Automatic Fault Communication and Annunciation System to Improve Productivity in Manufacturing Industries

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Abstract

This paper explains about Automatic Fault Communication System which is the component concerned with detecting, isolating and assist in resolving problems in the shop floor. A properly implemented system can keep the assembly line running at an optimum level provides a measure of fault tolerance and minimizes downtime. A set of functions or applications designed specifically for this purpose is called a fault/management platform.

Important functions of Automated Fault communication System includes: definition of threshold for potential failure conditions, constant monitoring of system status and usage levels, general diagnostics

Online monitoring of the system elements including workstations and servers, alarms that notify administrators and users of impending and actual malfunctions, tracing the locations of the actual malfunctions, detailed logging of system status and actions taken.

The objectives of this paper are to design automatic fault communication system to connect fault management to system management protocols and software, and to enrich the tools and common architecture for research underlying failure modes.

Key Words: *Automatic Fault Communication System, potential failure, fault tolerance*

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1. INTRODUCTION

Automatic Fault Communication System is the component of management concerned with detecting, isolating and assist in resolving problems. Properly implemented, the system can keep the assembly line running at an optimum level provide a measure of fault tolerance and minimize downtime. A set of functions or applications designed specifically for this purpose is called a fault/management platform.

Important functions of Automated Fault communication System includes:

- Definition of threshold for potential failure conditions.
- Constant monitoring of system status and usage levels
- General diagnostics
- Online monitoring of the system elements including workstations and servers.
- Alarms that notify administrators and users of impending and actual malfunctions.
- Tracing the locations of the actual malfunctions.
- Detailed logging of system status and actions taken.

The objectives for the automatic fault communication system are to

- Connect fault management to system management protocols and software
- Evolve and enrich the tools and common architecture for research underlying failure modes.

This system contains multiple components that can interact across multiple departments in the production floor. As a result, determining the root cause of failures in the assembly line can be frustrating and might take several hours or even days. Delays in determining the root cause of the faults can adversely impact system availability. Finger pointing, also known as root cause analysis or failure diagnosis, involves detecting errors and/or failures and assigning blame to their underlying cause. It is used to protect the data in the case of failure. It aims at improving system availability and providing better fault containment.

If the root cause of a failure can be diagnosed quickly, this gives us a window of opportunity to initiate recovery proactively, instead of waiting for the failure to be detected through the manual system. Knowledge of the root cause can assist in deciding the appropriate course of action for recovery.

As we become more dependent on our manual system, faults and downtime become very costly. Therefore, the development of a practical and effective system for fault diagnosis becomes an imperative and critical task. Reliability of automated fault diagnosis, mode of fault management (manual vs. automated), and fault dynamics affect variables including root mean square error, avoidance of accidents and false shutdowns, subjective trust in the system, and operator self-confidence. Trust in automation but not self-confidence was strongly affected by automation reliability. Operators controlled a continuous process with difficulty only while performing fault management but could prevent unnecessary shutdowns. Final authority for decisions and action must be allocated to automation in time-critical situations.

Automation plays an increasingly important role in the world economy and in daily experience. Engineers strive to combine automated devices with mathematical and organizational tools to create complex systems for a rapidly expanding range of applications and human activities.

Automation is the use of control systems (such as numerical control, programmable logic control, and other industrial control systems), in concert with other applications of information technology (such as computer-aided technologies [CAD, CAM], to control industrial machinery and processes, reducing the need for human intervention.[1] In the scope of industrialization, automation is a step beyond mechanization. Whereas mechanization provided human operators with machinery to assist them with the muscular requirements of work, automation greatly reduces the need for human sensory and mental requirements as well. Processes and systems can also be automated.

Specialized hardened computers, referred to as programmable logic controllers (PLCs), are frequently used to synchronize the flow of inputs from (physical) sensors and events with the flow of outputs to actuators and events. This leads to precisely controlled actions that permit a tight control of almost any industrial process.

Human-machine interfaces (HMI) or computer human interfaces (CHI), formerly known as man-machine interfaces, are usually employed to communicate with PLCs and other computers, such as entering and monitoring temperatures or pressures for further automated control or emergency response.

Automation has been responsible for the shift in the world economy from agrarian to industrial in the 19th century and from industrial to services in the 20th century.[3]

Currently, for manufacturing companies, the purpose of automation has shifted from increasing productivity and reducing costs, to broader issues, such as increasing quality and flexibility in the manufacturing process.

