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PARTIAL STROKE TESTING FOR EMERGENCY SHUTDOWN VALVE USING INTEGRATED PLC CONTROL DESIGN AND HUMAN-MACHINE INTERFACE

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To my beloved family

Whom fueled my interest in science, education and technology from early on, and always encouraged and supported me to pursue the path I have taken.

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Gratitude … is a sickness suffered by dogs. - Josef Stalin

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ABSTRACT

Partial stroke testing (PST) is a technique that is regularly practiced in oil and gas industries to test the emergency shutdown valve (ESD) by closing a certain percentage of the valve position and stop any flow through the pipeline. Generally, it only functions when there is an emergency occurs in the production system. When the ESD valve remains in one position for a long period, there is a risk and potential of fail on demand which is, the ESD valve fail to operate during the emergency shutdown. The partial stroke testing system still requires manual ignition by human. The distance between the control box with the plant area is limited which might increase the risk in safety issue to the workers. The objectives of this project are to design the PST automated system based on PLC design and to test the performance of the PST design system using lab scale PST system design. The capability of Mitsubishi GT-Designer 3 and Mitsubishi GX-Developer / GX Works 2 as the Human-Machine Interface (HMI) simulation platform for the PST design is applied. The system control and monitoring of PST will be developed by using Mitsubishi GT-Designer 3 interfacing it with Mitsubishi GX-Developer. This interfacing does not only control the mode of the system, it allows data monitor from the HMI which is the PC such as the state of the valve, alarm when PST failed, the alarm history records and pressure flow data. Then, the PST is simulated and tested in real time using PLC design system connected with a PC.

ABSTRAK

Ujian strok separa adalah teknik yang seringkali dipraktikkan dalam industri minyak mentah dan gas asli untuk menguji injap penutupan kecemasan pada peratusan yang tertentu dan seterusnya menghentikan semua aliran dalam paip. Injap penutupan kecemasan akan berfungsi hanya apabila kecemasan berlaku dalam system produksi. Apabila injap penutupan kecemasan berada pada satu kedudukan untuk jangka masa yang lama tidak beroperasi, akan ada risiko potensi untuk injap tersebut gagal berfungsi bila berlaku kecemasan. Sistem ujian strok separa yang sedia ada masih memerlukan tenaga kerja manual oleh manusia. Jarak antara kotak kawalan utama dengan tapak proses adalah terhad, secara tidak langsung akan meningkatkan risiko keselamatan pekerja. Antara objektif projek adalah untuk merekabentuk system ujian strok separa automatic berdasarkan PLC dan untuk menguji prestasi ujian strok separa dengan menggunakan rekabentuk system berskala makmal. Kemampuan perisian Mitsubishi GT-Designer 3 dan Mitsubishi GX-Developer / GX Works 2 sebagai platform simulasi Human-Machine Interface (HMI) telah diaplikasikan. Sistem kawalan dan pengawasan bagi system ujian strok separa dibina dengan menggunakan gabungan antara perisian Mitsubishi GT-Designer 3 dan Mitsubishi GX-Developer / GX Works 2. Gabungan ini bukan hanya berfungsi untuk mengawal mod system, ia juga mengelola data-data dari HMI iaitu computer seperti keadaan injap, penggera apabila sistem ujian strok separa gagal, rekod data kecemasan dan data aliran tekanan. Seterusnya, sistem ujian strok separa ini disimulasi dan diuji dalam masa sebenar menggunakan rekabentuk PLC.

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PST	-	Partial Stroke Testing
PLC	-	Programmable Logic Controller
ESD	-	Emergency Shutdown
HMI	-	Human-Machine Interface

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Potential disasters in the industrial processing plant may include accidents resulting in massive release of toxic materials, an uncontrollable and devastating explosion. Some industries are more prone to one over another of these catastrophes, but every company must guard against all potential disaster scenarios. It is important for plants and refineries to have emergency arrangements for the safe and effective shutdown of equipment in a controlled manner.

Emergency Shutdown (ESD) Valves provide dependable performance to protect employees, equipment, and the environment in emergency situations. In the event of an emergency, valve closure should be as quick as is possible. For ESD valves used in safety instrumented systems it is essential to know that the valve is capable of providing the required level of safety performance and that the valve will operate on demand when it is required to do so. For this reason, testing procedures that do not caused downtime are preferred. ESD valve will only function when there is an emergency occurring in production system, the valve should close and stop the flow of anything through the pipeline.

In this project, the concept and theories of Partial Stroke Testing (PST) will be studied based on PLC. The PST is focused for small ramp of the ESD valve, which is 15% moving down from 100% and moving up from 85% to100%. PST is important to be performed in order to predict the status of the ESD valve. PST via PLC can reduce the production downtime and cost repair of ESD valve. The opportunity to develop the human-machine interface for this system offers the potential to increase the stability and effectiveness of the system besides the safety factors of the workers but the seamless integration of sensor fusion, system control, data interface, software design, and communication can be challenging though it is more applicable in real life system.

1.2 Problem Statement

When the ESD valve remains in one position for a long period, there is a risk and potential of fail on demand which is, the ESD valve fail to operate during the emergency shutdown. The partial stroke testing system still requires manual ignition by human. The distance between the control box with the plant area is too short which might increase the risk in safety issue to the workers and the time consumption to perform the test manually has also become a downfall.

