The designing analysis process of constituent attributes by using VSM and Six Sigma to enhance the productivity in industry of bearings

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Abstract. The objectives of this paper is to study the process and production flow in the manufacturing of bearings, to analyse the designing process of constituent attributes towards manufacturing tool to enhance the productivity in manufacturing of bearings and to propose the factors that will increase the productivity rate in the manufacturing of bearings. Based on several literature reviews of regarding lean manufacturing tools, it was acknowledged that lean is a technique that is significant to enhance the performance of service at various industries through spotting and tackling its criticalities. There are five principles of lean thinking in which it is identify the value, mapping the value stream, creating flow, establishing pull and seeking perfection. There are various lean manufacturing tools that can be used to improve productivity, however for this paper is to study the value stream mapping (VSM) along with six sigma methodology are combined to analyse the productivity rate and propose factors that can enhance productivity. The wastes allocated in this study were successfully obtained through 7 lean type of wastes which are overproduction, defect, inventory, inappropriate processing, transportation, waiting and motion. Lastly, the proposed factors were to improve working environment along with motivation of workers and Total Productive Maintenance (TPM) to improve productivity in this bearing manufacturing factory.

Keywords. Productivity; Value Stream mapping (VSM); Six Sigma methodology; Total Productive Maintenance (TPM)

1. Introduction

Productivity plays an important role in the manufacturing industry as it is a tool to determine whether a business in a company can be successful or collapse into failure. To determine the efficiency or effectiveness of a business, it can be done through the measure of productivity. For example in the manufacturing industry of bearings, the productivity can be measured through the output efficiency of bearings throughout the day. The main aim of productivity is to maximize utilization of resources for yielding abundant amount of goods and service, to satisfy customers at low cost [1]. One of the key factor for manufacturing excellence is productivity improvement, in which it is needed to attain pleasant operational and financial performance. From the improvement of productivity, customer satisfaction will rise and it will lessen time and cost to develop, produce and deliver products [2].
There are plenty of ways to enhance productivity such as reduction of cycle time in the manufacturing of bearings. Reducing cycle time is a crucial element in a successful manufacturing due to the rising demands of consumers wanting manufacturers to respond promptly based on their wants and needs. In general, this became a common trend and brought attention to abundant amount of companies regarding their order-to-delivery cycle time [3]. Every company in the manufacturing industry wants to sustain their business for survival and profitability, thus attaining the ability of reducing cycle time in production will improve productivity. For certain organizations, reduction in cycle time of the product development consists of a change in the strategic planning process from the standardized development process being used in the 1980s to the commonly flexible methods used in the present [4]. Line Balancing and Six Sigma Methodology are examples of methods being used today to reduce cycle time in the production process.

The previous case study that has been conducted, the raw data of grinding & assembly cycle time in a production line was collected to detect the underlying problems in the production process. Through several previous studies in one of Bearing industry in Malaysia, it was found that specific bottle neck machines in grinding and assembly processes did not meet the target cycle time to run the production, thus producing less output and low efficiency. Nevertheless, if the other machines would run faster than the target cycle time in comparison with the bottleneck machines it would maintain the efficiency rate. Second, the production process in the manufacturing of bearings are divided into three separate components which are the grinding, assembly and packaging processes. The main problem occurs when the machines did not respond comprehensively towards the given cycle time. A cause that would delay the cycle time of a machine is due to less manning activities (technician) to check on machines when the reject chute (rejected outer/inner rings) outlet is full, hence the machine would stop temporarily till the rejected rings are remove. In addition to this, manning activities would include the replacement of stones & wheels in the grinding machines, in which throughout the day these consumables would be used up and has to be replaced by the technicians on duty. In the packaging process, it includes manning process of removing the bearings from the conveyor belt of the assembly to the wrapping packaging process. Manning activities should be improved in the production process as it will increase productivity. Value stream mapping is a tool that maps the process flow and assists to identify cycle time problem as mentioned in the case study [5].

