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ARTICLE

Cutting tool quality improvement: a case study of electronic parts manufacturer

Thanatorn Chuenyindee[1,*], Piyaphong Yongphet[2,3], Phongchayont Srisuwan[1]

[1] Logistics and supply chain management program, Faculty of Management Sciences, Nakhon Pathom Rajabhat University, Thailand
[2] University Business Incubator, Valaya Alongkorn Rajabhat University under The Royal Patronage, Pathum Thani 13180, Thailand
[3] Research and Development Institute, Valaya Alongkorn Rajabhat University under The Royal Patronage, Pathum Thani 13180, Thailand

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ABSTRACT

Electronic parts are an important part in the modern manufacturing industry. The purpose of this study was to enhance the quality of cutting tools in electronic parts manufacturing process by utilizing statistical methods. Through these approaches, it was found that the cost of precision boring blade (S2F0409R05F35R10PTD) was significantly decrease from 457 THB to 315 THB, this research can maintain the process capability value (Cpk) at the customer satisfaction level (rather than 1.5) and reduce production cost from 2,104,739 THB per year to 1,598,857 THB per year (5 months payback period). The proposed statistical methods approaches could also be applied to other electronic parts manufacturing industries worldwide.

1. Introduction

Electronic part plays an integral part in modern manufacturing. It is well-known as one of every electronic gadget's most useful parts (Govindaraju et al., 2001). In addition, it is also widely utilized due to its timing capabilities (Mirghafoori et al., 2020; Jeyaraman and Kee Teo, 2010; Walsh and Antony, 2009). Electronic gadgets, machinery, and even military armies are constantly utilized to heighten productivity and mechanism.

Thailand is well-known as one of the electronic part manufacturers. As the electronic device growth is high, the demand for the electronic part is also extremely increasing; thus, it is too significant to enhance the productivity and quality of electronic parts in Thailand to sustain its competitiveness.

Despite the significantly increasing number of electronic manufacturing in Thailand, its quality is relatively low. Also, the waste generated from production is quite high. Thus, it is required to consistently enhance the production line's efficiency by controlling the error value variability. Besides, it is also important to enhance the electronic part's measurement system and consistently do the process inspection to minimize the production cost.

A case study manufacturing process that produces electronic parts and reduces the production cost incurred in the spindle motor’s sleeve production line and is also high in production costs.

* Corresponding author.
E-mail address: thanatorn.chuen@vru.ac.th (Thanatorn Chuenyindee)
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Significantly, the cost arising from cutting tools usage, labor cost, and raw materials price has increased, spindle motor's sleeve has not adjusted the sale price and the rising cost. This affected the low turnover rate in the company or lost. Therefore, this study focuses on improving the usage of cutting tool used to reduce production costs. By utilizing time study principles and statistical methods to analyze and improve the cutting tool process, reach expected results.

2. Improvement

This study proposed statistical methods to solve cutting tools used in the electronic part manufacturing process (Govindaraju et al., 2001; Mirghafoori et al., 2020; Jeyaraman and Kee Teo, 2010; Walsh and Antony, 2009). The data gathered in this study were obtained from one electronic part manufacturing company in Thailand.

2.1. The study of spindle motor sleeve

In the study of the sleeve production process, it was found that there are many types of workpieces in the manufacturing process. Since the workpiece that is designed depends on the manufacturing process's technology, the sleeve is divided into two main types depending on the type of workpiece, consisting of a sleeve workpiece 3 production processes and sleeve product finished in one process. In this research, a sleeve workpiece that passed 3 production processes is selected. Details are shown in Fig. 1.

2.2. The cutting tool process analysis

The cutting tool process before improvement, the cutting tool usage data to determine the causes that affected the using cost of the cutting tool exceeds the estimated budget, create a path to improve consumption in order to reduce costs incurred and increase efficiency in the production process (Lin et al., 2018; Lin et al., 2019; Miraja et al., 2019; Martinez et al., 2019; Torres et al., 2019; Lin et al., 2019; Prasetyo et al., 2014; Lin and Prasetyo., 2019; Prasetyo, 2019; Prasetyo and Widyaningrum, 2019; Bamford and Greatbanks., 2005).

