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Reducing Waste in the Crankshaft Manufacturing Process by Using Seven QC Tools

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Abstract. In today's automotive parts manufacturing industry, waste problems in the production process can affect automotive part manufacturers. Moreover, increased production costs hinder the organization's competition with other competitors. This research aims to study and find a method to reduce the amount of waste in crankshaft production processes by applying the seven quality control tools (7 QC tools). Moreover, reduce costs of products to provide customers with the highest satisfaction. From the past 6-month data collection, it was found that the waste in the crankshaft manufacturing process averaged 3500ppm per month, representing the damage and opportunity cost of about 22,095 baht. The result shows that the primary defect type in the production process was dent caused by the jigs that did not press the workpiece tightly. And the problem of the outside diameter is lower than the specified is caused by the holder corroded and collapsing to make the insert is not tight. These problems caused the main reasons; (1) Working methods (2) Worker (3) Machine and equipment. After improvement, it was found that the waste in the crankshaft manufacturing process was reduced. Initially, the dent problem of 148 pieces was reduced to 8 pieces, a reduction of 140 pieces, representing 95%. In addition, the outside diameter problem was lower than the specified, reduced from 117 pieces to 22 pieces, a reduction of 95 pieces, representing 81%. Therefore, it could save the cost of 7,919.76 baht. In total, this production line was able to reduce waste from an average of 3500 ppm/month to only 930ppm/month.

Keywords: 7 Wastes, 7QC Tools, 5W1H, Crankshaft, Part Per Million (PPM), Tool Change Reference (TCR)

1. Introduction

At present, there is very high competition in the automotive parts manufacturers industry. Therefore, the auto parts manufacturer must consider effective production planning with reasonable cost and deliver products on time and in quantity, including quality products as customers' requirements. This way, the organization will be successful and grow sustainably. In addition, the organization should be focusing on "quality" in products and services through reducing waste in the production process, like the loss of raw materials from the production method from the machine or preventing mistakes from employees by having practical control guidelines. If the organization has effective control methods, problems will not increase or occur less. When issues arise, there should be a systematic approach to quality improvement. Various losses will be reduced concretely.

There are many tools and techniques to reduce wastage or waste in the production process. But the most popular and familiar in the manufacturing industry are 7 QC tools. These tools can be used to collect problems, prioritize the frequency of issues, and analyze the problem's root cause. Including Flow chart, check sheet, Histogram, Pareto diagram, Cause and Effect Diagram, etc. [1] [7] through the PDCA cycle to systematically and continuously improve the production process's efficiency [2] [7]. Analysis with the 5W1H technique can help identify the true nature of the problem and explain it with complete accuracy and completeness. [6] Kaizen and TPM techniques are used to improve to achieve the goal of reducing waste in the production process [1] [6] including cost optimization [5-6]

Current Company case studies manufacture automotive parts, including shaft, gear, and hub. The components of the compressor of the air conditioner in the vehicle. From the data collection for the past six months, it was found that these parts manufacturers faced the problem of waste in the crankshaft production process. The number of defects is up to 3500 ppm per month, approximately 22,095baht worth of damage and opportunity cost. Therefore, this project aims to reduce waste using 7QC tools. The crankshaft was manufactured to reduce waste to ≤ 990 ppm according to the goal of the customer to develop suppliers.

2. Methodology

This research study data only on the crankshaft production line of an auto parts manufacturer in Nakhon Ratchasima Province, Thailand. Seven quality control tools were used to reduce waste by studying the machining process of the crankshaft production line. In addition, the research covered the application of techniques and tools on quality control theory by comparing before and after the investigation.

2.1. 5W1H technique was applied to find the root cause of the defect.

