Production Monitoring System for Monitoring the Industrial Shop Floor Performance

S. K. Subramaniam, S. H. Husin, R. S. S. Singh and A. H. Hamidon

***Abstract*—** Efficiency and accuracy at the production lines enables a better production and utilization of the available resources. The data available should be interpreted accurately in order to identify the various faults at production level and to immediately rectify them to improve efficiency. An accurate data management and shop floor monitoring system (PMS) is equally important in improving production performance. A number of production floors are utilizing manual methods of data collection for producing reports. Manual data compilation leaves room for both inconsistencies and inaccuracies. When manual data collection is practiced, there is usually a second step of manually compiling the data. This is most commonly accomplished by entering in the information into spreadsheets. When the data is collected without the help of a PMS then the data can be inaccurate. Where there is human intervention on the recording or collection of data, the truthfulness of the collected data is no longer reliable. This paper presents the benefits and usefulness of an automated data collection and display system for production lines. Once the data is displayed, it is transferred into computerize spreadsheet in the remote office by authorized personnel for reporting purposes. The system will generate an automated report which stays in place and the management only needs to act base on the results. This cost effective automatic data collection is the alternative to manual data collection. It significantly improves the accuracy of the valuable reports for the managements.

***Keywords*—** Production lines, Shop floor monitoring system, data collection, production monitoring system, automated data display system

I. THE CONCEPT OF JIDOKA

The "andon" system is one of the elements that make up the principle of Jidoka. In ancient Japan. Jidoka is a Japanese term for autonomation (automation with a human element) and refers to principle of stopping work immediately, when a problem occurs [1]. In the olden days andon is a paper lantern which is a handy vertical collapsible paper lampshade with an open top and a candle placed at the central section of the closed bottom. To the ancient Japanese, andon functioned as a flashlight, a signaling device in distance, or even a commercial sign. The interaction of an andon system is as shown in Fig. 1 below.

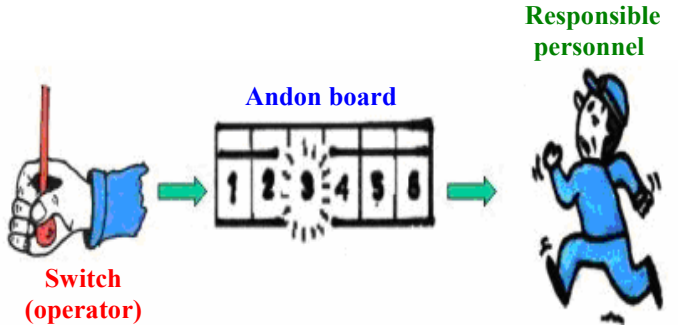

Fig. 1 The interaction of andon system

It is a technical installation supporting execution of four-step process of abnormality handling [1].

- Detect the abnormality.
- Stop.
- Fix or correct the immediate condition.
- Investigate the root cause and install a countermeasure.

The development of science and technology has seen many new technologies being implemented. This result in the evolution of the Production Monitoring System (PMS) Nowadays, the systems of "andon" in many industries are advanced into electronic devices with audio and color-coded visual display.

There are many industries rely production data from such devices to know their true production capacity. Some even have computer bases system which is very high in accuracy and better in performance in processing the production information for each production shift. The most important element here is whether the management is capable to improve

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their production process with the collected data Fig. 2 below illustrates the production life cycle using the concept of Jidoka.