2. PROBLEM DEFINITION

In the assembly line, each part needed for the equipment is assembled as desired in a systematic manner. The assembly line can be manual or automatic. There are all chances of faults to occur during the assembly. These faults have to be corrected for the easy flow, higher efficiency and productivity in the assembly line. In this era of technology, we prefer components with the highest level of efficiency and precision. Hence the faults have to be eliminated with very little compromise. Here comes the need for Fault Monitoring System. The system used for the monitoring of faults could not be relied upon completely. Because the system had discrepancies regarding the communication and proper utilization of time.

It was observed by one of the largest Automobile manufacturing company at Bangalore that during the assembly there was no proper communication from the assembly line to the supervisor and the respective support department, of the faults occurred. These problems were divided into 4 categories:

- Material
- Maintenance
- Quality
- Knitting
- If any faults occurred in the assembly line, it leads to the stoppage of the assembly of the upcoming parts in the assembly line. Therefore the faults occurred had to be communicated and corrected as soon as possible for continuous flow. The major problem existed with the fault communication itself. As, faster the communication, faster the rectification, lesser the idle time hence higher productivity. The fault occurred should be communicated to concerned department, person in charge and the engineer. This definitely takes a lot of time. If the faults are not rectified in the stipulated time, the assembly station becomes idle, this leads to consumption of more time and this incurs higher costs.

3. METHODOLOGY

To decrease the idle time during the assembly and to have a proper monitoring of time taken to acknowledge and clearing of the fault, we have proposed for a complete and precise automatic reporting of the faults occurred.

This helps in systematic monitoring of the total time taken by the concerned department to solve the encountered problem for further investigation of the problem solving process.

It is an online monitoring system which enables to get a snap shot of the ongoing process. It displays the status of the assembly line and the nature of the fault's encountered, in the production department with the help of latest devices.

This enables the production department to have monitoring of what's going on the shop floor. With the help of this system further improvements can be made and there is always scope for continuous improvement in the organization and operational efficiency increase every day. Overall this helps the organization to increase the productivity and faster ROI.

This project focuses on automated data capturing system using Electronic hardware and customized software developed exclusively for effective monitoring of assembly. This system captures the relevant production stoppage information directly from the shop floor without any human intervention and reports the same on real time basis.

- The major components and technologies used in the model are: PLC
- GPRS Modem

Cables, HMI Screen, SMS Gateway, LED, Wi-Fi

4. WORKING PROCEDURE:

The Functional procedure of the *Automatic Fault Communication System is shown in the figure 1Which is self explanatory*.

5. FUNCTIONAL DIAGRAM

The actual functional diagram is shown in figure 2.

