International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 4 Issue 6, September-October 2020 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Position Repeatability Test for Knife Gate Valves with Electro Pneumatic Positioners

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ABSTRACT

Repeatability is an important characteristic of the measurement of faithfulness of the response of a system over a period of time. Be it mechanical or electronic equipment, over a certain period of time, there is a certain amount of hysteresis that sets in which renders the system incapable of carrying out its operation with the necessary precision. In applications that employ Knife Gate Valves to control the flow of lesser demanding solid particulate media like powders and fine mixtures, it is necessary that the positioners mounted on the valves display repeatability at all values of opening in every operating cycle. At least during the serviceable life of the valve, it is imperative of the positioner to ensure that hysteresis is not set in and that the internal mechanism is capable of yielding precise results. This paper shall consider four positioners mounted to Knife Gate Valves and subject the same to a repeatability test wherein the valves will be opened to a predetermined opening percentage for two cycles. The current input readings corresponding to these percentage openings shall be noted and graphs shall be plot to understand the repeatability behaviour. The mean values of current input readings for the four positioners shall be plot to determine the reproducibility of the experiment. A conclusion shall be drawn thereafter considering the experimental observations.

KEYWORDS: *Valve, electro, pneumatic, positioner, repeatability*

How to cite this paper: Gourav Vivek Kulkarni "Position Repeatability Test for Knife Gate Valves with Electro Pneumatic Positioners" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-4 | Issue-6, October 2020, pp.1065-1067, URL: www.ijtsrd.com/papers/ijtsrd33572.pdf

IJTSRD33572

A. Introduction to Electro Pneumatic Positioners in Knife Gate Valves

Knife Gate Valves are one of the most versatile valves used in a wide variety of demanding applications right from solid particles' handling to sludge and slurry. These valves are also suitable for processing industries including packaging and distribution of materials.

At times, there is a requirement of a precise percentage of opening of the valve gate to ensure calculated amount of flow media is passed on to the next section of flow. Electro Pneumatic Positioners aid this operation by their ability of precise control.

Positioners may be smart or manual. Smart positioners are included with electronic circuits to enable auto calibration using a suitable feedback module. Manual positioners need manual calibration and maintenance from time to time.

However, it is necessary to establish the ability of the positioner to perform as desired in various conditions. This paper shall consider one such case being the position repeatability.

B. Position Repeatability test

For every mechanical or electronic equipment, on continuous cyclic loading, a property called hysteresis becomes prominent. It is quite unavoidable but knowledge of its occurrence can be helpful in designing systems that can be robust.

In case of electro pneumatic positioners, a certain current input corresponds to a certain percentage of opening. This one to one mapping needs to be consistent throughout the serviceable life of the valve.

Thus it is essential to ensure that the positioner exhibits repeatability and the hysteresis at various intermediate percentages of opening is known. The experiment can be extended to determine its reproducibility if the trends of all the curves indicate a similar variation.

C. Significance of the test and effect on the application

Any precision engineering equipment should exhibit certain characteristics which form the basis of performance evaluation of the same. These include accuracy, precision, response time, repeatability, reproducibility and so on. These characteristics need to be evaluated at different fronts to validate and ensure the safe and faithful working of the equipment. Two such characteristics viz. repeatability and reproducibility shall be considered in this study.

Repeatability stands for the ability of equipment to produce the same results for the same inputs and under the same conditions for multiple iterations. The key output of repeatability analysis is the measurement of ability of the equipment to read and display similar results irrespective of the number of iterations. The band width of faithful results can also be determined from such analysis.

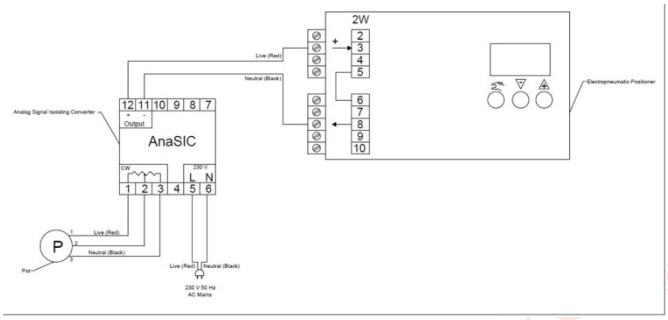
Reproducibility stands for ability of multiple equipment of the same kind to produce similar results and trends for the

similar pattern of outputs and same conditions for single or multiple iterations. By this, the performance of an array of equipment can be validated.

