Finishing Line Evaluation of Bracket product FWD RR Spring BT 1702 by Applying 8 Steps 7 Tools Method Toyota Production (Case Study: PT BA)

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Abstract. PT Bakrie Autoparts is a company which runs in foundry and mainly produces cast iron such as wheel hub, brake drum, disc rotor and flywheel. The major problem encountered by this plant is the slow delivery to consumers because the finishing process takes too long time along with the increasing demand while there is no significant improvement. This research focuses on the mapping of the hindrances and problems in the finishing line of Bracket FWD RR Spring BT 1702, how much the actual output is, what causes the problem, and what improvement can be done to remove or reduce the hindrances. The method used is 8 Step 7 Tools Toyota Production System. Time measurement result and Output Standard calculation is based on finishing line cycle time 142 seconds per pcs and output Standard 25 pcs per hour. After applying the method of 8 Step 7 Tools Toyota Production System, cycle time line finishing can be reduced to 66 seconds and the output Standard to 53 pcs per hour. The output line finishing improvement reaches 112% faster than the previous one. Besides that, the improvement makes a better performance Standard in the finishing process of Bracket FWD RR Spring BT 1702 so the product is in better quality and it ensures the operators’s work safety.

Keywords: Lateness, Hindrances, finishing Line, 8 Steps 7 Tools TPS

1. Introduction
The tight industry competition nowadays is measured by not only the ability to produce highly qualified products and competitive selling price but also the on-time product delivery to customers. PT. Bakrie Autoparts is one of the foundry companies producing automotive items with cast iron as the main material and its produces brackets, brake drums, disc rotors, wheel hubs and flywheels. Casting process can be briefly described as a series of continuous steps in making metal casting starting from the casting design to the finishing process. The casting design is the first stage of the casting process. The design is then converted into a pattern and core box as the reference to make the mold and core mold. The next process is melting the metal all at once or sequentially. The metal liquid is then poured into the mold. The metal liquid in the mold will cool down in a period of time. The next process is removing it from the mold and cleaning the casting (finishing).
The main problem that the plant encounters is that the products are not delivered on time to the customers as there are hindrances and waste during the finishing process - finishing line - caused by the increasing demand while there is no significant improvement.

The finishing process of Bracket FWD RR Spring BT 1702 consists of several steps, some of them are processes using a machine grinder, a manual grinder, the final inspection on the end product and the last process is arranging the casting from the roller to the pallet (keeper). The finishing line system works in parallel and continuous way in the production as the company has set the hourly output needs to be fullfilled in its production.

The writers think that the output done in in the finishing line is not optimal yet as the high or low output in a continuous production line is highly affected by the bottleneck and the time balance between one process with another in the line. Bottleneck is a condition where an operation or a facility limits or hinders output in one sequence in a production line, Gaspersz, 2005). Bottleneck can also be described as a work station which has the highest service time compared to other service stations in the production line, (Groover, 2001).

Based on the observation done earlier, the factors causing the hindrance in the finishing line when producing Bracket RR Spring BT 1702 lie in the process of product handling. Unnecessary work and ineffective method used in working also contribute to the problem.

The hindrances and problems are evaluated and verified in this research. The method used is 8 Step dan 7 Tools Toyota Production System. The result of this research is to improve the method used in working so it will become effective and efficient in order to give the expected production output and at the same time prioritize work safety and product quality.

2. Literature Review
The advanced step (fettling) on the casting covers all steps from cooling down the metal in the mold ends (casting cooling) up to its arrangement to be delivered. The processes comprise cooling down, removing the casting from the mold, cleaning the casting from runner, gates and risers, first inspection, parting lines, grinding, improving, last inspection, packaging, and shipment.

TPS (Toyota Production System) puts its all effort to completely eliminate waste, avoid overburden and uneven work in all sectors to enable its members to work effectively and efficiently. TPS, having high Standardd, ensures the method used is safe and the approach is consistent to get the best quality. Toyota Members always keep improving their Standardd and procedures to get the best result, increase efficiency, and eradicate wastefulness.

