Filter Rod Detection by using Poka Yoke

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Abstract— Diesel fuel is a complex mixture of hydrocarbons and it is well known that in extreme cold operating conditions some of these (paraffin) form wax crystals that will block the fuel filter and prevent engine operation. Also, due to dust and foreign particles engine may get damage. Filtration is mainly done with filter rod. If this rod is missing, then filter will not work properly and hence will result into the dysfunction. Poka-yoke is a concept in total quality management which is related to restricting errors at source itself. It deals with "fail-saving" or "mistake-proofing". A poka-yoke is any idea generation or mechanism development in a total productive management process that helps operator to avoid (yokeru) mistakes (poka). The concept was generated, and developed by Shigeo Shingo for the Toyota Production System. This paper is based on project for detection of the missing filter rod by using Poka yoke method.

Key words: Mistake-Proofing, Total Quality Management, Total Productive Management, Filter, Diesel Engine, Fuel Filter, Fuel Injector, Poka Yoke

I. INTRODUCTION

Fuel injection is a system for introducing fuel into internal combustion engines, and into automotive engines, in particular. On diesel engines, fuel injection is a necessity, while on petrol engines fuel injection is an alternative to the carburetor. Fuel is transported from the fuel tank and pressurized using fuel pumps. Maintaining the correct fuel pressure is done by a fuel pressure regulator. Often a fuel rail is used to divide the fuel supply into the required number of cylinders. The fuel injector injects liquid fuel into the intake air. When signaled by the engine control unit the fuel injector opens and sprays the pressurized fuel into the engine. The duration that the injector is open (called the pulse width) is proportional to the amount of fuel delivered. Depending on the system design, the timing of when injector opens is either relative each individual cylinder, or injectors for multiple cylinders may be signaled to open at the same time.

The fuel injectors consists of a filter rod/pin. It does the job of filtering the fuel. Filters help to protect the most expensive parts of the engine by filtering out foreign particles that can damage a fuel injector. A damaged fuel filter can result in erratic performance, poor gas mileage and in some cases, complete engine shutdown. Even the smallest particles can cause considerable wear and tear to an engine. Protecting the fuel system and the engine from harmful particles, helps to prolong the life of your vehicle. Ensure dependable and trouble-free performance with a Fuel Filter. Thus we can say that filter is significant in healthy working of the injector and ultimately the vehicle.

This project is designed to detect the presence of filter rod within an injector using poka yoke methodology. Where poka yoke is a mistake proofing technique which helps people and processes work right the first time. The use of simple poka yoke ideas and methods in product and process design can eliminate both human and mechanical errors. Poka yoke ensures that proper conditions exist before actually executing a process step, preventing defects from occurring in the first place. Poka yoke perform a detective function, eliminating defects in the process as early as possible.

II. PROBLEM DEFINITION

It was noticed that the products were sent back by the consumers due to absence of filter rod within the injectors. For the smooth and efficient working of the vehicle, filter rod was important in injectors. Also a lot of injectors come back for inspection with a deviation in flow that is the result of improper filtration.

Here's Bosch's take on fuel injector filtration:

"Resistance to Fuel Contamination - Quality of the Medium. Dirt particles and contaminants in fuel represent a potential danger to the fuel injectors. They are to be avoided in order to preserve the correct function of the injectors. The dirt content in the fuel system must therefore be minimized via a suitable filter. Recommended filter quality: nominal rating 5µ, minimum 82% capture efficiency according to ISO/TR19438; dirt particles >35µ are not permissible. The basket filter in the injector serves only to catch residual particles. Nonconformance of the recommended filter quality can cause damage to and failure of the components"

So Bosch recommends a 5µ filter and says anything over 35µ can cause injector damage. Also initial detection of filter rod the repair cost after the product is sent back, reduces.

III. PROCESS CONTROL

A. *What is process control?*

The process of recognizing the state of the process at all times, process the information according to the set rules and guidelines and accordingly actuate the control elements is referred to as process control.

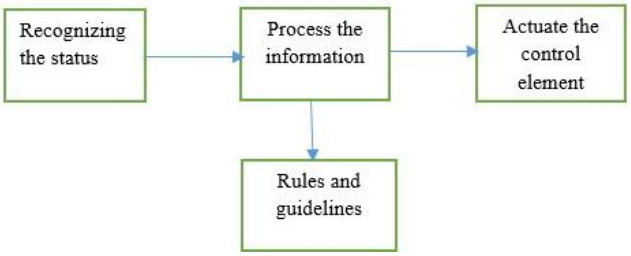

Fig. 1: Process Control

In the control of process, all these actions can be taken manually with human involvement or in a semiautomatic or fully automatic manner.

B. *What is automation?*

Automation is basically delegation of human control functions to technical equipment aimed towards achieving-

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- Higher productivity
- Superior quality of end product
- Efficient usage of energy and raw material
- Improved safety in working conditions

IV. LITERATURE SURVEY

After the products are being sold out, if the consumer finds any defects in them they send back those products to the company as the "defective products". The company then works again on those products for their improvement. These defects mostly includes:

- rusting
- top face damage
- flatness bad
- cleaning
- leak off
- Spot face damage.