D. Testing Procedure

Following step by step testing procedure can be followed to carry out the experiment and note the results. It may be noted that zero error of measuring instruments if any, needs to be accurately accounted corresponding to the rated operating range and least count of the same.

Step 1: Complete the electrical circuit connections according the instructions manual in the presence of trained personnel. Following diagram may be used as a reference.



Step 2: By operating the Pot 'P', keep the valve in closed position i.e. 0.0% opening and note down the current reading in the Ammeter

Step 3: Operate the pot until the display on the Electro pneumatic Positioner reads 25.0 i.e. 25% opening. Note down the current reading in the Ammeter

Step 4: Operate the pot until the display on the Electro pneumatic Positioner reads 50.0 i.e. 50% opening. Note down the current reading in the Ammeter

Step 5: Operate the pot until the display on the Electro pneumatic Positioner reads 75.0 i.e. 75% opening. Note down the current reading in the Ammeter

Step 6: Operate the pot until the display on the Electro pneumatic Positioner reads 100.0 i.e. 100% opening. Note down the current reading in the Ammeter. This completes half the cycle

Step 7: Repeat the same procedure of noting the current reading successively for 75%, 50%, 25% and 0% thus completing one cycle i.e. two iterations

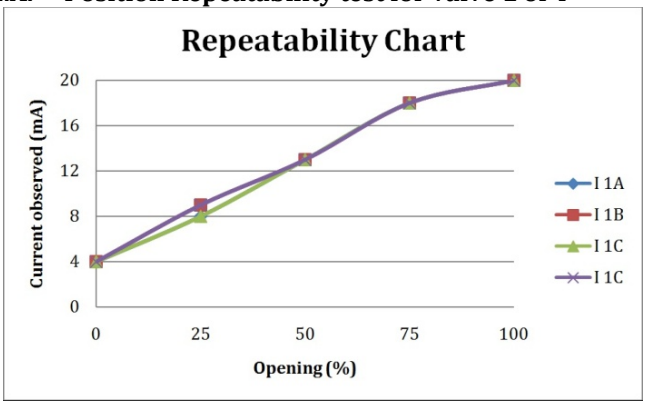
Step 8: Carry out one more cycle and note the readings as observed

Step 9: Compile the results and comment on repeatability of a Positioner and reproducibility of the experiment in total

E. Results and Discussions

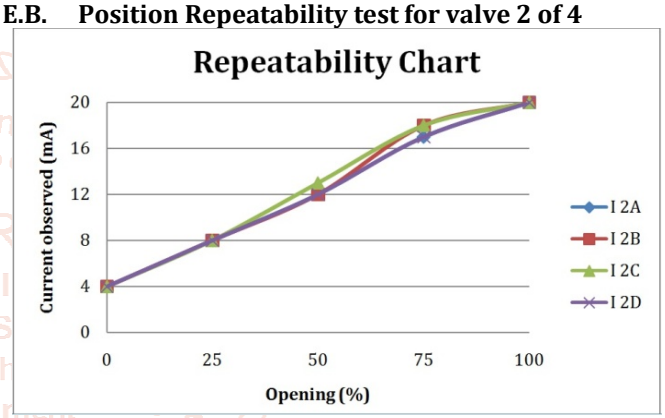
This section shall include the compilation of observations with respect to the repeatability for various percentage opening. The data has been presented in the form of graphs for enhanced comprehension and associated visualization.
The make of Electro Pneumatic Positioners used for this experiment was SIEMENS and the model used was 6DR5223 Smart Positioner. The results obtained have been presented graphically in the following sections.

E.A. Position Repeatability test for valve 1 of 4



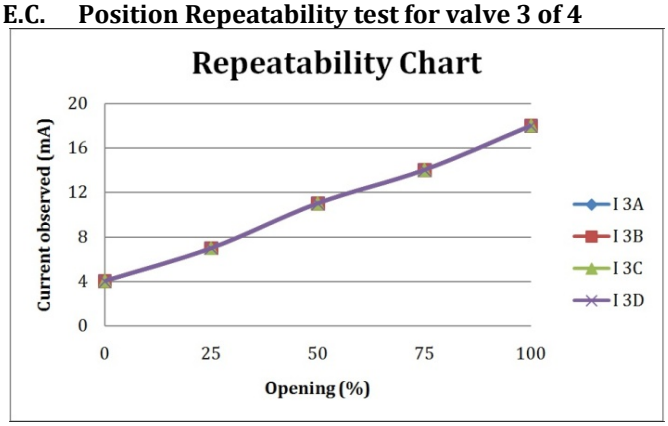
Thus it can be observed that the trend of variation in current corresponding to the opening is similar for the four iterations undertaken thereby displaying repeatability of performance.