Third, in a production line of the manufacturing of bearings it is needed that every technician should be cautious in case of a break down or little stops. Little stops occurs when inner/outer rings and bearings would be in their improper position and stuck on the conveyor belt. When this incident would happen, the following machines ahead of the little stop would be forced to stop, as there are no rings or bearings available to process, hence the production efficiency would decrease. It is needed that the interval time to be short, thus the machines in front would not stop and technicians must quickly intervene if little stops would occur. Break down of machines in the production process would cause a long downtime, in which it would involves process and quality engineers to handle the problem. Break down activities needs to be reduced to ensure efficiency rate would not drop. Zero loss study method would assist in allocating the losses and identifying the main problems in a production line throughout the day. In addition, this paper proposed factors were to improve working environment along with motivation of workers and total productive maintenance (TPM) to improve productivity in this bearing-manufacturing factory by using VSM and Six Sigma Methodology.

2. Theoretical approach
The focus of this study is the designing process of constituent attributes towards manufacturing tool to enhance productivity in the industry of bearings. The study will be conducted by collecting cycle time data and zero loss study analysis in which it will be used to identify the problems that cause low productivity in the manufacturing of bearings.
2.1. Value stream mapping (VSM)
To begin with, the use of process mapping-based improvements for clearer visualizations has been known for a period in countless numbers of sectors. It was introduced by Gilbreth and Taylor, whilst establishing different kinds of charting, timing and recording concepts [6] during the beginning of scientific management era. Nevertheless, the usage to reduce various wastes, by exposing value adding and non-value adding components of a process and in monitoring ‘lean’ is particularly new. Thus, researches are extending it further, in green [7] and health care areas [8]. The form of value stream mapping came to the picture when a new set of tools, graphic symbols and concepts were placed into process mapping with a particular plan to enhance visualization, highlighting wastes and value separation. VSM is known as an important; enterprise improvement methodology capturing inter- and intra-company level which gives a depth in visualizing the whole process, capturing material and information flows with the timeline [9]. VSM was introduced through Learning to See by [10] which first shown in 1999 and then in 2003.

To simplify VSM, it is a method of lean manufacturing in which it uses symbols, metrics and arrows to visualize and improve the flow of inventory and information required to produce a product or service which is to be sent to a customer. A value stream map is a visual representation which allows one to determine where the waste takes place. Value stream maps are being used to evaluate current manufacturing processes and produce ideal and future state processes. In a company, VSM allows a company to map the process flow and assist in identifying factors as below [5]. This helps in recognizing and removing (waste), thus implementing lean principles.

- Value Added Time (time taken to produce an end product)
- Non Value Added Time (time taken which do not add to the production of an end product)
- Cycle Time (time taken required to perform a process)
- Changeover Time (time required to change a tool)

The value stream map can help identifying the most common types of waste, such as the seven deadly wastes. Those are overproduction, waiting, transport, extra processing, inventory, motion and defects [11]. Lastly, it is easier to make improvements to a business in which it is simpler to visually identify where the waste is allocated and how to improve/ remove it. The VSM can be used to plan improvement events and experiment improvement theories. From the evaluation Value Stream Mapping methodology, it can be summed up that VSM has both its advantages and disadvantages which varies on the situation given. Nevertheless, as for the study to improve the productivity of the manufacturing of bearings, it would seem that this technique of VSM would be highly recommended as it can assists in reducing the cycle time process and removes unwanted waste. Therefore, acquiring this method would help in enhancing the productivity and guarantees satisfaction from the customers.

2.2. Six sigma methodology (DMAIC)
Six sigma was taken as a method, which focus on reducing waste due to process inefficiencies in manufacturing, and for quality improvement of a product. Nevertheless, it is now applied by all industries including service industries such as health care management, all due to successful implantation programs [12]. Six sigma methodology was initially developed by Motorola in the 1980s and it has been successful over the last years as it produced remarkable savings to the bottom line of countless organizations. This methodology was originally introduced to manufacturing processes, however today it has been adopted to plenty of industries such as marketing, purchasing, billing and human resource with the motive of continuously reducing defects throughout a company processes [13].

