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A Visual Board to Facilitate Production Flow Regulation at Sequential Processes

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Abstract

A visual system allows one to assess the production status of a shop floor at a single glance and detect abnormalities like deviations from the production plan. This paper presents a case study of a visual system application on an electronics backend assembly that consists of several mixed-model sequential processes. The production flow is regulated by a push system. Isolated scheduling at the front end significantly contributes to erratic arrival of parts at the backend. A generic visual board was designed and implemented to avoid significant inventory build-up, shorten average flow time, and ensure maximum production leveling. The visual board is named as visual Work-in-progress (WIP) flow monitoring board and is described in terms of its physical appearance, component functions, and operating procedures performed by different levels of staff. The paper also includes the implementation of the visual board and performance evaluation after ten months of execution. The system was found to produce positive results.

Key words: *visual system, production control, shop floor improvement, system design*

1. INTRODUCTION

Production control regulates the implementation of production plans with the prior agreed supply of necessary resources [1]. A production plan specifies production rate, flexibility, and quality within regulatory requirements to enable the company to meet demand targets within a specific period. Resources include various machines, people, materials, and information. The workplace constantly changes as it works to meet the production plan. Production control deals extensively with the generation, collection, processing, transmission, and interpretation of information from the manufacturing system. Production control involves rapidly verifying whether the current status of operations conforms with the standard, detecting any deficiencies, and making corrective decisions promptly.

Numerous manufacturing facilities perform various tasks on a daily basis. Schedules are constantly rearranged due to unpredictable events such as machine breakdown or material shortage. The resulting production flow becomes erratic, especially with shared processes; a single production order is not processed continuously throughout the production because of sharing. At certain points, the order has to be split into smaller batches of varying sizes for separate processing. This scenario occurs as a result of a large batch size, intermittent supply of materials, unbalanced process cycle times, and significant setup times. To optimize the individual process, different loading rules are applied, sometimes without the awareness of management, which then result in asynchronous production flow, unpredictable lead time, and rampant growth of non-value added activities.

The paper presents a case study in which an electronic assembly plant is managed by separate units. The research investigates the proper production control mechanism with the objective of reducing inventory, shortening average flow time, and ensuring maximum production levelling. A visual board system, termed as visual Work-in-progress (WIP) flow monitoring board, is setup to track and provide graphical representations of the amount of specific WIPs between a set of sequential processes. Such a visual board system has not been reported in academic literature. The functional novelties of the visual board system are explained and demonstrated in the current study.

The remainder of the manuscript is organized as follows. Section 2 provides a general description of the visual board. Section 3 provides a background of the case study. Section 4 provides details regarding the visual board system and various functions of the board, and contains a short graphical summary of the implementation process. Section 5 presents the conclusion.

2. LITERATURE ON VISUAL SYSTEM

On a shop floor, ubiquitous visual cues reveal multiple levels of information important to the performed activities. With the notion that these clues can be extracted, enhanced, or reformatted to benefit production control, the visual system has become increasingly prevalent in many companies.

A visual system allows one to understand the organizational context at a glance by merely looking around [2]. A single glance at the visual system allows one to immediately recognize the problems, abnormalities, and types of waste that exist in the workplace at that point [3]. [4] identified nine areas commonly served by a visual system: transparency, discipline, continuous improvement, job facilitation, on-the-job training, creating shared ownership, management by facts, simplification and unification. [5] underscore the need for “seeing” the value stream. A visual system improves organizational performance through connecting and aligning the organizational vision, core values, goals, and culture with other management systems, work processes, workplace elements, and stakeholder [6]. Four advantages are generally expected [3]. First, the system allows rapid comprehension of and response to problems, which increase productivity and work efficiency, reduce man-hours, minimize late deliveries and defects, prevent overproduction, and ultimately reduce costs. Second, the system simplifies and ensures effective control without time costs or negative effects on workplace environment and attitude. Third, the system increases awareness of control technology among supervisory and control personnel, and increases workers’ awareness of problems and costs. Finally, the plant runs more efficiently, and employee morale increases accordingly.