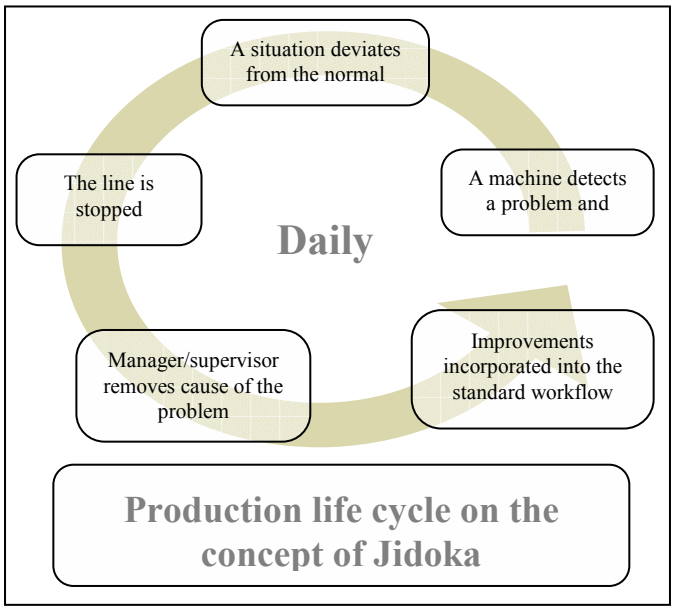

Fig. 2 Concept of Jidoka in industries

II. INTRODUCTION TO PRODUCTION MONITORING SYSTEM

A real time PMS is a production tool that helps the management to gather and distribute information to everyone in the shop floor as events are happening. Real time PMS is essential in helping the industries to achieve realistic production goals, at reduced down time and increase in yield. The prototype of a PMS is shown in Fig. 3.

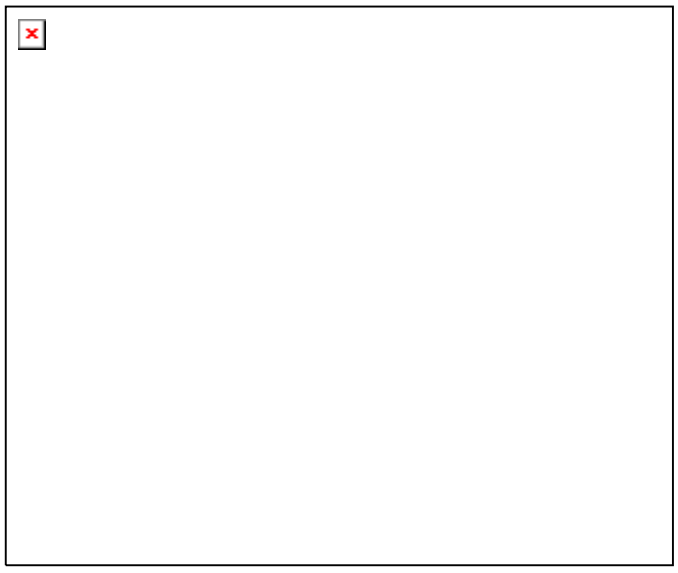

Fig. 3 Laboratory testing using one of the PMS prototype

Developing a reliable system which is truthful in data capture and displaying them is not a factor, yet there are certain limitations in the available devices [2]. Based on studies conducted, various approaches are taken to further lessen the problems faced by the management in industries. These problems are critical when there are human interventions in the production process [2] - [4].

This study is conducted to develop a real time PMS to replace human supervision on production lines. Information from production lines is essential for the management to enhance the production yield in all stages [2] – [6]. Capturing and interpreting this production data without human intervention is a major challenge for the management. Collected data may not be truthful due to the improper monitoring system, the inaccuracy of the monitoring device and human intervention.

III. CONCEPT OF A PRODUCTION MONITORING SYSTEM

The real time production monitoring system should provide the right information to the respective personnel at the right time. Presenting too much production information to the production workers or operators is not essential to their task. With too much unfocused information thrown at them, workers or operators are not able to digest what is necessary to modify on their current production outcomes. Whereby presenting too little information to the supervisors, supporting departments and the managers can be like watching the production operations through a keyhole. Each level of people in the industrial shop floor has their role in keeping up to the set goals [7].

