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Supervisory Control and Data Acquisition Systems for Pneumatic and Electrical Actuated Knife Gate Valves

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ABSTRACT

Automation in all fields is picking up pace due to its inherent ability to complete a given piece of work much quickly and efficiently as compared to manual work which although skilled, requires greater lead time and may lead to reduction in productivity. Industries which are mainly concerned with energy conversion are obsessed with the maximum utilization of the exergy to get the most efficient outputs. Technological advancement in the field of mechatronics and microprocessors has led to continuous up gradation in the systems that govern and control such applications. Valves are an integral part of any flow system. In order to have a wider control over operations of large energy conversion units, supervisory control and data acquisition systems are employed. This paper shall consider scope of the same for applications employing actuated Knife Gate Valves. The actuation considered shall be pneumatic type which generally comprises of a double acting pneumatic cylinder. Considerations for controls and data acquisition shall be done for pneumatic circuit accessories like solenoid operated direction control valves of various types, limit switches, proximity switches and electro pneumatic positioners with an initial explanation of role and working of each. A conclusion shall be drawn thereafter regarding the employability of knife gate valves with supervisory control and data acquisition systems.

KEYWORDS: *Valve, Control, Data, Actuation, Automation*

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INTRODUCTION

A supervisory control and data acquisition system, hereafter referred as SCADA is generally designed to be the bridge between the mechanical array of equipment and a control room operator.

Those times have now become extinct when human beings cherished abundance of raw materials and resources in order to get their work done. In this modern age, as every second lost equates directly to monetary loss, obsession to energy efficient systems has increased rightly.

Coming to energy conversion units, it is of greater necessity that these units display maximum resource utilization and process efficiency. In any process involving flow of solids, liquids or gases, valves form an integral part of making the overall process efficient and the energy conversion effective. While there are numerous types of valves used as the application demands, this paper shall be limited to consideration of knife gate valves used in applications involving handling of thick slurry, powders and food items.

These are specific applications in which knife gate valve can be used as flow regulating valves if selected with smaller nominal bore sizes. Amount of flow is directly proportional to the extent of opening of the valve.

A. Working and actuation methods in Knife Gate Valves

Knife Gate Valve comprises of a wafer type compact design with a gate in the form of a plate with a beveled radial edge of suitable thickness to restrict the flow. owing to its design, these valves best suitable for demanding applications involving thick slurries and materials that need to be cut through which gives the valve its name.

As the gate opens the flow area, flow of the material can be facilitated. Generally, the flow takes place at atmospheric pressure by the action of gravity and a differential head observed thereby.

There are quite a few methods of actuation which makes this valve versatile and suitable for a number of applications [2]. These include manual actuation, pneumatic actuation, hydraulic actuation, electrical actuation and so on. While this paper deals only with pneumatic and electrical actuation, other methods have been briefly explained for acquaintance and ease of comprehension.

Manual actuation involves the use of muscular energy to apply a torque which is further converted to a thrust by means of a mechanism. In this type of actuation, mechanical advantage can be achieved by using gear mechanisms for valves that require greater thrust. The aim should be to actuate the valve with the minimum manual effort to ensure ergonomics.

Hydraulic actuation requires a complete hydraulic circuit starting with the pump and filter to the directional control valve and associated accessories. These are generally noisy

and consume a greater quantum of energy as compare to pneumatic actuators.

Having comprehended the basics of actuation, focus can now be moved to SCADA and its application in context of pneumatic and electrical actuation systems and associated accessories.

B. Knife Gate valves with double acting pneumatic cylinder actuator

Pneumatic double acting cylinder actuators are preferred when the actuation needs to be done quicker and against lesser resistance. Such instances involve handling of various powders and solids of similar consistency.

Similar to the hydraulic circuits, pneumatic circuits also require certain basic circuit elements for adequate functioning. These include air compressor, air preparation units and direction control units. Certain additional accessories may also be included to determine the extent of opening of the gate which include limit switches, proximity sensors and electro pneumatic positioners.

A basic pneumatic circuit starts with a source which can be an air compressor tank or an accumulator tank. Thereafter air preparation units like air filter, pressure regulator and lubricator condition the air to suit the application requirements. Conditioned air is then passed through the direction control valve which ensures appropriate actuation of the pneumatic actuator.

SCADA is most effective when all these accessories are connected in tandem to deliver a specifically defined operation. In the following sections, the same shall be discussed in depth. The role of each of these accessories shall be known at first after which controls and data acquisition for each shall be discussed.

C. SCADA for control of solenoid operated direction control valves of various types

Direction control valves in a pneumatic circuit facilitate the channelizing of compressed air so that the actuation action can take place accordingly. These valves come with a number of variants. Firstly, with regards to actuation, these may be pilot operated, cam operated, solenoid operated and so on. This paper shall consider only the solenoid operated direction control valves.

