



Quality Improvement of Molding Machine through Statistical Process Control in Plastic Industry

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PAPER INFO	ABSTRACT
<p>Chronicle: Received: 20 November 2018 Revised: 07 February 2019 Accepted: 11 February 2019</p>	<p>Enhancing the process capability is a must in quality improvement of process manufacturing in the industry. Usually, Statistical Process Control (SPC) is applied to measure the activity of quality improvement. In this case, the statistical process control is used to measure the process capability of molding machine in regard to force the result of inner contact rubber button in the plastic industry. The forces of inner contact rubber button which are produced by molding machine already become the critical point as a judgment of malfunctions or not. Meanwhile, the forces problem still is found in molding machine that affects to the inner contact rubber button as defect product. Furthermore, as the show of SPC, the process capability of molding machine is 0.63. This means the process capability is needed for improvement. Seeing that the result of quality improvement is made by applying Poka-Yoke, the process capability of molding machine is improved to 1.65.</p>
<p>Keywords: Statistical Process Control. Process Capability. Quality Improvement. Poka-Yoke Buzzer.</p>	

1. Introduction

Today, the digital game industry has become one of the most profitable industries, along with other main industries. Also, this fore-mentioned industry has led to economic growth and increase of employment in many countries in the world. According to the statistics from internet resources in the United States, "the turnover of this industry was about twenty-five billion dollars in 2010". Around forty percent of China annual revenue is allocated to the sale of digital games. This volume of sales has been contributed many gaming companies to gamble on mobile games, along with computer game products [1]. In spite of the high sale and income of existing companies in the game industry and along with the best-selling games, there are always unsuccessful game products and failed companies. This indicates the emergence of a performance evaluation system in the game industry [2]. To this end, in this paper, we introduce a new performance evaluation model based on BSC-AHP for the digital game industry.

Quality has already become the top priority among plastics industries. As the surveys are conducted every year, the plastics industry in US responds that no single attribute ranked lower than 3 out of 5 in terms of importance of quality [1]. This importance puts as the stressed of plastics industry to perform

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quality improvements in achieving quality requirements. These improvements have to perform in every stage of production in order to produce the final product of customer needs [2]. Thus, the Statistical Process Control (SPC) could be applied to improve the process capability.

As in a plastic industry which produces inner contact rubber button for automotive component, the quality improvements have to carry out in molding machine in regard to customer complains. Historically, the customer has complained on the malfunctions of inner contact rubber button produced in molding machine which is caused by force problem. The force of inner contact rubber button was found as the critical point for the consideration, either the product can be used or not. However, the force check cannot be detected for every single product produced in molding machine. As of the force check is required a long time and a special measurement instruments which makes sampling method to carried out for checking the force. The force of inner contact rubber button can be detected by using intelligent load tester. This measurement instrument will check the force of the production line that produced in molding machine. The illustrations of force checking as shown in the Fig. 1.

