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Research Paper

PART AND INFORMATION FLOW CHART (PIFC) MAPPING FOR ESTABLISHING PULL SYSTEM IN HEAT TREATMENT AND MACHINING LINE

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This paper is to demonstrate the adoption of the Part and Information Flow Chart (PIFC) to establish PULL/Just-In Time (JIT) System at an automotive industry for a model component in Heat Treatment and machining line. PIFC is one of the lean tools, also known as Material and Information Flow Chart (MIFC) or Value Stream Mapping (VSM). It is widely used as a framework for systematic and structured improvement activities in JIT implementation. In addition, PIFC is a versatile tool to scrutinize in detail relationships between materials and information flows from the beginning until the end of any process. The PIFC used is a means to map how the materials and information is been delivered along the system, in visualizing the studied area. Findings show that PIFC is an effective tool in identifying wastes (Muda) and source of the waste, areas for improvement as well as appropriate tools for Kaizen activities.

Keywords: Kaizen, Muda, PIFC, PULL System/JIT, TPS

INTRODUCTION

The process of structuring, operating, controlling, managing, and continuously improving industrial production systems is commonly associated with basic philosophy of Toyota Production System (TPS). The process of finding the points that harm quality, costs, safety and production at workplace, and to improve them is commonly associated with basic philosophy and concepts of Kaizen. The philosophy of TPS defined as a process of optimizing the existing production activity based on customers' need by identifying and understanding the customers' values. Hence, it is characterized as customer focused, eliminating waste, creating value, dynamic and continuous. Just-In Time (JIT) production principle mainly based on producing only saleable products that market need, which represents the spirit of creation by the founder "Kiichiro Toyoda".

TPS is not new to most automotive industries; manufacturers from Japan, such as Toyota, Kayaba and Honda, initiated it by which

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local car assemblers and their suppliers follow it. The reasons why it is applied may vary but it is been executed with the same objectives, which include on-time delivery, to maintain quality, to increase profit by reducing operations costs and to remain competitive in the local as well as global markets.

The main goals of TPS are cost reduction and improvement of productivity, which focuses on activities such as eliminating waste, reducing inventory and continuous improvement.

Thus, this research seeks to identify all wastes and source of wastes as classified in the TPS philosophy and to implement appropriate lean tools for improvement activities for the model component at Heat Treatment and Machining line.

LITERATURE SURVEY

In TPS, waste is been defined as anything related to the process that adds cost but does not add value to the final product produced. Waste identification and elimination is one of the TPS's goals and believed to be one of the most effective ways to reduce the production cost and increase the profitability of many companies. Some of the examples of wastes elimination activities are elimination of rework, unneeded transportation, waiting time, rejects and non-value-added activities such as multi handling, recheck and marking process. To eliminate waste (Muda), it is important to understand what waste is and source of the wastes.

Taiichi Ohno, Toyota's Chief Engineer, during the development of the TPS almost 50 years ago, identified seven wastes (Muda). It is been classified as: (i) transportation; (ii) inventory; (iii) motion; (iv) waiting; (v) over processing; (vi) over production; and (vii) defect. Ohno believed that these wastes account for up to 95% of all costs in non-Lean Manufacturing environment. The Lean Enterprise Research Centre, Cardiff, UK, through their research reinforced the above statement, which concluded that, for a typical physical product environment, 5% of the total activities were Value-Adding Activities (VAA), 60% were Non-Value-Adding Activities (NVAA), and the remaining 35% are necessary but NNVAA. Since NVAA is a waste, many manufacturers who are aware about this matter strived to eliminate as much waste as possible in their system.

The effectiveness of TPS are supported by a set of lean tools such as Kanban system, Standardized Work (SW), PIF (MIFC/VSM), Total Productive Maintenance (TPM), Single Minute Exchange of Dies (SMED), Continuous Flow Manufacturing System, Kaizen, 5S, Heijunka system and others.

PIFC is the most widely used tool in JIT (Pull System) implementation. Taiichi Ohno, the creator of the TPS and Kanban system in Toyota created this tool. PIFC is been used to teach TPS and lead major TPS projects in Toyota. The main function is to; visually represent the flow of material and information on individual processes. Originally, this tool within the company passed on; through the learning by doing, without any standard document on how to develop the PIFC. Eventually, this idea was put forward and formalized by Rother in his book "Learning to See", which teaches the methodology on how to exploit this tool and named it Value Stream Mapping (VSM).