(**First W – What** is the nature of defects?) (1) Dent from in drilling process (2) The outside diameter is lower than the specified in turning process (**Second W –When** did this defect occur?) Observed from the monthly defect report and found in the drilling and turning process (**Third W -Where** did this defect occur?) (1) The dent occurs at the drilling process at Operation 40 (2) The outside diameter is lower than the specified occurs at the turning process at Operation 20. (**Fourth W-Who** reported this defect?) Both defects were found and collected by production workers. From random checks every 24th and monthly data collection to reporting the problems. (**Fifth W-Why** bother with this flaw?) (1) The dent is the most significant volume in this production line, and (2) The outside diameter is lower than the specified is second most. As well as the customer's goal of reducing the defect by 990 ppm/month, that's why both flaws were selected to be improved first.

2.2. 7 QC Tools

7QC tools can be considered to solve problems effectively. These tools collect and apply statistical methods with reasoning, science, and knowledge in various fields to deal with problems and eliminate waste.

- **Flow chart***;* the crankshaft production line is the most wasteful and eighteen types of defect data were collected. It was found that two significant problems are affecting this production line. Including the problem of the dents from the drilling process and the outside is lower than the specified in turning process. The flow chart helps to identify where the error is. And it's advantageous in showing how the process works.

- **Check sheet;** the check sheet is designed to collect waste data. It has been designed specifically for each work to gather important information easily and systematically. In this research, a check sheet is designed and used to collect information such as the number of different defects in the crankshaft machining process. Data were collected through a 12-months check sheet from January 2021 to December 2021, including before and after improvements.
- **Histograms;** after collecting information through a check sheet, the data obtained were analyzed for the frequency of defects each month as shown in Figure 1 and calculated as ppm (Part per Million). Using the following formula:

$$\text{Part per Million (PPM)} = \frac{\text{Quantity of defect} \times 1{,}000{,}000}{\text{Quantity of produce}}$$

  It was found that the total defect in the process before the improvement in January – June 2021 was high, averaging at 3500 ppm.

- **Pareto Diagrams;** It is used to show the size of the problem and to prioritize the issue. From the Pareto Diagram, the frequency of each problem is known. It brings such information to prioritize these problems. Considering the severity and frequency of occurrence, MA02 was dent 148 pieces in the drilling process, and MA32 was outside diameter is lower than the specified in turning process 117 pieces were gathered from the past six months. The two significant problems were chosen for improvement, as shown in Figure 2.

