

Reducing Black Spot Waste from Motor Housing Parts- Model EM-14 with Qc7 Quality Tools

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Purpose: This research aims to examine the plastic part injection process, analyze the causes and find ways to improve the production process to reduce waste in Motor housing parts, model EM-14, regarding the black dot defect problem using quality tools (QC 7 Tools). It consists of 4 steps as follows: 1) Problem identification 2) Analysis 3) Improvement, and 4) Control step.

Methods: Before improving, the average black dot was 1.19% defect. From the results of analyzing the cause of the problem using fishbone diagrams, brainstorming, and analyzing the symptoms of failures and their effects.

Findings: The findings reveal that the problem of black dot defects in the plastic injection process is reduced by 58.82%, with an average of 0.49% defect, equivalent to a waste value in the production of up to 47,139.00 baht per year and can reduce costs as well. The organization's production can achieve the organization's set goals, which is the percentage of defects not exceeding 0.7 %

Research Implications: It was found that factors affecting the problem are plastic injection machines caused by screw wear from the screw tip that rubs against the non-reverse ring, causing metal scraps to escape during plastic injection, fluid carry out improvements and control defects. **Originality/Value:** By creating a plan to maintain the plastic injection machine (Plastic Injection Machine) every 6 months, the spare screw must be changed every time to fix the problem of screw wear.

Keywords: O Quality improvement, Black spot reducing, QC7 quality tool, Motor housing parts, Production engineering.

1. Introduction

Thailand is one of the world's important plastic production bases. The overall economic value of the industry is 1.1 trillion baht (2022), with key strengths being that Thailand's petrochemical industry is large and has relatively high production potential compared to ASEAN countries. Therefore, it increases the strength and competitiveness of the plastic pellet industry, which is a downstream product of the petrochemical industry. In addition, major Thai operators are ready to research and develop the efficiency of plastic pellets

to meet the ever-changing market needs. This allows Thailand to produce plastic pellets to support various downstream industries, both in terms of quality and price. In 2021, Thailand can produce up to 9.5 million tons of plastic pellets and import only 2.0 million tons, with 59% of the plastic pellets being exported to the overseas market, and 41% are processed into products to support downstream industries in the country such as automobiles, electrical and electronic appliances, and construction. Thailand's plastics converter industry has a production chain that covers both upstream raw materials, including domestic natural gas products, midstream industries include the petrochemical industry (manufacturing plastic pellets) and downstream industries including various downstream industries.

There are more than 3,262 plastic product processing industry operators in the country in 2022, approximately 88.5% are small and medium enterprises (SMEs) and 11.5% are large enterprises. Most of them produce plastic products for general use (Commodity products), so the competition in the business is quite intense (Krungsri.com, 2023). There are two main factors that affect consumer decisions: price and quality. This causes the plastic injection industry to have to improve. It is necessary to use appropriate techniques to improve production to have low product costs and high quality in order to compete in the market and enable the organization to survive.

Case study company has operated an industry related to plastic injection. The products produced are electrical appliance parts. Currently, there are problems with product quality control. From collecting production data from January – May, there were 18,624,308 pieces in production. It was found that the total amount of waste generated was as much as 53,606 pieces, equal to 2,900 DPPM or 0.29%. There are Motor housing parts, model EM-14, which are parts used to cover the motor, fruit blender products There was a total of 959 pieces of waste, equal to 11,900 DPPM or 1.19%, which is not in line with the target set by the company, which is that waste from production must not exceed 0.70% or 7,000 DPPM.

Therefore, this research focuses on studying the plastic injection process. To analyze the cause of the problem by using the quality tool QC 7 Tool as a guideline to help solve problems that arise to reduce waste generation and reduce production costs for the case study company.

2. Objective

To examine the causes and reduce the amount of waste of Motor housing parts, model EM - 14, from the plastic injection process.

3. Methods

Method of operation to study the causes of waste and reduce the amount of waste of Motor housing model EM - 14 parts from the plastic injection process consists of 6 main steps: study of the plastic injection process steps Setting up a problem-solving team Selection of problems Problem analysis and corrections and improvements.

