cut through the same. As a general principle of physics, lesser the area for an applied force, greater is the pressure. This is the basic principle of design of the Gate. The Gate of a Knife Gate Valve is designed in the form of a plate; rectangular at one edge and rounded at the other. The rounded edge rests on the seat of the valve and facilitates the necessary sealing. While the valve is handling thick media, highly viscous fluids and solid particles of varied sizes, it is required that while closing the valve, the gate effectively and literally cuts through the media to allow complete isolation. This is done by providing a Knife edge at the rounded portion of the gate. The knife edge is blunt enough to ensure no damage to the media and at the same time is sharp enough to effectively cut through the same. The bluntness of the edge is a function of machining while the relative sharpness and effectiveness of cutting through the media is a function of the beveled angle. The Gate is designed as a Plate to ensure maximum arrest by means of minimum span. Hence as compared to the Flanged Gate Valve, a Wafer type Knife Gate Valve has a considerably less face to face distance.

Two standpoints shall now be considered to discuss the purpose of using a knife gate valve viz. free flowing media and pressurized flow media. For free flowing media, as the working pressure is in close proximity to the ambient pressure the resistance faced by the gate while closing is minimum. This allows for ease of optimization of the design and facilitates a gate that can be easily used for working pressure nearer to ambient pressure. For pressurized flow, as the gate begins to descend, the flowing media tries to distort the gate for the visible crescent region until it is fully closed. In the fully closed condition, the fluid pressure acts uniformly on the gate. Thus design of gate has to be done considering two modes of failure viz. direct shear and deflection or distortion on account of pressure acting on the gate.

D. Suitable and unsuitable media

As basics of design, it should be known that every product cannot facilitate every application. Each product has certain strong points and weak points and trying to regularize the same would result into a technical as well as commercial toss wherein the certainty of success is feeble. Therefore there are certain suitable and unsuitable media with respect to knife gate valve.

As a pre-requisite, it should be defined that what is considered as suitable and what is considered as unsuitable. Suitable media are those that ensure leak proof tightness by virtue of their physical properties like density, viscosity, composition and form. Unsuitable media are those which are susceptible to leakage by virtue of their physical properties like density, viscosity, composition and form.

Media in liquid form with a density lesser than water are more susceptible to leakage due to their ability to escape fugitively at higher pressure in order to maintain the equilibrium. Hence it is not recommended that Knife Gate Valve is used for media whose density is lesser than water. The straight seat design with an annular contact can provide leak proof tightness for media with a density greater than that of water as by virtue of their physics; they tend to be more viscous. Solid particles with any value of density are

suitable as they do not inherently have a property of fugitive leakage on account of their form. This entails that careful valve selection needs to be carried out with respect to the density of flow media.

The property called viscosity is applicable only for fluids and not for solid particles. Less viscosity refers to lesser ability of cohesion which results into chances of leakage. Linking viscosity with adhesion, it can be concluded that lesser the viscosity, lesser the adhesion and thus lesser is the ability to provide leak proof tightness in case of pressurized flow. As the viscosity increases, the cohesive and adhesive properties of the fluid increase thereby rendering the fluid to withstand high pressure and at the same time provide a leak proof tightness.

Composition of the flow medium plays an important role in the distribution of the particles in the medium. Practically, no flow media is homogeneous because there is minimal non-homogeneity in the same. This paves way to the study of additional physical properties like particle size distribution, abrasiveness, corrosiveness and so on. For liquids, if there are suspended particles in the same, there is chance of leakage if the suspended media is of fugitive nature. However for solid media, a particle size up to 200 – 250 microns is acceptable and for a particle size of max. 500 microns, certain heat treatment processes like Chroming or Nitriding has to be carried out to avoid damage to valve seat and associated internals.

E. Working parameters like pressure, temperature and ambience

While the valve is in operation, there are three working parameters that mainly govern the flow conditions. These shall be elaborated in this section.

Pressure refers to the working pressure or the pressure at which the flow is taking place. This pressure is caused by energy or work absorbing devices like pumps or compressors. Pressure acts as a voltage during the flow. Therefore if the electrical analogy is considered, the flow is current, pressure being the voltage, the resistance offered is from two sources; one being the succeeding media layers themselves (also known as viscosity) and another being the closed gate. The principle of low resistance flow is equally applicable in the case of pressurized flow too. If a pressurized fluid is blocked, it tries to flow through the path of least pressure. This paves way to an important requirement of equal resistance to flow in all directions. The design of flow enclosure should ensure that there is no such direction wherein there is a susceptibility to leakage due to lesser flow resistance. Thus design as well as selection has to be done keeping the point of view of working pressure.