Six sigma methodology consists of two main methods which are DMAIC and DMADV. DMAIC is (Define, Measure, Analyse, Improve and Control), whereas DMADV is (Define, Measure, Analysis,
Design and Verify) which is to be used for product improvement. Nevertheless, on this research it
would only focus on DMAIC as it is preferable to do so. DMAIC focuses on making improvements to
a business process in order to reduce or eliminate defects and it also a routine for transforming
established routines or for designing new routines. This method applies in daily life as a common
problem solving and improvement activities [14]. DMAIC should only be applied when a product or
process is in presence at a company, however is not as per consumer requirements.

It can be acknowledged as genuine cost savings, in which DMAIC means to identify waste and
unwanted rework. A successful DMAIC implementation can pay for itself several times over by
humongous increasing the effectiveness of a process. The cycle of DMAIC can be used again as
businesses can continually repeat the process, identifying further enhancements and improvements in a
period. Secondly, it uses structured thinking, as the DMAIC process is systematic. In which it allows
decisions to be made based on actual data and measurement and not on a gut feeling. The various tools
and techniques used in the analysis phase can exterminate problems and issues that might not have
been exposed and the approach quite often produce a route of thoughts, which is to be developed
processes. Thirdly, it is good for long term. DMAIC implementation is rarely about simple fixes of
problems. This approach is used for longer-term process, so for established businesses or business
with complications it will work effectively. Plenty projects plays with a problem, which then needed a
quick fix and then would be gone temporarily. The control phase of DMAIC methodology will
guarantee that this would not occur. Fourthly, it creates rise of profit and reduced in cost in which
implementation of Six Sigma methodology leads to increase of profitability and reduction in costs.
Thus, improvements achieved are strict related to financial results. Lastly, Six Sigma is prospective
methodology as compared to other quality programs as it concentrates on prevention of defects rather
than fixing it.

Although this DMAIC approach seems to be reliable, on how accurate the data is to produce a better
outcome for improvements. Nevertheless, as for this study to improve the productivity of the
manufacturing of bearings, it would seem that this technique of DMAIC would be suited as it can
assist in allocating the wastage and downtime of a production. Therefore, acquiring this method would
help in enhancing the productivity and provides satisfaction towards the end users.

3. Methodology
The methods in this study of assessing the raw data which is the cycle time and zero-loss study data
are by using VSM and Six Sigma Methodology with DMAIC approach. The VSM methodology will
be used to identify unwanted waste and reducing high cycle time. The DMAIC approach will be used
to evaluate the downtime of a production line based on the zero loss study analysis data. Both of these
methods will be useful in assisting to enhance productivity levels in the manufacturing of bearings.
Two times of data collection had been done in which, the cycle time and zero loss study analysis data.

Zero Loss Study and Cycle Time Data are the main approach to be used and the expected outcome
are reduce of cycle time, improvement of productivity and increasing of efficiency.

- Cycle Time: This is develop based on the production line machining list, in which it consists of
  machine names based on their facility layout of machines without skipping a process. The cycle
time data consist of target and actual cycle time column.
- Zero Loss Study: The Zero Loss Study Data is also based on the facility layout of machines
  which consist of cycle time data and machining operations behaviour in which for how long it is
  running, idle, breakdowns, and little stops throughout the period of operation.

In this case, a production line is known as a channel. There are three types of channel depending on
the bearing types, the focus only towards Deep Groove Ball Bearings (DGBB) are located in Channel
3. The process will be divided as depicted in table 1.
Table 1. Production process.

| Process                        | Description                                                                 |
|--------------------------------|-----------------------------------------------------------------------------|
| Grinding of Outer/Inner Rings  | Each machine grinds different surfaces of the ring.                        |
| Assembly of Outer/Inner (Pairing) | • Pairing of the outer rings and inner rings.                           |
|                                 | • Greasing, marking, ball placement and weighing took place here.          |
| Packaging                       | • Wrapping & boxing                                                        |
|                                 | • Final Process                                                            |

4. Analysis and discussion

The data was analysed and discussed in Six Sigma (DMAIC) approach towards productivity.