Therefore, most manufacturers, journals and books use the terms VSM to demonstrate this tool instead of PIFC, which is used by Toyota and its' suppliers only. As research done by Toyota Assembler Team, rather than VSM, the PIFC term and methods is used.

Both tools, PIFC and VSM have similar functions and serve the same purpose except for some differences in the iconic illustrations during the mapping process. They are rated as one of the most efficient visual illustration mechanism in capturing the current state of the system, identifying the long term vision, and developing a plan to get the target. In VSM, lead-time for each process is been shown at the bottom of the map, in the form of total lead-time for the process. While in PIFC, lead-time and related information about the process such as working time and shift operation are located at the top of the map. Therefore, it is easy to access via PIFC, the detailed information about process.

CASE STUDY BACKGROUND

The assembly line of the automotive industry works on the customer demand, which works on a PULL system. The assembly line acts as the customer for its subsequent process, machining line and heat treatment area. My case study area for this research is between heat treatment area and machining line for a model line component PART X*. The machining line produces PART X-part, that is supplied to next process (Heat Treatment-Jig Setting), which is currently working on a PUSH system. The PART X part has two types—one groove (1G) and two grooves (2G), which requires tool change and type changeover at the machining line. The machining line runs on 8 h per shift and runs in two shifts per day, all year long except for public holidays and major shutdowns.

The machining line is a semi-automated production with manual loading and unloading at the beginning and the end of the process. The Team Leader (TL) would do the tool change and type changeover from 1G to 2G or vice-versa once every day depending on the requirement of the customer (Assembly PULL). The type change takes a minimum of 30 min or may vary. The heat treatment runs a batch production process and maintains some amount of Work-In-Process (WIP) to meet the customer demand without any assembly line stoppage.

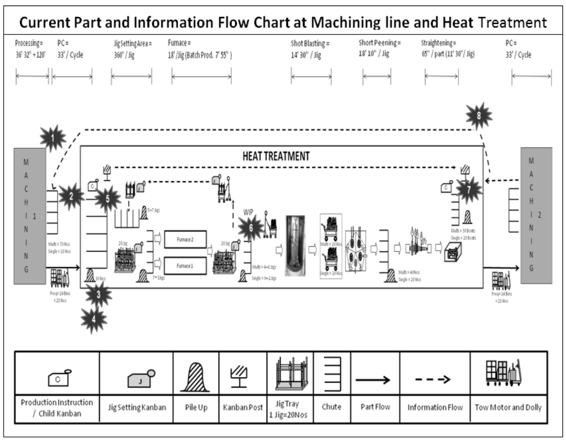
Part transfer or loading and unloading process between the two work areas is done by a material handler (PC-Production Control member) in large quantities according to the production order, i.e., the PC member takes care of this transfer using tow motor and dolly to carry parts. When the request arrives, the PC member will refer to the requested part using Kanban and accordingly load the parts. If no parts were available, PC member would post a delay Kanban indicating the requirement of part.

The production planner/production control department on a monthly basis prepares the production schedule. This schedule used as a reference point by the production department to monitor their weekly and daily production outputs and variations in fulfilling the customer's order. The schedule usually is, updated further as needed according to daily requirement.

METHODOLOGY

This is a model component based case study; therefore, through the following process data was gathered. Observation were done during normal production time with the aid of documents such as Standard Operating Procedures (SOP), existing Process Flow Chart (PFC), Daily Production Report (DPR) and conversation with the production engineer and line leader. By using stopwatch and by referring to Production Control System (PCS) data is collected. For cycle time analysis, time study method was been used according to the method introduced by Frederick W Taylor. Then, standard cycle times and batch processing time for the studied line were been studied. These data was been used during line analysis, mapping current PIFC and data comparison. Current PIFC for model line component PART X is as shown in Figure 1.

Figure 1: Current Part and Information Flow



ANALYSIS

There are many wastes identified in the system. Kaizen Point Check Sheet (KPCS) is been used to document all the wastes and areas that were identified for Kaizen, as in the Table 1 below.

We would focus on improving the system with the help of PIFC for the model line using the Type-III standardized procedure for which "takt time cannot be calculated, and the same work is not repeated", using the Operational analysis chart, Workload chart. For any Type-III standardized work, Total Workload = Regular Working Hours.