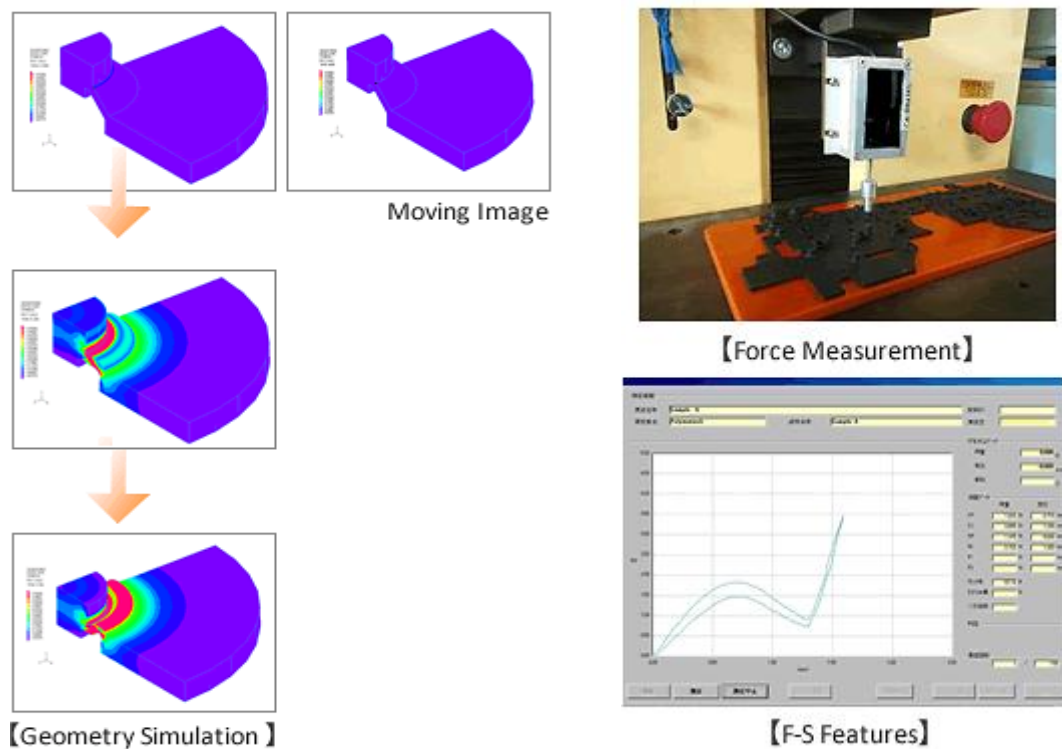


Fig. 1. The process of force checking using intelligent load tester.

Fig. 1 shows the intelligent load tester that checks the inner contact rubber button by push every single of button in order to check the force. If the force of button is out of specification, the product will be malfunctions. In this case, every product that produces in molding machine has a variation of force result, and makes molding machine still having potential to produce a malfunctions product.

As the achievement of a good quality production, the statistical process control can be applied as a method in the statistical principles and techniques at every stage of design, manufacturing, and services [3]. Furthermore, when it find that molding machine is statistically under control, the force of production is still met the specification. Otherwise, when it is not statistically under control, the

variation of force cannot be predicted and the malfunctions product can possibly produce. Therefore, the statistical process control needs to be carried out as a quality improvement in molding machine in order to make sure the force is meet the specification and molding machine is continuing producing the product that meet customer specification.

2. Literature Review

As in the stage of mass productions, statistical process control has a signification contribution in improving quality control. In the previous description, the quality control methods were performed by checking the product produced to determine whether they meet the customer specifications or not. The product that does not meet the specification will be categorized as reject and sent back to machine for re-work or counting as a scrap. Thus, the statistical process control is applying as the vital part of quality production to make sure all production activity is under control while it is used as the quality control methods [3]. The product, which is categorized as under control will be short in production that does not meet the customer specification. The illustration of previous quality control methods and statistical process control will be shown in the Fig. 2 as below.