Hence there are various techniques or machines due to which these faults are eradicated. Bosch maintains a monthly record of the details regarding these occurring faults.

In recent years, apart from the defects mentioned above, "filter rod absence" defect was also observed. Hence there was a significant need to eradicate this error occurring in the fuel injectors produced. This machine thus serves the need of detecting filter rod in the injector.

A. Poka yoke:

Poka-yoke is a quality assurance technique developed by Japanese manufacturing engineer Shigeo Shingo. The aim of poka-yoke is to eliminate defects in a product by preventing or correcting mistakes as early as possible. Poka-yoke has been used most frequently in manufacturing environments.

Poka-yoke (pronounced "POH-kah YOH-kay") [1] was invented by Shigeo Shingo in the 1960s. The term "poka-yoke" comes from the Japanese words "poka" (inadvertent mistake) and "yoke" (prevent) [2]. The essential idea of poka-yoke is to design your process so that mistakes are impossible or at least easily detected and corrected. Shigeo Shingo was a leading proponent of statistical process control in Japanese manufacturing in the 1950s, but became frustrated with the statistical approach as he realized that it would never reduce product defects to zero. Statistical sampling implies that some products to go untested, with the result that some rate of defects would always reach the customer.

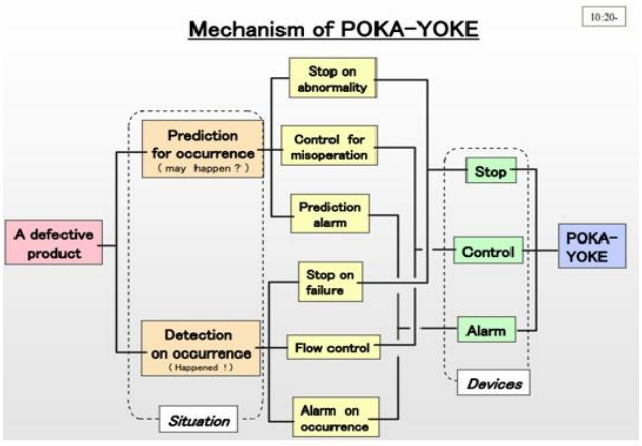

Fig. 2: Mechanisms

While visiting the Yamada Electric plant in 1961, Shingo was told of a problem that the factory had with one of its products. Part of the product was a small switch with two push-buttons supported by two springs. Occasionally, the worker assembling the switch would forget to insert a spring under each push-button. Sometimes the error would not be discovered until the unit reached a customer, and the factory would have to dispatch an engineer to the customer site to disassemble the switch, insert the missing spring, and re-assemble the switch. This problem of the missing spring was both costly and embarrassing. Management at the factory would warn the employees to pay more attention to their work, but despite everyone's best intentions, the missing spring problem would eventually re-appear.

V. BLOCK DIAGRAM

A. Electric Panel:

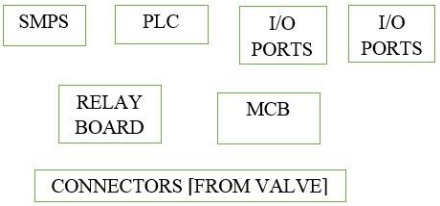

Fig. 3: Electric Panel

B. Description:

1) SMPS:

A switched-mode power supply (switching-mode power supply, switch-mode power supply, SMPS, or switcher) is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a source, like mains power, to a load, such as a personal computer, while converting voltage and current characteristics. Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. Ideally, a switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time. In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies may also be substantially smaller and lighter than a linear supply due to the smaller transformer size and weight.

2) PLC:

A programmable logic controller, PLC, or programmable controller is a digital computer used for automation of typically industrial electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures. PLCs are used in many machines, in many industries. PLCs are designed for multiple arrangements of digital and analog inputs and outputs, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory.

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3) MCB:

A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and interrupt current flow. Unlike a fuse, which operates once and then must be replaced, a circuit breaker can be reset (either manually or automatically) to resume normal operation. Circuit breakers are made in varying sizes, from small devices that protect an individual household appliance up to large switchgear designed to protect high voltage circuits feeding an entire city.

4) Relay board:

Available now our new large relay board. This board is ideal for switching appliances, control switches, valves, lighting and much more. This relay board uses heavy-duty 12V relays to switch the control load, with each relay suitable for switching up to 10A. Each output is easily controlled with a standard +5V TTL signal. This unit can be used with any of our control boards or with a computer control system. The 8 Relay Board features a high degree of isolation with the use of opto-isolators for isolation between control signals and output controls. Each relay includes LED indication of the relay state. PCB Power terminals are included on the board for cable connection. Standard 0.1" headers are provided for easy connection to other control systems or our development boards.

A 12V power supply is required for the relay coils.

- I/0 Ports:

This are used to get input from valves and output devices.

- Connectors:

This are mechanical components used to connect valves.

