Understanding of Non-Value-Added Overtime in Manufacturing Operations

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Abstract. The manufacturing industry plays a crucial role in the production process to meet the demands of the market and to raise the standard of living recently. Nevertheless, one of the most common issues associated with the industry is unnecessary overtime. Overtime has produced a variety of negative consequences on production output. This paper aims to identify the various causes of unnecessary overtime, and the causes have been categorised through the seven wastes of lean manufacturing. This paper also focuses on unnecessary overtime occurred in industries. The method used in this paper is by reviewing the relevant literature from conference papers and journal publications, including the International Journal of Scientific and Technology Research, Journal of Advanced Manufacturing Technology, and International Journal of Engineering and Technology, amongst many others. Finally, the critical components of NAO have been finalised according to the necessariescopes of operation, which considered as factors which are pre-production, in-production, and post-production. Based on the final critical components, there were two critical sub-factors in pre-production components, six critical sub-factors in-production elements, and five critical sub-factors post-production components.

Keywords: Overtime, Lean Manufacturing, Non-value added, Standard Time, Performance measure

1. Introduction
In today's working environments, manufacturing industries are trying to satisfy their customers. To achieve customer satisfaction, they must compete with each other to produce high-quality products by improving the performance of workers or employees. However, many companies are putting pressure on their employees to do more and work more hours without taking into account the losses they faced in the overtime period. Recently, overtime has been prevalent in the production line among the workers without seriously taking the reasons why the workers need to do overtime. The International Labor Organization (ILO) describes overtime as work hours which exceed regular mandatory hours[1]. Extra time is used to increase production and fulfill the order volume of the customer. However, excessive overtime can somehow improve the operation cost and may adversely influence on physiological and behavioral wellbeing of employees. Thus, global organizations such as the ILO, the EU, and national regulations are imposing limitations on overtime [2]. In this situation, overtime could be required when it is necessary. However, it also could be unnecessary when there are no urgent orders that need to be completed.

This study will be focused on the factors and sub-factors that contributed to the unnecessary overtime or Non-value Added Overtime (NAO) in manufacturing industries. In this study, the identifying of
NAO causes will be based on seven wastes of Lean Manufacturing (LM). Besides, NAO is one of a part of an additional working hour because NAO is done after office hours. Thus, unnecessary overtime is identified as detailed in Lean Manufacturing.

2. Understanding of Additional Working Hour

Referring to the MALAYSIA EMPLOYMENT ACT (1955), all other workers are obligated to a whole day's break and are thus allowed to work six days per week. Normal operating hours per day will be eight hours, with a total of 48 hours per week. When a corporation operates less than six days a week, workers will be restricted to a maximum of 10 hours per day (except for break times) and 48 hours per week. Nevertheless, in certain cases or even in mutual decision, the worker can extend the regular working hours as indicated earlier. Those extra working hours shall therefore be pointed to as overtime which shall be charged an extra 1.5 times the daily salary.

Campbell (2002) described the overtime may be classified as either compulsory or voluntary. He also explained in detail the compulsory overtime. Compulsory overtime is extra working hours implemented by the employer on specific grounds. In the United States, the most frequent workers who are subject to mandatory overtime are nurses, who are typically expected to work 12-hour shifts at one time. Voluntary overtime is the extra working time preferred by the employee and not enforced by the employer. Voluntary overtime is now becoming increasingly common in the Malaysian industry as workers are inspired by the fact that they are paid 1.5 times more than their regular hourly wage. However, when performed excessively and not supervised, unpaid overtime can have an overall negative effect on both the employer and the employee (Campbell, 2013).

Dewi et al. (2013) expressed the opinion that to remain competitive in this period, companies face an unprecedented challenge by offering a variety of goods that have always hindered their productivity. Apart from that, productivity is one of the crucial things that companies are working on it[4]. Productivity refers for output to all or some of the resources used to create the production. Resources include labour, money, time, energy, and raw materials. Productivity is translated directly into cost savings and productivity [5]. According to Patel et al., (2017), there are two productivity measures which are overall productivity factor and partial productivity factor. In overall productivity factor, the outputs and all inputs have been considered while in partial productivity factor, the outputs and single or chosen inputs are considered[6].

