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PRODUCT QUALITY IMPROVEMENT THROUGH POKA YOKE TECHNIQUE

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ABSTRACT

This paper focuses on a quality improvement project at JWS (company's name abbreviated for confidentiality) using mistake proofing technique or Poka Yoke. The study is aimed at providing improvement ideas for existing problems at the manual assembly stations for product at D73A line. Investigations were conducted to identify causes of defects. Using results of unstructured interviews, and relevant data and from factory observations, the problem was analyzed using cause and effect diagram where the main causes were identified. To improve the existing problems, alternatives are generated using Poka Yoke and successive inspection techniques. Each alternative is evaluated in terms of its expected potential improvement and estimated cost of implementation. The evaluation indicates that Poka Yoke device proved to be the best alternative. This alternative was later presented to the company's management for further evaluation and comments. The study culminates with proposed solutions to improve productivity at the factory and future study.

Keywords: *Poka Yoke, quality improvement.*

1.0 INTRODUCTION

In this highly competitive world, the desire and expectation for high-quality and reliable goods are growing on a daily basis. Consumers now have access to products of higher design, quality and functionality at lower prices than were previously possible. Quality becomes the dominant issues in the market place where customers make their buying decisions based on product quality; sometimes they can even pay more for what they consider as high quality product.

Continuous improvement (CI) is one of the core strategies towards manufacturing excellence and CI is necessary to achieve good financial and operational performance. It will enhance customer satisfaction and reduce time and cost to develop, produce and deliver products and service. Quality has a positive and significant relationship to performance measurement for process utilization, process output, product costs, work-in-process inventory levels and on-

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time delivery. Quality is defined in terms of an excellent product or service that fulfils or exceeds the customer's expectation [1].

Improvement can be in the form of elimination, correction (repair) of ineffective processing, simplifying the process, optimizing the system, reducing variation, maximizing throughput, reducing cost, improving quality or responsiveness and reducing set-up time [2]. Some of the commonly used tools to solve problems in Industrial Engineering (IE) include work study, quality control, line balancing, Poka Yoke, and others [3].

Errors are defined as unintentional unplanned events in the design, planning or production of a product or delivery of a service. Some of the causes of defects are due to human errors and defects are the results of neglecting those errors [4]. It follows that a mistake will not turn into defects if worker errors are discovered and eliminated beforehand. Poka Yoke (also known as mistake proofing) device is any kind of mechanism that either prevents a mistake or defect occurring or makes any mistake or defect obvious at a glance [5]. An example is using an automatic counter with light signals to indicate correct number of spot welding points in car body assembling process instead of relying on workers to count the number of points themselves each time. Mistake proofing devices can be classed as control and warning methods.

This project involves a case study on quality improvement at an automotive part assembly plant. The causes of quality problems were identified and the use of Microchip Peripheral Interface Controller (PIC) in developing Poka Yoke device was demonstrated. Analysis and evaluation of alternatives were conducted based on the estimated performance output of the model. This paper begins with the description of the case study company followed by problem identification and descriptions of the problems. Based on the problem identified, major causes to the problems were determined and the construction of the alternative solutions as well as Poka Yoke device setup are discussed. The following sections describe the findings of this study.

2.0 COMPANY PROFILE

This study was conducted at an automotive part assembling factory which specializes in the assembly of wire harness for Japanese automobile models and some local models. The company was established in December 1979 and was set up as a manufacturer of automotive wire harnesses. The company currently has a workforce of approximately 2000 workers and the facility is capable of producing 6,000 units of wire harness per month. Their products include automotive cables, high tension ignition cables (HTIC) and wire harnesses. This study focused on the sub-assembly line of model D73A.

2.1 Manufacturing Process

The company adopts Group Technology layout in its production floor design. The production floor is divided into different sections which are cut and crimp, sub-assembly (manual and machine), final assembly, clip/clamp, final inspection 1 (visual 1), circuit continuity board, option tape, final inspection 2 (visual 2) and finished goods packing. The sub-assembly station starts from accepting single wire from the warehouse, wire insert and finally the sub-part is stored in the buffer storage area before sending to the final assembly. All the insertion work is done manually.

3.0 PROBLEM IDENTIFICATION

The next step in this project involved identifying problems that occur in the selected production line. Selected tools and techniques such as Pareto diagram, Cause and Effect diagram, together with the basic problem identification methodology were employed to identify major problems. The problem identification methodology employed in this study is shown in Table 1.