Motor housing parts, model EM-14, are parts used for the assembly in products. The fruit blender acts as a cover for the motor unit and supports the fruit blender bowl. It has a round shape. The diameter is 166 millimeters, the height is 123 millimeters, the wall thickness of the parts is 2.5 millimeters. The production method is from the Injection molding process using plastic pellets. Polypropylene (PP) grade PP - UB5210 in molding, there are steps in the plastic injection process consisting of 6 steps: Raw material, Molding installation, Parameter set up, Operated injection machine, Quality inspection, and Packing as shown in Figure 1.

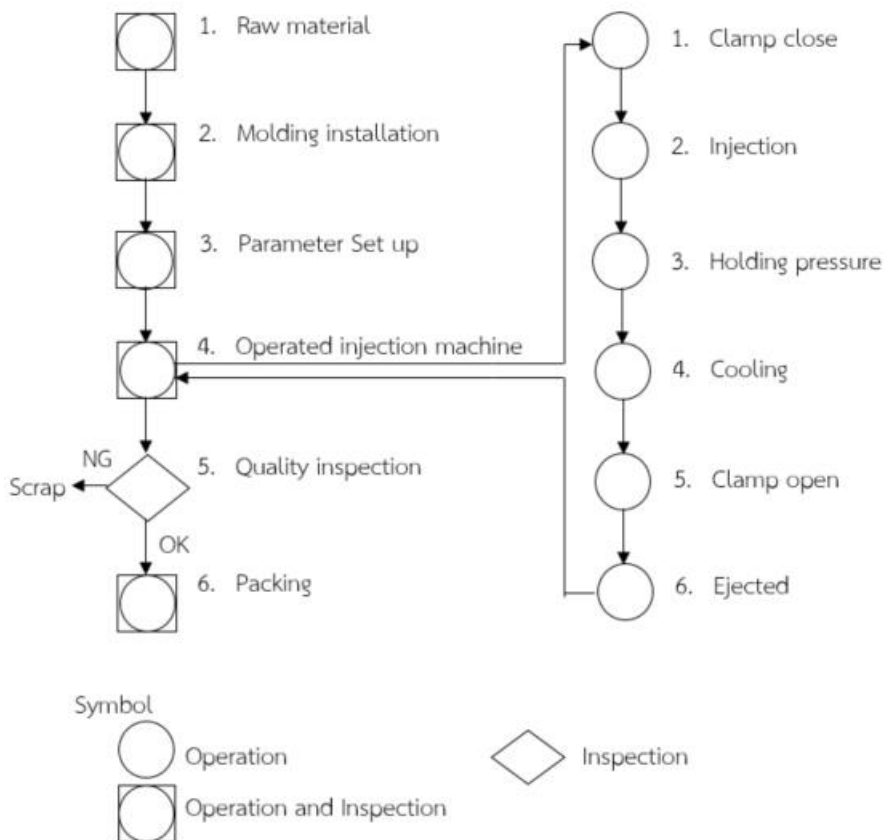


Figure 1: Plastic injection process

From collecting production data in the plastic injection process at the plastic parts production department of the case study company from January-May, there was a total production of 18,624,308 pieces. It was found that the amount of waste generated was as muc as 53,606

pieces, accounting for a DPPM equal to 2,900 DPPM or 0.29% Defects as shown in Table 1

Table 1: Production information for parts from the plastic injection process (Information from January-May)

Injection Data (Production)	Month					Total (Jan–May)
	Jan	Feb	Mar	Apr	May	
Total Injection (Pcs)	3,892,374	3,750,016	3,749,260	3,476,590	3,756,068	18,624,308
Total NG (Pcs)	11,733	11,733	9,976	10,281	9,883	53,606
% NG In process	0.30 %	0.31 %	0.27 %	0.30 %	0.26 %	0.29 %
DPPM	3,000	3,100	2,700	3,000	2,600	2,900

When taking all production data of parts from the plastic injection process, separate waste according to the nature of defects as follows: Black dot, Silver streak, Short shot, Weld line, Scratch, Burn mark, Sink mark, Jetting, Flashing, Flow Mark, Warpage, and Cracking. Proportion of total waste. is shown in Table 2 and Figure 2