It was found that the cost per piece arising from the usage of the cutting tool could not be controlled to achieve the target. It can be observed from the red line graph showing the actual usage above the targeted green line graph, which estimates the cost of the cutting tool against the good finish amount compared to the cost per piece. When analyzing data using Pareto chart, it shown that the cutting tool usage percentage is "S2F0409R05F35R10PTD", "S2B0415R10PTD","S2F05510R09F15R25PTD" and "S2F0250-8R10R35PTD" for 20%, 14%, 13%, and 11%, respectively.

2.3. Lot acceptance rate analysis

Lot Acceptance Rate analysis (%LAR) currently manufacturing is 100% accepted, and 0% rejected, for establish Sleeve Hubble current manufacturing process to maintain sustainability performance.

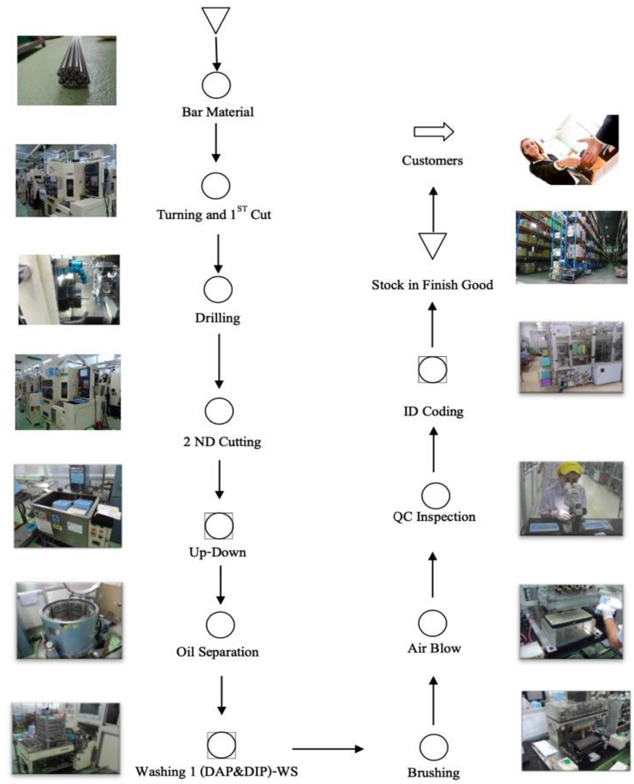


Fig. 1. Sleeve workpiece that passed 3 production processes.

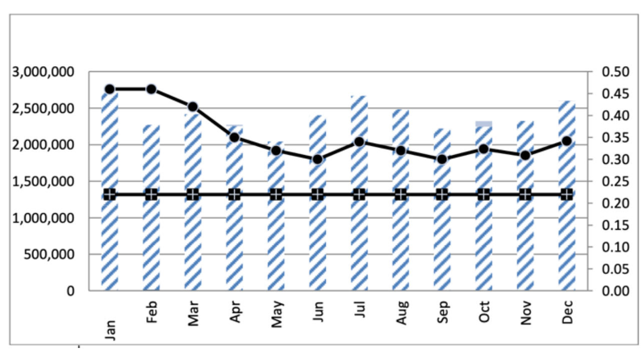


Fig. 2. A bar chart shown the cost of cutting tool in the production process.

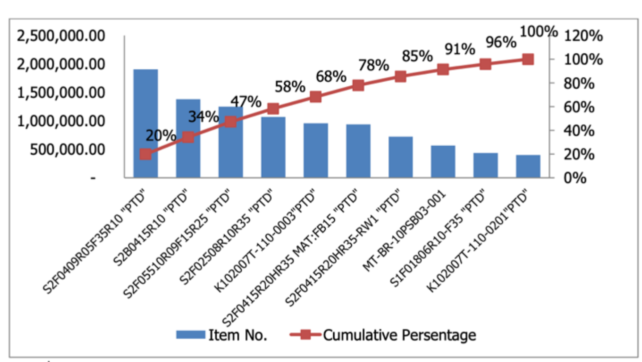


Fig. 3. A chart shown the cutting tool cost quantity.