The systems are available in various forms, from sign boards mounted on the shop floor to sophisticated computerized systems. Despite the potential involvement of all human senses, namely, sight, hearing, feeling, smell, and taste [6], the visual system is primarily based on information delivered through vision. [2] provided general principles for visual board design, including clarity of messages and effective use of colors, reference points, and symbols, to reduce the risk of unintentional errors during operations. Visual systems must be simple and should display information that adds value to the management of the process [7]. In addition, an electronic version of the system must be avoided given the inherent drawbacks of a software and computer-based system; such drawbacks include consequent loss of ownership as system maintenance is handled by an exclusive group of people. Systems can be customized to ensure greater ownership and reflect different goals to suit local needs [7].

An effective visual system ensures the availability of timely, complete, and accurate information. The three important components of a complete visual system [8] are the indicator, signal, and control process. The indicator constantly displays the latest performance status, and the signal promptly triggers action when an abnormal discrepancy in performance measure occurs. A well-defined systematic control process assures fulfillment in accordance with the indicator and signal. A number of studies provide specific guidelines and information on visual systems. In terms of communication, [9], based on their ABC model, divided a visual system into activators, behavior, and consequences. The activators are the cues from the environment, behavior is the sequence of observable actions presented by activators, and consequences are outcomes and probability of occurrence associated with the behavior.

A visual system should be self-ordering, self-regulating, and self-improving [10]. The decision making system is decentralized by broadening employee involvement in managing production units. [2] specified three fundamental rules for the visual system: situations are visible to everyone, goals and rules are visible to everyone, and each person participates in the process. Sustaining and perfecting a visual system requires simplification of the controlled systems, more effective distribution of responsibilities, restoring trust among staff, greater coherence in decision making, and effectiveness in terms of scheduling. For example, all relevant parties, including management and executive levels, have to agree on the data to be displayed. Therefore, cultural transformation is essential to ensure that all levels in the firm are open to and prepared for changes in the control system.

Visual systems have been applied in production planning and control systems for decades. The Gantt chart, devised by Henry Gantt in 1910, was implemented in Frankford Arsenal for visual production control as well as to record the type and time of activity and the daily work [11]. A production status board is a common visual process indicator on the shop floor and records information such as jobs in progress, productivity, output, and lead time, among others. [12] presented an example of simple input-output control for loading jobs. The control identifies the overloading and backlogs that occur in a monitored machine at a particular time. Kanban provides visual signals to production to show the maximum WIP levels, thus preventing overproduction or limiting the quantity of WIP in the production line without starving the downstream workstation. If production requires some forms of leveling, the Heijunka box is usually adopted. The box is compartmentalized with distinct production time brackets. Each compartment contains a fixed number of cards which represent a combination of small lot orders from different products. The rationale is to create a production rhythm that ensures equal daily output of each product type. A visual scoreboard, also known as glass wall management, communicates the performance of individual manufacturing units such as cells [13]. The displayed information varies and could include the achieved daily output, machine utilization, quality, and changeover time. [7] applied lean visual process management tools in three case study companies. The first company implemented a visual system on a large board to relay information of the required output generated by the ERP system to the shop floor. The second company used a visual process board to track manual production and performance of the different parties. The third company used boards to monitor the resources utilized in jobs.

3. VISUAL WIP FLOW MONITORING BOARD

Primarily, the visual board aims to monitor WIP level as well as to regulate and synchronize production flow. In providing information, context communication should be unequivocal to avoid ambiguity and arbitrariness. Management decentralization is achieved through system self-organization. Information visibility is adequate in the team's space and to the relevant personnel, particularly the operators. The technical details are provided below.

3.1 **Production environment**

An *n* number of sequential processes, $m_1, m_2 \ldots m_n$ is regulated by the proposed visual board system. Multiple product models undergo these processes in identical sequence. The production is pushed and completed in batches. Buffers are allocated between these processes, and parts are transferred manually in varying quantities. These processes are largely manual or semi-automatic. Only the flow of the main component is traced by the visual board.

3.2 **Instrument and devices**

The main instrument is a substantially rectangular display board with a glossy surface, usually white, suitable for non-permanent markings. The board is commonly used in many industries to display information. The surface of the board, which faces outwards, is the receiving surface and is made of ferromagnetic material. In general, a display board adequately houses two tables of information required by this visual system. However, both tables on two display boards can be separated when necessary.