Table 2: Waste Separated by Defect Characteristics (January – May)

Defects	MONTH					Waste (pcs)	Total Waste (pcs)	Waste (%)
	JAN	FEB	MAR	APR	MAY			
Black Dot	3738	3669	3120	3215	3159	16901	16901	31.65%
Silver Streak	2629	2652	2255	2324	2211	12070	28971	22.52%
Short shot	957	965	821	846	805	4393	33364	8.19%
Weld Line	846	853	725	748	711	3883	37247	7.24%
Scratch	768	774	658	679	646	3525	40772	6.58%
Burn Mark	583	588	500	515	490	2676	43448	4.99%
Sing Mark	516	520	443	456	434	2369	45817	4.42%
Jetting	420	424	360	371	353	1928	47745	3.60%
Flashing	409	412	350	361	344	1876	49621	3.50%
Flow Mark	307	309	263	271	258	1408	51029	2.63%
Warpage	198	199	169	175	166	907	51936	1.69%
Cracking	192	194	165	170	161	881	52817	1.64%
Others	172	173	147	152	145	789	53606	1.47%

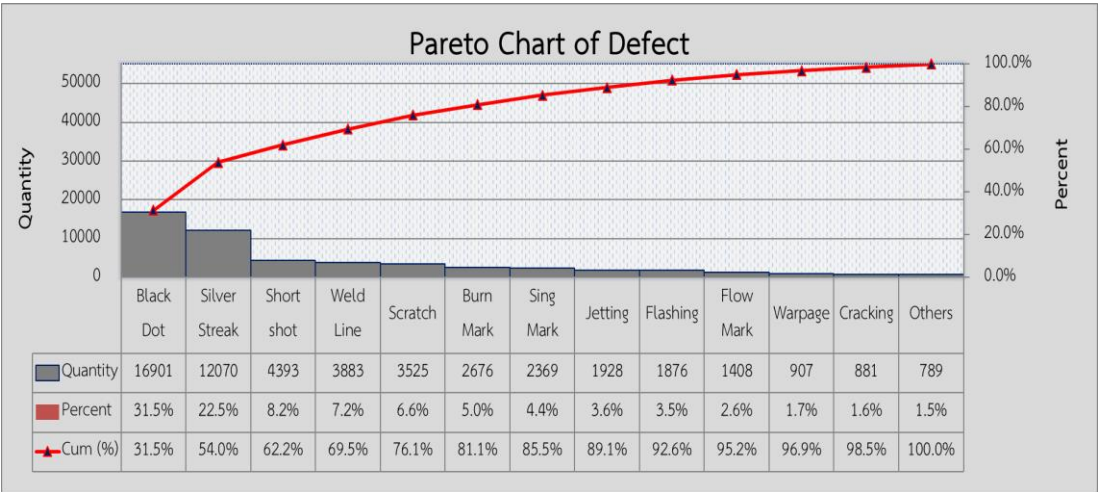


Figure 2: Waste data separated by defect characteristics

According to waste data separated by the nature of defects occurring in the plastic injection

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process, the first order is Black Dot parts. The part with the most Black Dots is the Motor housing model EM-14 shown in Figure 3. It is a part used. Assembled into a fruit blender product which is white, making the Black Dot easily visible.



Figure 3: Motor housing part No. EM – 14

From collecting production data starting from January - May. Motor housing parts, model EM - 14, have been produced in the amount of 80,767 pieces. It was found that black waste The resulting Dots were 959 pieces, equal to 11,900 DPPM or 1.19%, as shown in Table 3. The goal of this research is to reduce the rate of Black Dot by another 0.49%, or equal to 4,900 DPPM, to meet the target set by the company, which is that waste from production must not exceed 0.70%, or equal to 7,000 DPPM, as shown in Figure 4.