The most important requirements of any data collection and reporting system is that the system is economical, accurate and easy to set up on a production line. Supervisors generally have an aversion to computer based systems because of ongoing headaches with custom made software and other solutions. They are often more comfortable with a production monitoring system (PMS) which is capable of providing straightforward connectivity to switches, sensors, PLC outputs and other common industrial equipments. If a PMS can be easily connected to each work stations and machineries on a production line, then management needs for this critical data can be easily satisfied. If the true production data can be automatically captured and presented in a simple, understandable way to the operators, they will become a more integral part of the improvement process. An effective system should be comprised of the following three elements:

A. Collection

Connects to automated, semi automated and manual production to count and collect data with minimal or no human intervention.

B. Display

Presents relevant production information back to operators, line leaders, supervisors, the supporting departments and the management. Seven segment display panels have become the method of choice of many industries because they can combine the benefits of color with the numerical values.

C. Analysis

Should provide sufficient production data for the management to conduct relevant analysis at all level in the shop floor.

IV. TASK OF A REAL TIME PRODUCTION MONITORING SYSTEM

The real time PMS in manufacturing industries enables both the management and the production team to continually monitor real time production status with regard to reliability, accessibility and maintainability of the equipments. Information must be collected at each shift end and disseminated accurately in order to meet the production goals [8].

The ability of the PMS to collect production information on real time basis would enable the production team to respond, in a timely manner, to solve any production related issues that may arise.

The task of a PMS is to assist the production team to produce their best within the available resources. Apart from that PMS helps in improving quality matters and reducing overheads. The layout of a PMS is shown in Fig. 4.

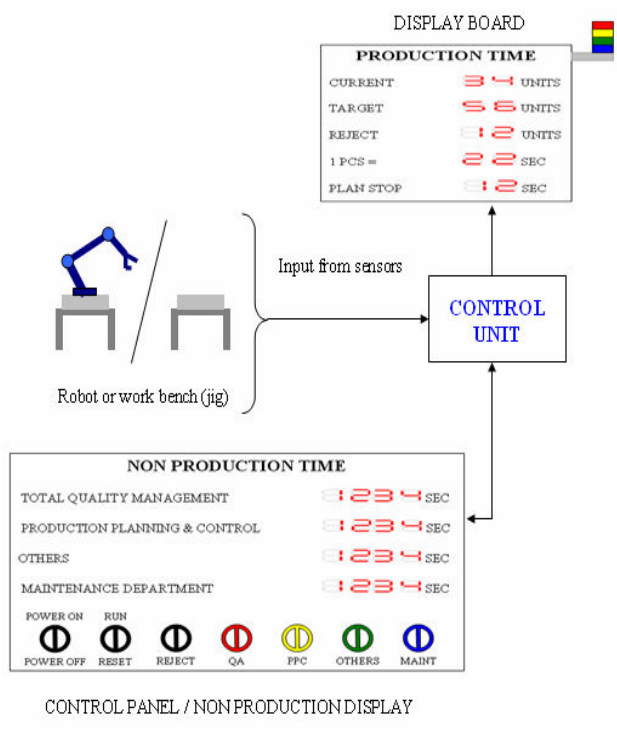

Fig. 4 Layout of the real time PMS

This system should also proactively detect and react to the faults by informing the relevant personnel in the departments before they escalate. Data collected should be used in analysis and should be ranked for further action. Base on the analysis carried out, counter measures are applied for better results in the on coming days.

V. DESIGN ELEMENTS OF A REAL TIME PRODUCTION MONITORING SYSTEM

The PMS is a complete system consisting of a display unit for displaying the production status and alerts the respective departments involved in the production process in the event of a fault. There are two display boards in this PMS which are the production time display and the non-production time display. Real time PLCs are used as the primary control unit for this system. The secondary control unit is used for generating pulses for the display boards.

A. Production time display board

This display board displays information on the production status when the production is running smoothly. This display board will be used as a guiding tool by the production teams, especially for the operators to know of their daily goals and current achievements. The tower light attached to the production time display board will be used to alert the respective departments on the event of a fault. The five display line on the production time display board helps both the production team and the management to display details on the production status.

