Development of Gap Adjustment for Plugs using PLC

Kavya E[1], Rudranna Nandihalli[2]

[1]PG Student, Department of Electrical and Electronics Engineering, RV College of Engineering, Bengaluru
[2]Department of Electrical and Electronics Engineering, RV College of Engineering, Bengaluru

---

Abstract:- In many of the industries automation is an important tool to increase the production. The increased consumerism pushes the factories to produce more and more in less duration of time. So, industrial automation is serving as a solution to increase production, quality and also to decrease the cost. Implementing systems involved in the production control using the relay logic causes inflexible operation. Programmable Logic Controller(PLCs) are adaptable in automating most of the processes, because the operation and behavior of the system is changed without varying the electrical connections, as well as monitoring the system and the undergoing operation is possible. In this paper, the design and the development of an automated system for Spark gap adjustment is implemented using Siemens PLC S7-300. The process is also monitored through Totally Integrated Automation (TIA) software.

Index Terms- *PLC, TIA, Automation, S7-300, Profibus.*

I. INTRODUCTION

Due to the demand in the market for goods and products with improved quality and also the quantity, leads the industrialists to work with latest and promising technology to meet the expectations of the market's demand, developing and implementing the systems that reduces time, manufactures better quality product, increased number of items and also reduces the cost of manufacturing[1]. This leads to the uninterrupted advancement in the progression of technology that grow up to the requirements. Programmable Logic Controllers(PLCs) is one of the advanced and recent technology in the present modern industrial systems for automating a wide range of applications, such as in plastic manufacturing, elevator systems, filling systems, automobile manufacturing, petroleum fields and others. Their inter-connection with the Human Machine Interfaces (HMIs), the operations of the system are controlled and looked after by the operator. Numerous methods are incorporated to connect the PLCs with HMI and other devices[2]. The spark gap adjustment is an important part of the Spark plug manufacturing process. Spark gap is required to produce the sparks between the electrodes that ignites the fuel in the combustion chamber. Thus maintaining the spark gap in the Spark plugs is an important attribute during the manufacturing of Spark plugs.

This paper presents the implementation of automatic Spark gap adjustment with the help of SIMATIC S7-300, it is monitored through the TIA software[3].

Sensors like proximity sensors, Linear Variable Differential Transformer (LVDT) sensors are used to know the condition of operating system.

II. AUTOMATION OVERVIEW AND SPARK GAP PRINCIPLES

Automation in the industries is a technology resulting in the operation of industrial processes and machines without any intervention of the human [4]. It simply defines as to carry out an industrial process work automatically.

The developments in the recent technology, such as in the field of automation using electronics, semiconductor devices and the integrated circuits(ICs), Programmable Logic Controllers are used in place of the hard-wired relays in the most of the industries, and leading to the automation in the factories[5]. The PLCs logics are developed with the help of ladder logic and this is a easier method to make modifications and to control the behaviour and operation of the machines retaining electrical connections [6].

A. Programmable Logic Controllers

A PLC is an industrially used controller, receives the input signals from various sources and then processes them as per the program logic based on the particular application [7].

The architecture of the PLC constitutes of the following elements:

1) The Central Processing Unit: CPU helps in processing the data as per the logic stored in its memory.

2) Memory: All the instructions and the programs of the CPU and also the user functions and data are usually stored in memory that helps in data processing.

3) Input/output Modules: The input/output (I/O) module helps in interfacing the input and output devices with the CPU.

4) Extension lines: The inputs/outputs and as well as the ports for the communication purpose are increased based on the applications with the help of extension lines.

5) Power supply: It converts the higher voltage levels to the lower voltage levels to power the CPU and other modules of the PLC [8].

Fig. 1 shows the basic block diagram of a PLC [9].

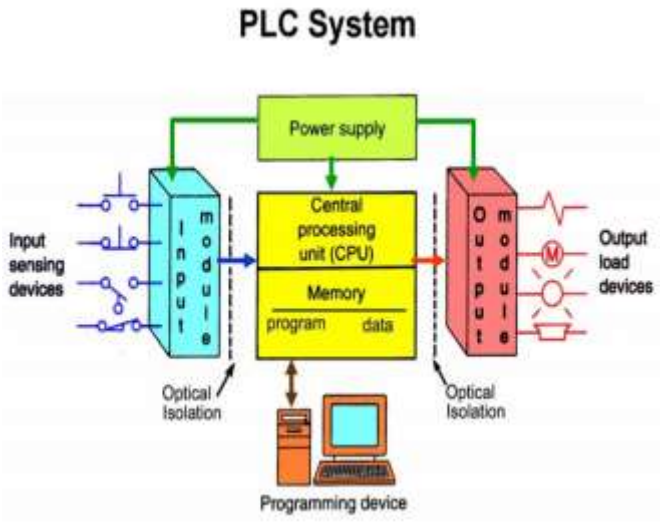

Fig.1. Basic block diagram of PLC controller.