Table 3: Waste parts of Motor housing model EM-14 (data from January-May)

Injection Data (Motor housing)	Month					Total
	Jan	Feb	Mar	Apr	May	
Total Injection (Pcs)	13,350	15,241	20,754	17,406	14,016	80,767
Total NG (Pcs)	173	164	246	214	162	959
% NG In process	1.30%	1.08%	1.19%	1.23%	1.16%	1.19%
DPPM	13,000	10,800	11,900	12,300	11,600	11,900

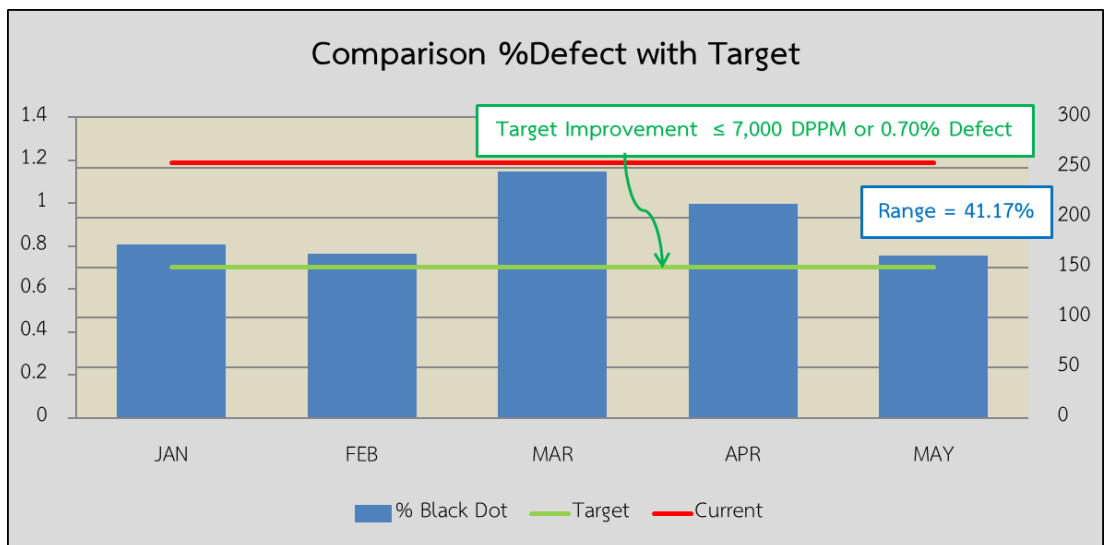


Figure 4: Comparison of Black Dot defect quantity data

Motor housing parts, model EM – 14, with the target values set by the company.

4. Results

4.1 Problems Analysis

The problem of this study is the occurrence of black dot defective parts of the Motor housing model EM - 14. From the analysis of the cause of the defective problem that occurred, by analyzing the 4 main causes (4M, 1E) using the Why-Why Analysis principle and creating a fishbone diagram as shown in Figure 5.

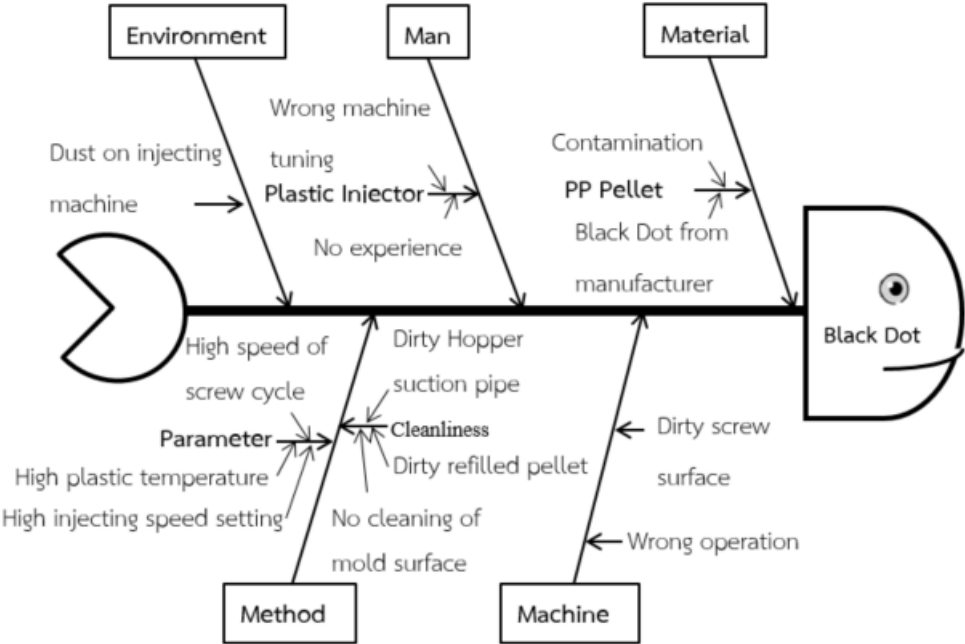


Figure 5: Fishbone diagram showing cause and effect of factors affecting the Black Dot problem.