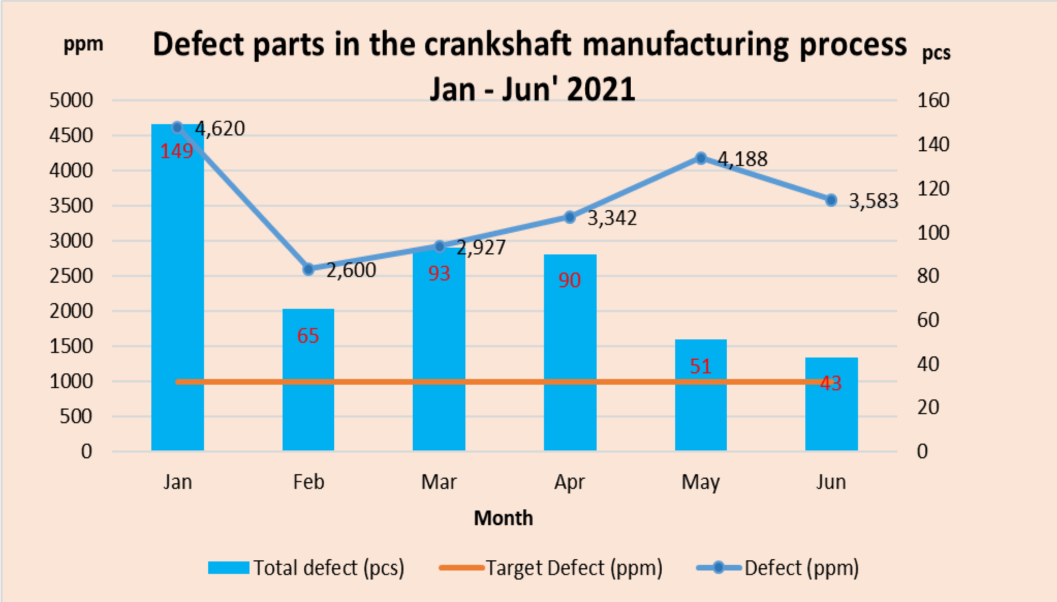


Fig. 1 Defect parts in the crankshaft manufacturing process Jan – Jun' 2021

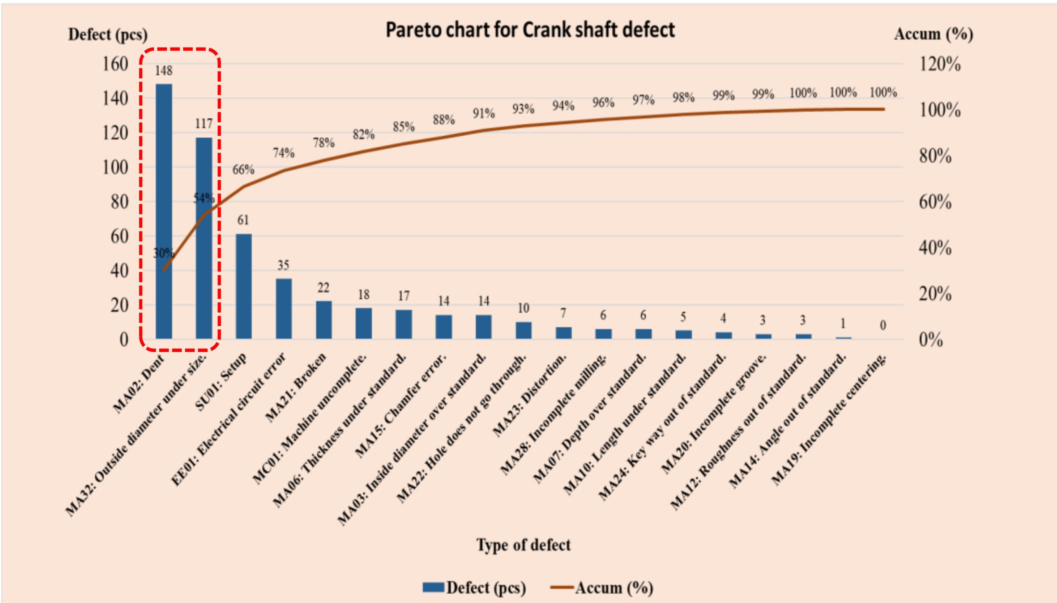


Fig. 2. Pareto Diagram for defect of crankshaft

- **Cause and Effect Diagram;** Cause and effect diagram is used for root cause analysis of problems occurring in a product, process, or system. The issue of a dent in at the drilling process and the issue of the outside diameter is lower than the specified at the turning process easily. Preliminary data from the January-June 2021 check sheet showed a very high level of deficiencies as shown in Figure 3, and a characteristic of the defect is shown in Figure 4. Therefore, cause-and-effect diagrams are used to find the root cause. The main reasons are (1) Working method, (2) Worker, and (3) Machines and equipment. The material is on specification since incoming inspection process. It does not affect to the problems of workpiece. As well as having a stable and appropriate environment control. It does not affect the problem that arises as well.

The first problem, MA02 is dent in the drilling process caused by the jig presses the workpiece corroded. It was causing the press not to reach the workpiece so that the workpiece could move. As a result, the drilling position is expected to move, causing the workpiece to be dent from drilling in the wrong position.

The problem of MA32 is the outside diameter is lower than the specified caused by the holder corroded and collapsing to make the insert is not tight. As a result, this can cause the angle and inserts position to be wrong, making the outside diameter lower than specified, as shown in Figures 5 and 6.