4.1. Define

This step concentrates on the problem identification that affects the enhancement of productivity in the manufacturing of bearings. It was highlighted that the DGBB channel 3 (production line) was producing bearings with a low efficiency of below 55%. For the manufacturing company to consider a high efficiency production line it must produce bearings above 70% and if it is still lesser than that amount, it is considered unproductive as the production line has a low productivity output. Likewise, to identify the root cause of this disturbance in productivity, it is needed to take a few measures such as recording cycle time of the production line machines.

4.2. Measure

To measure means to take raw data of cycle time from DGBB Channel 3 (grinding machines and XHM assembly machine only) and zero loss study action. The cycle time data was recorded twice during that day in which at 9:55AM and 1:10PM to check the consistency of the data taken. For the zero loss study action, it was to take all of the data for the grinding machines and XHM assembly machine that are needed to check whether the machine is running efficiently based on the hourly outputs. Additionally, with zero loss study it helps to identify how many hours does each machine in the grinding section runs efficiently. These 2 actions was taken on the same day and the data recorded will be shown and elaborated in the table 2 and table 3. In addition, the list of machines and their functions as per shown on table 4.
Table 2. Cycle time at 9.55 AM.

| Stop watch / Machine 9.55 AM | Target cycle time | Average |
|-----------------------------|-------------------|---------|
| SPC IR                      | 5.834             | 6.6     | 5.83    |
| SPC IR MIB                  | 4.62              | 6.6     | 4.62    |
| SGB                         | 6.054             | 6.6     | 6.05    |
| SHG 1                       | 6.158             | 6.6     | 6.16    |
| SHG MIB                     | 4.62              | 6.6     | 4.62    |
| FGM 1                       | 13.97             | 6.6     | 13.97   |
| FGM 2                       | 12.07             | 6.6     | 12.07   |
| TKB IR                      | 2.84              | 6.6     | 2.84    |
| SPC OR                      | 4.872             | 6.6     | 4.87    |
| SPC OR MIB                  | 3.93              | 6.6     | 3.93    |
| CL                          | 5.81              | 6.6     | 5.81    |
| CL MIB                      | 5.84              | 6.6     | 5.84    |
| SSB                         | 6.263             | 6.6     | 6.26    |
| FSF 1                       | 10.45             | 6.6     | 10.45   |
| FSF 2                       | 10.13             | 6.6     | 10.13   |
| FSF 3                       | 8                 | 6.6     | 8.00    |
| FSF 4                       | 10.78             | 6.6     | 10.78   |
| TKB OR                      | 2.29              | 6.6     | 2.29    |
| XHM                         | 5.6               | 6.6     | 5.60    |

Table 3. Cycle time at 1.10 pm.

| Stop watch / Machine 9.55 AM | Target cycle time | Average |
|-----------------------------|-------------------|---------|
| SPC IR                      | 5.513             | 6.6     | 5.51    |
| SPC IR MIB                  | 5.29              | 6.6     | 5.29    |
| SGB                         | 5.878             | 6.6     | 5.88    |
| SHG 1                       | 6.382             | 6.6     | 6.38    |
| SHG MIB                     | 6.07              | 6.6     | 6.07    |
| FGM 1                       | 13.98             | 6.6     | 13.98   |
| FGM 2                       | 12.01             | 6.6     | 12.01   |
| TKB IR                      | 2.97              | 6.6     | 2.97    |
| SPC OR                      | 5.012             | 6.6     | 5.01    |
| SPC OR MIB                  | 3.88              | 6.6     | 3.88    |
| CL                          | 6.07              | 6.6     | 6.07    |
| CL MIB                      | 4.56              | 6.6     | 4.56    |
| SSB                         | 6.347             | 6.6     | 6.35    |
| FSF 1                       | 10.44             | 6.6     | 10.44   |
| FSF 2                       | 10.15             | 6.6     | 10.15   |
| FSF 3                       | 8                 | 6.6     | 8.00    |
| FSF 4                       | 11.2              | 6.6     | 11.20   |
| TKB OR                      | 5.15              | 6.6     | 5.12    |
| XHM                         | 5.6               | 6.6     | 5.50    |
The zero loss study action help in allocating the total loss or waste that was done throughout the entire study activity. The zero loss study activity was done for 6.5 hours for the grinding machines until XHM assembly machine of DGBB Channel 3 for 1 product bearing.