Information is displayed on the board through card devices. The card device is made of magnetic substrate, thus exhibiting permanent magnetic properties. The outward surface of the card device can be marked or labeled. The marking should be visible and readable from a specific distance. Card devices are of two types, namely, type I and type II. The card devices in each type are identical in size. The first type displays the product name and the second displays the lot quantity.

3.3 **System description**

As mentioned previously, the generic visual board contains two tables: a master table and a regulation table. The information from both tables is read from left to right and top to bottom. The master table consists of three main columns. The first two columns outline the product models to be produced and their respective targeted quantities at a particular time interval. The third column records the output produced thus far to fulfil the targeted quantities. When time intervals need to be refined further, for example, into multiple shifts in a day, the last column can be sectioned into subcolumns, each corresponding to the output achieved within a refined time interval. No specific rules are imposed in selecting the number of rows for the master table. As a general rule, the master table should sufficiently cater to the maximum number of product models expected for the selected time interval. Limiting the number of rows forcibly limits the possible product models that exist in the system at a given time.

The regulation table tracks the movement of WIPs (by using the selected main component as indicator) between the sequential processes, divided according to product models predetermined in the master table. The table consists of a number of columns. The first column identifies the product model. The remaining columns, except the last one, represent the WIP levels (in process and complete parts) contained by individual processes. Each column is uniformly divided into *l* subcolumns, and a regular grid is produced. The width of a subcolumn should be able to hold one card device type II that represents one product lot. The numerical value written on that card signifies the corresponding lot quantity. The number of subcolumns for each process therefore determines the maximum allowable number of lots held in buffer for a specific product at one time. The final column of the regulation table is reserved for recording the achieved aggregate output for each product model, the value of which will be updated on the master table.

3.4 **Updating the master table**

A specific time interval for fulfilling a number of work orders is selected. Each work order specifies the product model and respective quantity to be produced. At the beginning of the time interval, the information is transferred onto the master table via type I card device or written in respective columns. The work orders should be placed on individual vacant rows according to processing priority, from top to bottom. This arrangement could be based on the corresponding order due date. As it is a rolling table, adjustments and rearrangements are made to pending or open orders from the previous time interval.

3.5 **Updating the regulation table**

The work orders listed in the master table are duplicated onto the regulation table. Incoming raw materials available for the studied sequential processes are determined and represented by type II card devices at the respective subcolumns. To begin a new production lot following an arbitrary process, such as

m_i, the operator in charge of the process first retrieves available incoming material and implements the change by simply dragging and dropping the card device (type II) representing the lot from the incoming WIP column m_i to the incoming WIP column of the next process (that is m_{i+1}) on the regulation table. The operator could make a recognizable mark on the card device to indicate that the lot is currently under processing but is not yet available for the next process. Upon retrieving the new lot, the operator at the last process should keep the card device type II and remove this card device only upon completing the lot. If no subcolumn is vacant for the incoming WIP in the next process of a selected product, the lot belongs to other products which need to be changed. This scenario forces product change, thereby ensuring production leveling.

Generally, simple, intuitive loading strategies can be incorporated in selecting the lot to be processed. Such strategies include the following:

1. Product orders with the highest priority should be fulfilled first if the material is available.
2. The process that requires a significant amount of setup time should process the lot from the same products as long as the material is available.

Visualization could exert some forms of passive regulative control on the shop floor, for example, rapid identification of bottlenecks in the workflow. The changes on the board which reflects the actual shifting of WIP enables assessment of the productivity and synergy between processes. Job schedules can be manipulated interactively to alleviate bottleneck or improve production flows. In addition, the visual board is operated manually and presents information intuitively, thus promoting timely decision making for better productivity. The WIP can be controlled in two ways: by limiting the maximum lot quantity that can be represented by one card device and by reducing the number of subcolumns in each process.

4. CASE STUDY

4.1 **Background of the case study company**

Company X is an electronics assembly plant and an electronics manufacturing service provider. Most of its operations are performed in three shifts per day, six days a week (overtime on Sundays are only for backlogs). The company assembles a daily average of 4,000 products from multiple product families.

