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Development of a control system for compression and expansion cycles of critical valve for high vacuum systems

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HIGHLIGHTS

- Control system with feedback loop of pressure gauge is developed for measuring the life cycle of vacuum isolation valve.
- GUI based software developed for easy use and handling of control system.
- Control system tested with an experiment showcasing the capability of the control system.
- Control system can operate valve based on pressure inside the chamber, which helps to know the degradation of sealing capabilities of valve.
- Control system can monitor the total closing and opening time of valve, cycles and pressure inside the vessel.

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ABSTRACT

A control system with feedback loop is designed, developed and tested to monitor the life cycles of the axial valve and bellows used in vacuum valves. The control system monitors number of compression cycles of any bellow or closing and opening cycle of a valve. It also interfaces vacuum gauges or pressure gauges to get pressure values inside the system. To find life cycle of valve, the developed control and monitoring system is integrated with an axial valve experimental test set up. In this system, feedback from the vacuum gauge attached to valve enclosure, is given and the life cycle test is automated. This paper describes the control and monitoring system in details and briefs the experiment carried out for valve life cycle. The same system can be used for life cycle estimate for bellows. A suitable GUI is also developed to control the function of the components and resister the number of cycles.

1. Introduction

Valves are generally used for attaching the components to a vacuum system which at times needs to be isolated from the system [1,2]. Hence theses valves are closed (isolating the component from vacuum system) and open (connecting the component with vacuum system) many times during operation of any vacuum system. One of these components is vacuum pump [3,4], which is attached to a vacuum system with the help of a valve. These pumps need to be attached to vacuum system for creating the required pressure levels (vacuum levels) inside the system and at times needs to be isolated for regeneration, if pump is entrapment type of pump [3]. Towards Indian fusion program an Indigenous fusion grade Cryopump with pumping speed more than 50,000 l/s is being developed [5–8] and a project towards development of an axial valve system [8] for fusion Cryopump is taken up by Institute for Plasma Research, India. The function of this valve will be isolating the Cryopump from TOKAMAK [8,9] at times of regeneration and reconnecting back the Cryopump with TOKAMAK, without disturbing the functioning of TOKAMAK.

In this axial valve system, the closing and opening mechanism occur with the help of an actuator. The valve life is directly proportional to the life of various components of valve system. The life cycle of valve means the closing and opening cycles of a valve, it can cater before it starts leaking. In high vacuum systems, maximum leak rate allowed for valve is 1e–8 mbar-l/s [3,10].

Life cycle test for valve is a long process as the life cycle of proposed valve can be of the order of thousand numbers. Hence a control and monitoring system is developed, which can monitor the closing and opening cycle of any valve by simulating the direction of actuation of the actuator.

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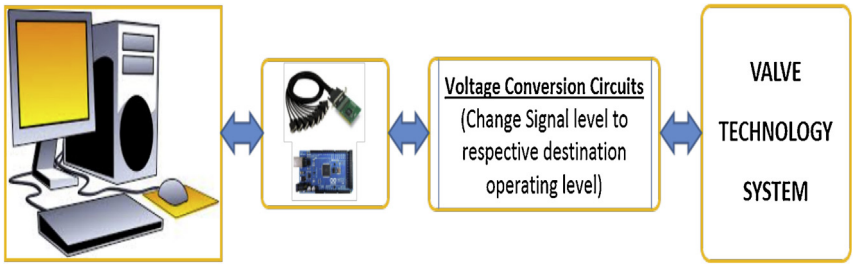

Fig. 1. Hardware of control system of critical vacuum valve.