VI. HARDWARE DETAILS

A. *Components used:*

- PLC[Siemens S7-300]
- SMPS[Siemens, DC 24V/5A]
- 64 Input / Output ports
- Relay board and relay [Omron, G2R-1,24V DC]:3 Relay boards, 8 relays on each board.
- MCB[Siemens]
- Valve indicators [24V AC/DC-4A, MURR, ELECTRONIK 7000-2902]

B. *Components Specifications:*

Block diagram of PLC: 1-PHASE 230V,50Hz

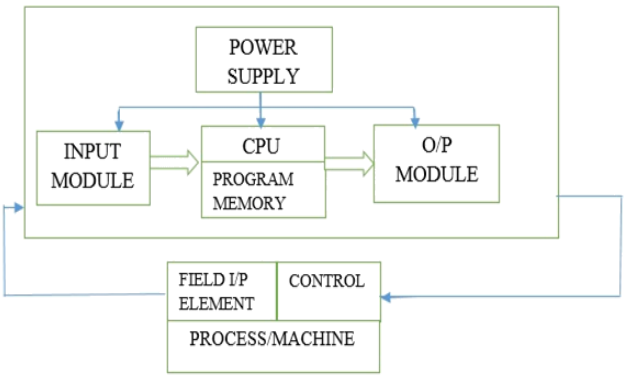

Fig. 5: Block diagram of PLC

With the coming of microprocessors and associated peripheral chips, the whole process of control and automation underwent a radical change. Instead of achieving the desired control or automation through physical wiring of control devices, in PLC it is achieved through a program or say software.

As desired logic control is achieved through a 'program', these controllers are referred to as PLC.

1) Advantages of PLC:

- Reduced space
- Energy saving
- Ease of maintenance
- Economical
- Greater life and reliability
- Tremendous flexibility
- Shorter project time
- Easier storage archiving and documentation

2) Fuel injector:

Fuel injection is a system for admitting fuel into an internal combustion engine. It is a primary fuel delivery system used in automotive engines and has replaced carburetors. The advantage of injector over carburetor is that fuel injection atomies the fuel through a small nozzle under high pressure.

3) MCB:

MCB stands for miniature circuit breaker.

MCBs are used to protect plants in buildings and for industrial applications. The device can be used as main switches for the disconnection or isolation plant.

For industrial application and in plant engineering, miniature circuit breaker can be supplemented with additional components, such as auxiliary switches, fault signal contacts, shunt tips, under voltage release, remote controlled mechanism and RC units.

MCB protect electrical systems against overload and short circuits with tripping characteristics A,B,C,D all field of application in Industry, residential and non-residential building are covered.

Rated current is not more than 100 A.

4) Proximity sensor:

The proximity sensors will detect the presence of injectors on the assembly line. When the injectors arrive proximity sensors will signal the PLC for further control. The plc will give signal to the cylinder which will move up and the plungers will move down as a result of this the injectors will be mounted upon the pins and filter rod will be detected. If the filter rod is present then the operation will continue and if absent then the alarm will buzz and indicators will turn on the injector will be then removed manually.

The machine contains four controls:

- Manual/auto
- Part clamp/unclamp
- Pin cycle up/down
- Lifting cycle up/down

Using which machine can be operated in manual or auto mode. When in manual mode other controls can be used. But auto mode the machine performs automatically.

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VII. FLOWCHART

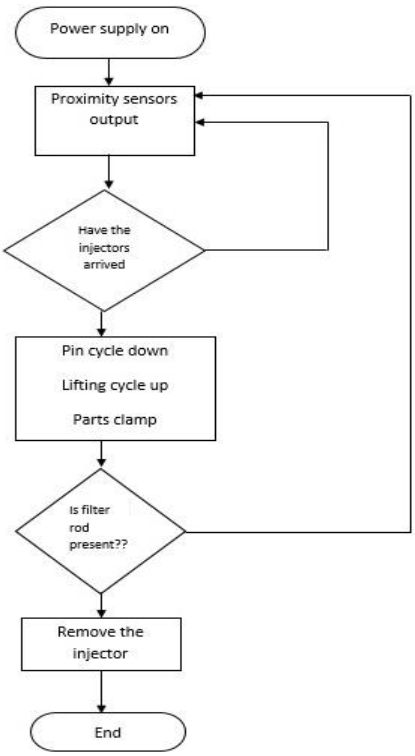

Fig. 4: Flowchart

VIII. MERITS AND DEMERITS

A. Merits:

- Reduces repair costs
- Presence of filter prevents fuel contamination
- Due to prevention of fuel contamination the efficiency of the vehicle/fuel injection system increases
- Whole system is automated
- Advanced components are used

B. Demerits:

- The removal of injector from the assembly line is manual but not automated.

IX. CONCLUSION

- Thus by using advanced PLC this machine resolves one defect in the fuel injectors.
- The early detection of presence of filter rod prevents the later repair cost and time.
- The consumers trust is maintained as they get a efficient product.
- The presence of filter in the injector makes the fuel injection process more efficient thus saving the vehicle from any damage caused due fuel contamination.

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