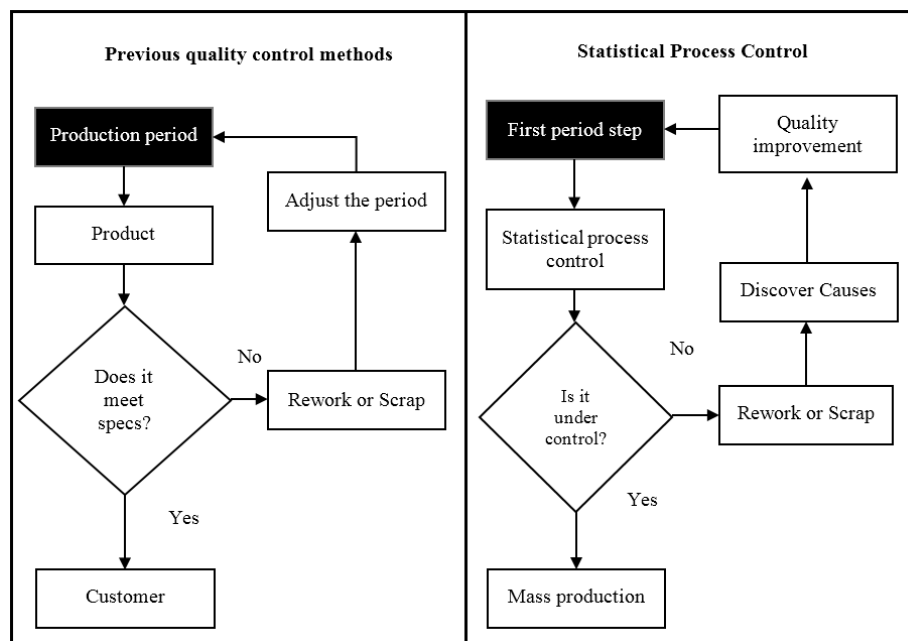


Fig. 2. Quality control methods.

Furthermore, statistical process control also can be used to determine whether a process is stable or not by differentiating between the presence of common cause variation and assignable cause variation [4]. The difference of variation could be seen through control charts and at the same time also could be used to check for process stability. In this case, a process will be defined as under control, if the probability distribution representing the quality characteristic is constant. If there is some change over the time in this distribution, the process will be defined as out of control [5].

There were a number of previous researches that discussed the process capability as a quality improvement activity. It also proved that quality improvement shows that the capability of the machining process to meet the customer requirements of the thickness and diameter have been substantially improved [6]. Meanwhile, the control process and quality management philosophy were

defined based on quality requirements from customer. However, the requirements that still not enough attention for quality were paid by managements. It was happened when there were several decisions that need to execute which do not meet the quality requirement in regard to resources in performing production activity [7]. Thus, the statistical techniques and roles for process development considering recent research works were some examples especially on statistical techniques that were used for quality improvement. Then, the application of statistical process control in manufacturing of chemical and plastic products also have discussed the successfully optimizing the process capability in producing product that meet customer requirements [8].

In the other hand, as in automotive industry, the quality is expressed through the customers' satisfaction in relation to the products and offered services [9]. As the increasing of quality requirement, the statistical process control can be defined as a set of tools for process management and for determination and monitoring of the quality of an organization objective [10]. This tool also becomes the strategy for improving capability through the reduction of variability of products, deliveries, processes, materials, tools, and equipment [11-13]. The successful implementation of the statistical process control can be lead to decisions making based on facts, a growing perception about quality at all levels, a systematic methodology concerning problem resolution, a gathering of experience of all kind of improvement, even in communication. Majority in manufacturing and focusing on quality, the statistical process control is the most widely used technique [14] and once it appropriately apply, it will improve the operational and achieve the financial benefits [15].

The process control can also be used in creating a qualification measurement for potential and performance of process industry, which includes capacity [16]. The capacity analysis was carried out by elaborating data in statistical calculations for defining the systems capability. Thus, the capability analysis could be used to determine the ability of manufacturing parts on the tolerance limits and engineering values. Capability analysis also gives the information on the system development during the period of time [3]. Process Capability (Cpk) could also be used to determine the process ability that work better in the system rather than specification limits. If the value of Cpk be equal to 1, it means that the production activity is going on track in the system specification limits staying at 99.73% level (± 3 sigma limits) [17].

3. Methodology

In order to reduce the malfunction of inner contact rubber button that is produced from molding machine, the statistical process control will be performed as quality improvement. The statistical process control started from collecting the force result from molding machine. The force result of inner contact rubber button was used for performing statistical process control to find the process capability of molding machine. After finding the process capability, the causes that make the process capability small will be discovered. Then, the possible quality improvement will be applied. Finally, the statistical process control will perform in molding process after quality improvement applying. The new process capability of molding machine will be discovered and become the answer to customer complain as reduction of the malfunction of inner contact rubber button. The following steps of this research will be show in the figure below.

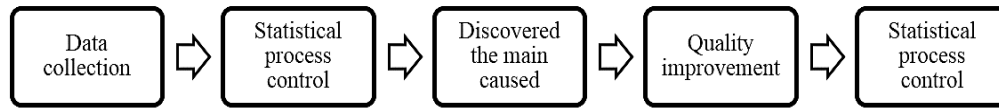


Fig. 3. Flow process of research.