Actual

This is the total number of completed parts or item from the start of production. A signal will be generated to the PLC using a few sensors attached on the work station to detect the completed process. A signal then is generated to accumulate the number of total completed parts on the display.

Target

This is the total number of parts or items set for production by the management. In other words, target is the goal set by the management for the shift. PMS has an accumulation target shown to the workers and this will assist them in achieving the set goals. The running goal is based on the cycle time of the produced parts. At each complete cycle time, set in the PLC, a signal is generated to add a number to the target display. In the event a down time is recorded, this target will be paused for the length of time taken to solve the faults.

Reject

This is the total number of parts or items produced that are out of specification. This number takes into account the reject (rework and scrap). A few sensors will be attached to the work table to detect the event of faults and then a signal will be generated by the PLC to add a number to the reject display.

Cycle time
This is the time-span for the specific parts or items to be produced. This is usually set by the production planning and control department (PPC) after a time study on the process is done. The process cycle time will be programmed into the PLC.

Planned stop
This is the length of time during which there is production. This is when the workers have no productivity as planned by the management. A switch will be used to generate pulses for the display to capture the duration of no productivity.

B. *Non production time display board*

This board will be used to capture the production interruption time according to the departments involved in the production process. Basically there are 3 main departments in all industry which are the total quality management department (TQM), PPC and maintenance department

Total Quality Management
This is when a fault is detected due to improper parts being produced. The operators on the work station have to press the switch to alert the department and at the same time the display will capture the time taken to solve the fault.

Production Planning and Control
When the operator detects that they are running out of the raw materials, then the operator have to press the switch to alert the relevant department. At the same time the display will capture the time taken to solve the fault.

Others
This display is used to capture the length of time taken by outside vendors on their duration of work on production lines. This could be an improvement process or system upgrading.

Maintenance
When a fault is detected due to machine or technical failure, the operator has to press the switch to alert the department and at the same time the display will capture the time taken to solve the fault.

VI. PROCESS FLOW OF THE REAL TIME PRODUCTION MONITORING SYSTEM

The implementation of a PMS and its operation flow is as shown in Fig. 5. Data displayed is collected by the supervisor or the line leader as in level three in the shop floor of industries for analysis.

The data will be tabulated into a spread sheet by the production team in level two. Table 1 shows the types of data collected and the possible analysis which can be carried with the available data. Based on the daily performance of the shop floor, basic analysis is attempted to ensure better production performance to the set bench mark which is set by the PPC and the management. The final level of analysis is done by the top management whereby the tabulated data and the changes are monitored.

A post mortem report will be generated by the responsible personnel to the management stating the specific factors affecting the production lines and the counter measures taken to reduce or minimize the highlighted problems.