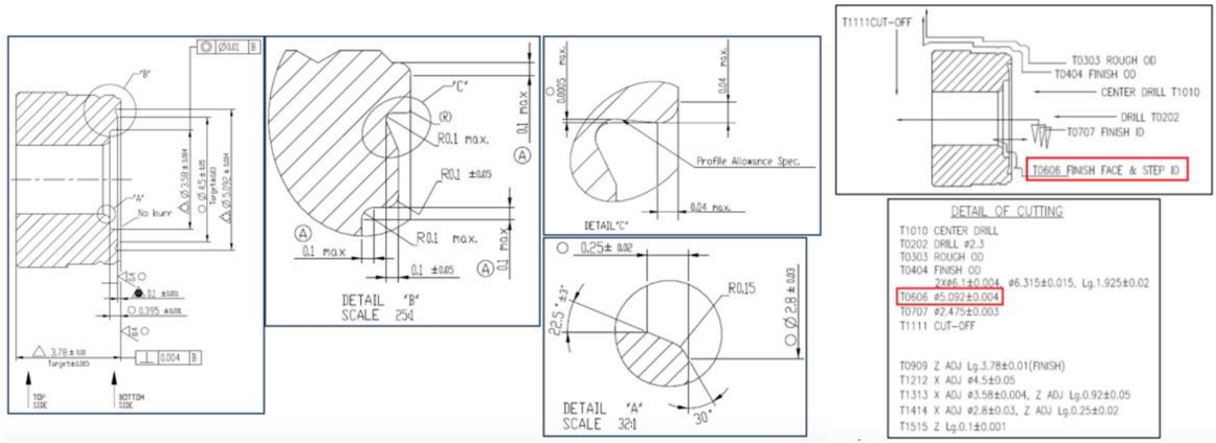


Fig. 4. The "S2F0409R05F35R10PTD" boring blade.

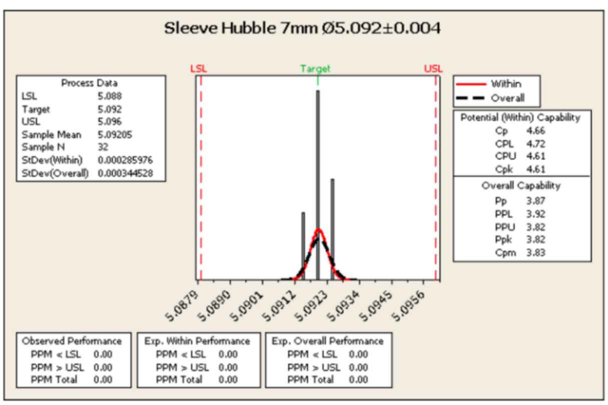


Fig. 5. The production capability of Sleeve Hubble 7 mm. with 5.092 ± 0.004 inner diameter (before improvement).

Fig. 5 found that the value of Cpk was equal to 4.61, and Ppk was equal to 3.82, which means that the production capability of Sleeve Hubble 7 mm 5.092 ± 0.004 inner diameter was also lower than the standard. Therefore, it was also necessary to enhance the manufacturing process.

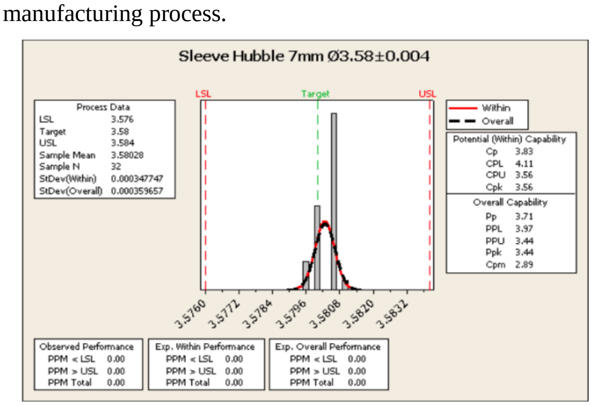


Fig. 6. The production capability of Sleeve Hubble 7 mm. with 3.58 ± 0.004 inner diameter (before improvement).

Fig. 6 found that the value of Cpk was equal to 3.56, and Ppk was equal to 3.44, which means that the production capability of Sleeve Hubble 7 mm 3.58 ± 0.004 inner diameter was also lower than the standard. Therefore, it was also necessary to enhance the manufacturing process.