| Machines     | Activities                                           |
|--------------|------------------------------------------------------|
| 1. SPC IR    | The first phase of grinding for inner rings          |
| 2. SPC IR MIB | To scan and check defect of inner rings              |
| 3. SGB       | The second phase of grinding for the inner rings     |
| 4. SHG 1     | The final phase of grinding for the inner rings      |
| 5. SHG MIB   | To scan and check defect of inner rings              |
| 6. FGM 1     | To polish the inner rings                            |
| 7. FGM 2     | To polish the inner rings                            |
| 8. TKB IR    | To wash the inner rings                              |
| 9. SPC OR    | The first phase of grinding for outer rings          |
| 10. SPC OR MIB | To scan and check defect of outer rings              |
| 11. CL       | The second phase of grinding for outer rings         |
| 12. CL MIB   | To scan and check defect for outer rings             |
| 13. SSB      | The final phase of grinding for outer rings          |
| 14. FSF 1    | To polish the outer rings                            |
| 15. FSF 2    | To polish the outer rings                            |
| 16. FSF 3    | To polish the outer rings                            |
| 17. FSF 4    | To polish the outer rings                            |
| 18. TKB OR   | To wash the outer rings                              |
| 19. XHM      | To assemble the outer and inner rings                |

The process analyst and manager informed that the data needed can only be taken from machines mentioned previously and nothing beyond the XHM machine. This study is recorded for every 10 minutes to check for the running consistency of each machines indicated by the legends. To analyse based on the legend given at the template, it can be depicted that starting from 9AM the XHM had zero outputs because there were too many problems from the FSF machines on that day which was the outlet chute for FSF 1 and FSF 4 had a breakdown activity due to outlet chute troubles. The XHM machine is crucial, as it is needed to assemble both inner and outer rings together, therefore if the rings
would not come out from the FSFs and FGMs machines, there is no available bearings to be produced. There are a couple of little stops that occurred throughout the study especially at the FSFs machine due to outlet chute trouble.

The hourly output of each grinding machines and XHM assembly machine was taken for every hour from 9AM until 4PM. This was done by pressing a button on the machines to receive the output being produced at that hour. From the hourly output, the efficiency of each machines can be calculated as shown per above figure. The XHM machine is crucial to determine the efficiency of the whole production line as it is the assembly machine. The efficiency of this machine will be roughly the same as the whole production line efficiency.

4.3. Analyse

For this analysis step, value stream mapping methodology was used to identify problems in relation with the recorded cycle time and reduce waste/losses. In the literature review and methodology section, it has been explained broadly regarding VSM in which it consists of a detailed process from reviewing steps of a product and flow of information from supplier to customer. The first step is to identify the product family on which it will be focused on. For this case study, only one item family was examined for the mapping process, in which it is the manufacturing of bearings. The task for this family was only understood and followed by a single process. Value stream map that was illustrated for this case study is a snapshot in time of how a specific task that belongs to a product family is extinguished and needs to work together to perform an image of the SKF production system. By VSM, it will help in reducing the lead-time, inventory and cycle time. Table 5 clearly shows the steps on how to create a VSM and table 6 is the data calculated for the VSM plotting.