4. Result and Discussion

4.1. Data Collection

Data collection started from collecting the sample of product after molding as much as 30 cycles. A cycle of molding machine produces two inner contact rubber buttons which means there is 60 samples that need to check. These samples were taken from molding machine that run normally. Then, the force checking will be performed used intelligent load tester in order to know the force result of samples. The force result of samples will be shown in table below.

Table 1. Force result of samples before improvement.

Cycle	Sample	Force Result	Cycle	Sample	Force Result	Cycle	Sample	Force Result
1	S1	7.341	11	S21	6.934	21	S41	7.014
	S2	7.01		S22	6.855		S42	6.44
2	S3	7.157	12	S23	7.059	22	S43	7.056
	S4	6.705		S24	6.829		S44	6.94
3	S5	6.791	13	S25	6.48	23	S45	7.445
	S6	6.374		S26	6.75		S46	6.967
4	S7	7.109	14	S27	6.974	24	S47	7.144
	S8	6.64		S28	7.262		S48	7.118
5	S9	6.851	15	S29	6.582	25	S49	7.021
	S10	6.526		S30	6.519		S50	7.3
6	S11	7.278	16	S31	6.828	26	S51	7.139
	S12	6.868		S32	7.239		S52	7.01
7	S13	6.837	17	S33	7.162	27	S53	7.337
	S14	7.252		S34	6.844		S54	7.208
8	S15	6.945	18	S35	6.62	28	S55	7.403
	S16	6.708		S36	7.196		S56	6.866
9	S17	7.159	19	S37	7.251	29	S57	7.432
	S18	6.602		S38	7.075		S58	7.131
10	S19	6.933	20	S39	7.085	30	S59	7.038
	S20	6.444		S40	6.536		S60	7.358

4.2. Statistical Process Control

After carrying out the data collection, the statistical process control will be performed. The statistical process control method follows the current research [18]. The result of statistical process control calculation will be summarized in the figure below.

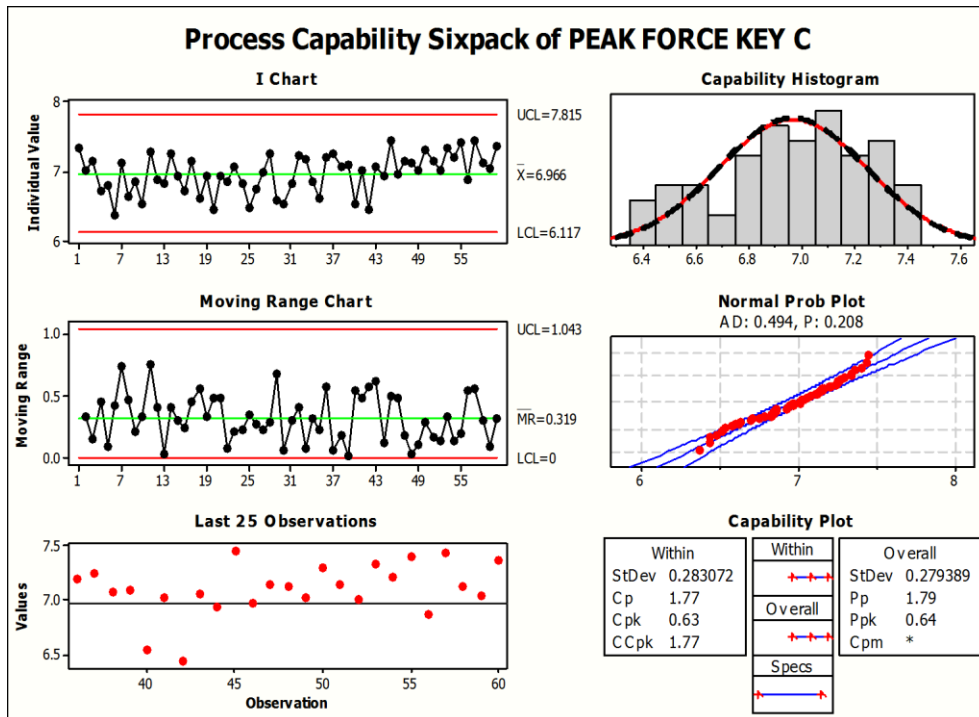


Fig. 4. The result of statistical process control before quality improvement.