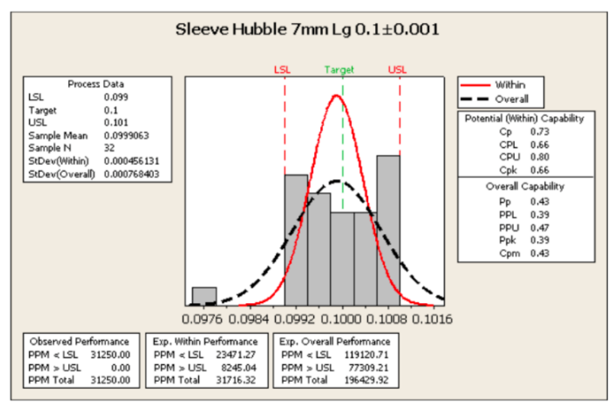


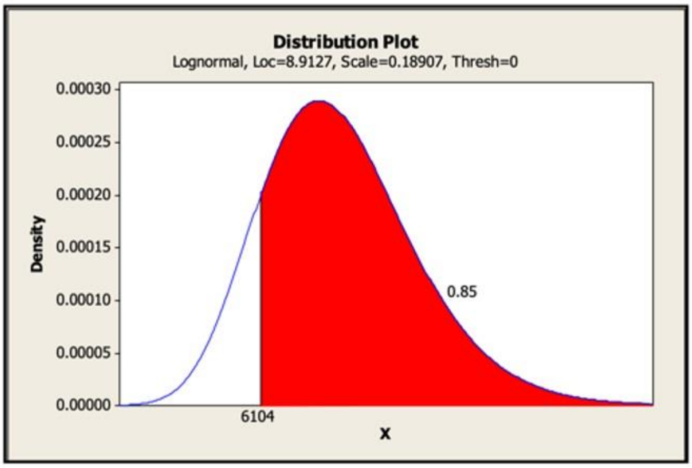
Fig. 7. The production capability of Sleeve Hubble 7 mm. with 0.1 ± 0.001 inner diameter (before improvement).

Fig. 7 found that the value of Cpk was equal to 0.66, and Ppk was equal to 0.39, which means that the production capability of Sleeve Hubble 7 mm 0.01 ± 0.001 inner diameter was also lower than the standard. Therefore, it was also necessary to enhance the manufacturing process.

Fig. 8 found that the analysis of sleeve workpiece cutting capability by using Minitab at 85% reliability, a cutting tool was able to cut 6,104 workpieces per 1 corner, or 1 piece of the cutting tool can cut 6,104 workpieces.

2.4. Determinative guideline for cutting tool process improvement

After setting guidelines for improving the cutting tool usage by changing the type of blade from Boring Blade into Inserts Blade as follows.



Cutting tool sample test result	
No.	Usage from test
1	6,500
2	7,000
3	6,500
4	6,000
5	8,000
6	10,500
7	9,500
8	6,000
9	8,000
10	7,500

Fig. 8. The process repeatability before improvement

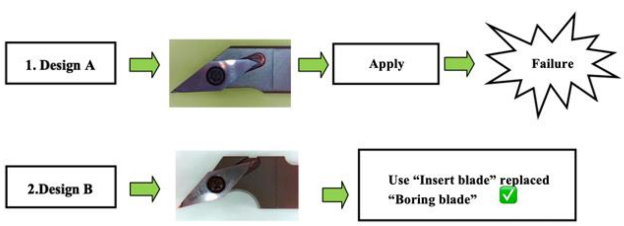


Fig. 9. A guideline for improving “S2F0409R05F35R10PTD” boring blade.

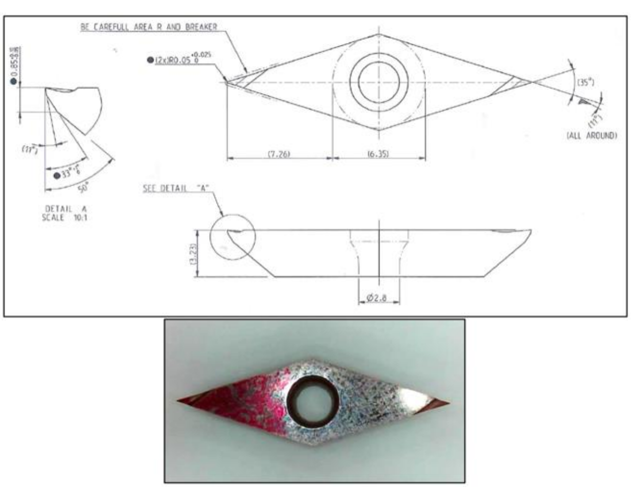


Fig. 10. A “S2F0409R05F35R10PTD” boring blade.

