CRITICAL FACTORS FOR PRODUCT CHANGE TIME LOSS IN MANUFACTURING OPERATION

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Presented at International Symposium on Research in Innovation and Sustainability 2019 (ISoRIS '19) 28 -29 August 2019, Penang, Malaysia.

ABSTRACT: *This paper aims to identify the elements affecting manufacturing performance. These elements are derived from the operation's Time Loss (TL) which results in a decrease in productivity. TL is a non-value-added activity and time delay during the manufacturing operation. The methodology used was using findings from the literature review and performing a comparison study through Microsoft Excel Spreadsheet as a tool. Then, basic 4M Factors (Man, Machine, Method, and Material) are applied as a specific cluster in order to further investigate and classify the critical elements influencing the operation TL. Based on the critical elements classified, further literature research is done to identify the sub-elements. Finally, three categories of the critical elements and twelve sub-elements affecting the manufacturing performance by TL had been identified. These critical elements provided the manager's useful insight prior to taking appropriate improvement actions on activities related to the critical elements identified. The results of this study help to increase the operational performance especially improvement in the productivity through the increase in the production rate. Further, the critical elements identified will be used to develop a Time Loss Index (TLI) framework structure.*

Index Terms: Time Loss, Manufacturing Operation, Productivity, Production Rate...

I. INTRODUCTION

In the current era of globalization, industries are facing obstacles to producing goods to compete and survive in the global market. In order to meet customer requirements, almost companies are facing a global obstacle and competition in offering a variety of products and enhancing their manufacturing output. In order that measuring time is one of the activities used to improve the operational performance. The most daunting issue faced by manufacturers today is how to produce their products quickly at zero or minimum production time reflected to the TL. A specific approach is being used to focus on certain aspects or elements of the manufacturing process to eliminate or minimize non-value added activities and improve quality while processing time and cost are reduced, which regards the use of resources for any work other than the creation of value for the end customer is waste and thus, a target for elimination [1].

II. UNDERSTANDING OF TIME LOSS FACTOR

In order to address the intent of this study, the attempt of finding the critical elements of TL was based on the steps that are explained further in this section. At the beginning of this study, the assessment elements were defined based on the literature review as a qualitative data collection, and a comparison study was done based on the 4M factor (Man, Machine, Method, and Material). This was done prior to sorting the sub-elements into the 4M categories then clarify which factor has the highest impact on the TL by looking at the highest percentage of journals reviewed as presented in Table II. Then, the factor was further classified into measurable and un-measurable sub-elements for the purpose of developing the index for a measurable element. The measurable sub-elements were further researched through reviewed journals resulting in classified sub-elements which are the Input, Operation, and Output terms according to Inputs-Outputs Model. Further literature research also showed operation has a major impact on the cumulative total lead time. Then, it categories the sub-elements in operation in order to extract a critical element into Pre-process, In-process, and Post-process terms. The flow of processes will be explained in detail in the next section.

A. Comparison Study

A comparison study on the reviewed journals was done using the Microsoft Office Excel spreadsheet as a platform to identify which factor is the most critical related to the TL. The factors were divided into 4M factors (Man, Machine, Method, and Material) as the main contributor to TL. Table I shows the further analysis for the aspects or sub-elements that are affected by the TL in the manufacturing operation being acknowledged and sorted by the 4M factors.

From the literature search in Table I, further searches were done to summarize the sub-elements of TL in the manufacturing operation, and use these sub-elements to determine the variables for this study. Table I shows a summary of the percentage of journals categorized into each of the 4M factors. Results showed that many papers have appraised the time-based implication on the operational outcome and the perspective of lead time or the non-value-added aspects. Only a few authors focused on the waste related to time. There has been no consistent agreement about operations performance of TL elements elimination or minimized execution.

Table I: Sub-element Comparison Study

Journal	(1)	(2)	(3)	(4)	(5)	(6)
MAN		Labour utilization [10]	Staff skill [3]		Worker movement [4]	Improper manpower utilization [12]
MACHINE			STR, Maintenance, Equipment layout [3]			Improper machine use [12]
METHOD	Waiting time [14]		defect quality [3]		Overproduction, waiting [4]	inefficient work organization [12]
MATERIAL			JIT supplier, material flow & handling [3]	Material flow and handling [11]		improper selection material [12]

B. Selection of Crucial Factors of Time Loss

The statistic shown in Table II are abstracted from fairly extensive literature in Table I and provided a representative view of the components comprising the aspects of the manufacturing operation. Based on the total of journals reviewed in this paper the method is identified as the most critical factor with the highest percentage compared to the man, machine, and material factors.