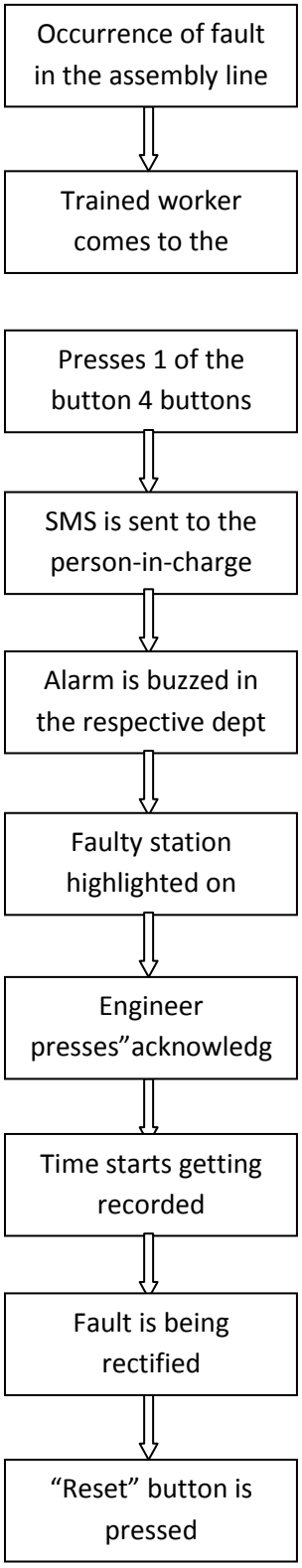

Figure 1: Functional procedure of the Automatic *Fault*

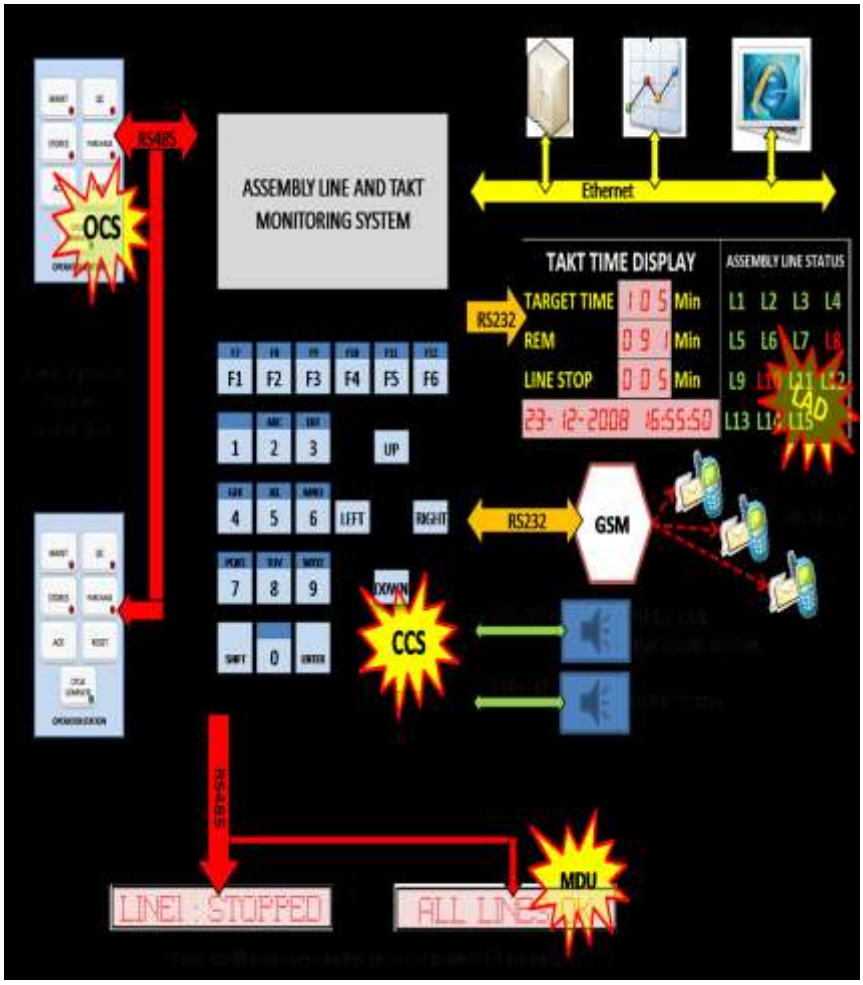

Figure 2: Functional Diagram

The main steps involved in the working of our proposed model are as follows-

- On the HMI screen, the series of operations of the assembly line is being displayed.
- At the occurrence of the fault in the assembly line, the trained worker has to press one of the four buttons, with respect to the four categories of faults, viz.
    - Material
    - Quality
    - Maintenance
    - Knitting
- Once the button is pressed, a series of functions takes place-
    - A SMS is sent to the concerned person in charge.
    - An alarm is buzzed in respective department on HMI screen
    - On the HMI screen, the faulty station is being highlighted.
    - The time is being recorded which indicated the time at which the button was pressed.
- In the least possible time, a person has to come to rectify the fault from the concerned department.
- As soon as he reaches the location of fault, he has to press the "ACKNOWLEDGE" button to indicate his presence. From then on, the time taken to resolve the problem is being recorded.
- After the rectification of the fault, the person has to press the "RESET" button to indicate the completion of his job.
- Once the entire assembly is over, the "CYCLE COMPLETITION" button has to be pressed.