Size and specifications of “S2F0409R05F35R10PTD” boring blade must be controlled during the production process, which includes,

1) Inner Diameter, where the specified value is 3.58 ± 0.004 mm., 5.092 ± 0.004 mm.

2) Straightness control, where the specified values are 0.004 mm., and the roughness of the workpiece surface is specified value as 0.4 mm

3) Inner Diameter The set value is 0.01 mm.

4) Length size are 0.1 ± 0.001 mm., 0.395 ± 0.001 mm.

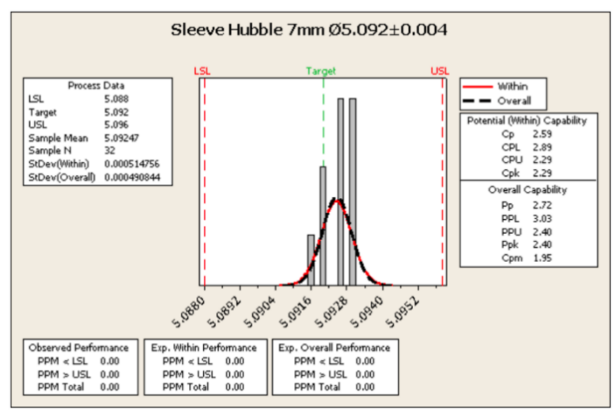


Fig. 11. The production capability of Sleeve Hubble 7 mm. with 5.092 ± 0.004 inner diameter (after improvement).

Fig. 11 found that the value of Cpk was equal to 2.29, and Ppk was equal to 2.40, which means that the production capability of Sleeve Hubble 7 mm 5.092 ± 0.004 inner diameter was also following the standard. Therefore, it should be also necessary to control the manufacturing process for sustainability.

Fig. 12 found that the value of Cpk was equal to 2.19, and Ppk was equal to 1.99, which means that the production capability of Sleeve Hubble 7 mm 3.58 ± 0.004 inner diameter was also following the standard. Therefore, it should be also necessary to control the manufacturing process for sustainability.

Fig. 13 found that the value of Cpk was equal to 0.78, and Ppk was equal to 0.72, which means that the production capability of Sleeve Hubble 7 mm 0.1 ± 0.001 inner diameter was also following the standard. Therefore, it should be also necessary to control the manufacturing process for sustainability.

Fig. 14 found that the analysis of sleeve workpiece cutting capability by using Minitab at 85% reliability, the cutting tool was able to cut 5,072 workpieces per 1 corner, or 1 piece of the cutting tool can cut 10,144 workpieces.

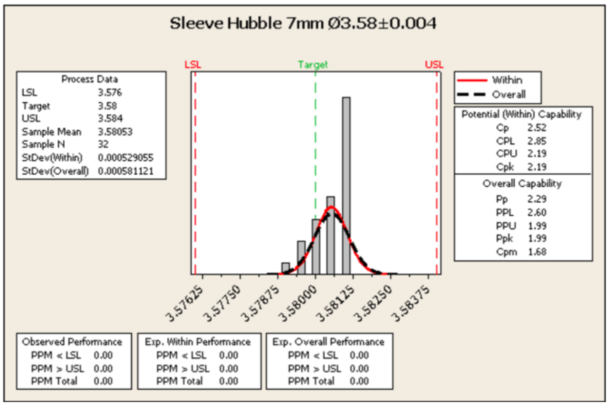


Fig. 12. The production capability of Sleeve Hubble 7 mm. with 3.58 ± 0.004 inner diameter (after improvement).