Production can be classified as high-mix variable volume with unbalanced and asynchronous flow. On the shop floor, the process begins with scanning and labelling printed circuit boards (PCBs), which are then sent to the surface mounting equipment (SME) for solder printing, followed by chip placement, heating in an oven, and automated optical inspection. The PCBs are transferred to depanelling in which an unwanted area of a PCB is removed by using either a punching machine or a routing machine. The depanelled PCBs are kept in partitioned carton boxes. The boxes of PCBs are moved to the backend. Production flow is regulated through a push system. The job order quantity is large and processing is staggered in smaller local batches. The push system creates significant inventory build-up, erratic arrival of parts, and scheduling problems at the backend. The full adoption of a pull system is believed to be premature and will severely affect the productivity of the SME.

4.2 **Studied processes**

The study focuses on backend processes. The processes include depanelling, dip soldering, touch-up, In-Circuit Test (ICT), and Functional Visual Test (FVT). The machines are either manual or semi-automatic. Two supermarket racks were installed to store incoming materials from SME and ICT. The processes are shared for several other models. The incoming materials arrive through a push system from SME. Outputs from Cell-B are sent to quality assurance, and the changeover time for ICT and FVT is 10 minutes each. Except FVT which has two homogeneous workstations, each process consists of one workstation. In general, the product flow can be classified into two types. The first type is composed of eight percent of the model variety but utilizes thirty percent of the product volume. This type skips the depaneling process at the backend. The remaining model variety is classified as the second type. At the backend, this model requires depanelling before entering ICT.

Only supervisors and line leaders are authorized to update the schedule. Operators have to fulfill production output as dictated by the daily schedule updated by supervisors, often verbally. The model to be loaded is largely determined depending on operator discretion and the availability of the model in supermarkets. In general, operators continue production of the existing model when the materials are available. Otherwise, the operator consults a supervisor regarding model changeover.

As shown in Figure 1, the layout is in the form of a "quasi cell" job shop. Although workstations are arranged largely into a manufacturing cell, operations are similar to a job shop, as evidenced by the following observations. Operations are not smooth, and machines often operate as standalone processes. The arrival of parts from the SME is highly inconsistent. The SME often fails to deliver the required material to meet daily processing at the backend. The upstream model change affects production flow of the studied processes. In turn, the processes either starve or face a sudden influx of parts. Operators remain idle during cases in which the raw material is not ready or all orders have been completed. Additionally, parts may also arrive from the rework center or failure analysis. The processes encounter delays during particular periods. In some cases, more than two weeks elapse between the arrival and updating of a particular order, whereas other orders are processed in a few days.

Consequently, many partially processed parts often accumulate at the supermarket area. In supermarkets, the parts are not properly stored and sequenced. Retrieving material from supermarkets takes about two minutes with minimum searching. The maximum stock level in supermarkets is relatively high at approximately 82 bins, which complicates searching during withdrawal.