1.3 Objectives

The main objectives of this project:-

i. To develop system control and monitoring of PST system with Mitsubishi GT Designer 3 and Mitsubishi GX Developer / GX Works2.

ii. To test the performance of the PST system after interfacing Mitsubishi GT Designer 3 and Mitsubishi GX Developer /GX Works2 as the stable Human-Machine Interface (HMI) simulation platform for the PST design.

1.4 Scopes

The scopes of this project are divided in several phases which are mainly the research, material selection and lastly testing all the integrated software with hardware that will be developed. The scopes are listed as following:

i. Utilizing the means of data communication by cable .

ii. PST design and simulation based on PLC with ladder diagram.

iii. Mitsubishi GT Designer 3 and Mitsubishi GX Developer / GX Works2 as the Human-Machine Interface (HMI) simulation platform with the application of Mitsubishi FX1S-30MR .

REFERENCES

1. Angela E, Glenn Raney, “*Common cause and common sense, designing failure out of your safety instrumented systems (SIS)*”, ISA Transactions Volume 38, Issue 3, July 1999, Pages 291–299.

2. Riyaz Ali, “*Use Of Digital Technology To Test Shut Down Valves For Sis Applications*”, 2009. Director, Instruments Unit,MEA Emerson Process Management – Fisher Divn, Dubai – UAE.

3. Paris Stavrianidis, Kumar Bhimavarapu, “*Performance-based standards: safety instrumented functions and safety integrity levels*”, Journal of Hazardous Materials Volume 71, Issues 1–3, 7 January 2000, Pages 449–465.

4. John J. Sammarco, “*Programmable Electronic and Hardwired Emergency Shutdown Systems: A Quantified Safety Analysis*”, IEEE Transactions On Industry Applications, Vol. 43, No. 4, July/August 2007.

5. A.F.M. Prins, “*Partial Stroke Testing”, Yokogawa, system centre Europe*, 2010.

6. Harley Dearden, “*Partial Stroke Testing. Diagnostic or Proof test?*” Inst. M&C, vol.46, no.5 June 2013.

7. Robin McCrea-Steele, “*Partial Stroke Testing Implementing for the Right Reasons*”, ISA EXPO 2005, 25-27 October ,2005.

8. Anke Geipel-Kern, “*Automated Partial-Stroke Testing Enhances Process Reliability and System Availability*”, (ID: 317390) | Archiv: Vogel Business Media, 04/Nov/2009.

9. Emerson Process Management, “*Improving Safety Instrumented System Reliability*”, Fisher Controls International LLC 2002, 2007, 2012.

10. J. J. Sammarco and T. J. Fisher, “*Programmable electronic mining systems: Best practice recommendations (In Nine Parts); Part 2: 2.0 system safety,”* NIOSH, Pittsburgh, PA, IC 9458, 2001.

11. Mary Ann Lundteigen, Marvin Rausand, "*Spurious activation of safety instrumented systems in the oil and gas industry: Basic concepts and formulas*", Reliability Engineering & System Safety Volume 93, Issue 8, August 2008, Pages 1208–1217.

12. Haitao Guo, Xianhui Yang, "*Automatic creation of Markov models for reliability assessment of safety instrumented systems*", Reliability Engineering & System Safety, Volume 93, Issue 6, June 2008, Pages 829–837.

13. Harvey T Dearden, "*Partial Stroke Testing: Diagnostic or Proof Test?*", Measurement and Control June 2013 vol. 46 no. 5 152-153.

14. Yoshinori Sato, "*Introduction to partial stroke testing*", Institute of Electrical and Electronics Engineers, SICE Annual Conference, 20-22 Aug. 2008, pages 2754 – 2758.

15. Curt Millera, Lindsey Bredemyerb, "*Innovative safety valve selection techniques and data*", Journal of Hazardous Materials, Volume 142, Issue 3, 11 April 2007, Pages 685–688.

16. Hui Jin, Marvin Rausand, "*Reliability of safety-instrumented systems subject to partial testing and common-cause failures*", Reliability Engineering & System Safety Volume 121, January 2014, Pages 146–151.

17. Alexander Grigorieva, Nadejda V. Grigorievab, "*The valve location problem: Minimizing environmental damage of a spill in long oil pipelines*", Computers & Industrial Engineering, Volume 57, Issue 3, October 2009, Pages 976–982.

18. Mary Ann Lundteigen, Marvin Rausand, "*Common cause failures in safety instrumented systems on oil and gas installations: Implementing defense measures through function testing*", Journal of Loss Prevention in the Process Industries Volume 20, Issue 3, May 2007, Pages 218–229.

19. Haitao Guo, Xianhui Yang, "*A simple reliability block diagram method for safety integrity verification*" Reliability Engineering & System Safety, Volume 92, Issue 9, September 2007, Pages 1267–1273.

20. EMU (2004). Subsea Cable Decommissioning: A Limited Environmental Appraisal. Report for British Telecommunications plc, Cable & Wireless, AT&T. March 2004. pp 67.

21. Featherstone, J., Cronin, A., Kordahi, Mi. & Shapiro, S. (2001). Recent trends in submarine cable faults. SubOptic `01. May 2001. Kyoto, Japan.