As said by Mpanza & Nyembwe (2014), productivity measures the effective and efficient use of available resources. Many variables affect productivity[7]. Sidabutar & Matondang (2019) stated that productivity covers processes, quality management, and technology. Thus, productivity can be changed when overtime work is done at the company[8]. Overtime can be two types, which are necessary overtime and unnecessary overtime. Ebrahim et al., (2017) stated that necessary overtime could be referred to as additional working time required to meet the output target. However, unnecessary overtime is where time loss has occurred[9].

A variety of activities may cause time loss in manufacturing operations (e.g., waiting, system failure, and lack of workforce). These are usually known as common factors such as individual, material, process, method, management, and climate or otherwise referred to as Man, Method, Machine, Material, and Environment (4 M 1E). The most secret trigger is time loss due to unnecessary work, which is closely related to the method of operation [4]. Unnecessary work or non-value added activities would then contribute to the occurrence of unnecessary overtime. Therefore, it is essential to evaluate unnecessary affecting overtime in manufacturing industries.

Thus, the overtime regulations should be taken seriously in order to increase the company's profit because the workers need to be paid whenever they are done during the overtime work.

2.1. Non-value Added Activities

According to Poornashree & Ramakrishna(2019), a value can be described only as what the consumer is willing to pay for purchasing the product. If the customer does not want to pay for it, there is no value for it. Something or someone who does not contribute or increase value is a waste. However, non-value added activities are activities which require time, resources and capacity but not to bring value to the task. In the terminology of lean development, this term 'Non-Value Added Activities'
(NVAA) is known as waste. NVAA is a waste of time, which could have been prevented if the process was prepared, conducted, monitored, and managed more carefully. We should be extracted when NVAA is detected whenever possible [10]. Value-added activities represent the right combination of operations and processes needed to produce the product, producing the best quality, at the lowest possible cost, to the customer on time [11]. This kind of waste is known in Non-value added activities because it does not add value to the others.

2.2. Factors of Non-value Added Overtime (NAO)

From the past literature study, the structure and the equation of Unnecessary Overtime (UOT) have been developed. Figure 1 shows the structure of UOT resulted from past literature [9].

\[
\text{UOT} = t_{\text{tot}} - t_{\text{not}}
\]

Where, \( t_{\text{tot}} \) is total overtime given to achieve the production line target, \( t_{\text{not}} \) is necessary overtime.

Thus, \( \text{UOT} \geq 0 \).

In this regard, the determination of UOT was based on the deduction value of \( t_{\text{tot}} \) by \( t_{\text{not}} \). In this method, it is difficult to improve due to the uncertain factors of \( t_{\text{not}} \) identification. Therefore, in the next step of enhancement, it is necessary to identify the potential factors and sub-factors in order to cater effective formula of NAO. Thus, effective and efficient improvement will be taken more appropriate in manufacturing industries [9].

3. Methodology

In this study, it is crucial to identify the factors for NAO. In order to figure out the causes of the NAO, to make the tasks more organised and straightforward, the process flow of the purpose is given, as shown in Figure 2. The first step is the studies of literature, which will be clarified in the next section.
3.1. Literature Studies
Extensive literature studies are performed in order to determine the causes of NAO. The literature studies aim 30 papers published in the last five years. The literature studies concentrate on operation and production management, manufacturing management, industrial engineering, operational study and quality, and performance. The literature studies would be used to explain the selection of a significant factor, including the description of seven LM wastes (i.e., Waiting, Transportation, Motion, Defect, Over-processing, and Inventory) and measurable elements.

3.2. Classification of Seven Wastes
Sundar et al., (2014) found that Lean Manufacturing (LM) is a concept that aims to eliminate waste in all areas of production, including product design, supplier networks, and customer management. This concept has come from Japan. It is expected that, with the implementation of lean manufacturing, a quality product will be produced by reducing waste there. Nowadays, many companies use LM to improve their production productivity[12].

While the process of adding value (value-adding activities) is the process of converting/transforming raw materials, changes in shape or quality: changes in the raw material into a particular part or product[4]. According to Womack & Jones (1997), lean is a quality and process improvement method that emphasises customer needs, employee involvement, and continuous improvement. The wastes involve in Lean Manufacturing are Defects, Motion, Transportation, Inventory, Over-processing, and Waiting[5].

