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THE CAUSE AND EFFECT ANALYSIS IN PRINTING MACHINE PROCESS OF THE MANUFACTURE OF CONTACT RUBBER SILICONE

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ABSTRAK

Industri otomotif merupakan penopang utama perekonomian global. Saat ini semakin tingginya tingkat kebutuhan masyarakat dibidang peralatan kendaraan bermotor dan komponennya, dunia otomotif terus mengalami persaingan dan masalah kualitas dalam pertumbuhannya. Makalah ini menjelaskan sebuah proyek yang dilakukan disebuah perusahaan industri komponen otomotif, dengan tujuan untuk mengurangi produk cacat pada proses printing keypad rubber silicone. Permasalah terjadi pada proses printing seperti unfunction product, bad appearance, and improper shaped. Data sebelum perbaikan diambil dari bulan Januari 2021 sampai Agustus 2021. Hasil perbaikan telah terjadi penurunan produk cacat yang terlihat pada bulan Agustus 2021 - April 2022 dengan meningkatnya level sigma dari 3,9 σ menjadi 5,2 σ atau DPMO 7770,6 menjadi DPMO 93,793. Tingkat perbaikan cukup berhasil dalam metode six sigma dengan memakai improvement Poka Yoke untuk mengurangi tingkat kesalahan yang terjadi diproses printing. Six Sigma metode dalam penelitian ini dapat mengurangi produk kegagalan proses printing contact rubber silicone. Sehingga dapat meningkatkan keuntungan perusahaan karena penurunan kegagalan produk.

Kata kunci: *Proses Printing, Six Sigma, Mistake proofing, Quality Improvement*

ABSTRACT

The automotive industry is a key pillar of the global economy. At present, the level of public needs is high in the field of motor vehicle equipment and components, the automotive world continues to experience competition and quality problems in its growth. This paper describes a project carried out by an automotive component industry company, to analyze the problem of reducing product defects in the contact rubber silicone printing process. Problems occur in the printing process such as product malfunction, poor appearance, and incorrect shape. The data before the repair was taken from January 2021 to August 2021. After analyzing and making improvements with the Six Sigma method approach, the result was a decrease in defective products seen in September 2021 - April 2022 with a decrease in defective products from 18,088 pcs to 211 pcs or 3.9 sigma to 5.2 sigma. The results of the analysis found that the cause of the problem occurred at the level of the ink print in the container which was less than 6 millimeters. The problem was fixed by installing the sensor as mistake-proofing. So that it can increase the company's profit due to the decrease in product failure.

Keywords: Printing Process, Six Sigma, Mistake proofing, Quality Improvement

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INTRODUCTION

Constant changes to customer needs, new markets, innovations and other external factors, encourage organizations to continuously improve the quality of their current processes and develop new processes to meet market trends [1]. Therefore, quality management methodologies such as Six Sigma can be used to strengthen quality [2]. Six Sigma is an organized and systematic and customer-oriented system that aims to improve the performance and quality of processes, products and services by using statistical techniques and scientific methods to analyze data and make decisions [3]. Six Sigma can increase profits by reducing waste, reducing variations and defects from a process. DMAIC Six Sigma methodology is a scientific problem-solving approach to validating and identifying the root cause of the problem. Intuition-based solutions never provide the root cause of the problem [4]. An organization that works on the direction of implementing Six Sigma into practice or working to build the Six Sigma concept with improved process performance and customer satisfaction is considered a Six Sigma company [5]. Six Sigma aims to achieve perfection in every corporate process [6]. The term Six Sigma means to have less than 3.4 defects per million chance (DPMO) or a success rate of 99.9997%. In this regard, Six Sigma is a methodology that allows companies to review their existing status and direct them in making improvements by analyzing their status through statistical methods [7]. For most industries, sigma is a level that measures process improvement and thus can be used to measure the degree of defect. The Six Sigma define-measure-analysis-improve-control (DMAIC) methodology is a highly disciplined approach that helps the industrial world to focus on developing perfect products, processes, and services [8].