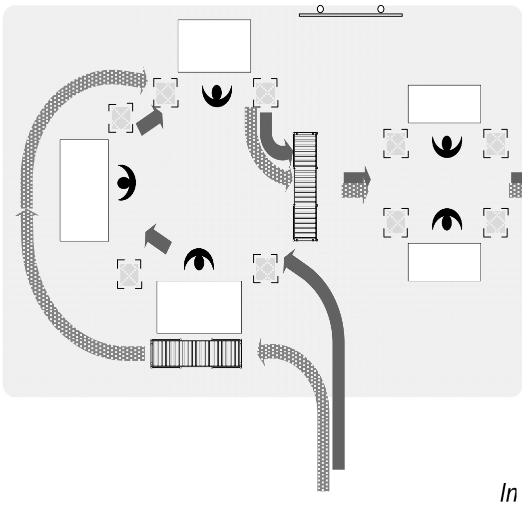

Figure 1. The layout of backend

5. VISUAL WIP FLOW SYSTEM

5.1 Description of the board

A 3’ × 4’ magnetic white board is used to house the master and regulation tables (figure 2). As shown in figure 3, the master table is placed at the top, and the regulation table is placed at the bottom of the board. The master table contains four main sections: the product name, part numbers, plan quantity, and the output for each shift. A separate study on recent data revealed that a maximum of ten variants can exist in an arbitrary day; therefore, ten rows are given in the table. The WIP movements in the form of PCB between the ICT and FVT processes are traced. Therefore, the master table contains five columns: product model name, part number, T/Up dip soldering, ICT, and FVT. Similarly, ten rows cater to the maximum number of foreseeable product models. Columns which represent T/Up dip soldering and ICT are each further divided into five small columns. Each small column of a particular row can hold one card device type II which has a numerical value of 10, 20, 30, 40, or 50. This numerical value corresponds to the lot size of the batch currently held at one process. For example, three card devices with values of 20, 30, and 50 for column T/Up dip soldering at row with product X means three batches with the aforementioned lot sizes are queued for ICT. The maximum WIP level per model allowed to queue or be completed is 250 pieces. The total output column records WIP which exits FVT or those that have completed all three processes.

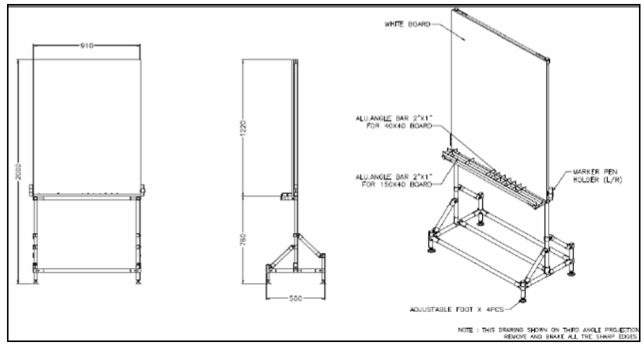

Figure 2. The appearance and dimensions of the board

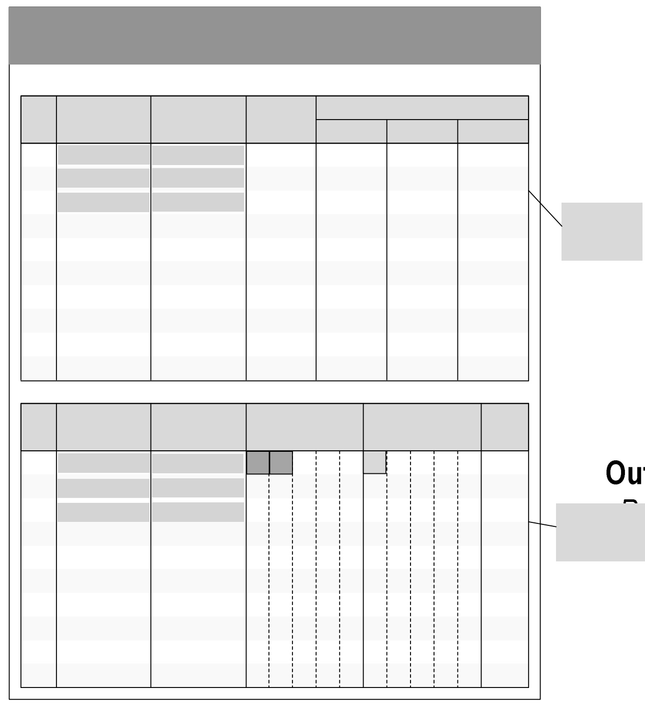

Figure 3. The design of the visual WIP flow monitoring board

5.2 Operating procedures

A production day begins with the night shift of the previous day. Therefore, during the night shift, the shift leader converts the planner schedule into a daily plan based on available and incoming PCBs. The leader identifies the product models and variants to be produced that day. The card device of product models and the related quantity are placed on the top table. Their processing sequence may be altered later according to resource availability. The table is updated by the shift leader at the change of shift.