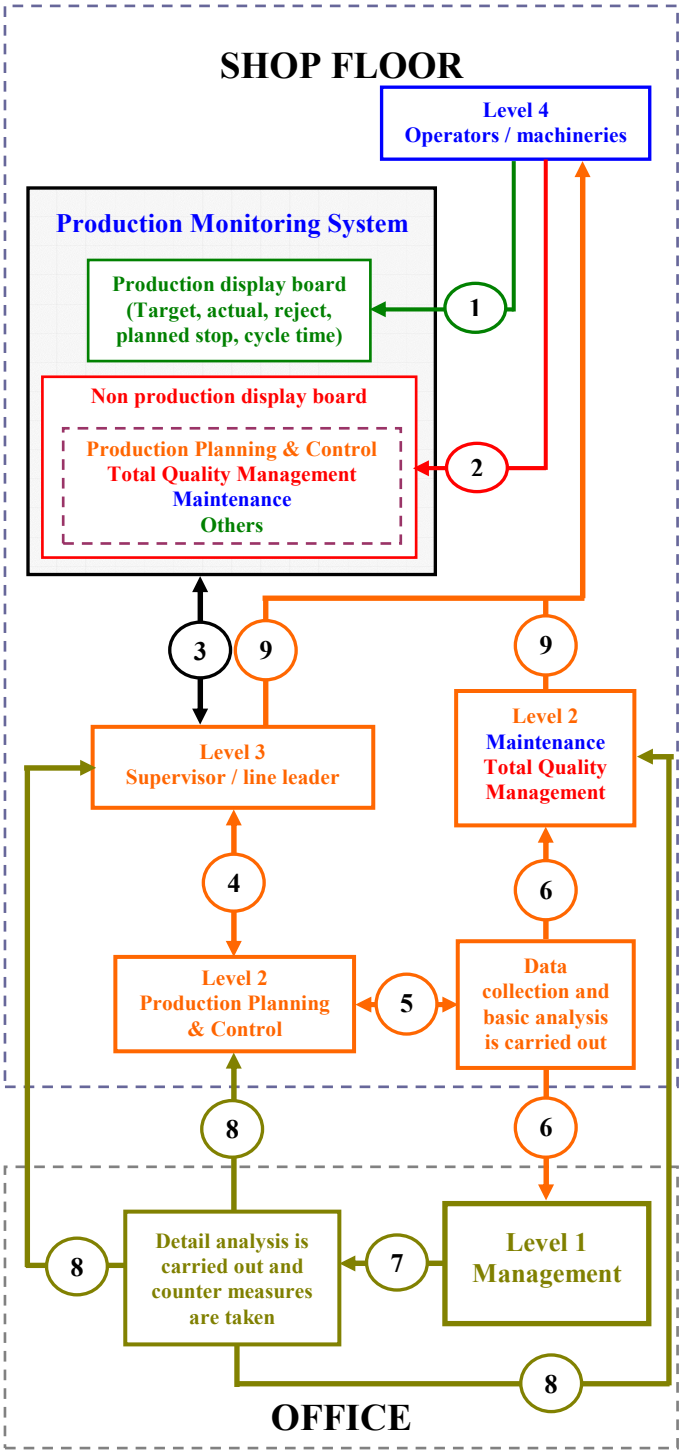

Fig. 5 Production information and data flow in a typical industrial shop floor

A second step of studying the problems and counter measures is designed by the management in level 1to be in line with the companies' target. The counter measures are directed to the proper channel to detect and rectify them.

Table 1: Factors on mail delivery

Flow	Responsible personnel	Data collected	Analysis
1	Operators	Target, actual output, rejected output, planned stop duration.	Comply to set targets and rejects cost
2	Operators	Down time of all supporting department.	Non
3	Supervisor/ line leader	Targeted output, actual output, rejected output, planned stop duration and down time of all supporting department.	Down time factors, unmet targets, rejection rate, man power utilization, planning for next production.
4	Production team		
5	Production team		
6	Production team	Down time of all supporting department.	Down time factors, unmet targets, rejection rate, preventive maintenance, production line improvement and OEE.
7	Management	OEE, man power utilization, performance of the supporting department and production status	Detail analysis on all factors of production and improvement is being planned. Distribute improvement plans by responsible departments.
8	Management		
9	Supporting department	OEE, man power utilization, performance of the supporting department and production status	Corrective measure being implemented on both operators and machineries.

VII. USEFULNESS OF A REAL TIME PRODUCTION MONITORING SYSTEM

The benefits of installing an effective and efficient real time PMS is the immediate on screen access to all production related information. Besides relevant production information's, the system also helps various level of people in industries to optimize their performance at all means.

A. Man Power (Operator)

The proposed PMS is a reliable tool for assisting the operators especially in informing operator of their performance to date.