E.B. Position Repeatability test for valve 2 of 4



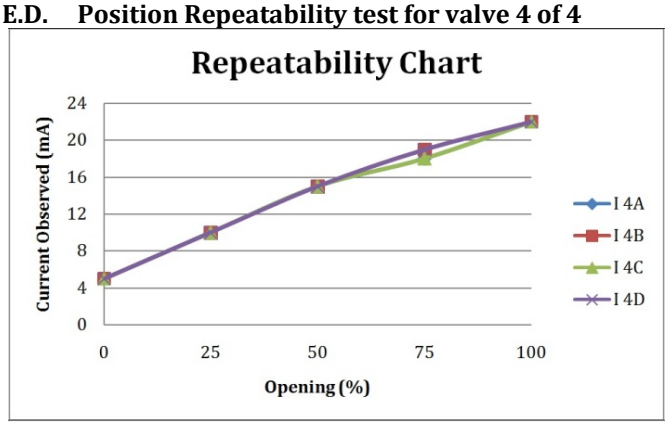
Thus it can be observed that the overall trend of variation in current corresponding to the opening is similar. For an opening of 50%, there is an average deviation of 0.25 mA which is acceptable. For an opening of 75%, the average deviation is 0.5 mA which is accepted taking into account the degree of precision of the variable pot. Thus the desired repeatability is observed in this Positioner.

E.C. Position Repeatability test for valve 3 of 4



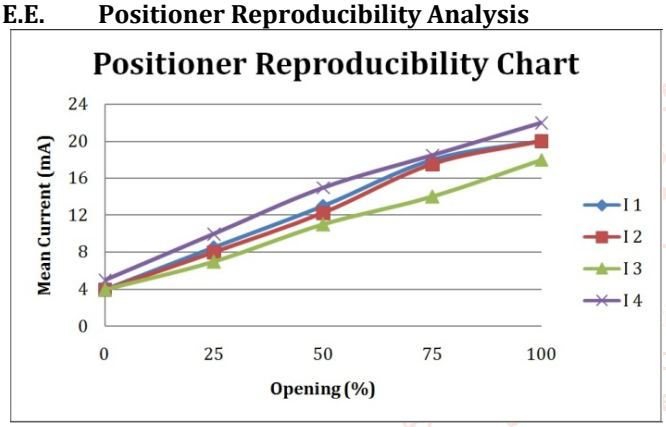
Thus it can be observed that, all the corresponding current readings for the respective valve opening percentages are in complete agreement with each other across the iterations carried out. Thus the positioner shows complete repeatability for the iterations carried out.

E.D. Position Repeatability test for valve 4 of 4



Thus it can be observed that the positioner exhibits an average deviation of 0.5 mA at an opening of 75% across the iterations which is acceptable while at all the other openings, there is complete agreement among the readings and repeatability is observed accordingly.

E.E. Positioner Reproducibility Analysis



Thus from the Reproducibility Chart, it can be observed that the overall trend of variation of mean current with increase in the opening percentage is same for all the positioners. Variations are observed in the mean values at particular opening percentages with a major deviation of 3 mA for particular positioner wherein individual repeatability is confirmed, thus making the deviation acceptable. This dictates that the experiment is reproducible and the results obtained from the same are faithful within the acceptable limits.

Conclusion

Thus it can be concluded that the Repeatability of the Electro pneumatic Positioner is verified from the experiments conducted. On compiling the results, it was found that the experimental procedure produces reproducible results and that the same can be employed in future for validation.

Acknowledgement and disclaimer

The author thanks Management and Staff of Expert Valve and Equipment Private Limited, Belagavi, Karnataka for their continuous support and inputs to come up with this work.

This paper in no means intends to advertise or promote any brand or make of electro pneumatic positioners. The models and brands considered have been chosen at random to ensure applicability of the experimental procedure and results thereof to a wide variety of similar equipment.