Results of Failure Mode and Effects Analysis to give RPN - Score to be used to consider selecting important defects. Use the Pareto principle to analyze important data section, there will be only a small amount, in the slightly important data section there will be a large amount, approximately 80 : 20, or you can select defects with an RPN value of more than 100 to be corrected. Shown in Table 4

Table 4: Results of analysis of defect characteristics and impacts

Principle Input Process			Defect	Impact	S E V	Cause	O C C	Current Control	D E T	R P N
Man	1	Plastic Injector	Wrong machine tuning	Black Dot	6	No experience, No training	5	WI Checklist	3	90
	2	Plastic Injector	No experience	Black Dot	7	New employee	4	WI Checklist	3	84

Machine	3	Dirty screw surface	Burnt plastic attach	Black Dot	7	No screw cleaning	6	No	8	336
	4	Wrong operation	large plastic syringe stays in the pipe for a long time.	Black Dot	5	No experience	4	WI Checklist	3	60
Method	5	Parameter	High speed of screw cycle	Black Dot	6	No Trial and error for correct tuning	4	WI Checklist	4	96
	6	Parameter	High plastic temperature	Black Dot	6	No Trial and error for correct tuning	4	WI Checklist	3	72
	7	Parameter	High injecting speed setting	Black Dot	6	No Trial and error for correct tuning	4	WI Checklist	4	96
	8	Cleanliness	Dirty Hopper suction pipe	Black Dot	4	Do not follow the SOP	5	WI Checklist	3	60
	9	Cleanliness	Dirty refilled pellet tank	Black Dot	4	Do not follow the SOP	4	WI Checklist	4	64
	10	Cleanliness	No cleaning of mold surface	Black Dot	4	Do not follow the SOP	5	WI Checklist	4	80
Material	11	PP Pellet	Contamination	Black Dot	4	Dirty dusted and PP pallet bag	5	WI Checklist	3	60
	12	PP Pellet	Black Dot from manufacturer	Black Dot	5	Manufacturing process and internal receiving process	5	WI Checklist	3	75
Environment	13	Dust on injecting machine	Contaminate with pellet	Black Dot	3	No Cleaning around the machine	5	5S Plan	5	75

From Table 4, the results of the analysis of defect characteristics and impacts, scores can be summarized in the analysis for important defects as shown in Table 5 to create a Pareto diagram as shown in Figure 6

Table 5: Summary of the order of scores in the analysis of major defects.

Rank	Cause	RPN-Score
1	Screw surface, dirty syringe	336
2	High screw rotation speed	96
3	Set high speed	96
4	The technician adjusted the machine incorrectly.	90
5	The injection technician lacks experience.	84
6	The surface of the mold was not cleaned.	80
7	There is a Black Dot on pellet from the manufacturer.	75
8	Contaminated with plastic pellets	75
9	Set up parameter temperature	72
10	The pellet filling tank is not clean.	64
11	Using equipment that does not meet standards	60
12	Hopper, suction pipe not clean	60
13	Contamination.	60