In Fig. 4, the process Capability (Cpk) of molding machine is equal to 0.63 which means the variant of force is still high. The variant of force also can be shown in capability histogram that the result of force is start from 6.4 until 7.4. If this conditions continue, the force problem will be possibly occurred. This force problem will be lead to malfunction of inner contact rubber button.

4.3. Discovered the Main Caused

In discovering the main cause, the current conditions of molding machine were observed. Thus, it found, there are several causes that make the inner contact rubber button had force problem. The force problem was caused by Man, Machine, Material, and Method. These causes lead to create an adverse effect which is a quality problem that occurred [19]. Meanwhile, the Fishbone diagram that is known as a tool for analyzing and illustrating a process by showing the main causes and sub-causes leading to an effect will be used for describing these causes and finding the main causes. The following of fish bone diagram will be shown in the the Fig. 5 below.

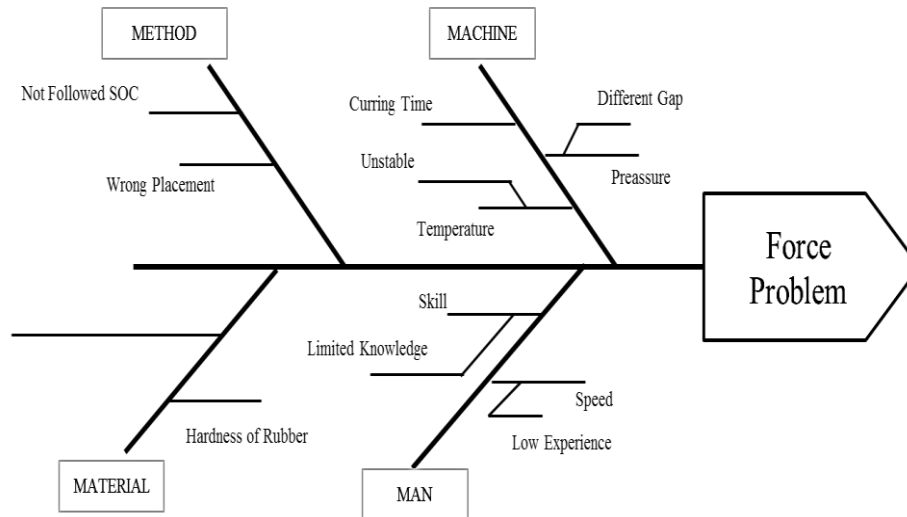


Fig. 5. Fish bone of force problem.

In Fig. 5, it is shown a number of problems that cause force problem. After discussion with experts in the manufacturing line, the main causes that create the force problem are happened in machine, which are curing time, temperature, and pressure. Therefore, the quality improvement needs to perform in order to solve the force problem as the cause of malfunction.

4.4. Quality Improvement

In performing quality improvement, the several activities were decided to solve the problem that were caused by curing time, temperature, and pressure. Previously, the curing time, temperature, and pressure were set manually. The setting of those parameter followed the specification from customer. However, during production activity, those parameters were possibly changed by several external factors. The change sometimes was not recognized by operators which make them to continue run the molding machine although those parameters were changed.

After realizing the problems, the unstable of curing time, temperature, and pressure are hard to control regarding to machine life time. However, the parameter change still can be noticed by additional buzzer for informing the operator to do not run the machine. If operator noticed the parameter changes, the operator can ask their leader/supervisor to set the ideal parameters. Hence, the molding machine can run with ideal parameters that follows the customer specifications. This quality improvement actually already carried out in previous research that was called Poka-Yoke system which used as a control or a warning. The Poka-Yoke also can be used as a warning, a buzzer or flashing light alerts the worker to a problem that is occurring [20]. The following quality improvement will be shown in Fig. 6.