Direction control valves are further specified by the number of ports and the number of positions. For example, a 5/2 solenoid operated direction control valve refers to a direction control valve with five ports, two positions; one each for open and close operated or actuated by a solenoid coil. Depending on the application, one may employ 3/2 or for that matter 5/3 direction control valves where one of the ports may be permanently shut to ensure stay put condition.

As stated earlier, since solenoid operated direction control valve is primarily controlled by electrical energy, SCADA can be introduced to control the actuation of the coil. This is related to the number of positions of the direction control valve. For single coil solenoid valves, the logic may be such that energizing the coil may indicate the open position while de-energizing may indicate the close position and vice versa. In case of double coil solenoid valves, logic can be set such that at a given time, only one of the coil is energized and the desired actuation is facilitated.

In the data acquisition systems, separate programmable modules can be set to automate the overall process such that on setting up the timing, the solenoid is actuated automatically and there is minimum human interference.

Direction control valves play a vital role in the direction of the process. Complete chemical kinetics of the reactions if applicable depend on the rate and quantity of fluid flowing. Although there are checks and measures to ensure continuity, these systems may require periodic maintenance to guarantee trouble free operation from time to time.

D. SCADA for mechanically actuated limit switches

Every electronic system or circuit would be incomplete without a feedback system. Limit switches play the role of a feedback system.

There are times when the valve is located at a remote location from the observer's chamber. At such times, one can solely rely on feedback systems to know the current status of the valve.

Limit switches are connected in the feedback system such that it can be known whether the valve is open or closed. This can facilitate immediate action as and when required.

Mechanically actuated limit switches comprise of an internal signal providing circuit that is either opened or closed by actuating a switch by mechanical action. This actuation may be by a roller or a protrusion on the gate. Limit switches are generally employed in pairs where one indicates a normally open position while the other indicates a normally closed position.

SCADA can be integrated with solenoid operated direction control valves and mechanically actuated limit switches to develop different kinds of circuits like switching circuits, continuous open close actuation circuits, limit circuits and so on.

Data acquisition systems can record the frequency of operation and can pave way to sustainable developments in the process such that streamlining of activities is facilitated with effective elimination of bottle necks at distinguished stages.

E. SCADA for inductive proximity switches or sensors

These are used in lieu of limit switches wherever necessary. Unlike mechanically actuated limit switches, these switches do not have any contact parts and work on the principle of electromagnetic induction.

Similar to limit switches, these also are employed as normally open and normally closed switches. These switches can be customized largely to suit specific requirements of the application.

Similar circuits can be designed as that for limit switches with the help of SCADA and it can serve as an efficient indicator of the instantaneous condition of the valve.

F. SCADA for electro pneumatic positioners

The accessories discussed till this point have something in common. It is that all these can ensure only complete opening or closing of the valve but cannot facilitate intermediate opening. Initially, it is necessary to know why intermediate opening may be required. Applications that involve controlled flow of powders of all kinds, crystals and materials like spent grain and husky items, it may be required at times that the gate is opened for a certain predetermined percentage opening to allow calculated amount of charge for further processing. It would be quite a difficult task to calibrate the systems to carry out this feat in the absence of an electro pneumatic positioner.

Electro pneumatic positioner can perform as a direction control valve, limit switch and as a hand held valve actuation device. This versatility of these devices make them a much sought after accessory in the pneumatic actuated valves.

As a direction control valve, the positioner is connected to the pneumatic cylinder by means of tubing to control the flow of air. A correctly designed pneumatic circuit can ensure relation between the display on the positioner and the actuation of the double acting pneumatic cylinder.

Since the positioner can accurately indicate the instantaneous location of gate opening or opening percentage, it can easily discharge the duties of a limit switch. However, switching circuits may have to be programmed separately in the SCADA interface.

There are two main types of electro pneumatic positioners. First are manually calibrated and the second are smart type. Manually calibrated positioners require the operator to define the limits and intermediate positions while smart positioners have the facility of auto calibration. Both are equally effective and can be employed as the application demands.

SCADA for electro pneumatic positioners can be initialized to ensure desired opening of the gate as and when required according to the need of the application. Flexibility in actuation at will can be easily and sufficiently demonstrated by such systems.

Data acquisition systems can very well ensure the repetitive behaviour of the system in terms of the extents of opening and the correlation of the same with the process being carried out in the line.

G. SCADA for Electrical actuators

Electrical actuators are basically induction motors that can be controlled to apply a desired torque. These generally come with inbuilt limit switches and torque switches for fine tuning as per the line requirements and application specifications.

SCADA for these systems can be employed with limit switches or proximity sensors to know the instantaneous position of the gate.

Data acquisition systems can be helpful to know the variation in the applied torque and thereby thrust to actuate the gate against variable line pressure. This can help in designing optimized systems to ensure applicability for a wider range of process parameters.

Conclusion

Thus it can be concluded that for implementation of supervisory control and data acquisition systems for applications employing actuated knife gate valves, the basic idea of SCADA and data acquisition systems has been enumerated with regards to pneumatic circuits with various accessories and electrical circuits. Findings can be helpful in designing customized solutions for dedicated applications with optimum design considerations.

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