The application of Six Sigma in the iterative process has brought significant advantages for the automotive company to increase its productivity [9]. The automotive industry is the main support of the global economy [10]. Automotive companies that are always evolving are a market by always issuing new innovative products that are constantly followed by market competition. Therefore, improvements are needed to strengthen the value of its products without producing a competitive advantage [11]. Currently, the increasing level of public needs in the field of motor vehicle equipment and its components, the automotive world continues to experience competition and quality problems in its growth. This paper describes a project carried out in an automotive component industry company, with the aim of reducing defective products in the rubber silicone keypad printing process. Rubber silicone keypads are widely used in the automotive industry for the function of keys in cars [12]. In its manufacture, the electricity contact on the keypad is needed a printing machine. The electrical contact on the rubber silicone keypad determines the function of conducting electric current in the electronic device system in the car. But in its implementation, the manufacture of silicone rubber keypad contacts experienced three types of product defects, namely unfunction products, bad appearance, and improper shaped. The Six Sigma method approach is expected to solve the problems that occur. Six Sigma is excellent for increasing profitability and reducing defects in the Industry [13]. Six Sigma has been adopted by many organizations to develop and strive for excellence in quality standards and innovation [14]. Solving problems in defective products processed printing keypad rubber silicone will be solved with the DMAIC method approach. Six Sigma DMAIC (define, measure, analyze, improve and control) methodology used to reduce variation and defects in the process [15]. For its repair, Poka-Yoke was listed as a solution to 3 types of defective products in the printing process of the rubber silicone contact keypad. Some modern factories rely on the use of appropriate cost-effective techniques such as mistake proofing. Any improvement of the mechanism or idea produced to avoid mistakes can be considered a Poka-Yoke concept or technique in the process of productivity management that helps and the operator in avoiding mistakes [16]. In addition, errors can occur even if intentionally or unintentionally so it is necessary to consider the concept of Poka-Yoke[17]. This concept has been shown to save costs in building quality into a good production process to eliminate poor quality. Poka-Yoke guarantees suitable conditions on

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the process to reduce significant errors. Poka-Yoke can be applied using simple equipment such as sensors [18].

METHODS

This research was conducted in the contact rubber silicone printing machine industry in the automotive parts industry. Improvements made to this process must be analyzed and carried out because many result in not good products. Before the improvement is done, I will describe some of the materials.

The printing machine

In this case the printing machine is used for the printing process on contact rubber silicone. if this process has problems, the contact rubber silicone does not function to carry electric current to electronic devices. In the process, the machine only prints carbon as a liquid that is used for electricity when it is dried by an oven after the printing process occurs (Fig. 1).

Figure 1. Printing machine for contact rubber silicon

If the result of this process does not match the carbon liquid level, what happens is that the contact rubber silicone has a poor surface. A bad surface is of course the result of the product not being able to conduct electric current in electronic devices in automotive parts such as tape recorders, door locking system buttons, and other button switch devices in a car (Fig. 2).

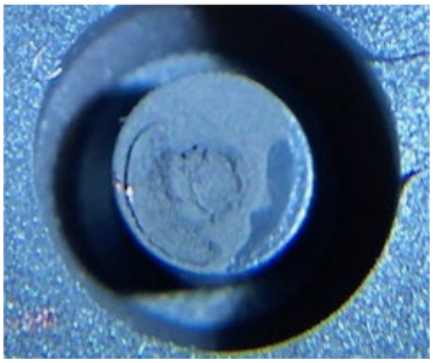

Figure 2. Not good product contact rubber silicon

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RESULTS AND DISCUSSION

Define

The Define stage is to define the activities carried out to find out the problems that occur based on consumer needs and the reduction of product failures. This is the first step of the define stage. At this stage, it defines the activities that occur in the process of printing the rubber silicone contact keypad with the aim of knowing the problems that occur. The sequence of SIPOC activities in the process of printing keypad contact rubber silicone can be seen in the SIPOC Diagram in Figure 3.