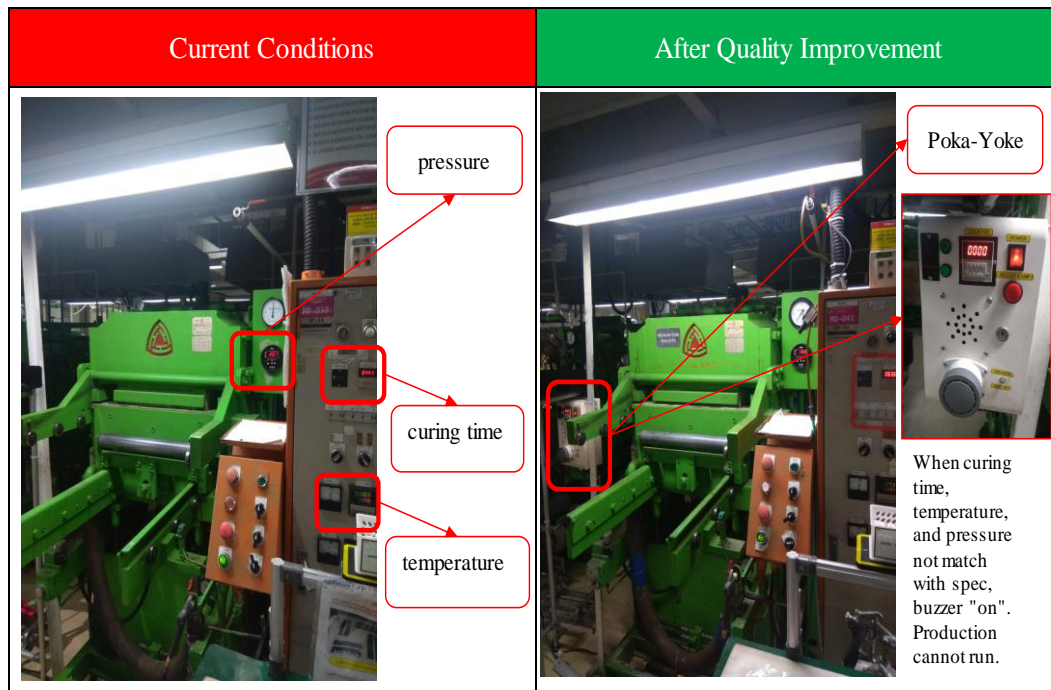


Fig. 6. Quality improvement activities.

As shown in Fig. 6, the current conditions of molding machine do not have any kind alert system to make sure whether the machine runs based on specification parameter. Then, the Poka-Yoke system was applied in molding machine with connecting to the buzzer system of current molding system. The Poka-Yoke buzzer will show a signal if the parameter changes. When one of the parameter changes, the buzzer will be “ON” and the machine cannot be run until the Poka-Yoke system shuts down. Therefore, the operator cannot run the machine with parameter that do not meet the customer specification.

4.5. Statistical Process Control

After performing the quality improvement, the product from molding machine that already is improved by additional Poka-Yoke buzzer will be take as much as 30 cycles. As explained before, in 30 cycles, the molding machine will be produce 60 samples. Those samples will be checked in order to know the force result. Then, the result of force data will be used in statistical process control for analyzing the process capability of molding machine that uses Poka-Yoke system. The following force result is shown in Table 2 and the statistical process control is shown in the Fig. 7.

Table 2. Force result of samples after improvement.

Cycle	Sample	Force Result	Cycle	Sample	Force Result	Cycle	Sample	Force Result
1	S1	6.745	11	S21	6.694	21	S41	7.054
	S2	6.411		S22	6.391		S42	6.753
	S3	6.384		S23	6.156		S43	6.817
2	S4	6.893	12	S24	6.651	22	S44	6.654
	S5	6.375		S25	6.625		S45	6.698
3	S6	6.429	13	S26	6.4	23	S46	7.131
	S7	6.615		S27	6.523		S47	6.665
4	S8	6.224	14	S28	6.132	24	S48	7.137
	S9	6.406		S29	6.699		S49	6.995
5	S10	6.213	15	S30	6.393	25	S50	6.97