With the help of workload chart as shown in figure 2 and 3, operation analysis chart shown in figure 4 and 5, it is found that PC-2 member was doing a supplementary job of walking to other PC member (PC-1) to collect child Kanban, Kanban post exchange with PC-1 member. This included muda of 1.67 %(7min 28sec) of walking and 0.51 %(2 min 20 sec) of exchanging. The PC-2 member also did the irregular job with the muda percentage of 4.48% (19 min 50 sec).

Through Operation analysis and Workload chart of the PC members under study, it was found that PC-2 member was doing a supplementary job of walking to other PC member (PC-1) to collect child Kanban, Kanban post exchange with PC-1 member and this included muda of 1.67% (7 min 28 s) of walking and 0.51% (2 min 20 s) of exchanging. The PC-2 member also did the

Table 1: Kaizen Point Check Sheet (KPCS)

Line No.	Machining Line and Heat Treatment Types of waste	Component: Areas	Part X (1G and 2G) Description
1.	Transport	Part handler (PC member- PC1: Heat Pick up and supply, PC2: Machining Pick up and supply)	Muda of waiting and walking for kanban exchange between both the PC members was been identified.
2.	Inventory	Machining- FG chute line side	No FG inventory or Large FG stored of the type that is not required / requested by next process.
		Heat treatment (Jig setting)	No stock available for the actual required part to do jig setting and also at instances, there is no stock of either type of the variant of a particular part.
3.	Motion	Machining Line	TL has to check the status of stock and delay posted at the Heat Treatment (jig setting area) to do type change. No proper triggering for machining line happening.
		Heat Treatment	The child kanban moved from jig setting area to heat out by the member.
		PC 2 member (Machining Pick up and supply)	For exchanging the kanban post, the PC member is walking back and forth.
4.	Waiting	Heat Treatment (Jig setting)	Parts are not available to do jig setting. The stock piled up on the chute side is a mismatch of what is required and what's requested. Delay of parts.
5.	Over production	Machining Line	Due to frequent machine breakdown and the bottleneck process within the machining line, it takes extra man-hours and energy such as electricity, oil.

irregular job with the muda percentage of 4.48% (19 min 50 s).

The following are the conclusions made through data collection and observation:

1. Triggering at the machining line for doing a type changeover is not taking place properly.
2. No standardized work applied at study area and operators performed their task without fully adhering to SOP.
3. Operators frequently stopped production due to machine breakdown.
4. Large delay of parts at Heat treatment-jig setting area, waiting for parts from the machining line.