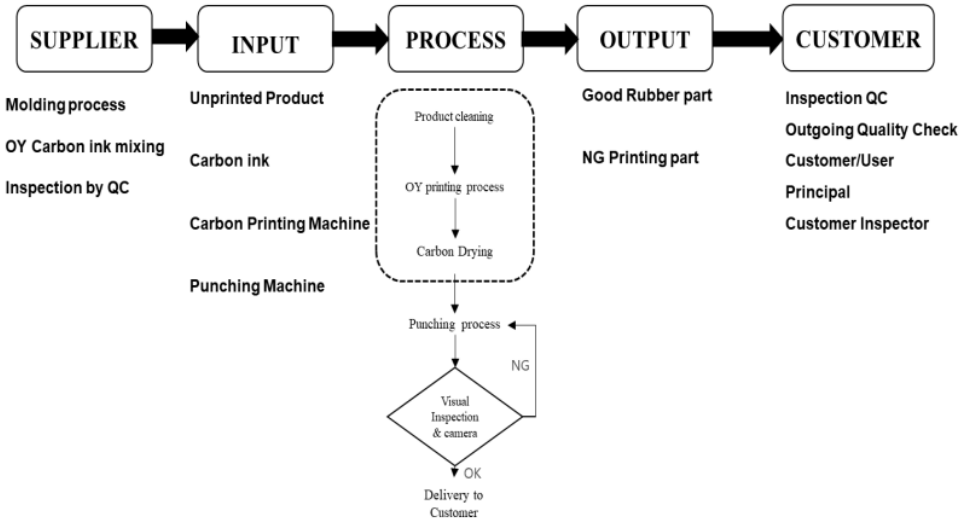

Figure 3. SIPOC Diagram printing process

Figure 3 shows that the main focus of the problem to be solved is in the printing process. Product failure in this process is very high. Failure in this process has three types, namely unfunction product, bad appearance (Fig. 2).

Measure

After defining it, proceed to the Measure Stage. This stage is the second stage in the improvement quality improvement program with the Six Sigma method. At this stage the measurement of defective product data, the level of sigma and DPMO (Defects per Million Opportunities) will be measured. This data is used to measure the quality and productivity capabilities of the printing machine. As the improvements from the data that was successfully collected from February to March 2021. The results of the measurement will be continued at the analysis stage. The data can be seen in Table 1.

Table 1. Production data on the printing process from January - August 2021

No	Periods	Output	Product Defects (pcs)	CTQ	DPMO	Level Sigma	Line Printing
1	Jan 2021 week 1	745.464	19.621	3	8775,507	3,875	8
2	Jan 2021 week 2	745.464	19.634	3	8779,320	3,875	8
3	Jan 2021 week 3	745.464	15.707	3	7023,366	3,956	8

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4	Jan 2021 week 4	745.464	19.634	3	8779,320	3,875	8
5	Feb 2021 week 1	769.116	18.547	3	8038,233	3,907	8
6	Feb 2021 week 2	769.116	14.837	3	6430,326	3,988	8
7	Feb 2021 week 3	769.116	22.256	3	9645,706	3,840	8
8	Feb 2021 week 4	769.116	18.547	3	8038,233	3,907	8
9	March 2021 week 1	839.381	16.189	3	6428,944	3,988	8
10	March 2021 week 2	839.381	17.138	3	6805,809	3,967	8
11	March 2021 week 3	839.381	23.036	3	9148,011	3,860	8
12	March 2021 week 4	839.381	16.455	3	6534,577	3,982	8
13	Apr 2021 week 1	776.745	20.144	3	8644,622	3,880	8
14	Apr 2021 week 2	776.745	19.456	3	8349,372	3,893	8
15	Apr 2021 week 3	776.745	17.680	3	7587,218	3,928	8
16	Apr 2021 week 4	776.745	18.916	3	8117,636	3,904	8
17	May 2021 week 1	756.788	17.819	3	7848,521	3,916	8
18	May 2021 week 2	756.788	16.546	3	7287,818	3,943	8
19	May 2021 week 3	756.788	14.375	3	6331,584	3,993	8
20	May 2021 week 4	756.788	15.672	3	6902,858	3,962	8
21	Jun 2021 week 1	786.543	16.274	3	6896,847	3,963	8
22	Jun 2021 week 2	786.543	19.432	3	8235,193	3,898	8
23	Jun 2021 week 3	786.543	16.934	3	7176,552	3,948	8
24	Jun 2021 week 4	786.543	17.833	3	7557,544	3,930	8
25	Jul 2021 week 1	776.647	18.746	3	8045,697	3,907	8
26	Jul 2021 week 2	776.647	16.987	3	7290,743	3,943	8
27	Jul 2021 week 3	776.647	18.926	3	8122,952	3,903	8
28	Jul 2021 week 4	776.647	17.653	3	7576,587	3,929	8
29	Aug 2021 week 1	756.775	19.349	3	8522,568	3,886	8
30	Aug 2021 week 2	756.775	18.736	3	8252,563	3,898	8
31	Aug 2021 week 3	756.775	18.364	3	8088,710	3,905	8
32	Aug 2021 week 4	756.775	17.384	3	7657,054	3,925	8

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Total	775.932	18.088	3	7770,584	3,920	8

From Table 1, it can be seen that the data collected in the process of the printing line 8 machine for makers of keypad contact rubber silicone products from January – August 2021 has a DPMO value of 7770.6 and a sigma value of 3.9 σ. After knowing the sigma level with a value of 3.9 σ the company wants to increase the sigma value so that the printing process line 8 underwent significant improvements to bring down its failed products

Analyze

Furthermore, the Analyze Stage is the analysis stage. This stage looks at the aspects of machine, man, material, methods. In this case the problem will be analyzed in more depth as fig. 4.