In ATQC system, the 8 steps are used to solve problems or make improvement. The basic principle of the 8 steps are PDCA (Plan, Check, Do, Action) and later on it will be called 8 steps PDCA. Problem solving and improvement cannot be applied only once, instead it is a continuous process. Therefore, the 8 steps PDCA should be applied with the purpose of continuously improving (kaizen) something.

The 8 steps of improvement start from determining the theme, analyzing the present condition, setting the target, analyzing the cause and effect, planning action, applying the action plan, evaluating the result, Standarddizing and creating follow up actions. Seven tool management is a check sheet, stratification, graph and control map, pareto diagram, cause and effect diagram, scatter diagram, histogram.

Stop watch time study was first introduced by Frederick W. Taylor in the 19th century. The method is best applied in short-term and repetitive work. The result can show the fixed time needed to finish a work cycle.
3. Methodology
In the research methodology are described as the stages of problem solving, the 4 steps known as PDCA (Plan, Do, Check and Action). Plan consists of selecting the theme or title of a problem. Do refers to how to solve the problem. Check is the result of the problem solving. Action is Standardizing and making follow up action regarding the next problem to solve. The flow diagram of problem solving can be seen in Figure 1.

![Figure 1. Problem-solving flow diagram](image)

During the data collection stage, stopwatch time study is used to find out the Standard output in the finishing process of *Bracket FWD RR Spring* BT 1702. The steps to apply the measurement can be seen in Figure 2.

![Figure 2. Stopwatch time study steps](image)
4. Results and Discussions
This stage describes the result of analysis based on the 8 steps 7 tools Toyota Production System method and the result after improvement is implemented based on the existing problem. Moreover, the calculation of the finishing line output and result analysis uses QCDMPE (Quality, Cost, Delivery, Safety, Morale, Productivity, Environment) method after improvement becomes a significant point according to the target reached.

4.1 Analysis using 4M1E method
Analysis result using 4M1E (man, material, metode, machine, environment) method can be seen in Table 1-5.

Table 1. Man Factor Analysis

| No. | Analyzed Points                      | Standard                  | Actual                  | Assessment |
|-----|--------------------------------------|---------------------------|-------------------------|------------|
| 1   | Number of operators needed           | 5 People                  | 5 People                | OK         |
| 2   | Average age                          | • GM: 22-35 Years         | • GM: 25 Years          | OK         |
|     |                                       | • GT1: 22-35 Years        | • GT1: 28 Years         |            |
|     |                                       | • GT2: 22-35 Years        | • GT2: 29 Years         |            |
|     |                                       | • FI: 22-35 Years         | • FI: 30 Years          |            |
|     |                                       | • KP: 22-35 Years         | • KP: 23 Years          |            |
| 3   | Mental attitude, character, work ethic| Diligent, Hard Worker, and Tenacious | Diligent, Hard Worker, and Tenacious | OK         |
| 4   | Skill or ability to work             | Able to grind properly and correctly, inspection in accordance with the Standard | Able to grind properly and correctly, inspection in accordance with the Standard | OK         |

Table 2. Machine Factor Analysis

| No. | Analyzed Points                  | Standard                  | Actual                  | Assessment |
|-----|----------------------------------|---------------------------|-------------------------|------------|
| 1   | Grinding Machine Condition       | • GM: Good                | • GM: Good              | OK         |
|     |                                   | • GT1: Good               | • GT1: Good             |            |
|     |                                   | • GT2: Good               | • GT2: Good             |            |
| 2   | Grinding Machine RPM             | • GM: 1950 -2000          | • GM: 1950 -2000        | NG         |
|     |                                   | • GT1: 1000               | • GT1: 1000             | OK         |
|     |                                   | • GT2: 1000               | • GT2: 1000             | OK         |
| 3   | Grinding Stone Quality           | • Sharp machine grinding stone at 2000 rpm rotation | • Sharp machine grinding stone at 2400 rpm rotation | NG         |
|     |                                   | • Sharp machine grinding stone at 1000 rpm rotation | • Sharp machine grinding stone at 1000 rpm rotation | OK         |
### Table 3. Material Factor Analysis