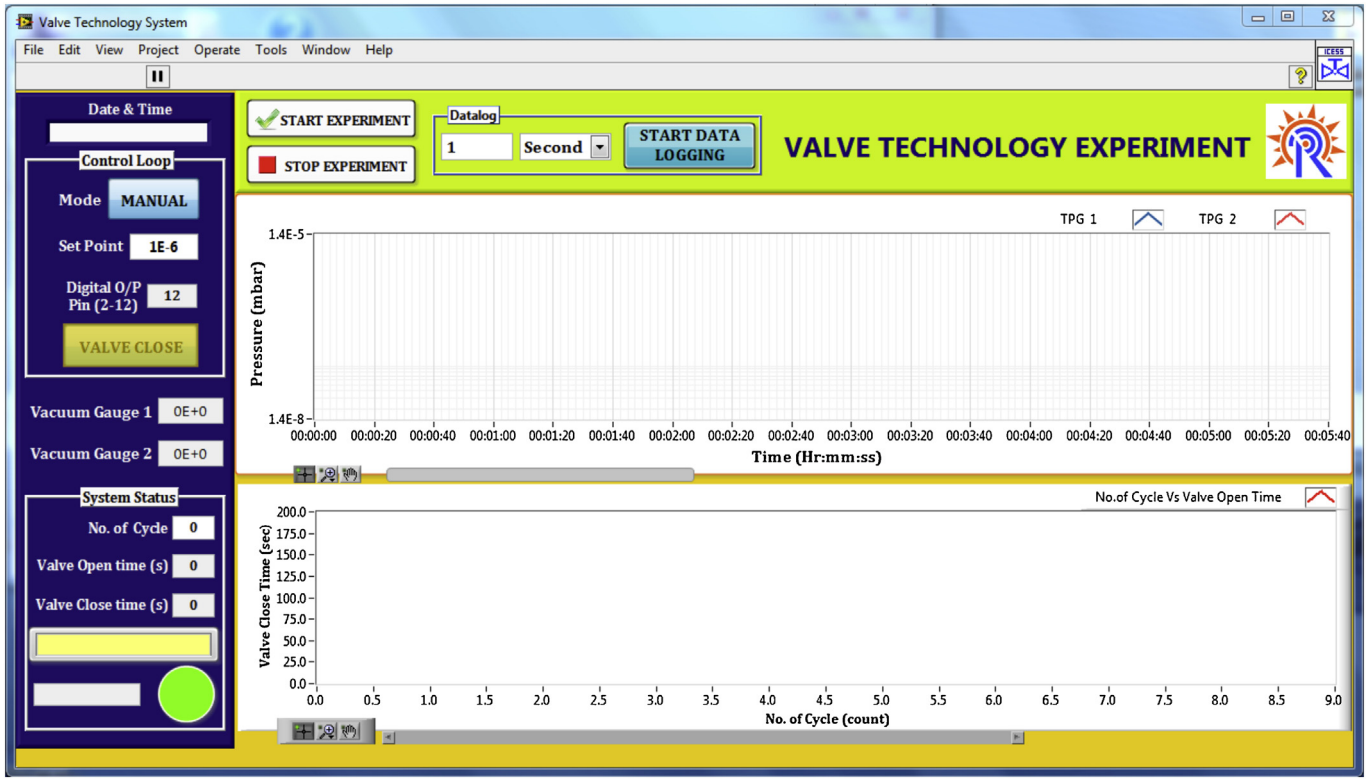

Fig. 2. Screen shot of GUI developed to control valve operation.

The developed control system also controls the actuation of actuator with respect to the pressure inside the axial valve enclosure system. This automates the life cycle test, reducing the manual interfacing. Also a user friendly GUI is developed for smooth run of the system.

For evaluating the performance of control system an experiment is carried out on a test bed simulating the actual valve, which explores the all capabilities of the control system. In this experiment, valve is closed and opened continuously. The cycles and pressure inside the vessel is monitored during closing-opening of valve. The closing and opening of valve is controlled with respect to the pressure level inside. The control system also monitors the open-close time of valve. Increased close time of valve indicates towards new leak generation in the system and triggers the leak rate testing of the entire system.

Description of control system and the details of the experiment carried out are briefed in upcoming sections.

2. Control system description

A control system for monitoring life cycle of valve is developed. The complete system comprises of hardware such as computer, embedded control board and PCIe express card along with a Labview based software with GUI. The used hardware and software developed are briefly described in this section.

2.1. Hardware system

To interface and control the valve system various hardware components are used. All these components nominal specifications are described here. And a diagram showing the interface between the hardware systems is shown in Fig. 1.

2.1.1. Desktop computer

A desktop computer which consists of a 1 PCIe timing slot for PCIe card is used. The minimum features required for operating the control system are Core i3 processor with Windows XP operating system and 2GB RAM. Any higher version of the mentioned can also be supported with the hardware and the software. Here a desktop computer with Core i5 processor and 2 GB RAM having Windows 7 as operating system is used.

The PC interacts with the embedded Control board which consist a clock and valve trigger. The computer will also store the data from pressure gauge being received through PCIe card.

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