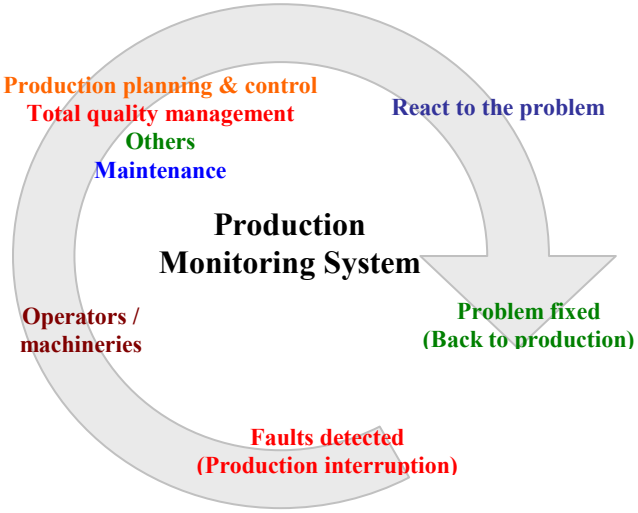

Fig. 6 The process cycle to problem solve faults at work stations using PMS

The PMS also will be able to guide the operator to maintain a consistent pace throughout the day and this will result in a better implementation of work morale among the employees. Once the operators have been tuned to react according to the PMS, this will automatically eliminate wasted time and hence produce more units per hour.

This system also empowers the operator to recognize faults and react to the system by alerting the respective departments to solve problems as they occur as shown in Fig. 6. Such interaction reduces the duration spend to alert the respective personnel and thus increases the efficiency of interaction between the production lines (operators) and all the supporting departments.

B. Machineries

Detail analysis will help the management and the production team to visualize truthful data on their machineries. With such valuable data, further improvement on the productions performance especially involving machineries and unwanted wastages can be eliminated. The available data on each machine can be categorized in 3 different aspects and summarized into a single number which reflects the machinery.

The first category is the availability which reflects the availability of the machine (running time) [9] – [10]. This will indicate the total usage of the machine for each shift. The machine utilization can be counted in numbers rather than assumption. The second category is the performance which reflects the performance of the machine (speed) [9] – [10]. This will indicate the actual running status of the machine for each shift. The third category is the quality which reflects the quality of products produced by the machine [9] – [10]. This will show the management the ratio of good parts being produced over the total produced parts for each shift. All the three above elements provides a complete measure of manufacturing efficiency in a single number which is the overall equipment effectiveness.

C. Supervisors

PMS also benefits the supervisors and the line-leader whereby it act as a supervisory tool, which enables the movement of people (operators) from one job to another when operators are absent or unable to meet production requirements. Such a display system helps the supervisor to monitor the performance of their production lines by referring to the parameters displayed. This will help them to keep the production output back on track to meet set goals within the planned production duration. The process flow of the PMS is shown in Fig. 5 illustrates the task of the supervisor (level 3).

D. Production team

The proposed PMS helps the production team to ensure production goals to be established and monitored continually. Apart from that PMS also helps to increase production at controlled production costs, at all levels of work force, within the set targets and enable continuous improvement of line balancing (bottle neck). PMS helps to screen the work progress and creates awareness when work is not flowing, i.e. it sustains the required production output. The process flow of the PMS as shown in Fig. 5 which illustrates the chore of the production team (level 2).

E. Management

All production related information is presented to the management and supervisors via display boards. These eliminate the clerical error which makes reporting easier compared to conventional methods. Relevant production information can be generated base on the industry requirement and this will help the management to summarize throughput, work in progress, stock information (produced parts) and work around solutions as problems occur. From the data-base the management can also eliminate bottlenecks, unwanted wastage and production interruption.

As a result of the analysis the managements can make counter-measures to ensure better efficiency and capitalize on the available resources for generating better production yield. The process flow of the PMS as shown in Fig. 5 illustrates the task of the management (level 1).