The main types of defects found were mis-location, missing component and half insert. Some possible causes for these three problems are workers not able to follow or are not following the standard operation procedure (SOP), inadvertent error, carelessness and no sensing device.

Table 1: Problem identification methodology used in this study

Step	Main activities
1.	Observation of the current operations and production line: The in-line study is carried out as it gives preliminary understanding of the operations in the entire system. Observation was made weekly during the working hours. Observations have been made regarding man, working method, layout and working condition and environment.
2.	Company documentation study: Reference materials are company documents which include operation standards, process flow layout, process flow chart, quality inspection plan, customer complaint and investigation report and procedure documentation. These documents helped to provide basic understanding on the operations in the line.
3.	Unstructured interview: Discussions were carried out in order to get a rough idea on how a problem occurs. This process is aimed at collecting useful experiences, opinions and also explanations from experienced personnel who works in the field, for example, supervisors, the line leaders, QA executive and senior engineers. Through these interview sessions, various opinions and views from different perspectives and level of expertise of the interviewees were obtained.
4.	Data collection and analysis: Relevant data regarding problem identification was collected and analyzed. The Cause and Effect (CE) diagram is used to identify possible causes to the problem faced in the sub-assembly line. Following that is the verification of the data which is used to find out the true causes. The four major causes being studied included human causes, material factor, machine factor and method factor.

4.0 PROPOSED IMPROVEMENT ALTERNATIVES

From observations and detailed interviews with the operators, it is believed that human error is a major issue in this production line. Since human cause is the major factor in this problem, as well as method and machine factor, attempt will be made to employ Poka Yoke or a mistake proofing technique. Some proposed Poka Yoke solutions will be developed and proposed at the end of this study.

4.1 Alternative 1: Poka Yoke Device

Rather than warning workers to pay more attention or 'to ensure not to forget anything', an appropriate device may be employed since workers will eventually or occasionally forget and tend to make mistakes. The first alternative suggested is to install a Poke Yoke device into the operation so that if a worker forgets something, the device will emit a signal, thereby preventing defects from occurring. This is the quickest way leading to the attainment of zero defect.