| Step | Procedure |
|------|-----------|
| First | Identify and illustrate the product flow from raw material point to the finished product point |
| Second | Calculate the Work in Process (WIP) for the components in each work cell |
| Third | Calculate the cycle time |
| Forth | Plot the current state map |

Based on figure 1, it shows the current value stream map. It consists of 3 essential part of the VSM which are information flow (from consumer demands), production control which list the raw material that is needed from the type of consumer demands, and material flow which is the raw material movement from the initial process till the shipping process. Additionally, cycle time processes were needed to calculate Value Added Time, Non-Value Added Time, Total Lead Time and the Percentage Cycle Efficiency.

Figure 2 shows that there are 19 processes that took place in the grinding and assembly of bearings for Product 1. In the Y-Axis is referred to the cycle time of each machine, while the X-Axis is referred to the type of machines. From the graph, it can be depicted that all of the machines were below of the target cycle time of 6.6 in which highlighted by the red line. Additionally, FGM 1 and FGM 2 are two equivalent machines that only counts as one cycle time, therefore the average value was taken in which both of the values was added, and then divided by 4. This applies to FSF machines as well, however FSF1 and FSF 2 are one pair of machines and FSF3 and FSF4 are another pair in which both works the same mechanism, thus only the highest value of one of the pairs will be added with each
other, then divided by 4. The formula to calculate the average was given by the process analyst. The target cycle time is also known as the Takt Time in which it is the highest cycle time for a machine to process to achieve consumer demands.

Table 6. Data calculation of VSM.

| Process Time | Example and Description |
|--------------|-------------------------|
| Takt Time    | \[
\frac{\text{Available time per work shift}}{\text{Customer demand qty. per shift}} \times 100% = \frac{8 \text{ hours}}{300 \text{ demand}} = 0.027 \text{ hours} = 97.2 \text{ seconds/demand} \]
| Total Lead Time | The time between the initiation till the completion of the production process |
|                | 130.12 seconds + 195 seconds = 325.12 seconds |

Process time to improve products

| Total Value Added Time | \[
\sum 5.83 + 4.62 + 6.05 + 6.16 + 4.02 + 13.97 + 12.07 + 2.64 + 4.87 + 3.93 + 5.81 + 5.64 + 6.26 + 10.45 + 10.13 + 8.00 + 10.78 + 3.29 + 5.60 = 130.12 \text{ seconds (Automated process)}
\]

Process time that adds no value to the finished product

| Total Non-Value Added Time | \[
\sum 5 + 15 + 10 + 16 + 5 + 9 + 9 + 10 + 10 + 5 + 10 + 5 + 10 + 14 + 14 + 14 + 10 + 10 = 195 \text{ seconds (Automated process)}
\]

Percentage of cycle efficiency

| Percentage of cycle efficiency | \[
\frac{\text{Total Value Added Time}}{\text{Total Lead Time}} \times 100\% = \frac{130.12 \text{ seconds}}{325.12 \text{ seconds}} \times 100\% = 40.02\%
\]

Working Days

| Working Days | \[
\frac{24 \text{ Hour}}{\text{Day}} \times \frac{30 \text{ Day}}{\text{Month}} = 720 \text{ Hour/Month}
\]

To discuss in relation with the analysis of VSM, there are presence of waste in which it will be explained by 7 types of wastes. The first waste is overproduction in which it occurs in the manufacturing process of bearings as the grinding of inner rings takes a shorter time than the grinding of outer rings therefore, it will not be equivalent to produce the right amount of bearings. Thus, excess inner rings will go to inventory. The second waste is defect in which it often occurs in the grinding area of the manufacturing process such as the SPCs and CLs machines are not running well enough and it can be detected with the MIBs machines. The MIBs machines will detect and reject all of the defect rings and it will dump it into waste deposit. The third waste is inventory in which this waste could be in relation with overproduction as the inventory excess will have to halt for future processes. The forth waste is inappropriate processing. This waste could not be detected in manufacturing process as all of the processes that occurs are machine based and human error could not be detected.
The fifth waste is transportation. It could not be detected because the layout of the machinery are in a proper arrangement for the rings and bearings to flow. The sixth waste is waiting as this could be detected at the manufacturing process of bearings. The reason that there are machines that runs slowly, little stop and having breakdowns activities that could put a halt of rings/bearings movement on the conveyor belt.