VIII. CONCLUSION

The PMS developed is an essential production tool in industries for both the management and the production team. The PMS captures and distributes unadulterated production information at all levels along the production process without human intervention. Data collected is crucial and this could be collected by using a real time production monitoring system. With the collected data, realistic production goals can be achieved when proper analysis is done and implementation is practiced. Events occurring can also be displayed with the help of a PMS. Production faults can be rectified instantly. A PMS enables the production team to operate efficiently optimizing all available resources towards a better production.

The real time production monitoring system works alongside OEE [11] – [13]. The awareness of OEE is vital when it comes to decision making. Companies have begun to value the great strength of OEE in its ability to help the management improve the overall operation performance of their machineries. With OEE decision making is made easy. The simple metrics of OEE brings to light all the valuable information required by the management [14] – [17].

One of the greatest strength of industries is human capital, whereby they are considered as the major role player in the development of our industries [18]. With the real time production monitoring system on one hand, it helps the management to efficiently monitor the workers and drive towards optimum man power utilization which is in line with the set requirements of industries. Information on human capital will further strengthen the true capacity of the worker's performance not only on the production lines but also to the supporting departments involved in the production process. When man power utilization is being optimized, this will engage morale towards a better production yield [18].

With the limited resources available on the industrial shop floor, the practice of using real time production monitoring system is crucial. The PMS should be fully utilized so that whatever resources available within the industrial sector were not wasted but used to the optimum to improve the production yield [18] – [19]. By taking these necessary steps industries can improve and maintain a more efficient production line.

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BIOGRAPHIES

Siva Kumar Subramaniam was born on 16 July 1981. He received his Diploma of Electronics Engineering from Politeknik Ungku Omar, Malaysia in 2002. He then graduated with a Bachelor Degree in Electronics Engineering (Industrial Electronics) from KUTKM Malaysia in 2006 and his Master studies in Electronics Engineering in the same institution in 2009 which is now known as Universiti Teknikal Malaysia, Melaka. Since his keen interest in industries matters and strong support from the university, the author is involved in the development of the industrial based application such as monitoring systems, automation for industries and control base applications. Engr. Siva Kumar has a few collaboration with industries in accomplishing a number of research projects and consultancy works in Malaysia for the past few years. Apart from research works with industries, Engr. Siva Kumar also supervises secondary school students for their final year projects. He was involved in such projects from his basic degree whereby he won bronze medal in national and international competitions such as the MTE (07 & 09) and ITEX (07 & 09).

Siti Huzaimah Husin currently working as a lecturer and also the Head of department for the Industrial Electronics Department in the Faculty of Electronics and Computer Engineering, Universiti Teknikal Malaysia Melaka. She gained her first Degree in Electronics Engineering (Telecommunications) from Multimedia Universiti Malaysia in 2001. In 2005, she graduated with Master in Electrical Engineering from Universiti Tun Hussein Onn, Malaysia. Her filed of interest in research is focused on embedded system especially on the finished products to solve industrial problems. Siti Huzaimah is a researcher who actively works with various industries and private organizations in many research works for the past 4 years. Siti Huzaimah has also been actively competing and exhibition in numerous competitions and exhibitions in both local and International events whereby she have won bronze medal in MTE 2007 and ITEX 2007.

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Abdul Hamid bin Hamidon @ Hamid Don was born on 3 March 1950. He received his Bachelor of Electrical Engineering from Monash University, Australia and Masters of Science (Electronics) from the University of Wales Institute of Science and Technology, Cardiff, Wales. In 1976 he began his career as lecturer with Fakulti Kejuruteraan Elektrik UTM. In 1986 he was promoted to Associate Professor and made the Deputy Dean (Academic) for 6 years. In 1995 he was Director of the Student Support Services Unit. He was also Head of the RF Subsystem Research Group and was responsible for several course and curriculum development. He was one of the task force responsible for the development of KUTKM now known as Universiti Teknikal Malaysia, Melaka. In 2001 he promoted to Professor and was made the Dean of the Electronic and Computer Engineering Faculty.