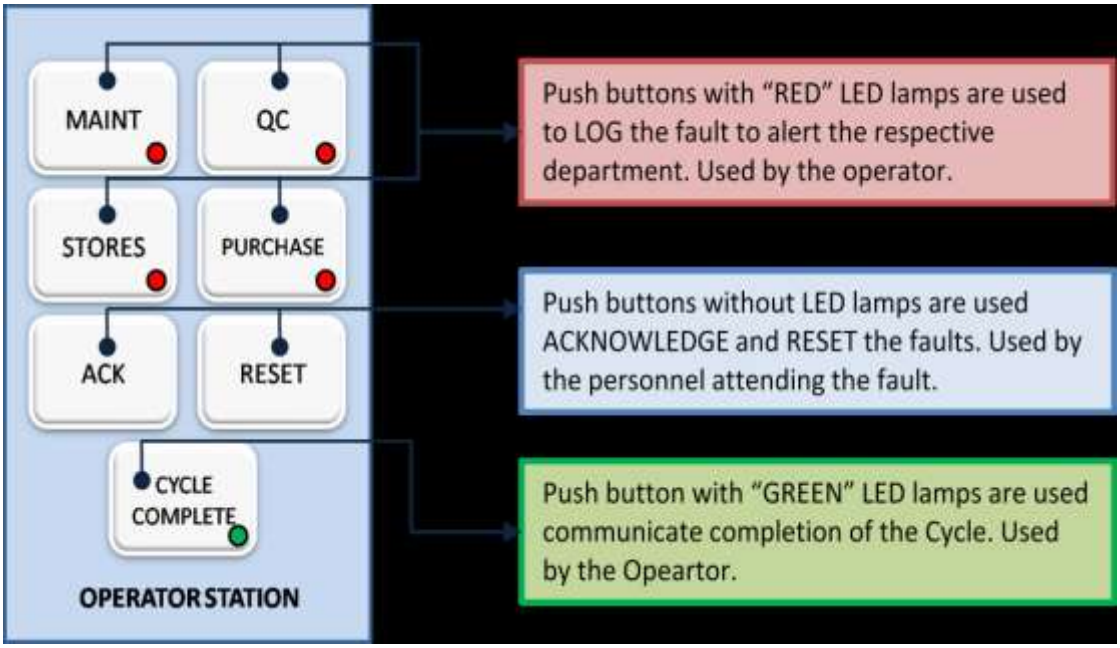

Figure 3: Operator Station

6. RESULTS AND DISCUSSION:

It was observed that on April 7, 20XX the entire assembly line had stopped. This occurred due to the fault occurred at the assembly station 7. There was a delay in the communication of the fault to the concerned support department. Hence the fault was not been rectified. This led to the stoppage of the entire assembly line.

The workers on the assembly line were not technically trained to identify the faults. It took 2 days to analyze the type of fault, which was actually regarding the quality of the material. It took another two days to resolve the problem, as the suppliers were notified for a fresh lot of material, urgently.

Now, if the faults were communicated faster to the concerned support department and the top management, the actions taken would have been much faster, which would resolve the problem in much less time. The benefits of faster communication are

- Increasing the productivity
- Effective utilization of the resources.
- Reducing the idle time of the workforce and the machines.

Assumptions and specimen calculations:

1 shift= 8 hours

1 day= 2 shifts

Therefore, 4 days= 8 shifts= 8*8 hours= 64 hours

So, it took 64 hours to resolve the problem.

Now, automated approach-

If the faults were communicated by the skilled workers as soon as the problem occurred, it would take hardly 2 hours for the management to take the actions.

So the net time saving will be

64 hours (Earlier approach)

\- 2 hours (Management actions)

- 32 hours (Procuring fresh lot of material)

30 hours (Net Savings whenever Material fault occurs)

(ie. 60-32-2=30 hours), 30 hours of production is able to produce around 18 equipment as per takt time calculations. So increased productivity less cost hence more profit to the organization.

- It alerts the maintenance in-charge on an unattended fault thereby ensuring timely closure of break downs.
- Workers were held accountable for the faults occurred, which creates a sense of responsibility.
- Helps the production personnel to track the shift-wise/ machine-wise performance of each assembly station.
- The entire production staff and the maintenance personnel can be aware of the exact problems being encountered in a particular shift, thus eliminating any kind of confusion on the shop floor.
- Automatic fault communication and monitoring system.
- Systematic assembly line monitoring
- Time required to complete and acknowledged the encountered problem.

Quicker communication of encountered problem to the concerned person in- charge through sms gateway.Though, our system is now designed for a particular company, in future it can be applied to other companies by customizing it according to their requirements and demands. So that it can be universally implied in various industries.

- The system can be made "Sensor Sensitive". It can have a voice recognition feature.
- The buttons used in the system can be further improved by the use of sensor buttons, which are more perceptive and user friendly.
- The Screens can have an eye-catching module which captures the data of the people who have witnessed the fault (Double camera with recording facility).
- Further analysis & study to be done on the shop floor during assembly to understand the impact on the production process, if the faults not corrected on time. Here, the faults have to be taken care of to understand and realise the various genres of the faults which can occur in the assembly.
- This system allows for a 'Continuous Improvement' which is a necessity for gaining a competitive edge.
- To understand the work progress and reasons for break down, systematically on daily basis. The preventive maintenance and the repairing work can be standardised and training can be given to the workers for reducing the repair work.
- There is possibility of linking the present system with the SAP. Presently, this particular software gives details regarding the inventory, purchase, sales etc. Our system has a scope of being connected to SAP which gives the snapshot of ongoing process, adding extra feature to the existing SAP.

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