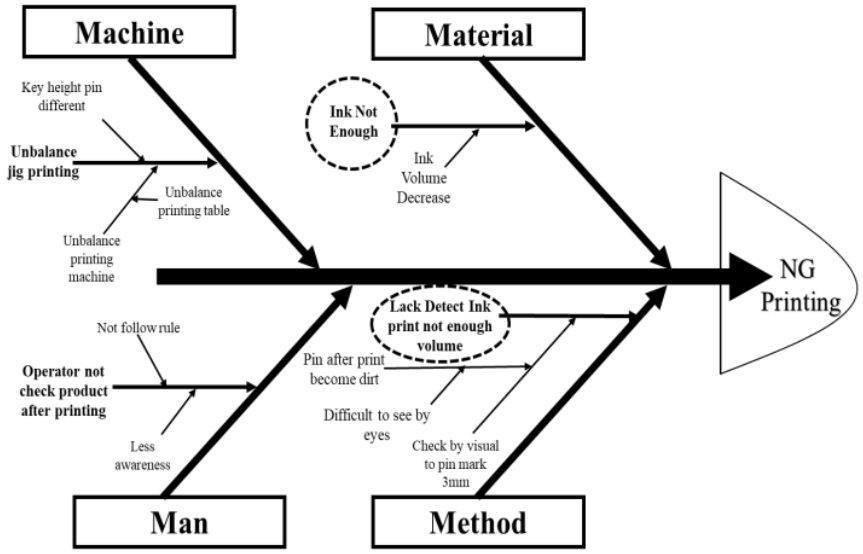

Figure 4. Fishbone diagram on the process of printing keypad contact rubber silicone

By looking at the analysis using fishbone diagrams, it was found that the root cause of the problem was because the printing machine ink was insufficient and there was no ink detection when the printing machine process was running so that the problem resulted in many defective products occurring. This becomes the 27 in root cause of the problem. At this stage, the root cause of the problem was found, namely that the height of the ink fluid was not enough in the container or less than the specification (6 mm). If the height of the ink liquid in the container is less than the specification, there will be many defective products. But on its implementation to control the height of the ink on the container is difficult. So a tool is needed to detect the ink height on the container.

Improvement

Furthermore , the Improve Stage is the stage of improvement by executing from the root cause that has been found. The improvement made is to use mistake proofing (Poka-Yoke) as a tool to detect failures that occur in the printing process early. The failure that will be detected is the volume of the ink on the ink container on the printing machine. Poka-Yoke used is an infrared sensor system to find out the number of inks available in the ink house (Fig. 5)

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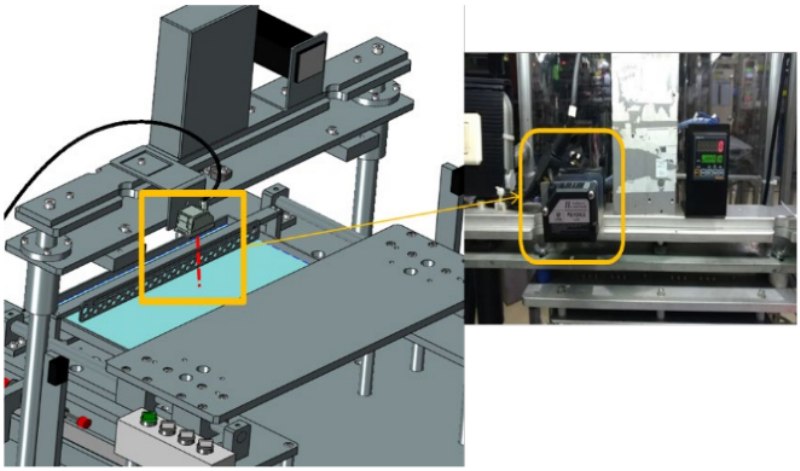

Figure 5. Mistake proofing sensor infra red level ink printing machine

The way mistake proofing works is by using an ink volume sensor on the printing machine to detect a decrease in ink by measuring the height of the ink in the container. If the height of the ink in the container is less than 6 mm, the machine will turn off and give a warning alarm. So that the printing process does not continue to make failed products. This is very effective in preventing product failures in the printing process.