Systematic identification and disposal of waste are considered to be a core element of the Lean Production ideology [11];[13];[14]. In order to determine the involved wastes in the production process, Ohno (1988) identified the seven types of waste: Defects, Motion, Transportation, Inventory, Over-processing, Waiting, and Overproduction[11]. These seven types of waste have revealed to be very useful for the identification of waste involved in the manufacturing process. The lean theory describes waste as any operation that adds costs or spends time but does not add value to the customer [5]; [11]. Table 1 below is the table of the seven wastes in Lean Manufacturing[15].
Table 1. Description of 7 Wastes [15]

| Type of Waste | Description |
|---------------|-------------|
| Defects       | The documentation has frequent mistakes, difficulties with the consistency of the product, or bad delivery performance. Impoverished organization of the workplace, leads to poor ergonomics, injuries usually bending or stretching, and mostly lost items. |
| Motion        | The people have excessive movement, excessive knowledge or items, leading in a waste of resources, effort and value. |
| Transportation| Extremely high storage and backlog of information or goods, leading to high cost and poor service. Passing through production process using the incorrect set of tools, methods, or systems, even when a more direct method would be more effective. |
| Inventory     | People, information, or goods have long periods of inactivity that leads to weak flow and long lead times. |
| Over-processing| Making too much or too little, typically results in an inadequate delivery of work or goods and an overload of inventory. |

3.3. Measurable and Non-measurable

Usually, it is easier to manage measurable elements than non-measurable elements. The reason why measurable elements are easier to manage is that measurable elements are the quantitative data, while non-measurable elements are qualitative data. According to Womack & Jones(1997), the measurable term came from the root word of "measure"[5]. However, according to Hair et al., (2019), the word calculation measure represents a measurement of physical properties or tangible objects such as weight, relative humidity, length, period[16]. The measurable data is explained in general information and not only focus on the engineering area. Thus, the Value Added activities and Non-value Added activities can take account of the measurable indicator.

3.4. Pre-production, In-production and Post-production

This study is established through the basic concept of production Input-Output (IO) which focuses on operations, and the elements have been defined through measurable elements in three phases of manufacturing operations; i) Pre-production, ii) In-production and iii) Post-production[17]. According to Rasib et al., (2019), Pre-process is any operation that is involved before the core process. In-process is a crucial task in pre-process operation where the post-process is an internal product before the finished products are transported to the next station, such as the Quality Assurance Department for quality inspection[19].

4. Results and Discussion

The major purpose of this study is to identify the various causes of NAO, and this objective is achieved. The findings thus demonstrate the potential for a synthesis of theory and practices. As a consequence, it consists of essential stages, as indicated, which are:

- Literature study
- Clarifying the Seven Wastes of Lean Manufacturing
Measurable and Non-measurable

4.1. Literature Study
The statistic shown in Table 2 is abstracted from the 30 studies that have been conducted. This table provides a representative view of the sub-factors in the aspects of factors that contributed to the overtime.

| Sub-factors of Overtime |
|-------------------------|
| Excess workforce inventory |
| High production unit |
| Annual paid leave |
| Sickness absence |
| Product defects |
| Workers shortage |
| Machine availability |
| Components shortage |
| Workers performance |
| Inappropriate OT planning |
| Bottleneck |
| Erratic variance (rework) |
| Low plant capacity |
| Incoming raw materials |
| Products delivery |
| High takt time |
| Extensive motion |
| Material defects |
| Delays |
| High workload |
| Excessive inventory |
| Long waiting time |
| High materials storage |
| Rework |
| Unscheduled downtime |
| High lead time |
| Workload control |
| High production volume in processing and finishing unit |

4.2. Clarifying the Seven Wastes of Lean Manufacturing
As far as the seven wastes of Lean Manufacturing are concerned, the statistic shown in Table 3. This table is a list of sub-factors from relatively comprehensive past literature that has been abstracted, as shown in Table 2. Based on the total of papers reviewed, the waiting waste is identified as the most critical factor with the highest percentage compared to the others. The motion waste is recognised to be the second-highest after the waiting waste.