Some authors explained that the manufacturing operation aspects are the main focus of the study. On the other hand, based on customer feedback, the operation methods are essentially changed to suit the requirement of the customer or to minimize the lead time of operation. Control methods capable of achieving JIT manufacturing of products that have been assigned customized lead times. The proposed methods are driven by distributing decision-making based on feedback, job ordering, and start time-controlled processing [13]. The design of the method of performing an operation when a new product is being put into production, or the improvement of a method already in effect, is a very important part of motion and time study. The logical and systematic approach to solve almost any problem [1].

Table III is a list of sub-elements of the Method factor, the list is the outcome data analysis by using Microsoft Excel Software Application, and it was used to summarize all the sub-elements that related to the Method factor without a double word, sentence, and meaning. Finally, the sub-elements list had been checked the spelling and declared as sub-elements of Method Factor.

The significant issues were derived from the details of the literature studied that related to the Method Factor, to be able to improve performance effectiveness, it is important to identify those significant issues of Method Factor that should be particularly, either because they are key to finding the crucial elements for monitoring that identified sub-elements on significant issues in the literature are generally connected to the operating performance. Unnecessary work based on the literature reviewed is defined as unsuitable activities requiring the least effort and suit the person who uses them [14]. The quality problem particularly in the productive process, much waste has been detected due to the manufacture of defective products. These are due to the absence of proper methodology [2]. Nonvalue added through the customer's eyes a process can be separated into value-adding steps and non-value-adding steps, also called waste [4]. The inter-task time is a generalization of non-value adding times: setup-change time between two tasks, workers' walking times between tasks [7].

III. MEASURABLE ELEMENT JUSTIFICATION

The purpose to justify the measurable sub-elements is to clarify the measurable sub-elements are more suitable for intangibility and quantitative to develop an index, the measurable sub-elements list and definitions with reference below explain:

i. Overproduction: Producing items for which there are no orders, generates such waste as overstaffing and storage and transportation costs because of excess inventory [15].
ii. Setup: In the production system, the setup time of a job is required when a switch between two different jobs occurs. It is sequence-dependent because the setup time is dependent on the previous job [16].
iii. Warm-up and Trial: Run-up is related to the adjustment activities in production until achieves quality level as the customer required [17].
iv. Defect, Rework, and Scrap (Finished Good, Part): Production of defective parts or correction. Repair or rework, scrap, replacement production, and inspection mean wasteful handling, time, and effort [15].
v. Processing: Processing time is the sum of the times spent processing apart at each workstation required in the production routing for the part [8].
vi. Review: Production time lost due to planned and unplanned stoppages. Planned downtime includes scheduled stoppages for such activities as shift start-up, and production meetings [18].
vii. WIP between stations: One of the factors to maintain the quality product is to reduce or eliminate WIP In determining the presence of bottlenecks or constraints in the line, at any point where the CT is more than the takt time [5].
viii. Lost Production is finished good losses due to rejection and output rate [6].
ix. Move: Reductions in moving time can be accomplished by reducing either the time required per move or the number of moves required. The time required per move can be reduced by increasing the speed of the material handling equipment (which may not be possible due to safety implications), or by reducing the movement distance require [8].

Table II: Examine of Time Loss Sub-element

Element	Literature support	Total Journal	%
Man	2, 3, 5, 6, 7, 12, 15, 17, 19, 21, 22, 23, 24, 26, 28, 29, 34, 62, 63, 66, 67, 88, 91, 94	24/96	25%
Machine	3, 5, 6, 7, 9, 10, 12, 17, 18, 21, 22, 23, 24, 26, 27, 45, 47, 50, 56, 57, 58, 59, 63, 65, 66, 67, 76, 78, 79, 80, 81, 82, 83, 84, 85, 86	36/96	38%
Method	1, 3, 5, 6, 7, 9, 10, 12, 15, 17, 18, 19, 20, 21, 22, 23, 25, 26, 29, 30, 34, 35, 36, 37, 38, 39, 41, 42, 43, 44, 45, 46, 47, 48, 49, 51, 52, 53, 54, 55, 56, 57, 58, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 76, 77, 84, 87, 88, 89, 90, 92, 93, 94, 95,96	68/96	71%
Material	3, 4, 5, 6, 7, 21, 22, 23, 24, 25, 26, 28, 34, 84	14/96	15%

A. Justification of Signification Operation

Time is an indicator of the utilization of the resources which operate the process in the manufacturing operation. For example, it is computed as the effective use of equipment (machine hours) or labor (man-hours) and working method (method hours). It relates to resource saturation when compared with the overall resource availability. This time concept is connected with minimizing idle times and in this way improving the productivity of the input resources. Time is a resource itself, consumed by the process in operation. This is the lead time of a given process and is a proper feeling of this time concept can be gained if we ideally embark on the object passing through the process. Thus lead-time strictly depends on the previous identification of the process [19]. While the delivery time is an external performance, the resource-related time concept and the lead time can be regarded as operating conditions 20].