The temperature of fluid can be understood in two different forms; one being continuous working temperature and another being an intermittent form of temperature where it may be fluctuating between a maxima and a minima. For continuous working temperatures, the material selection needs to be done smartly to avoid distortions or permanent damages. This can at times be a costly affair as other physical properties also need to be considered. Intermittent fluctuations can be withstood by regularly offered materials. Similarly ambient conditions like humidity and environment play an important role in the selection and subsequent operation of the valves.

F. Thrust and Torque to operate the valve

For knife gate valve the key design output is the torque to operate the valve. It depends on the Thrust required to cause the seating and de-seating of the gate. The thrust can be generally understood as the force required to overcome friction due to flow of fluid at given pressure, packing friction and the seating friction.

As there is an increase in the line pressure, the torque required to operate the valve also increases. Thus beyond a certain line pressure, the torque may exceed workable limits and cause problems in the ergonomics of operation since it is generally known that, the maximum rimpull that can be exerted by a human is approximately 35 kg.

For valves with a shorter opening or closing span, this may not be a serious problem but the task can be cumbersome in case of larger spans and opening distances. Thus it is recommended that a limiting torque is set corresponding to the line pressure.

G. Design of flat surfaces to withstand pressure

A flat circular plate subjected to pressure can behave in two ways. If it is constrained at the circumference, there with be minimal distortion at the circumference but the center of the plate will be distorted to the maximum extent. This can lead to deformation of the gate at the centre and cause a problem in the opening and closing operation of the gate.

Basics of physics state that flat surfaces subjected to high pressure should be kept as compact as possible to avoid distortion by reducing their relative span. An additional measure that can be undertaken is the provision of ribbing that needs to be done. But as a basic principle of design, the ribbing or any other support should not increase the weight considerably such that in the long run, self weight causes a certain amount of distortion.

The distortion of a flat plate or flat surface is primarily a function of the diameter subjected to pressure, the pressure acting on the plate or surface and material properties. Empirical as well as Correlative formulae and relations are available to calculate the minimum safe thickness and the maximum distortion. Thus any flat surface should be avoided as a pressure containing part.

H. Design of round surfaces to withstand pressure

Round surfaces are recommended for pressure containing parts due to their ability to withstand high pressure and avoid distortion. The more round and compact an enclosure is, greater is the ability to withstand the applied pressure. However while considering this standpoint, the basic difference between cylindrical and spherical surfaces needs to be taken under purview.

According to thin or thick cylinder theory, correlations like Lame's equations for internal pressure, Clavirano equation for thickness of closed cylinder and Birnies equation for thickness of open cylinders are available and can be used. The stress induced is a function of geometrical dimensions of the enclosure, pressure acting in the enclosure and material properties. Thus round surfaces should be employed as a pressure containing part.

I. Qualitative effect on feasibility of employing Knife Gate Valves for high working and testing pressures

It is recommended that flat surfaces should not be used as high pressure enclosures. But if the need arises, efforts need to be undertaken to make the valve capable of withstanding the pressure without any leakage.

For Unidirectional Knife Gate Valve, for sizes up to DN150, the gate can be subjected to 10 bar pressure and there wouldn't be observable distortion due to the stiffness offered on account of the size. But for higher size, due to increase in the diameter, there is reduction in the effective stiffness of the structure and the probability of distortion goes on increasing with increase in the diameter. This distortion can be of both, the body wall enclosure as well as the gate. Heat treatment can be a temporary measure to avoid the distortion but in the long run, the gate may be permanently distorted due to change in the material properties. This occurs due the inherent design of a Unidirectional Knife Gate Valve whose main purpose is to cut through the thick or viscous fluids flowing or solids moving at near ambient pressure.

In order to satisfy the condition of providing a high working pressure, it is necessary that the sealing is equally effective in all the directions of the enclosure. This includes the Gate, Seat and Gland Packing. The central alignment of the gate and effective gland packing can facilitate high working pressure for the valve with a probability of distortion of the wall and gate which needs to be overcome by means of design optimizations if found feasible on case to case basis.

Conclusion

Thus it can be concluded that since most of the constructional features of a Knife Gate Valve by virtue of its design are flat and not generally curved, the valve is most suitable for applications with working pressure nearer to the ambient pressure. However, within the limits of design, avoiding distortion and excessive torque which may lead to bad ergonomics, the valves can be employed in high pressure applications but it must be thoroughly studied whether Knife Gate Valve is the right valve for the application under consideration or is it being used only for economic feasibility and versatility which may otherwise be an inappropriate step owing to the technical feasibility of application and use of this class of valves.

References

[1] Ronald. C. Merrick, Valve selection and specification guide, ISBN 978-1-4684-6670-6

[2] G. H. Pearson, The Design of Valves and Fittings, Sir Issac Pitman & sons, Ltd, London, ISBN 978-0-8529-8404-8

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