3. Execution of the scenarios

From collecting problems and finding the root cause of the problem, determine how to improve and perform improvements, divided into two defects as follows;

1) The workpiece was dent in the drilling process. It was improved by redesigning the jig press for better pressing on the workpiece and more wear area. Set the life of the jig as a standard in the TCR to change as scheduled.

2) The problem of the outside diameter is lower than the specified. It was improved by the life of the holder and the replacement period are set as a standard in the TCR with preventive maintenance principles.

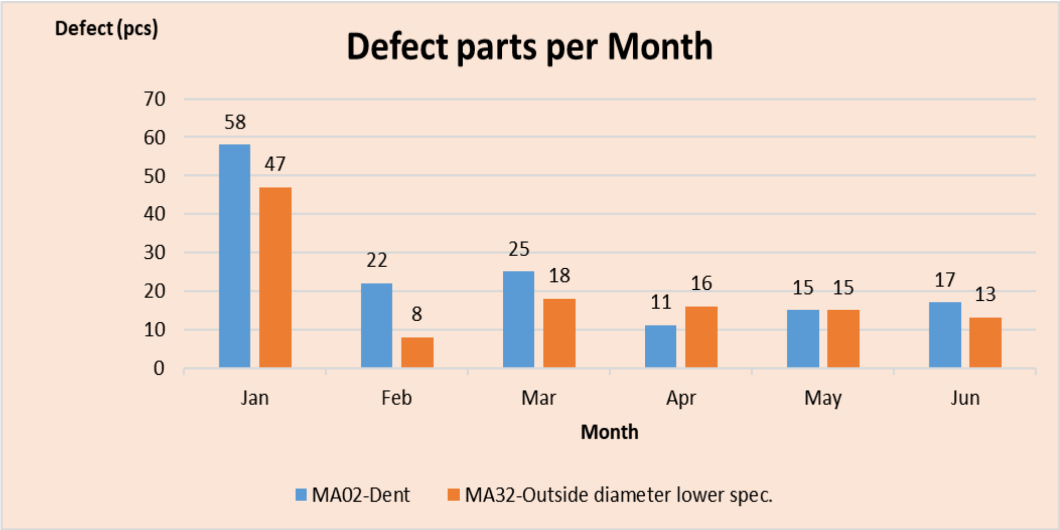
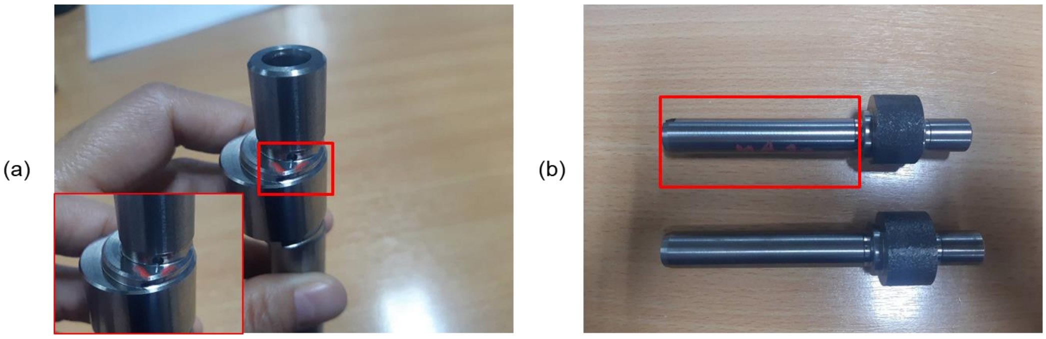


Fig. 3. Defect per month (pcs)



MA02: Dent from drilling hole in OP40 Drilling and Keyway process.

MA32: Outside diameter lower than the specified in OP20 Turning II process.