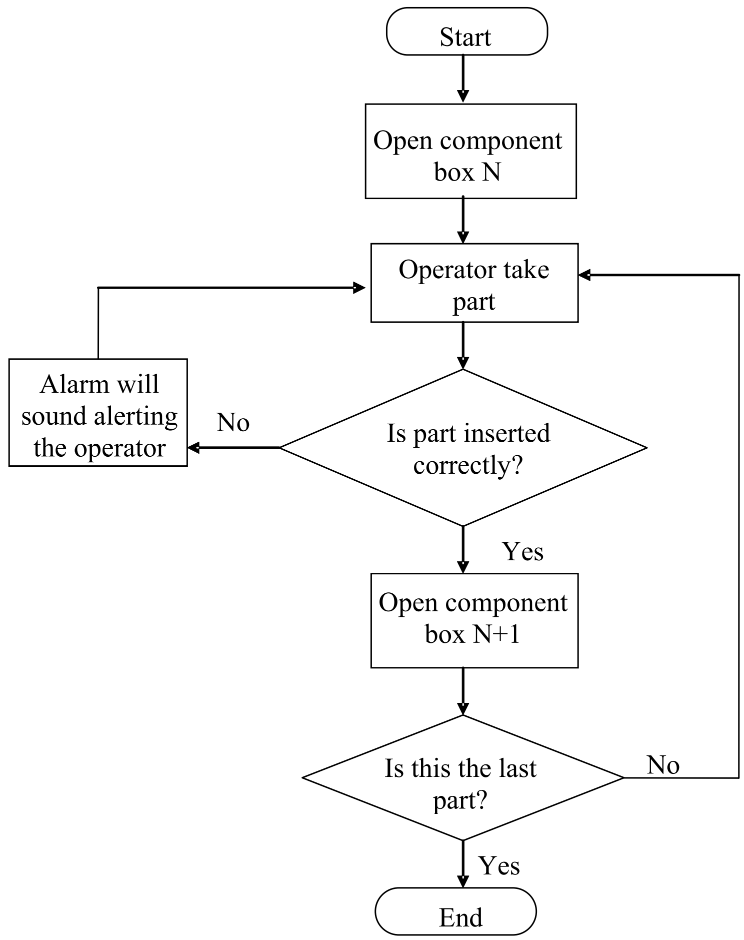

Figure 1: Concept design for Poka Yoke using automated sensor mechanisms

The concept of this device is to prevent operators from omitting parts during assembly. The worker tends to forget some parts such as connectors in the wire harness. Since it is a small part, the tendency to forget exists. The Poka Yoke device works on the following principles. When power is ON, the lid of the first part (say connector type A) will open and allow operator to take the part. If the part is inserted correctly, the touch sensor will detect it and the first lid will close while the second lid, having another part B, will open. A buzzer will sound if there is a missing item or if incorrect insertion or half insert is made. The sound from the buzzer will be for some period of time before it stops. The second lid will not open until correction to the error is made. The circuit is a closed-loop system and will keep on repeating until the last item is inserted. Figure 1 shows the flowchart of the automated sensor mechanism.

Having developed the concept design for the mechanism of the Poka Yoke device, the next step is the construction of a prototype hardware. The hardware consists of four parts which are the power supply, input (sensor), processor, and output (indicator and motor). Having reviewed the characteristic and comparison of the component, the final selection for the hardware is as follows:

a. The power supply task is to connect a 9 volt power source from battery into a 5 volt regulated supply available to all microchips in the device.
b. The input is the limit switch sensor which is used to detect correct position of the part and to send the signal to the microcontroller and a starting switch.
c. A unit of microcontroller PIC16F877A is used to process all inputs. This microcontroller is used to control the automated mechanism (opening of the lid, buzzer alarming, LED flashing) based on the signal received from sensor.
d. Outputs from the microcontroller are connected to the motor circuit in order to control the lid opening and LED which is used to guide which hole to be inserted. DC motor is selected for this system.

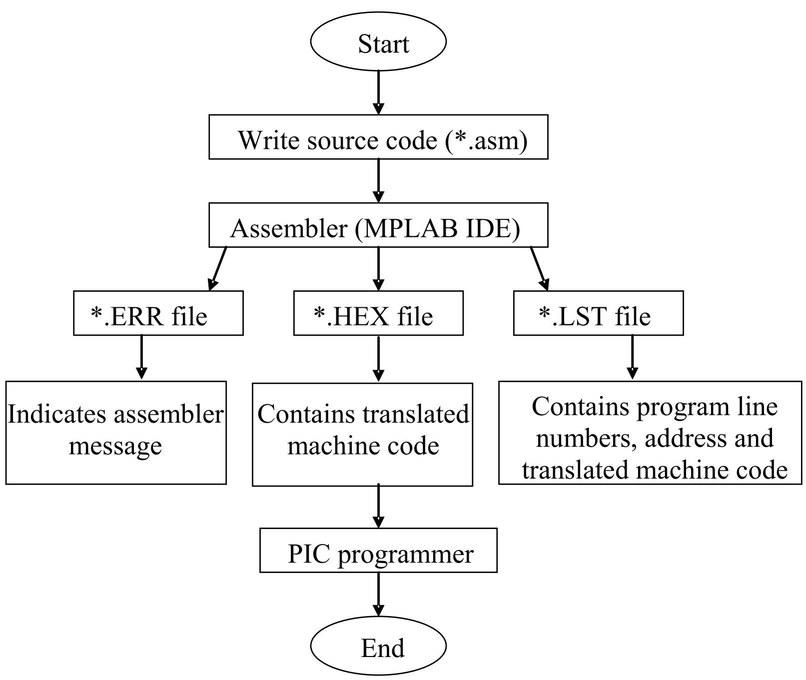

Figure 2: PIC programming procedure

The second part involves programming which is also called software development. The process starts by writing the program, assembling the program file, simulating the program and loading the program into the microcontroller [6]. The PIC programming steps are shown in Figure 2.

For software programming, an assembly language was used in constructing the command in order to get the best results with the least expensive micros. Assembly language can specify the exact instructions that the CPU will follow and one can control exactly the time and memory used for each step of the program. It is simpler than BASIC or C because in many ways it is similar to designing a circuit rather than writing software. After that, the program is assembled by using MPASM Assembler of MPLAP programmer to generate *.err file, *.lst file, *.hex file and *.cod file. After some simulation, the HEX.file is downloaded into the microcontroller using Hyperterminal software. The device is completed after verifying all the desired movements.