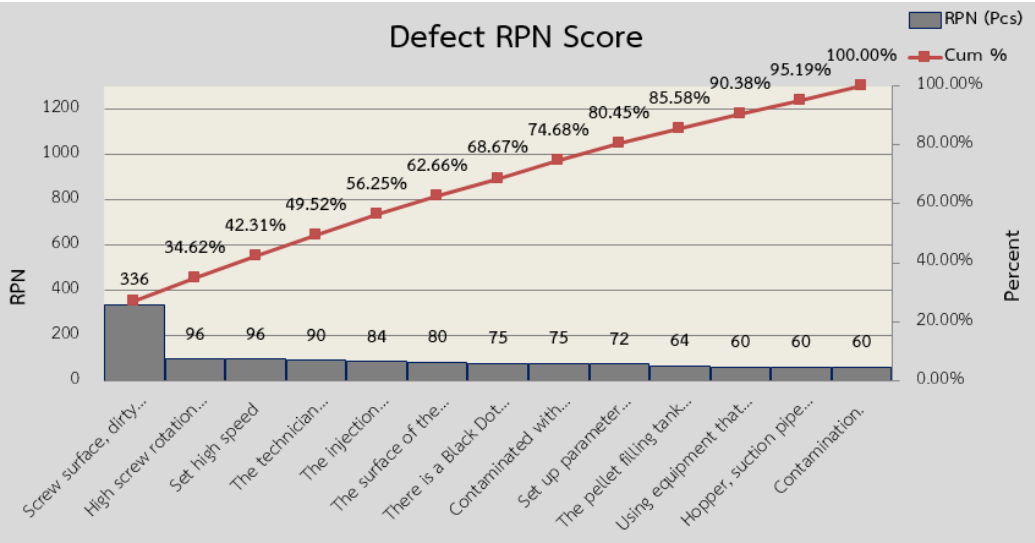


Figure 6: Pareto diagram sorted by RPN score

From Figure 6, it can be seen that the main cause affecting the problem of Black Dot defects in the plastic injection process is the dirty surface of the screw and syringe, with a value of 336 points. Therefore, the study was carried out in the next step by Proving the cause of the 3 GEN defect problem is shown in Table 6.

Table 6: Results of proving the cause of the 3 GEN defect problem

Cause	Method of Proof	Result of Proof	Conclusion of Proof
The surface of the screw and syringe is dirty.	Check at the actual work place and found that during January to May, the screws had never been removed for cleaning.	Proven by removing the screws to inspect the current condition, finding that there were black stains from burnt plastic clinging to the screws. The syringe has worn and tear on the screw tip.  Tested screw 	The results proved true. which affects the Black Dot problem that occurs

			
		Screw tip wear	

From Table 6, it is possible to find causes that affect the production process, which are caused by machinery factors: Plastic Injection Machine. This is a problem caused by the screw being worn out causing metal scraps from the screw tip that rubs against the return ring wears out and escapes during injection with the liquid plastic from not removing the screw to inspect and clean the syringe because a screw cleaning plan had not yet been determined. Therefore, the said problem has been solved by making a plan to maintain the Plastic Injection Machine every 6 months, the spare screw must be replaced every time in order to solve the problem of screw wear.

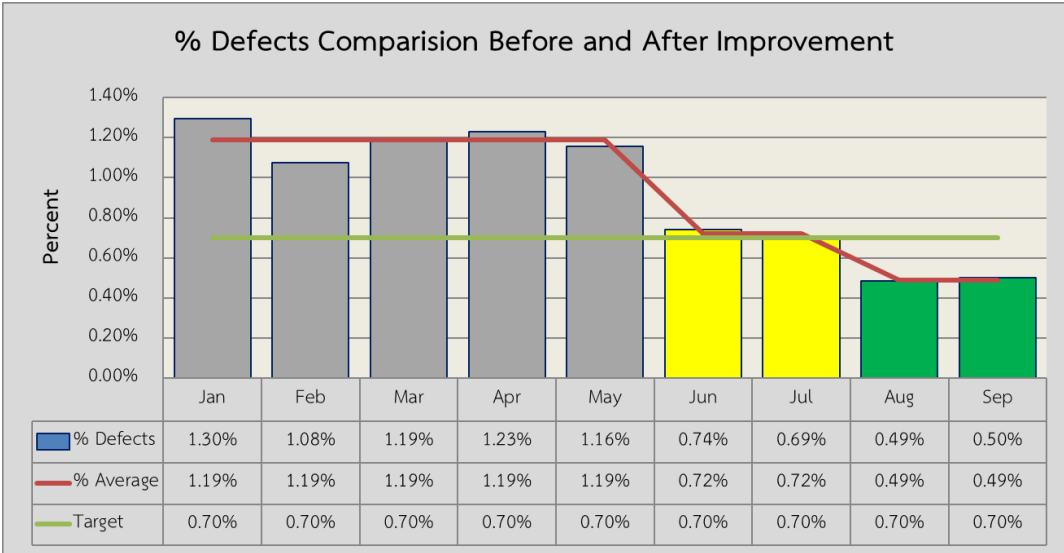
4.2 Experimental results after solving the problem