| No. | Analyzed Points                                                                 | Standard                      | Actual                        | Assessment |
|-----|---------------------------------------------------------------------------------|-------------------------------|-------------------------------|------------|
| 1   | Neck Fracture remainder adder and Line-In on Casting                            | • Notch ± 2 mm from the Object | • Notch ± 2 mm from the Object | OK         |
|     |                                                                                 | • Fair thickness              | • Fair thickness              | OK         |
| 2   | Casting conditions regarding the fins on the Casting                            | • Casting fin is small or absent | • Casting fins are thick and unnatural | NG         |

### Table 4. Factor Analysis Method

| No. | Analyzed Points                                                                 | Standard                      | Actual                                                                 | Assessment |
|-----|---------------------------------------------------------------------------------|-------------------------------|----------------------------------------------------------------------------|------------|
| 1   | Working Method of Each Element                                                  | • Notch ± 2 mm from the Object | • Notch ± 2 mm from the Object                                           | NG         |
|     |                                                                                 | • Fair thickness              | • Fair thickness                                                          |            |
| 2   | Additional Tools related to the Finishing Process                               | -                             | There is no use of tools to simplify and speed up the process of finishing | NG         |

### Table 5. Environment Factor Analysis

| No. | Analyzed Points                                                                 | Standard                      | Actual                                      | Assessment |
|-----|---------------------------------------------------------------------------------|-------------------------------|---------------------------------------------|------------|
| 1   | Finishing Area                                                                  | Wider Area                    | Wide enough for the Finishing Process       | OK         |
| 2   | Finishing Area Layout Arrangement                                               | Neat, Well Arranged, Clear Area Markers | Neat, Well Arranged, Clear Area Markers    | OK         |
| 3   | Finishing Area Lighting                                                          | Simply illuminate all parts   | Simply illuminate all parts                 | OK         |
| 4   | Temperatur atau Suhu di Area Finishing                                           | Cool, a little dust, and comfortable | Cool, a little dust, and comfortable        | OK         |

The analysis result using 4M1E method identifies that the problem lies in the finishing line; machine, material and method factors.
4.2 Treatment Implementation
The result plan to improve the machine factor is by replacing the grindstone machine with the one whose brand is “K” with grindstone specification of 2000 Rpm. The improvement is done by the maintenance team of PT BAP under the supervision of the maintenance supervisor. The replacement was done on the first week of February 2, 2015.

The result plan to improve the material factor is by making a new corebox using iron, RCS sand (burning core), the method of making it uses automatic machine utilizing RCS core machine. The improvement is done by the engineering team of PT BAP under the supervision of the engineering supervisor. The improvement was done in the first week of February on February 3, 2015.

The result plan to improve the method factor is by making a jig in manual grinding process 1 and manual grinding 2 using a steel plate and and making work instruction for every finishing process. The improvement was done in the first week of February on February 5, 2015.

4.3 Result Evaluation
In this stage, the Standard finishing output is done after the improvement and through some steps such as time measurement, bottleneck identification, setting the number of cycles, setting the number of observation, testing the data uniformity, adjusting work time and work performance, setting the loose time and fixed time. Moreover, the advantages of the improvement result are explained using the QCDSMPE method.

4.3.1 The Time Measurement Average during the Finishing Line Process and Identification of Bottleneck in the Finishing Line (after improvement)
Time measurement is done by the writer. The average time and the identification of bottleneck finishing can be seen in Table 6.
Table 6. Data of average time in the finishing line of Bracket FWD RR Spring after improvement

| Process         | Average Time (Second) |
|-----------------|-----------------------|
| Grinding Machine| 31                    |
| Hand Grinder 1   | 60                    |
| Hand Grinder 2   | 33                    |
| Final Inspection | 19                    |
| Keeper           | 13                    |
| Bottleneck       | 60                    |

The bottleneck of the finishing line takes place during the manual grinding 1, adequacy test, data uniformity and fixed time measurement will be done in manual grinding 1.

