ISSN: 2338-8412 e-ISSN : 2716-4411

Ekombis Review – Jurnal Ilmiah Ekonomi dan Bisnis
Available online at : https://jurnal.unived.ac.id/index.php/er/index
DOI: https://doi.org/10.37676/ekombis.v13i3

Production Utilized Capacity Improvement Proposal Using Lean Six Sigma: A Case Study At Plastic Injection Process PT Indonesia Trc Industry

Fikka Ruhaiya [1], Gatot Yudoko [2], Pennoh Philips Kembaren [3]
[1)]Master of Business Administration, School of Business and Management, Bandung Institute of Technology
[2.3)]School of Business and Management, Bandung Institute of Technology
Email: [1)] fikka_ruhaiya@sbm-itb.ac.id ;[2)] gatot@itb.ac.id ;[3)] philips.kembaren@itb.ac.id

How to Cite :
Ruhaiya, Fikka., Yudoko, G., Kembaren., Pennoh P.,. (2025). Production Utilized Capacity Improvement Proposal Using Lean Six Sigma: A Case Study at Plastic Injection Process PT Indonesia TRC Industry. EKOMBIS REVIEW: Jurnal Ilmiah Ekonomi Dan Bisnis, 13(3). DOI: https://doi.org/10.37676/ekombis.v13i3

ARTICLE HISTORY
Received [19 December 2024]
Revised [07 July 2025]
Accepted [09 July 2025]

KEYWORDS
Lean Six Sigma, DMAIC, Productivity, Plastic Injection.

ABSTRACT

The plastic injection production process often faces problems with products that do not meet quality standards (not achieved), which causes an increase in defect rates, decreased efficiency and failure to achieve production targets. This study aims to identify the main causes of these problems and apply the Lean Six Sigma method to improve productivity. Pareto analysis shows that most of the main causes of plastic injection production activities are caused by machine trouble. Through the DMAIC (Define Measure, Analyze, Improve, Control) approach, it was found that the factors causing machine trouble were influenced by unscheduled machine maintenance, temperature settings, pressure, and cycle time. In addition, the lack of adequate training for operators also plays a role in worsening molding quality. The improvement plan implemented includes the use of monitoring sensors such as the Internet of Things with the Kaizen approach.

INTRODUCTION

In Indonesia, the manufacturing sector has contributed around 19% to the country's GDP making this sector one of the main drivers of economic growth (World Bank, 2023). However, the level of production productivity in Indonesia's manufacturing sector has not grown at the same pace as other countries in the Southeast Asian region. As written in the Indonesian Manufacturing Sector Review Book in 2021, several manufacturing sectors in Indonesia are still operating at sub-optimal utilized capacity, where the results achieved are only around 70-80% of the company's maximum production potential. Based on the review, this is due to structural inefficiencies and obstacles in the scale of operations, thus hampering Indonesia's ability to compete with regional competitors such as Vietnam and Thailand.

Theoretically, the productivity decline in manufacturing companies can generally be attributed to several factors. First, inefficiencies in the production process can cause unbalanced workloads, where there are certain stages of production delayed due to congestion or machine downtime and constraints from uncontrollable labor. Second, there are problems related to resource utilization such as labor and machinery not fully optimized to get maximum production results. In addition, problems related to logistical delays in the supply of raw materials can also lead to inconsistent production cycles (Bappenas and ERIA, 2021)

This is relevant to the current situation faced by PT Indonesia TRC Industry. Before 2019, PT Indonesia EPSON Industry as the largest customer of PT Indonesia TRC Industry produced many cheap printers (consumer printers) in large quantities. However, since 2019, PT Indonesia EPSON has begun to shift its focus to producing high-end printers (business printers). A significant difference can be seen from the number of parts per unit, where consumer printers only require around 200 parts, while business printers require around 1500 parts per unit. In addition, the number of consumer printer models is less (around 5 models), but the production volume per model is much higher, reaching 100,000 to 200,000 units per model per month. On the other hand, business printers have more models, around 30-40 models, with an average production of only around 1,000 units per model per month. Due to this difference, although the total production volume remains the same, the number of components produced at TRC has increased eightfold, causing a decrease in utilized capacity from 90% to 75%. PT Indonesia TRC Industry faces a significant gap between the target and the realization of plastic injection product production during the period (April 2024 - September 2024) which shows that the company has a gap of 15% of the total production target of 90%, while PT Indonesia TRC Industry only provides a tolerance gap for a decrease in productivity below 10%. This imbalance has a serious impact on the company, because it increases production costs and disrupts delivery schedules.