Control

Next, do the last stage, namely the Control Stage. At this stage it is carried out to monitor and control the results after the upgrade. Before the control stage it is necessary to recalculate the level of sigma and the calculation of defective products. This is done to find out the results of the repairs that must be controlled. The process of standardization of new ideas needs to be carried out to avoid similar product failures that occur in the future. Based on data taken from the production and Quality Control Department, data can be seen after improvements are made to the printing machine process (Table 2).

Table 2. Production data after improvements to the printing process from Sept 2021-April 2022

No	Periods	Output	Product Defects (pcs)	CTQ	DPMO	Level Sigma	Line Printing
1	Sept 2021 week 1	745.464	227	3	101,503	5,215	8
2	Sept 2021 week 2	745.464	237	3	105,974	5,204	8
3	Sept 2021 week 3	745.464	233	3	104,186	5,209	8
4	Sept 2021 week 4	745.464	229	3	102,397	5,213	8
5	Oct 2021 week 1	750.333	215	3	95,513	5,231	8
6	Oct 2021 week 2	750.333	220	3	97,734	5,225	8
7	Oct 2021 week 3	750.333	213	3	94,625	5,233	8

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8	Oct 2021 week 4	750.333	209	3	92,848	5,238	8
9	Nov 2021 week 1	724.341	197	3	90,657	5,244	8
10	Nov 2021 week 2	724.341	201	3	92,498	5,239	8
11	Nov 2021 week 3	724.341	205	3	94,339	5,234	8
12	Nov 2021 week 4	724.341	189	3	86,976	5,254	8
13	Dec 2021 week 1	687.341	179	3	86,808	5,255	8
14	Dec 2021 week 2	687.341	187	3	90,688	5,244	8
15	Dec 2021 week 3	687.341	173	3	83,898	5,263	8
16	Dec 2021 week 4	687.341	177	3	85,838	5,257	8
17	Jan 2022 week 1	600.245	163	3	90,519	5,244	8
18	Jan 2022 week 2	600.245	168	3	93,295	5,237	8
19	Jan 2022 week 3	600.245	162	3	89,963	5,246	8
20	Jan 2022 week 4	600.245	166	3	92,185	5,240	8
21	Feb 2022 week 1	745.678	206	3	92,086	5,240	8
22	Feb 2022 week 2	745.678	203	3	90,745	5,243	8
23	Feb 2022 week 3	745.678	205	3	91,639	5,241	8
24	Feb 2022 week 4	745.678	210	3	93,874	5,235	8
25	March 2022 week 1	865.490	240	3	92,433	5,239	8
26	March 2022 week 2	865.490	237	3	91,278	5,242	8
27	March 2022 week 3	865.490	231	3	88,967	5,248	8
28	March 2022 week 4	865.490	243	3	93,589	5,236	8
29	Apr 2022 week 1	876.593	256	3	97,347	5,226	8
30	Apr 2022 week 2	876.593	253	3	96,206	5,229	8
31	Apr 2022 week 3	876.593	255	3	96,966	5,227	8
32	Apr 2022 week 4	876.593	259	3	98,487	5,223	8
	Total	749.436	211	3	93,793	5,235	8

Table 2 shows that the improvement results are at 5.2 σ with a DPMO of 93,793 which is better than the previous condition of 3.9 σ and DPMO of 7770.6. This data shows that the improvement rate is quite successful in the DMAIC method by using Poka Yoke improvement to reduce the error rate that occurs in the printing process. The ratio of sigma and DPMO levels increases to 5.2 sigma. So it proves that the Six Sigma method is very good for reducing the degree of disability. To avoid similar failing products,

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operational standard procedures (SOPs) in the process of printing keypad contact rubber silicone have been made so that the process is more controlled. Then the socialization of the repair results is delivered and taught at all levels of machine operators about how to operate the printing machine.

CONCLUSION

By looking at the results of this study, it can be concluded that the improvement results are at 5.2 σ with DPMO 93,793 which is better than the previous condition, namely 3.9 σ and DPMO 7770.6. The improvement rate is quite successful in the Six Sigma method by using Poka-Yoke improvement to reduce the error rate that occurs in the printing process. Six Sigma method in this study can reduce product failure of rubber silicone contact printing process. So that it can increase the company's profits due to a decrease in product failures. This study generally reinforces previous research that the Six Sigma method is effective in identifying and analyzing product failures, and can improve sigma levels to obtain better quality. Seeing the positive results in this study, it is recommended for further research on the use of the Six Sigma method in combination with other quality tools for use in improving quality in other automotive component industries.

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