The results of solving the problem of reducing waste and Black Dot defects that occur in Motor housing parts, model EM – 14, by applying quality tools (QC 7 Tools). The results of comparing production data before, during and after the improvement are shown in Table 7

Table 7: Comparative results of production data before, during and after the improvement of the Motor housing model EM-14 in the plastic injection process.

Status	Month	Order	Defect	DPPM	%Defect	%Yield
Before Improvement	January	13,350	173	13,000	1.30	98.70
	February	15,241	164	10,800	1.08	98.92
	March	20,754	246	11,900	1.19	98.81
	April	17,406	214	12,300	1.23	98.77
	May	14,016	162	11,600	1.16	98.84
	Sub Total Before	80,767	959	11,900	1.19	98.81
Between Improvement	June	18,770	139	7,400	0.74	99.26
	July	9964	69	6,900	0.69	99.31
	Sub Total Between	28,734	208	7,200	0.72	99.28
After Improvement	August	9864	48	4,900	0.49	99.51
	September	9172	46	5,000	0.50	99.5
	Sub Total After	19,036	94	4,900	0.49	99.51

From Table 7, it can be seen that when comparing the statistical data of the Black Dot type defect problem before the implementation of the solution during January-May, waste has an average value of 1.19% and the results of operations that have solved and improved the said problem can be divided into 2 periods: in the first period, there will be an analysis of the problem and the process of improving the said problem, which is during June – July, waste has an average value of 0.72%. For the remaining period results will be results after controlling factors that cause problems: during August - September. The average waste is equal to 0.49%, which can reduce the problem of Black Dot of motor housing parts, model EM – 14, achieved the set goal as shown in Figure 7



Black = before improvement, Yellow = during improvement, Green = After Improvement

Figure 7: Comparison of the results of solving Black Dot defects before and after improvements

From Figure 7, it is the result of collecting data before and after the improvement. It can be seen that the trend of Black Dot defects in Motor housing parts, model EM - 14, has decreased a lot and is consistent. It shows that this study can solve the problem of Black Dot parts in the plastic injection process including improving the quality of the production process and achieve the goals that were set.

The results of all studies in solving defect problems with the application of quality tools (QC 7 Tools) consist of defining Root cause problem analysis, Improving the plastic injection process and controlling various variables can reduce waste from Black Dot defects from the original average of 1.19% down to 0.49%, reducing up to 58.82% as shown in Figure 8 and achieve the target set, which is the percentage of waste not exceeding 0.7%.

5. Conclusion

From implementation of quality tools (QC 7 Tools) to help improve and solve the problem of Black Dot defects in the plastic injection process. It was found that before the improvement there was a problem of Black Dot with an average of 1.19% from the results of analyzing the cause of the problem using fishbone diagrams, brainstorming, and analyzing the symptoms and impacts. Then, there was a process to prove that the factor that affects the problem is Plastic Injection Machine, which is caused by the screw being worn out causing metal scraps from the screw tip to rub against the non-reverse ring, causing wear and falling out during the injection with the liquid plastic. The researcher therefore took steps to improve and control the shortcomings by controlling, creating a plan for the maintenance of plastic injection molding machines every 6 months, replacing spare screws every time to solve the problem of screw wear. As a result, the problem of black dot defects in the plastic

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injection process can be reduced by up to 58.82%, with an average after improvement of 0.49%, representing a value of waste in production of up to 47,139.00 baht per year, able to meet the organization's goals of waste not more than 0.70%

6. Recommendations

In this study, the result can solve only one problem of waste that occurs in the injection process and only one workpiece that has the most waste generated. There are also many other wastes generated in the plastic injection process that have not been studied to reduce the amount of other waste that has the same or similar characteristics as the parts studied, quality control tools can be applied as a guideline for reducing waste in other processes.

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