4.3.2 Adequacy Test and Data Uniformity (after improvement)

The data of elements in the manual grinding process can be seen in Table-7.

Table 7. Data of sampling method in the number of observation manual grinding process 1 of Bracket FWD RR Spring

| Element | Observation Time |
|---------|------------------|
| 1       | 3 3 3 3 3 3 3 3 8 |
| 2       | 6 5 5 5 6 5 6 5 6 |
| 3       | 11 10 10 10 10 11 10 11 10 |
| 4       | 20 20 21 21 20 21 20 21 20 |
| 5       | 6 5 5 5 6 6 6 5 6 |
| 6       | 9 9 9 9 8 8 9 8 8 |
| 7       | 2 2 2 2 2 2 2 2 2 |
| 8       | 2 2 2 2 2 2 2 2 2 |

Data management to see confidence test 95% and accuracy 5% in work element 1 in manual grinding process can be seen in Table-8.

Table 8. Data checking in level of confidence and accuracy in work element 1 in manual grinding 1

\[
N' = \left( \frac{40 \sqrt{(15 \times 130) - (44)^2}}{44} \right)^2 = 12 \text{ times observations, 15 times actual measurement time data after the adequacy test.}
\]

Result of data uniformity test in manual grinding 2 process of every element can be seen in Table 9.
Table 9. Data of data uniformity test in manual grinding 1 process after improvement

| Working Element | BKA  | BKB  | Data Uniformity |
|-----------------|------|------|-----------------|
| 1               | 3.23 | 2.64 | Uniform         |
| 2               | 5.13 | 3.94 | Uniform         |
| 3               | 6.06 | 4.87 | Uniform         |
| 4               | 11.06 | 9.87 | Uniform         |
| 5               | 21.06 | 19.87 | Uniform        |
| 6               | 6.13 | 4.94 | Uniform         |
| 7               | 9.13 | 7.94 | Uniform         |
| 8               | 3.13 | 1.94 | Uniform         |

The data of uniformity test in manual grinding 1 process shows that it is still in the range of upper control limit and lower control limit.

Table 10. Data result of fixed time calculation and the Standard output finishing line

| Working Element | \( \bar{x} \) (Second) | \( p \) (Second) | \( W_n \) (Second) | \( W_n \) (Total Menit) | % Allowence | Ws Jam/ Unit | Output Pcs/Jam |
|-----------------|-------------------------|------------------|-------------------|-----------------------|-------------|--------------|----------------|
| 1               | 2.93                    | 0.99             | 2.90              | 0.99                  | 10.41       | 0.0185       | 53             |
| 2               | 4.53                    | 0.99             | 4.48              | 0.99                  | 10.37       | 0.0185       | 53             |
| 3               | 5.47                    | 0.99             | 5.42              | 0.99                  | 10.27       | 0.0185       | 53             |
| 4               | 10.47                   | 0.99             | 10.37             | 0.99                  | 10.27       | 0.0185       | 53             |
| 5               | 20.47                   | 0.99             | 20.27             | 0.99                  | 10.27       | 0.0185       | 53             |
| 6               | 5.35                    | 0.99             | 5.47              | 0.99                  | 10.27       | 0.0185       | 53             |
| 7               | 8.53                    | 0.99             | 8.44              | 0.99                  | 10.27       | 0.0185       | 53             |
| 8               | 2.53                    | 0.99             | 2.50              | 0.99                  | 10.27       | 0.0185       | 53             |

4.3.3 Comparison between Before and After Improvement

4.3.3.1 Productivity

It is to measure the previous target with the achieved productivity after the improvement. The comparison between product output of Bracket FWD RR Spring before and after the improvement can be seen in Table 11.