Fig. 4. The characteristic of the defect

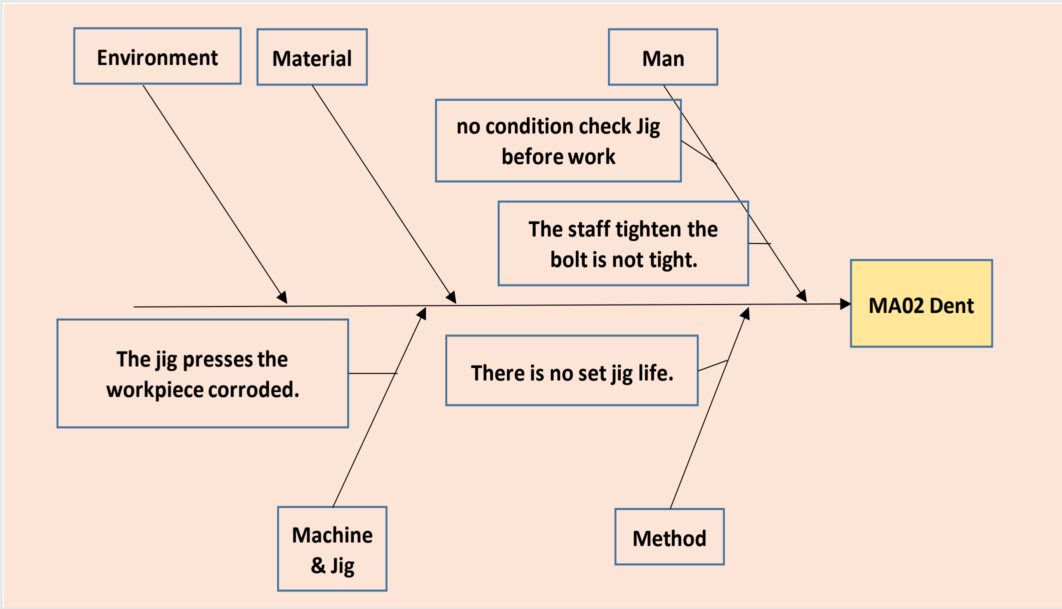


Fig. 5. Cause and effect diagram for MA02- Dent in Operation 40

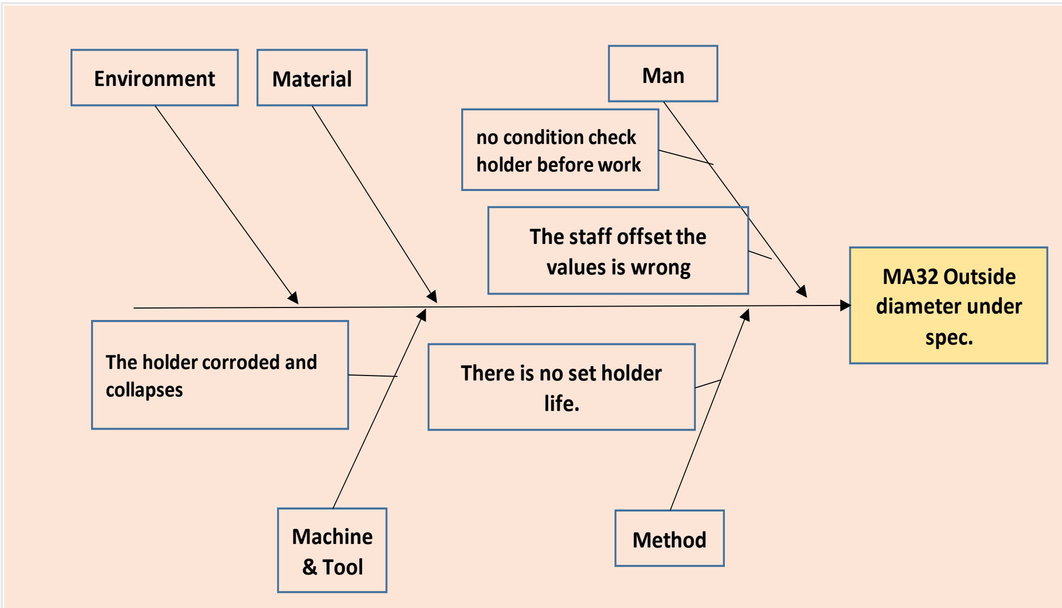


Fig. 6. Cause and effect Diagram for MA32- Outside diameter is lower than the specified in Operation 20