| Seven wastes | Journals | Total Journal | Percentage (%) |
|--------------|----------|---------------|----------------|
| Motion       | [7], [8], [10], [13], [14], [17], [19], [20], [22], [23], [25], [26], [1], [2], [3], [4], [5], [6], [8], [9], [11], [12], [14], [15], [16], [18], [21], [23], [24], [25], [26], [27], [28], [29], [30] | 12/49 | 24.5 |
| Waiting      | -        | 0/49          | 0              |
| Overproduction | [3], [8], [10], [21], [23], [25], [30] | 7/49 | 14.3 |
| Defect       | [23], [25] | 2/49 | 4.1 |
| Transportation | [23], [25] | 1/49 | 2.0 |
| Inventory    | [14], [17], [24], [28] | 4/49 | 8.2 |

4.3. Measurable and Non-measurable Indicators
From Table 3, the NAO elements then are classified into measurable and non-measurable indicators. In this study, the measurable indicators are only taken into account, and non-measurable indicators are being neglected because the non-measurable indicators cannot be observing during data collection. Thus, the elements of NAO is classified into measurable and non-measurable indicators, as shown in Table 4 below.

| Table 4. Measurable and Non-measurable Indicators of NAO elements |
|---------------------------------------------------------------|
| **Measurable**                                               | **Non-measurable**                      |
| High production volume                                       | Excess workforce inventory              |
| Product defects                                              | Annual paid leave                       |
| Machine availability                                         | Sickness absence                        |
| Components shortage                                          | Workers shortage                        |
| Bottleneck                                                   | Workers performance                     |
| Material availability                                        | Inappropriate OT planning               |
| Low plant capacity                                           | Excessive inventory                     |
| Incoming raw materials                                       | High materials storage                  |
| Products delivery                                            | Workload control                        |
| High takt time                                               |                                             |
| Extensive motion                                             |                                             |
| Material defects                                             |                                             |
| Delays                                                       |                                             |
| High workload                                                |                                             |
| Inspection time                                              |                                             |
| Replacement production time                                  |                                             |
| Rework and scrap                                             |                                             |
| Over-processing                                              |                                             |
| Long changeover time                                         |                                             |
| Unscheduled downtime                                         |                                             |
| High lead time                                               |                                             |
| Long waiting time                                            |                                             |

4.4. Pre-production, In-production and Post-production Segregation

Table 5 shows the listing of Non-value Added Overtime (NAO). The essential item of the NAO has been finalised and graded, as shown in three categories. The basic concept of manufacturing 'Input-Output (IO) is used because time is a significant indicator for Non-value Added Overtime (NAO). Thus, NAO is the total time of all processes as stated below.

| Table 5. Sorting of the NAO's Factors |
|---------------------------------------|
| **Pre-production**                    | **In-production**                      | **Post-production**               |
| Changeover time                       | Bottleneck and delays                  | Rework time                       |
| Incoming raw materials                | High workload                           | Scrap time                        |
| Machine availability                  | Replacement production time             |                                             |
| Material availability                 | High production volume                  |                                             |
| Low plant capacity                    | Inspection time                         |                                             |
| Long waiting time between the         |                                             |                                             |
| workstation                           |                                             |                                             |
5. Conclusion
There are two main issues worth highlighting in this study. The main problems may be the application domain and the basic technique. From the point of view of the application domain, most companies function with little experience beyond realistic execution during overtime. However, in the context of the basic technique, the current approach for calculating NAO does not consider all the factors comprehensively. Therefore, there is a need to enhance the formulation of NAO through a good understanding of the non-value-added factors for accurate manufacturing operational cost calculation. In this analysis, the critical components of NAO have been finalised according to the basic terms of operation (pre-production, in-production, and post-production). Based on the final critical components, there were two critical pre-production components, six critical in-production elements, and five critical post-production components. All the critical components of NAO were extracted from literature studies. Critical components may imply excessive activities and contribute to a significant amount of time wasted and thereby lead to overtime in manufacturing operations. Therefore, the minimisation of these factors will contribute to waste elimination and profit optimisation.

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