Cycle	Sample	Force Result	Cycle	Sample	Force Result	Cycle	Sample	Force Result
6	S11	6.65	16	S31	6.188	26	S51	6.512
	S12	6.241		S32	6.437		S52	6.946
	S13	6.509		S33	6.203		S53	6.871
7	S14	6.269	17	S34	6.458	27	S54	7.05
	S15	6.451		S35	6.597		S55	6.892
8	S16	6.068	18	S36	6.709	28	S56	6.9
	S17	6.319		S37	6.861		S57	6.847
9	S18	6.578	19	S38	6.453	29	S58	6.722
	S19	6.166		S39	6.582		S59	6.582
10	S20	6.71	20	S40	6.445	30	S60	6.519

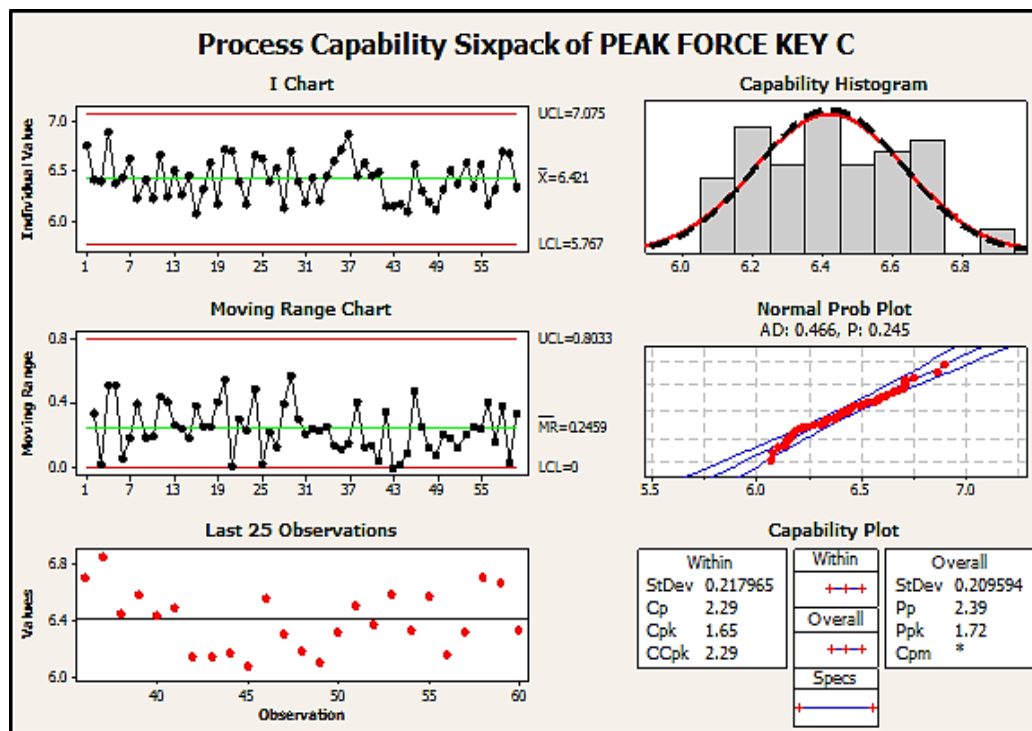


Fig. 7. The result of statistical process control after quality improvement.

As shown in Fig. 7, the process Capability (Cpk) of molding machine was equal to 1.65 which means the process capability gets better. The variant of force becomes controls with small variant of force result which is from 6.1 up to 6.7. It can be seen in I chart, moving range chart, and capability histogram that the range of data separation becomes small. It means the potential of molding machine to produce the product with force problem becomes small.

5. Conclusions

After applying the quality improvement in molding machine, the process capability increased from 0.63 to 1.65. The improvement of process capability was calculated by using statistical process control that showed the increase in process capability of molding machine after implementation of quality improvement. Statistical process control showed the variant of force of inner contact rubber button which decreased the malfunction product by molding machine. As the conclusion, in decreasing the

variant of inner contact rubber button malfunctions product (reduce defect), the quality improvement are already applied as a Poka-Yoke buzzer in molding machine.

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