4. Results

It can be seen that there has been a considerable improvement after using the 7QC tools to solve both problems. Defects before and after using the 7QC tools instrument is shown in Figures 7, and overall, the number of defect parts in the crankshaft production line per month was significantly decreased after the improvements were made, a PPM reduction to an average of 930 PPM/month is shown in Figures 8.

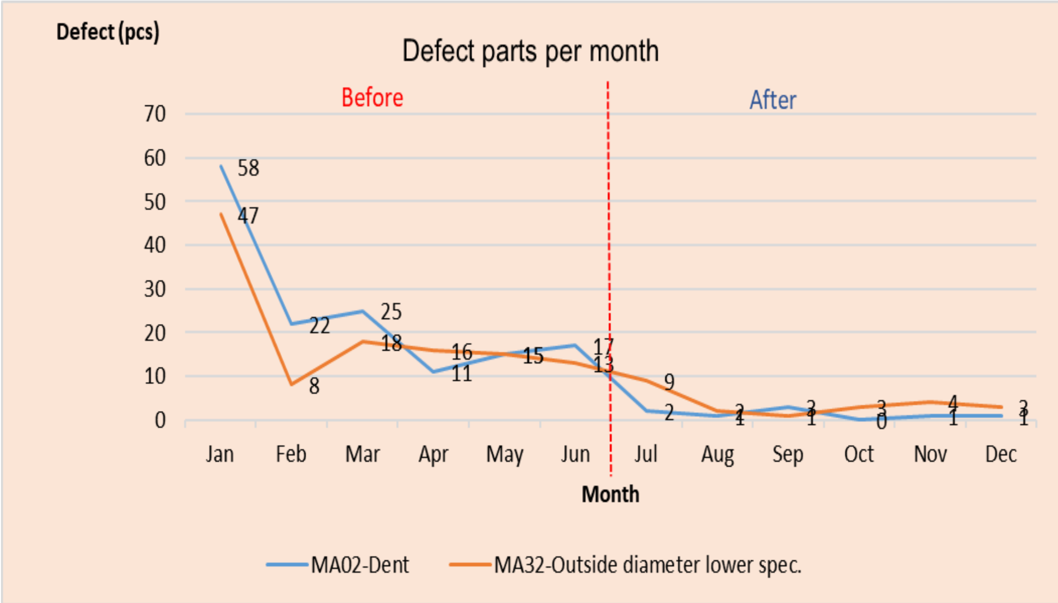


Fig. 7. Defect parts per month

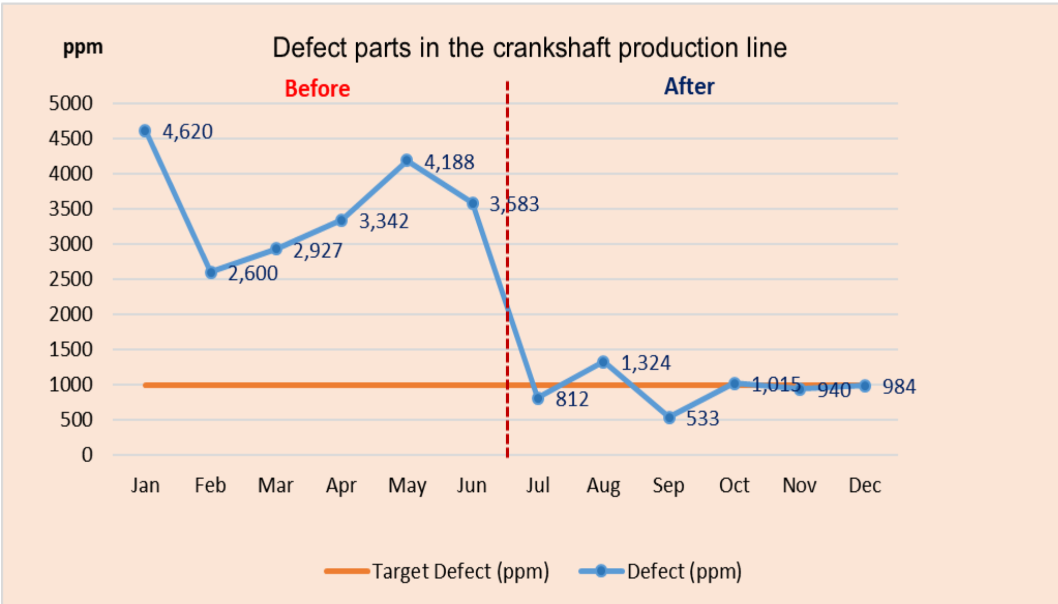


Fig. 8. Defect parts in the crank shaft production line

5. Cost analysis

In addition to reducing waste in the production process, there is also a cost optimization goal. The cost analysis before and after improvement is as follows;

Table 1: Crankshaft Manufacturing Cost

Crank shaft	Cost per piece	
Raw Material cost	14.10	THB
Machining cost	30.90	THB
Total cost	45.00	THB

Table 2: Various Consumables Cost

Tooling costs Description

Sr. no.	Tools	Material	Unit price (THB)	Tool life (pcs)	Cost per piece (THB)	
					OP20-Turning	OP40-Drilling
	OP10-OP20					
1	INSERT	WNMA 080412	85.00	1200	0.07	0.07
2	INSERT	TNMG 160404	95.00	1200	0.08	0.08
3	INSERT	DTE4-040- AH725	375.00	600	0.63	0.63