Table 11. Data of comparison between cycle time and output before and after the improvement

| The Control Point | Numbers |
|-------------------|---------|
|                   | Before  | Target | Actual |
| Goods That Can Be | 3300    | 5845   | 6360   |
| Produced (Pcs)    |         |        |        |
| Cycle time (Second)| 142.5  | 73.9   | 66.74  |
| Target per Hour (Pcs) | 25     | 49     | 53     |

The data proves that the improvement done in the finishing line when producing Bracket FWD RR Spring using 8 steps 7 tools Toyota Production System can decrease the cycle time in the finishing line.
to 75 seconds and increase the output finishing line to 28 pcs per hour. Production plan for production target in February was 5845 pcs (before the improvement), but now it can reach to 6630 pcs (after the improvement). Overall, the improvement done using the 8 steps 7 tools Toyota Production System method can increase the output in the finishing line to produce Bracket FWD RR Spring to 112%.

4.3.3.2 Quality

The data comparing the rejection of Bracket FWD RR Spring BT 1702 during the period of January to March 2015 can be seen in Table 12.

| Final Inspection | Before | After |
|------------------|--------|-------|
| Jan              | 3300   | 6560  |
| Feb              | 3250   |       |
| Mar              | 0      | 0     |

Based on the data acquired, the rejection over grinder from January to March 2015 was 0%.

4.3.3.3 Safety

The acquired data proves that the improvement done in the finishing line to produce the Bracket FWD RR Spring using 8 steps 7 tools Toyota Production System can decrease the potentials of accidents in the finishing process. Work safety increases, work method is more effective and work process is faster.

4.3.3.4 Cost

The data show that there is a production increase for 112% and the quality of products is good, stable and is able to estimate. The improvement using the 8 steps 7 tools Toyota Production System related to cost is effective as the company’s spending is accurately precise and resulting in big profits from the production.

4.3.3.5 Morale

Improvement regarding morale is the comparison in spirit or motivation of the operators before and after the improvement. After the improvement with 8 steps 7 tools Toyota Production System method, the operators become more motivated to make improvement in all job sectors.

4.3.3.6 Delivery

Comparison between the total order with the ability to deliver Bracket FWD RR Spring before and after the improvement can be seen in Table 13.

| Delivery | Before | After |
|----------|--------|-------|
| Order    | 4845   | 5845  |
| Produced Capacity | 3300 | 6360 |
| Outstanding | 1545 (minus) | 515 (stock) |

Based on the data acquired, outstanding (incomplete) order of Bracket FWD RR Spring before the improvement is 1545 pcs and there are more orders in the following month. After treated with 8 steps 7 tools Toyota Production System method with 5845 pcs per month, now it can reach to 6360 pcs per month. The conclusion is after the improvement is made, there is no minus in delivery causing no order debt in the following months, the production is over the stock and ease the production in the following months.
4.3.3.7 Environment

The data acquired show that the improvement using 8 steps 7 tools Toyota Production System can avoid dirty area in the finishing line, the clean area can make the operators more motivated and bring higher productivity in the finishing line.

5. Conclusion

Based on the application of 8 steps 7 tools Toyota Production System in the finishing line for Bracket FWD RR Spring, it is shown that this method can decrease the cycle time in the finishing line from 142.5 seconds to 66 seconds and the output finishing line from 25 pcs to 53 pcs. The output finishing line improvement reaches 112%. The result after the application of 8 steps 7 tools Toyota Production System in the finishing line when producing Bracket FWD RR Spring in February 2015 was only 5845 pcs per month - now 6360 pcs per month. There was no minus in delivery which affects no delivery debt in the following month. The production is over orders (stocks are available) and can ease up the following month production which causes no late delivery to customers.

In general, the analysis or improvement using the application of 8 steps 7 tools Toyota Production System method supports the increase of output in the finishing line for Bracket FWD RR Spring and creates a better work Standard.

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