According to the International Electro-technical Commission (IEC), languages preferred for the programming PLC are:

- Ladder diagram (LAD)
- Instruction List (IL)
- Functional Block Diagram (FBD)
- Sequential Function Chart (SFC)
- Structured Text (ST) – text language [10].

B. Spark gap automation principles:-

The minimum distance between the central electrode and earth electrode in the spark plug is known as the electrode gap and is as shown in Fig.2. The minimum electrode gap depends on the engine and the requirements of the manufacturer. Maximum precision is important to maintain the electrode gap is essential because an incorrect gap always results in considerable effects on the function of the spark plug, its efficiency and also on the performance of the engine. If the electrode gap is too small then it causes mis-firing, noise and also poor exhaust gas quality levels leading to air pollution.

Fig.2 Spark gap of the Spark plug

Larger the electrode gap, the chances of misfiring is more.

The following mechanisms are followed for spark gap adjustments:-

1. Shearing:- The length of the earth electrode is predetermined. For the effective sparking between the electrodes, the length of the electrode is maintained constant. Shearing is a process of maintaining constant the constant length of the earth electrode by removing the extra length. The length is measured with the help of LVDT sensors.

2. Bending:- Bending of the earth electrode towards the earth electrode is done to achieve proper offset and orientation between the electrodes. Without the proper offset and the orientation between them, it is impossible to create the spark for the ignition of the fuel in the combustion chamber.

III. SPARK GAP ADJUSTMENT MODEL

As mentioned in the automation principle, the process of shearing and bending is assisted with the help of sensors namely, Proximity sensors and LVDT sensors. There are multiple units and components used for designing the Spark gap adjustment and they are combined together to achieve the required design process.

A. Programmable logic controller (Siemens S7-300)

The S7-300 PLC is manufactured by the Siemens is having the capability to automate a variety of processes and machines. It consists of Central Processing Unit(CPU), digital or analog input and output terminals, Ethernet port, Profibus, Modbus, Profinet and high-speed counter, timer modules.

B. Capacitive proximity sensor

The capacitive proximity sensor, senses the value of the capacitance between the sensor plate and the object or target to be detected. It detects all the materials (metallic and non-metallic). The variation in the capacitance depends on the distance between the sensor and the target. It detects the objects and prevents from their interruption.

C. Inductive proximity sensor

An electronic sensor detects only the metallic objects within the specified range. The main components of the sensor are:- oscillator, detector, coil, output circuit. The operating distance depends on the actuator's shape and size and is also related with nature of the material. A metallic object approaching the coil alters the inductance of the coil, producing a change in current or a change frequency. The corresponding changes are detected, amplified, compared to a pre-set threshold to produce the required electrical pulses.

D. Electro-magnetic braked motor

Motors are generally stopped or disconnected from the power line, during inconvenient or emergency faulty conditions. The electromagnetic brake is situated on the motor. It enables the motor to stop immediately during undesired operation. One of the application areas of the electro-magnetic braked motor is in the conveyor or transportation systems to stop immediately in a desired position with high level of accuracy. Conveyor systems are helpful in transporting products from one place of the production line to another.

E. Totally Integrated Automation (TIA) software

TIA software is developed by the Siemens in 2011. It is an environment that helps in configuring and programming the complicated project in a easy way and in the single framework. TIA software is used to develop ladder programs for PLCs in configuring the distributed I/O units and do perform multiple tasks. TIA software consists of smaller software installed on a common base such as Siemens Step-7(S7). In this proposed paper, it is used to program Siemens S7-300 PLC for monitoring and visualizing the overall process with the computer.

IV. IMPLEMENTATION OF THE SPARK GAP ADJUSTMENT

The entire model of the proposed system consists of Shearing unit, bending unit, Servo motor, Siemens S7 300, Sensors, HMIs etc. Each of the mentioned units is interconnected properly according to the requirements.

A. System description

The overall process is explained with the help of the flowchart as shown in Fig.3.

The process is concentrated on the automatic operation of two major processes. One of them is the Shearing unit and the second is the bending operation. As per the flowchart, the supply is given to all the units and automatic operation is selected. In the meantime if any faults or emergency condition arises, the process is stopped immediately.

These faults and emergency conditions are made to display as the alarm on the HMI screen for the safe operation. If the fault is very severe, the process is immediately stopped or if it can be resolved then the process is restarted.