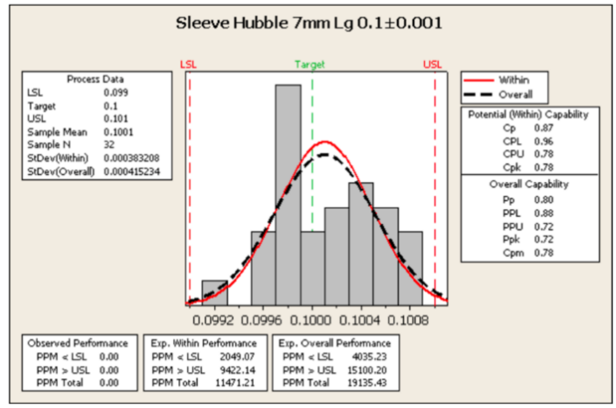
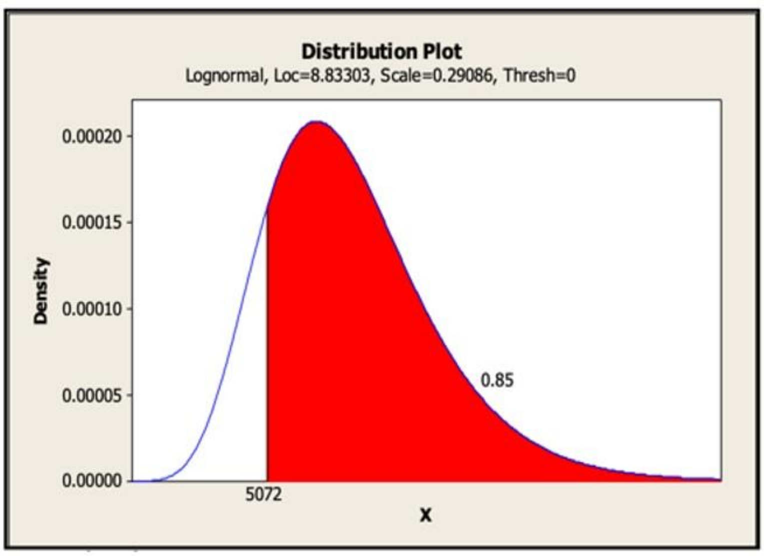


Fig. 13. The production capability of Sleeve Hubble 7 mm. with 0.1 ± 0.001 inner diameter (after improvement).



Cutting tools sample test result	
No.	Usage from test
1	7,500
2	5,500
3	7,000
4	5,000
5	10,500

Fig. 14. The process repeatability after improvement.

2.5 Comparative results between before improvement and after improvement

Found that the guideline path results using Boring blade the "S2F0409R05F35R10PTD" changed from Boring blade to Insert blade to improve and increase efficiency production process. It can be a comparative cutting tool before and after improvement as follows.

2.5.1 Comparison of boring blade "S2F0409R05F35-R10PTD" model for profiling in production processes. The price can be compared between the brand new cutting tool and the reworked cutting tool as detailed below.

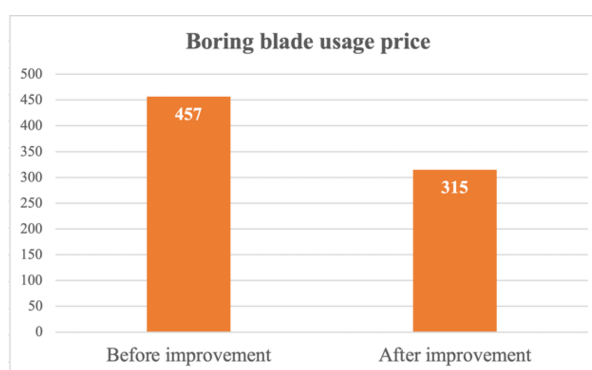


Fig. 15. Boring blade usage price before and after improvement.

Fig. 15 found boring blade usage price before improvement was equal to 457 THB and after improvement was 315 THB.

2.5.2 From Insert blade modification, we can comparison workpiece cutting capability between before improvement and after improvement below.

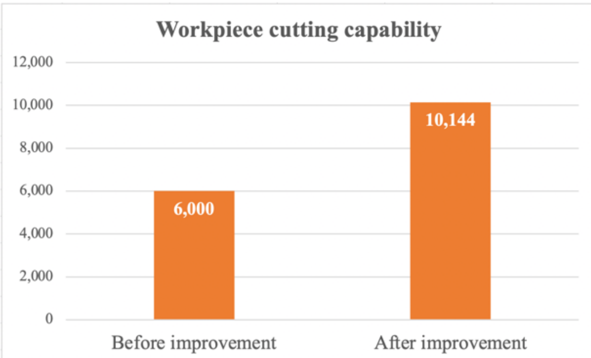


Fig. 16. Workpiece cutting capability before and after improvement.