Figure 1. Current value stream map.

Figure 2. Machine average cycle time.
The last waste is motion, in relation with space and technicians available could not be detected and would not consider a waste during a normal production as only few technicians are needed to inspect production line for the grinding, assembly and packaging area. From the waste identification using the method of seven of wastes, it results in four wastes causing inefficiency that are overproduction, defect, inventory and waiting.

4.4. Improvement & control
To improve productivity and control it is by eliminating four of the wastes, which causes inefficiency such as overproduction, defect, inventory and waiting. The proposed suggestion would be to improve the working environment and motivation of workers and total productive maintenance.

Point 1: Improve working environment and motivation of workers
Currently, the company is facing lack of technicians being available at each production line to help maintain the production line in which if rejects are plenty in amount, they would need cleared it up as soon as possible. Also, if little stops did occur it would be easier to be detected and cleared with the presence of a technician on the line. It is often being seen in the company based on the Zero Loss Study data, the line would be either full or empty for too long due to the reason there is a breakdown or little stops taking place for too long because there is no presence of workers in which it should be improved by (Das & Gopinadhan, n.d):

- Provide a suitable and healthy working environment for employees in order to do their regular task and responsibilities.
- Maintain a good relationship of production line workers with their superiors.
- The higher management should take caution of the effort by the production line workers and motivate them by providing incentives, empowering them by giving them an opportunity to raise their voice for improvement of the production line and offer opportunities to advancement of their career level.
- The higher management should consider an initiative to increase the employee salary to decrease the numbers of absentees as this was one of the reason why the production line was lack of workers.

Point 2: Total Productive Maintenance (TPM)
Waiting is one of the major waste that occurred in the production line in which it is due to the breakdown and little stops activities that occurred on the grinding machines, which would cause an empty chute at the front machines and full chute at the previous machines. Therefore, there would be tons of waiting processes that would be present on the conveyor belt. To reduce waste, Total Productive Maintenance (TPM) is highly encouraged as it is an approach to maintenance that helps to reduce the waste of waiting, waste of defects and lesser in amount of breakdown activities. This could be achieved as TPM concentrates on minimizing the downtime of machines and equipment in which it could be used for the FSFs machines which had plenty of breakdown activities. TPM helps in concentrating to empower technicians to maintain the equipment that they use and also it encourages these technicians to have greater involvements in the production line. In a suitable environment, TPM can be useful to improve productivity in which it will reduce cycle time and defects will be reduced.

5. Conclusions
In conclusion, the current VSM of Industry of bearing has been illustrated using tools to draw which made a specific view of the organization to determine which the value and non-value added values are. The graph of cycle time was established and it was found all of the 19 process machines were under
the target/takt time. Lastly, the factors that will increase the productivity rate in the manufacturing process of bearings were proposed. Two factors that were proposed which were improve working environment and motivation of workers and total productivity maintenance, with the guidance of 7 method of wastes in manufacturing to allocate the losses in productivity. Additionally, as for the success of this DMAIC approach of Six Sigma along with VSM analysis, it would be highly recommended to propose this towards various industry in Malaysia that it can be strategically applied such as franchise food industry, printing and ticketing services industry. In another words, this is to be proposed due to the capability of the methodologies being used can enhance these industries as mentioned previously, therefore it would achieve consumer satisfaction. In addition, there are various other lean manufacturing tools that can be used for future recommendation of productivity improvement activities, nevertheless there are limitations in which would need to be considered.

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