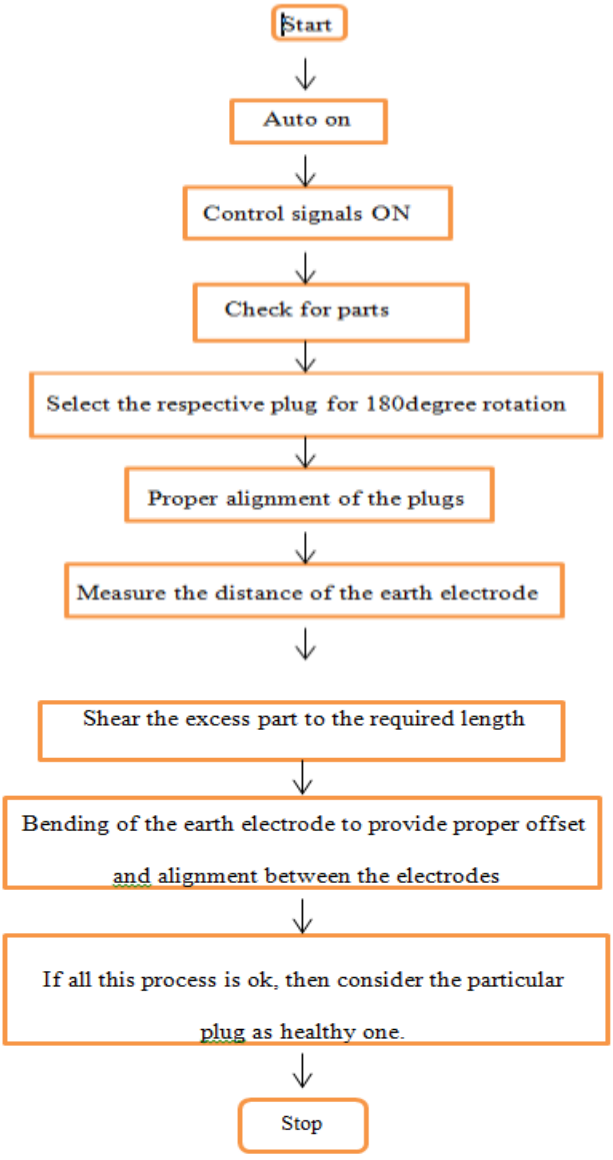

Fig.3. Flowchart of the overall process.

The control signals are provided to the respective units. Firstly the presence of parts is checked with the help of proximity sensors. A particular plug is selected and the height of the earth electrode is measured and compared with the master value, excess length is removed. The same earth electrode is bended towards the main electrode as per the pre-set values. The proper offset and orientation is

to be obtained to consider it as a healthy spark plug since Spark gap is very essential to produce spark and ignite the fuel in the combustion chamber.

B. Computer runtime monitoring

The complete process of the control or monitor in real instants is possible with the help of TIA software software through a wireless communication network. The connection is supplied between the wireless access point and the PLC. This process help personnel operating to observe the state of operation and its execution.

With this automation the operator is aware of the type of the Spark plugs in production, number of plugs produced, expected quantity, number of defective plugs after the shearing process and bending process as shown in the Fig.4.

Fig.4. The HMI screen depicting the overall process.

V. CONCLUSION

Automation based on PLC for the Spark gap adjustment system is implemented. Multiple devices are interconnected that mainly includes S7-300 PLC, sensors, electromechanical and mechanical devices. The system is monitored using TIA software software and as well as the user defined webpages in smart devices. After its implementation it is very easy to know the details of the operation and even the faults occured as it is displayed on the HMI screen.

REFERENCES

[1] Ernie Hayden, "An Abbreviated History of Automation & Industrial Controls System and Cybersecurity", International Journal of Computer Trends and Technology (IJCTT) Vol.23, No.3, May 2018.

[2] Khaled Kamel, Eman Kamel, "Programmable Logic Controllers- Industrial Control", McGraw-Hill Professional Publishing, 2018.

[3] Zhang, Peng, "Industrial control technology", William Andrew Inc, 2017

[4] W. Bolton, "Programmable Logic Controllers" 5th Edition, published by Newnes, 2017.

[5] Clarence T. Jones, "Programmable Logic Controllers the Complete Guide to the Technology", Patrick Turner Publishing Company, 2016.

[6] P. J. Fellows, "Food processing technology: Principles and practice" 3rd Edition, Woodhead Publishing Series in Food Science, 2015.

[7] Siemens Corporation, "SIMATIC S7-300 Programmable controller, System Manual", Siemens AG, 2012.

[8] Christopher Kilian, "Modern Control Technology" 2nd Edition, Delmar Thomson Learning, 2010.

[9] George Shultz, "Transformers and Motors" 1st Edition, Newnes, 2007.

[10] Gabor Takacs, "Electrical Submersible Pumps Manual_ Design, Operations, and Maintenance", Gulf Professional Publishing, 2007.

[11] J Schnetler, W Kohlhofer, T Gleeson, "Fitting and Turning", Person Education South Africa, 2005.

[12] T. L. Singal, "Wireless Communications" 1st Edition, Tata McGraw Hill Education, New-Delhi, 2004.

[13] Hans Berger, "Automating with SIMATIC_ Controllers, Software, Programming, Data Communication, Operator Control and Process Monitoring" 5th Edition, Publicis, 2003.