Lead time is the real competitive subject of a business. Products are in the manufacturing phase for a large part of the total lead-time, either as a stock inventory or as progress for a semi-finish product, since it is the manufacturing that controls the quality of the product, its delivery schedule, and eventually the total cost of production, it is necessary to study how to study in order to enhance manufacturing [9].

Table III: List of Method's Sub-element

Sub-Elements of Method Factor		
Waiting time Overproduction Inefficient work organization 5S weak Setup time No practice JIT Facilities layout Visual scheduling improper Output quality (defect) No practice FIFO Uncompleted product repositioning Level scheduling Mix model sequencing Organization not improve Bottleneck Product lead-time Less effort is made at the production planning and scheduling stage Lack of standardized procedure Poor level of housekeeping and cleanliness. Warm-up time Scrap Rework Unsuitable instruction Changes of production schedule and sop. Preparation during external setup before internal setup(convert internal to external setup)	Lost production Trial parts Production meeting Absenteeism KCS-Kanab Control Strategy for multi production based on production and inventory control Consist final Inspection Certain operations with higher handling time. Processing time SDST Scheduling methodology based on parts design Continuous-time Markov chain model to analyse multi-product manufacturing systems with sequence-dependent setup scheduling and finite buffer under seven scheduling policies. Flexible flow shop schedule problem Production schedule problem related to the existing material level status Flow shop scheduling problem Problem to minimizing make the span of processing product Group scheduling problem, kitting operation Lack of schedule problem Lack of resources to perform a set of activities in a period of time (makespan)	Lack of resources to perform a set of activities in a period of time(makespan) The unlimited buffer between stages Method how to do (procedure /instruction) No standardized setup method. Excessive transportation is necessary to get equipment for placement anywhere. Vertical polarization Horizontal polarization Single process Human effort Manufacturing space Change management in the manufacturing system Production rate Technology Process planning Move time

IV. RESULTS AND DISCUSSION

This paper represents a critical element of TL in manufacturing operations. The critical element was finalized and classified into three categories as shown in Table IV. All the critical elements have a significant impact on the manufacturing operation performance. The critical element focuses on the operational activities and under the operation, three factors had been recognized. These factors include the pre-process, in-process, and post-process. Pre-process is any activity involved before the core process.

Table IV: Critical Element Finalized

Operation		
Pre-process	**In-process**	**Post-process**
Move time	Move time	Internal defect quantity
Setup time	Processing time	Internal rework quantity
Warm-up and trial time	WIP between station quantity	Internal scrap quantity
Review time		Overproduction quantity
		Lost production quantity

This process is a core activity in operation in advance before the Post-process takes place where the Post-process is an internal output before the finished good has been delivered to the next station, for example, Quality Assurance Department for the quality inspection.

Based on the literature reviewed, there is no paper to date that focuses on the specific classification in operation itself. For example, the classical term activities before the operation are classified as Inputs and after the operation had classified as Outputs, the input-transformation output (ITO) model. It defines as raw material from suppliers, through the transformation or operation activities and next to the clients [21], whereby the transformation referred to the operation, hence this paper represents the focus on the Pre-process and Post-process before and after In-process under operation. On the other hand, this provides insight to the managers to visualize the TL occurring in the organization and the future possibility of reducing or eliminating them by early detection of the cause of the problem and the ability to increase the operation productivity performance.

V. CONCLUSION

In this study, the critical elements of TL have been finalized according to the specific terms in operation (Pre-process, In-process, and Post-process). Based on the critical elements finalized, there were six critical elements under Pre-process, three critical elements under In-process, and five critical elements under Post-process. All the critical elements of TL have been derived based on the literature studies. This study determined the influencing elements and the effects on the operation performance especially on the productivity by increasing the production rates. Furthermore, the critical elements of TL will indicate a lack of activities and contribute to an amount of time wasted in the manufacturing operation.

ACKNOWLEDGMENT

A Special thanks to Fakulti Teknologi Kejuruteraan Mekanikal dan Pembuatan of Universiti Teknikal Malaysia Melaka for the use of the facilities and valuable data in order to complete this study.

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