From Fig. 16, it was found that cutting tool 1 piece was able to cut 6,104 workpieces, and after improvement, able to cut workpieces more than 10,144 workpieces.

2.5.3 From Insert blade modification for cutting and forming processes, we can comparison process capability between the brand new cutting tool and reworked cutting tool below.

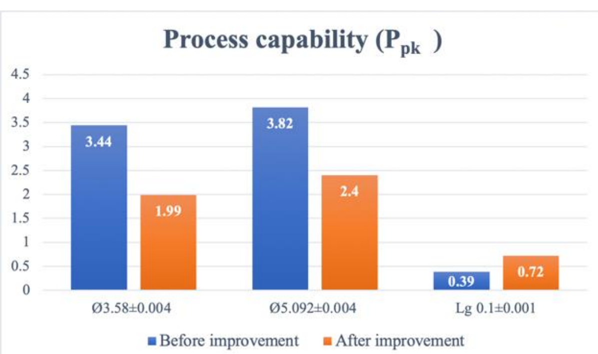


Fig. 17. Process capability before and after improvement.

From Fig. 17, it was found that cutting tool inner diameter process capability before improvement of 3.58 ± 0.004, 5.092 ± 0.004, and 0.1 ± 0.001 will have Process Performance Index (Ppk) was equal to 3.44, 3.82, 0.39 and after improvement was equal to 2.29, 2.72, and 0.8. From bar chart, inner diameter 3.58 ± 0.004 and 5.092 ± 0.004 have a lower Ppk, but can be accepted as the customer determines greater than or equal to 1.5.

2.5.4 From Insert blade modification for cutting and forming processes, we can compare machine capability between brand new cutting tools and reworked cutting tools by hypothesis testing used T-Test.

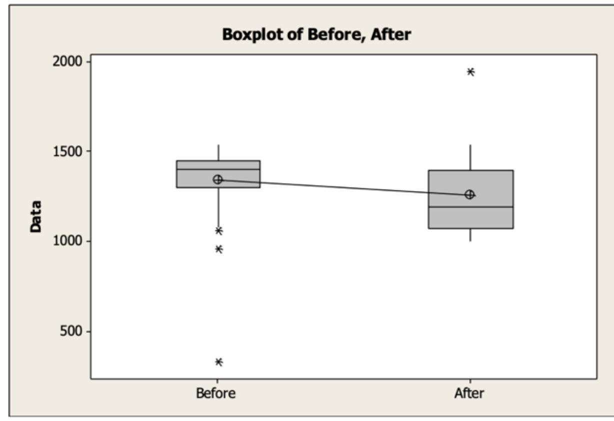


Fig. 18. Boxplot of machine productivity before and after improvement.

Fig. 18 compared the mean of machine productivity per 12 hours with T-test; it was found that the P-Value was equal to 0.933, which was greater than the 0.05 significance level. The mean data analyzed were not significantly different from the significance level.

3. Results and concluding remarks

This study purposed to enhance the efficiency of the manufacturing process and variation control of the cutting tools of electronic parts manufacturer by utilizing the statistical methods that can reduce cutting tool usage cost from electronic parts manufacturing.

From the analysis, it was found that the cost of the precision boring blade (S2F0409R05F35R10PTD) significantly decreased from 457 THB to 315 THB; thus, this research can maintain the process capability value (Cpk) at the customer satisfaction level (rather than 1.5) and reduce production cost from 2,104,739 THB per year to 1,598,857 THB per year (5 months payback period) methods e.g. process capability process repeatability, and sophisticated improvement tools and techniques were applied to determine those problems (Bamford and Greatbanks., 2005; Smętkowska and Mrugalska., 2018; Jones et al., 2010; Chuenyindee and Vanichchinchai., 2019; Chuenyindee and Prasetyo., 2020; Vanichcinchai, 2013). It was found that the defect significantly decreased when compared to the old process. To sustain the improvement, the firm should strictly follow the new operational standards. Suitable but straightforward tools and techniques can improve productivity in manufacturing enterprise according to previous studies (Bamford and Greatbanks., 2005; Smętkowska and Mrugalska., 2018; Jones et al., 2010; Chuenyindee and Vanichchinchai., 2019; Chuenyindee and Prasetyo., 2020; Vanichcinchai, 2013). In the end, the proposed statistical methods approaches could also be applied to other manufacturing industries worldwide.

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