4	DRILL	CARBIDE 8.3MM.	1,210.00	3000	0.40	0.40
5	INSERT CHAMFER	WBMT 060102	125.00	600	0.21	0.21
6	INSERT GROOVE	GB43R 150 (R0.1)	418.00	1200	0.35	0.35
7	INSERT	SPHX 120404R20	295.00	2000	0.15	0.15
8	CENTER DRILL	CENTER NO. 5	285.00	4000	0.07	0.07
9	INSERT	WNMA 080412	85.00	720	0.12	0.12
10	INSERT	TNMG 160404	95.00	600	0.16	0.16
11	INSERT GROOVE	GB43R145 (R0.1)	418.00	1200	0.35	0.35
	OP30-OP40					
12	DRILL	CARBIDE 9.0 MM.	4,600.00	2000		2.30
13	DRILL	CARBIDE 4.0 MM.	4,600.00	2000		2.30
14	CUTTER	CARBIDE Ø50MM.	4,700.00	5000		0.94
15	CENTER DRILL	TIN-NC-LDS 4X90	220.00	10000		0.02
16	DRILL	CARBIDE 2.2MM.	190.00	3000		0.06
17	DRILL	CARBIDE 2.0MM.	155.00	5000		0.03
18	CUTTER	CARBIDE Ø59MM.	5,500.00	5000		1.10
19	DRILL	CARBIDE 3.5MM.	970.00	5000		0.19
20	BOLT LOCK	M12X60MM.	80.00	3000		0.03
21	JIG LOCK		2,500.00	5000		0.50
Total					**2.58**	**10.06**

Table 3: Oil and Coolant Cost

Oil & Coollant

Sr. no.	Oil	Spec.	Unit price (THB)	Tool life (pcs)	Cost per piece (THB)	
					OP20-Turning	OP40-Drilling
1	OIL; MULTIWAY 68 M	NO. 68	10370	30000	0.14	0.28
2	COOLLANT	VANISOUL S306	19800	30000	0.26	0.53
3	Anti-rust	RUSTILO DWX 14	16100	30000	0.21	0.43
Total					**0.62**	**1.23**