In one round, a trolley with a maximum of four bins, each carrying ten PCBs, is processed. In completing these PCBs, the operator in charge of the touch-up/dipping process moves the PCBs back to the supermarket and updates the visual board by placing a card device of the respective quantity on the T/Up dip soldering. This step informs ICT operators of the availability of WIP ready for the process. Withdrawal of the lot from the supermarket requires the ICT operator to move the card device to the next column, which signals a change in process. Parts are moved from the ICT on a first-come, first-served basis. Upon exiting FVT, the operator of the FVT workstation removes the card device and updates the quantity at the FVT column.

Immediately after a product model reaches its target output, the operator in charge of the touch-up/dipping process begins processing the next unfulfilled product model and requests a product changeover from the team leader. At the same time, the team leader updates the top table to indicate that the demand for that model has been fulfilled and keys the total output into a computer before the end of the shift.

5.3 **Implementation**

Implementation takes place over a period of nine weeks. Progress over this period is shown in Figure 4, starting with a definition of the production flow problem at the backend process. The Kaizen team is established. Alternative ideas were conceived during several brainstorming sessions and gemba (on field visits), ranging from limiting the schedule change at the front end process to a one-piece flow within the process at the ID backend. Ideas are filtered through internal and management meetings based on practical solutions and the company's lean principles. Finally, the visual WIP flow system is selected. A detailed drawing of the display board is developed, parallel to the manual simulation on the shop floor, to obtain feedback from the line leaders and operators. Modifications are made accordingly. In addition, during the design stage, the engineering department is frequently consulted because any visual system to be implemented requires their approval.

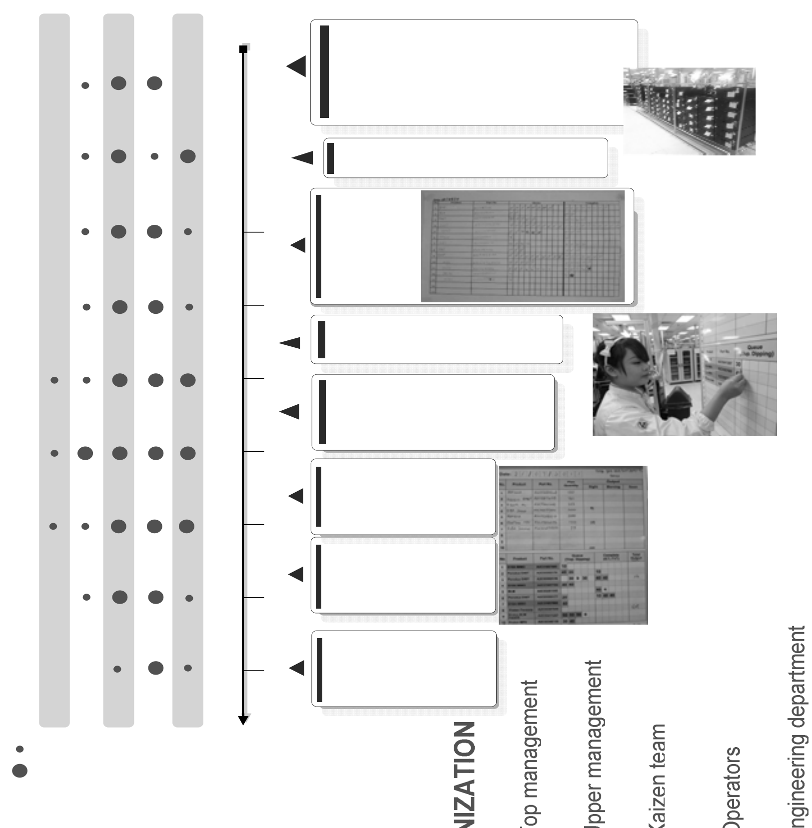

Figure 4. The progress implementation of visual WIP flow monitoring board

6. RESULTS AND DISCUSSION

To ensure the system’s long-term function, the shop floor was revisited and a survey was conducted ten months after implementation. The system continued to be implemented, and production deadlines were regularly fulfilled. Production control has become a habit among the staff, and the observed WIP levels matched the information on the board.

WIP between these processes was significantly reduced. Kaizen activities were conducted to bring the visual system to other departments, for example, in the printing and punching processes. Slight modifications were proposed to cater to specific needs of these departments, such as adding more information and using different color schemes to represent a new dimension.