5. No stock of required parts, due to a mismatch of, what is required and what's requested at Jig setting area.

Figure 2: Workload Chart of PC-2 Member-Machining Line

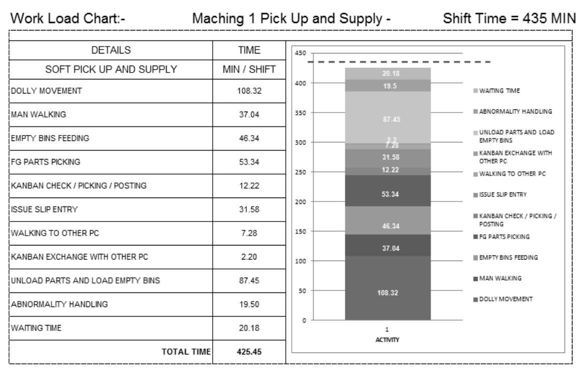


Figure 3: Workload Chart of PC-1 Member-Heat Treatment

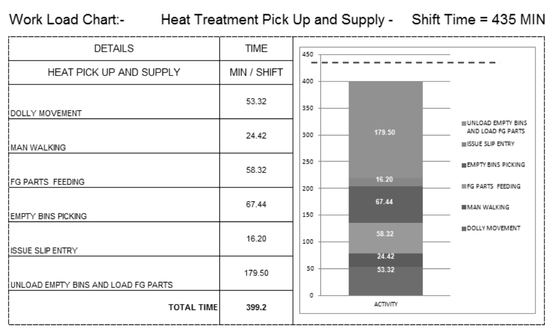


Figure 4: Operational Analysis Done for PC-2 Member-Machining Line

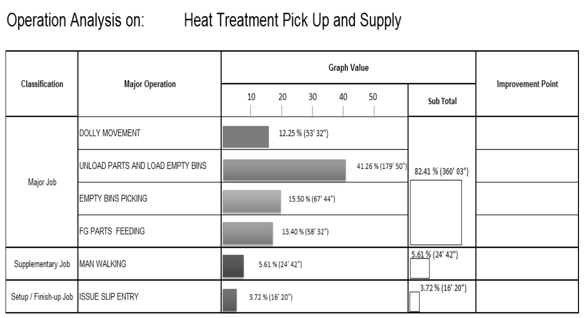
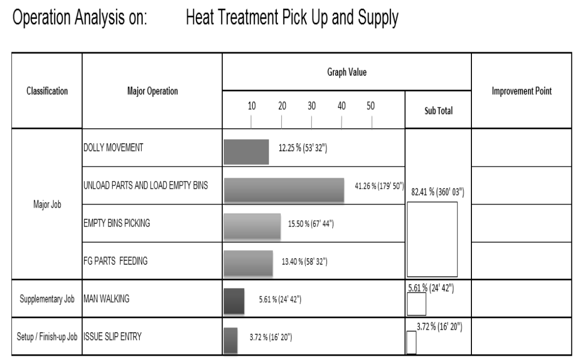


Figure 5: Operational Analysis Done for PC-1 Member-Heat Treatment



6. The machining line is operating on a PUSH system and limited continuous flow, with a delay of not producing the requested parts.
7. Bottleneck occurred between both workstations with low work-in-process stock.

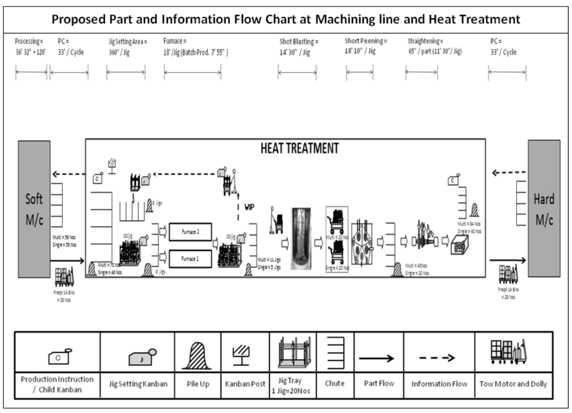
There are many non-value added activities such as walking to other PC member, collect child Kanban, movement of child Kanban within heat treatment area, movement of Team leader/Team members to collect the status of delay posted at heat treatment area.

IMPROVEMENT ACTIVITIES

A set of Lean metrics identified for the case study area, also known as, lean parameter is the most common tool used by many manufacturers to measure and monitor the impact of implementing JIT techniques in their company. This is been used as a guide for the team to achieve its target and it helps to drive continuous improvement and waste elimination.

For this case study of a model line purposes, the lean metrics such as product lead-time, cycle times, capacity, overtime, breakdown times, and continuous flow manufacturing system is been adopted. All the metrics are been documented in Cell Kaizen Target Sheet (CKTS) as shown in Figure 6. Target for the metrics was set based on the company's targets which is to run the production at or less than the assembly takt time. Then, improved PIFC designed and mapped as shown in Figure 6.

Figure 6: Proposed Part and Information Flow



Five major improvement activities are been implemented to achieve the mentioned targets:

1. De-link the routing between the workstations; eliminate the Kanban exchange between the two PC members.
2. Workload balancing and reduce bottleneck process.
3. Continuous flow manufacturing system and eliminate mouth-of-word communication (among the team leaders/team members) between both workstations.
4. Eliminate stability issues such as machine breakdown and quality problem through detailed root cause and counter measures analysis by using 5-Why methods.
5. Plan the production hours to meet any delay that occurs.

EXPECTED RESULTS

As the implementation is still in process, the results are to be calculated. After the implementation fully settled and stabilized as well as the line performance being achieved the set target, we use the Cell Kaizen Target Sheet (Table 2) to perform results comparison on the metrics used.

Table 2: Cell Kaizen Target Sheet (CKTS)

Line:	**Machining and Heat Treatment**	**Model line Component:**	**Part X (1G and 2G)**
Metrics	**Existing**	**Target**	**Results**
Line cycle time (s)	**78**	< 72	Yet to Calculated
Manufacturing capacity (parts/shift)	**300**	335	
Delay (Numbs)	**35/more**	zero	
Break-down time (h)	**2 h/more**	zero	
Continuous flow manufac-turing system	**No**	Yes	

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