4.2 Alternative 2: Successive Inspection

In the existing process approach, self-check is applied and the detection of abnormalities is performed selectively and corrective action takes place slowly. If the worker performs his/her own inspections, he or she might compromise on quality or might inadvertently let defects slip by. Hence, a concept is recommended where it uses 'the closest person', that is the operator at the next process to take on the job of inspector. This would have the benefit that information about any abnormality discovered could be relayed immediately to the worker of the previous process. Figure 3 shows the application of the method. The Successive Check System was devised as follows:

a. When operator A finishes processing an item, he or she passes it on to operator B at the next process.
b. Operator B first inspects the item processed by operator A and then carries out the processing assigned to him or her. Then operator B passes the item on to operator C.
c. Operator C first inspects the item processed by operator B and then carries out the processing assigned to him or her. When the work is completed, operator C passes the item on to operator D.
d. In this way, each successive worker inspects item from the previous process.
e. If a defect is discovered in an item coming from the previous process, the defective item is immediately PASSED BACK to the earlier process. Action is taken to prevent the occurrence of subsequent defects. The line is shut down temporarily at this time.

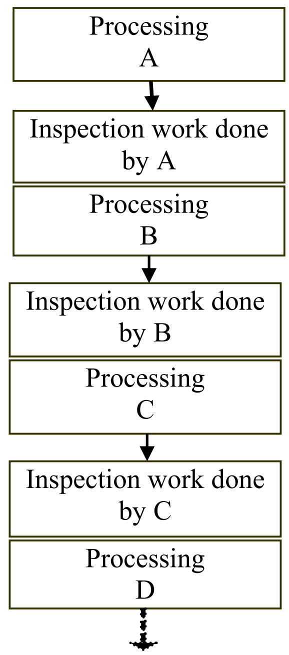

Figure 3: The sequence of successive inspection system

5.0 RESULTS AND DISCUSSIONS

The main selection criteria to be considered is the efficiency of the proposed alternatives in eliminating the defect, and more importantly, is the cost of implementing the proposed alternative as well as the overall quality and productivity performance.

The estimated output of part being produced assisted by the device is as follows:

Time to insert eight (8) items starting from switch on = 50 sec

As an example, for Station No. 17, there are 38 items, time taken

= 237.5 sec

Based on International Labour Standards (ILO),

Rest allowance = Constant allowance (personal allowance + basic fatigue allowance) + Variable allowance (standing allowance + close attention + mental strain + monotony)

= (7+4) + (4+5+8+4) = 32 %

Then, the standard time to complete a set of sub-part is

= [100 /(100 – Allowance)] x Normal Time

$$= \left(\frac{100}{100-32}\right) \text{ x } 237.5 \text{ sec} \quad = 349.26 \text{ sec}$$

$$\text{Total complete set within two hours is} = \frac{2 \text{ x } 3600 \text{ sec}}{349.26}$$

$$= 20.61 \text{ set} \qquad \sim 21 \text{ sets}$$

The results obtained from the comparison between the two alternatives are presented in Table 2. The performance measures considered are in term of setup cost, productivity performance and quality awareness.

From Table 2, in terms of cost estimation, it is shown that the application of Poka Yoke gives the lowest cost than assigning an additional person to do the successive inspection work. It is suggested that the company use the proposed device since it has the capability in self detecting error and in providing better output. It is believed that the use of this Poka Yoke device will reduce the problems and can be used as a basis for preventive approach in other similar work stations.

Table 2: Comparison of the alternatives

Features	Poka Yoke device	Successive inspection	Remarks (estimated)
Cost	☺		The cost of implementing Poka Yoke device (RM 113.25/month) which includes setup cost, maintenance cost and monthly electricity consumption is lower than recruiting new QA checker (RM520/month)
Productivity performance	☺		It is estimated that 21 sets of sub part could be produced if the device is implemented as operator can work faster with the guide of signal. Compared to manual method, only 16 sets are being produced. There is about 31.25% increase in productivity.
Quality Awareness	☺	☼	Any error discovered can be relayed immediately to worker at the previous process by the next station worker in successive inspection, but this method produces less self responsibility upon quality awareness. Workers in station might rely on the worker at next station to do checking for them.

☺ Strong positive effect/interaction ☼ Moderate effect/interaction
☻ Weak effect/interaction

6.0 CONCLUSIONS

This paper has presented the findings of quality improvement using Poka Yoke technique for a selected automotive part assembly process. This study has identified the problems affecting the quality in model D73A line. The problem can be overcome by using a sensing device where a mistake proofing device has been proposed and tested.

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