The survey consists of 17 questions on various aspects of production relevant to the visual board system. The answers to each question, except the last question, are either true or false. "True" indicates that a difference was noted, whereas "false" indicates no difference. Twelve people from different levels were interviewed. The supervisors, line leaders, and operators were randomly selected from different shifts. The results are shown in Table 1. A significant amount of evidence shows the benefits of the visual board to the staff involved in the applied processes. For example, they agreed unanimously that the WIP and the time spent searching and counting WIP were reduced. Staff members were highly aware of what would be produced next. Management appreciates the installation of the visual board in aiding detection of areas for improvement. However, only a weak reduction in process cycle time was observed, despite a largely perceived smoother production flow with daily demands being met constantly. Furthermore, the learning curve was inconsistent, as one operator required 30 days to be fully acquainted with the system. Further investigation revealed that this operator and another operator who required 14 days to learn the system were foreign workers who were new to the company. Both had limited proficiency in English and Bahasa Malaysia.

Table 1. The summary result of the survey

	AM	Tech Ex	S1	S2	L1	L2	O1	O2	O3	O4	O5	O6
Reduction in WIP	1	1	1	1	1	1	1	1	1	1	1	1
Time reduction in WIP searching	1	1	1	1	1	1	1	1	1	1	1	1
Time reduction in WIP counting	1	1	1	1	1	1	1	1	1	1	1	1
Less human errors	1	1	1	1	1	1	1	1	1	1	1	1
More conscious on what to do be produced next	1	1	1	1	1	1	1	1	1	1	1	1
More awareness on own production pace.	1	1	1	1	1	1	1	1	1	1	1	1
Product changeover happens more frequently.	1	1	0	0	1	1	1	1	1	1	1	1
Product changeover happens more systematically	1	1	0	0	1	1	1	1	1	1	1	0
Better coordination with other processes	1	1	1	1	1	1	1	1	1	1	1	1
Output increases	0	1	0	0	0	1	1	0	0	1	0	0
Easier daily recording or monitoring	1	1	1	1	1	1	1	1	1	1	1	1
Meeting daily targets	1	1	0	1	1	1	1	0	0	1	1	1
Smoother product flow	1	1	1	1	1	1	1	0	1	1	1	1
Easier to follow up during the shift change	1	1	1	1	1	1	1	1	1	1	1	1
Better supervision	1	1	1	1	1	1	1	0	1	1	1	1
Better detection of areas for improvement	1	1	1	1	1	1	0	0	0	1	0	0
Days to understand	7	7	1	2	1	7	7	7	7	1	30	14

Note: 1 =noticing different, 0 = no different, AM = assistant manager, Tech Ex= technical executive, S = supervisor, L = leader, O = Operator

In addition to the survey, a few functional novelties of the visual board were observed in the case study and are described as follows:

6.1 **Production flow regulation**

The current workload, namely, orders that need to be started and completed production, can be determined at a single glance. Rapid shift transition with minimum possible delay is achieved as operators can consult the board to determine which product models to continue processing. A supervisor collects data directly from the board during production. An executive can rapidly grasp backend conditions; for example, discrepancies in planned and actual output are detected, thus preventing overproduction. Previously, operators received verbal instructions from leaders, which caused misunderstandings. By knowing the total number of units received for processing, premature changeovers, particularly at ICT, can be prevented.

Implementing visual boards directly improves parts retrieval from supermarkets; the results are shown in Table 2. Previously, search time was high because an operator in one process needed to refer to the daily schedule and search for available materials based on a list. A visual board clearly indicates the processing priority and availability of materials, thereby eliminating decision making in searching.

Table 2. The result of time required to retrieve parts from supermarkets

Condition of Inventory level	Average time required to retrieve parts from supermarkets (ICT or FVT) (sec)	
	Before	After
High	189	96
Moderate	150	60
Low	80	60

Verification can be performed with data collected by the TPM program currently used by the company. For example, a machine breakdown results in slower production, and the accumulating WIP is shown on the visual board.