Table 4: Inspection Cost

Inspection cost

Sr. no.	Inspection	Man	Salary	Tool life (pcs)	Cost per piece (THB)	
					OP20-Turning	OP40-Drilling
1	QC inspection	1 person	15000	30000	0.50	0.50
Total					**0.50**	**0.50**

Table 5: Machining Cost

Machining cost

Sr. no.	Desc.	Man/Machine	Cost	Tool life (pcs)	Cost per piece (THB)	
					OP20-Turning	OP40-Drilling
1	Direct labor OP10	1.50	22,500.00	30000	0.75	0.75
2	Direct labor OP20	1.50	22,500.00	30000	0.75	0.75
3	Direct labor OP30	3.00	45,000.00	30000		1.50
4	Direct labor OP40	3.00	45,000.00	30000		1.50
5	Depreciation cost OP10	3.00	7,500,000.00	2880000	2.60	2.60
6	Depreciation cost OP20	3.00	7,500,000.00	2880000	2.60	2.60
7	Depreciation cost OP30	2.00	5,000,000.00	2880000		1.74
8	Depreciation cost OP40	3.00	7,500,000.00	2880000		2.60
Total					**6.71**	**14.05**

Total Cost per piece Associated In Operation 20 & Operation 40	**24.51**	**39.94**

Table 6: Comparison before and after implementing 7QC Tools

Comparison before & after Implement 7QC tools	Before	After	Save cost
Defect MA32- Outside diameter under spec. in OP20 (pcs)	117	22	
Total Cost (THB)	2,867.67	539.22	2,328.45
Defect MA02-Dent in OP40 (pcs)	148	8	
Total Cost (THB)	5,910.82	319.50	5,591.31
Total save cost (THB)	**8,778.49**	**858.72**	**7,919.76**

The cost per piece from defect MA32 Outside diameter is lower than the specified in the turning process = 14.10 +2.58+ 0.62+ 0.50+ 6.71 = 24.51 baht/piece. Before improvement, have 117 pcs defect x 24.51 baht/piece incurring wasted cost is 2,867.67 baht but after improvement, the defect reduced to 22 pcs. x 24.51 baht/piece incurring wasted cost is 539.22 baht able to save cost 2,328.45 baht.

The total cost from defect MA02 Dent work in drilling process = 14.10 + 10.06+ 1.23+ 0.50+ 14.05 = 39.94 baht/piece. Before improvement have 148 pcs defect x 39.94 baht/piece incurring wasted cost is 5,910.82 baht but after improvement the defect reduced to 8 pcs. x 39.94 baht/piece incurring wasted cost is 319.50 baht able to save cost 5,591.31 baht.

When comparing before and after improvement, the cost can be reduced by 7,919.76 baht.

6. Conclusions

This research investigates the reduction of defects in the crankshaft production line of the automotive parts manufacturer. It was found that the highest frequency of defects in the drilling process found a problem with 148 pieces of dent workpiece. The turning process found the problem was that the outside diameter was lower than the specified of 117 pieces in data collection from January - June 2021 (before using the 7QC tools). And after the improvement, the dent problem was reduced to 8 pieces. The outside diameter problem lower than the specified was reduced to 22 pieces from data collection in July-December 2021 (after using 7QC tools). The dent problem in the drilling process is a reduction of 95%, and the issue of the outside diameter being lower than the specified was an 81% reduction in the turning process. Overall, there was an average of 3500 PPM/month defect in process in the pre-improvement. After improvement, the average defect can be reduced to 930 PPM/month. This research achieved a customer target of ≤990 ppm/month and optimized product cost. It can lead to saving costs of 7,919.76 baht. Therefore, this can increase customer confidence, and the company's overall reputation gets improved.

7. Acknowledgements

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8. References

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