6.2 Pacing mechanism

The processes involved are not fully balanced. WIP accumulates and decouples the production pace of these processes. Although inevitable, the WIP level can be controlled. WIP levels of individual workstations are presented on the visual board. The visual board implicitly features a pacing mechanism which influences the WIP levels. The operators who run the processes have to be fully responsible for the WIP level. Any withdrawal of WIP from an upstream supermarket to a process indicates a transfer of WIP to the authority of that process. However, the WIP will not move to the next process unless it is retrieved by the downstream process, which establishes certain pulls in the push production. Operators obtain basic lean knowledge and recognize that WIP is an unwanted waste. When a high level of WIP in a process is detected on the visual board, the operator-in-charge slows production in that process. For processes with multiple workstations, one operator is freed to assist the bottleneck process until the situation improves. However, a low level of WIP in a process indicates that the upstream workstation is slow. To prevent starvation, that workstation needs to increase production speed.

Furthermore, in case of machine breakdown at the upstream process, a technician can roughly estimate the repair time that can be spent based on the WIP level. Filled subcolumns indicate gradual WIP buildup. When such abnormality persists, the situation is investigated.

6.3 Leveling

As mentioned previously, each process level is represented by five subcolumns. As the maximum lot size is 50 pieces, each level can accommodate a maximum of 250 pieces at once. When all the subcolumns that pertain to a particular product model are filled, a changeover to the next model is necessary, which indirectly facilitates production leveling. Production leveling aims to produce a mixture of products in a shared facility within a given time interval through processing alternate and preferably small batches. This process allows more frequent replenishment of WIP at the downstream process; therefore, service level is effectively improved without increasing the buffer level. When the maximum lot size of 50 pieces is used, and no withdrawals that entail transferring the card device to the subcolumn in the downstream process are made, every 250 pieces trigger a changeover. When the card device type II that represents a larger lot size is removed, production will have to run in smaller batches; therefore, more frequent changeovers can be expected.

6.4 Team spirit and instilling ownership

The distribution of responsibilities among supervisors, line leaders, and operators is clear. The system is accepted and the supervisor is no longer solely responsible for detailed monitoring of the progress of operations between these sections. Operators also gain limited autonomy in informing the supervisor of product change and deciding on the product processing sequence.

7. CONCLUSION

A visual system is important in factories as it allows one to understand production status at a glance. Through effective use of a visual system, problems, abnormalities, and the types of waste in the workplace at that point are instantly recognized and addressed. This paper describes a production flow monitoring technique that uses visual WIP flow monitoring board for multiple processes on asynchronously manned workstations. Movable cards for each manageable lot are positioned on a regular grid to represent the involved processes. The visual board helps users intuitively visualize and monitor certain aspects of the manufacturing process being studied. The system was successfully implemented and improved production processes for electronic assembly in backend processes. Evidence collected from the site proved the benefits of the system.

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Vizuelni prikaz radi pojednostavljivanja regulacije proizvodnog toka u uzastopnim procesima

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Rezime

Vizuelni sistem omogućava procenu statusa proizvodnje postrojenja jednim pogledom i otkriva abnormalnosti poput odstupanja od plana proizvodnje. Ovaj rad predstavlja studiju slučaja primene vizuelnog sistema montaže elektronskog krajnjeg dela procesa koji se sastoji od nekoliko uzastopnih procesa mešanog modela. Proizvodni tok je regulisan 'push' sistemom. Izolovano vremensko planiranje na početnom delu značajno doprinosi nestalnom dovodu delova na krajnjem delu. Generički info tabla je dizajnirana i primenjena kako bi se izbegla značajna nagomilavanja inventara, skratilo prosečno vreme toka i obezbedilo maksimalno ujednačavanje proizvodnje. Info tabla je označena kao tabla za vizuelizaciju zaliha u procesu (Work-in-progress-WIP) i opisan je na osnovu fizičkog izgleda, funkcija komponenti i operacionih procedura koje izvodi osoblje različitog nivoa. Rad takođe uključuje i primenu vizuelnog prikaza i evaluacije performansi nakon deset meseci primene. Pokazalo se da je sistem proizveo pozitivne rezultate.

Ključne reči: *vizuelni sistem, kontrola proizvodnje, poboljšanje postrojenja, dizajn sistema*