Therefore, in line with PT Indonesia TRC Industry's efforts to improve its production efficiency by 2024, it is important to identify the root causes of the productivity decline and implement solutions that will ultimately enable the company to optimize its production processes. By examining the challenges faced by PT Indonesia TRC Industry, this study aims to provide actionable insights that will help the company close its productivity gap and achieve its targeted output levels.

To refine and solve this problem, a formal concept with a Lean Six Sigma approach will use DMAIC and consist of tools to find the root cause such as the Current Reality Tree (CRT), and Pareto Chart, supported by production data. This tool will help identify the main problems related to the decline in productivity that occurred at PT Indonesia TRC Industry.

LITERATURE REVIEW

Lean Six Sigma

Lean Six Sigma is a management tool that combines the concept of Lean Manufacturing and the implementation of Six Sigma. Lean Six Sigma can provide continuous improvement in various industry sectors by eliminating defects and reducing variations in the product manufacturing process to gain excellence in business processes. Regarding cost reduction, the Lean method can eliminate waste by eliminating unnecessary processes, while Six Sigma focuses on eliminating quality-related issues by calculating the number of process opportunities that can result in defects before they turn into defects (Singh & Rathi, 2019)

Root Cause Analysis

Root Cause Analysis (RCA) is a comprehensive process designed to understand, address, and recognize problems that arise from the start. This can help prevent future incidents by identifying the origin of the problem through specific processes and tools. RCA focuses on finding out what factors can cause problems or unexpected outcomes. The main goal is to uncover what factors are related to the type, size, location, and time that are often influenced by behaviors or conditions that need to be changed so that similar mistakes do not occur again. (Page et al., 2022).

SIPOC Diagram

SIPOC diagrams are tools for process improvement that are used before starting work. SIPOC itself is an abbreviation for Suppliers, Inputs, Process, Outputs, and Customers. It's a visual tool used to outline all essential elements of a process from start to finish. In this approach, SIPOC is included in the DMAIC methodology definition phase to identify problems that cause bottlenecks in the company's production process. This method not only helps to outline the company's production steps but also highlights specific areas where congestion problems occur (Nandakumar et al., 2020).

Pareto Chart

Pareto chart is a graphical tool used to outline and organize components by category and size, highlighting problem areas and their impact levels. This chart is one of the tools used to identify the root cause of the problem. The concept of the Pareto chart was developed by Vilfredo Federico Damaso Pareto, who proposed an 80:20 ratio, where this comparison originated from socioeconomic research on Italian nobility. This principle concludes that 80% of Italy's wealth is controlled by the elite who amount to no more than 20% of the population. Although the Pareto principle (rule 80:20) is not an absolute law, it serves as a preliminary guide for building a Pareto chart, where the data collected can reveal the true relationship (Alkiayat, 2021).

Fishbone Diagram

Fishbone diagrams are particularly beneficial for organizations that implement knowledge management, as the systematic collection of group insights helps management understand and assess organizational problems (Page et al., 2022). In general, the Fish Bone diagram serves as an effective visual tool for analyzing phenomena that involve the investigation of various causal factors and their reciprocal relationships (Coccia & University, 2018).

Value Stream Mapping (VSM)

Value Stream Mapping (VSM) is a method used to visually visualize the flow of a product through the production process, which includes all stages from the supply of raw materials to the final product. This method is very useful for future reference, as it aligns performance and methodology. VSM combines all processing steps into a single visual framework, which offers a comprehensive overview of the production floor, facilitates improvements in the production area, and optimizes the production line. VSM involves translating value streams into a visual "map" that depicts the current state or desired future state of the manufacturing system. The "current state map" describes how materials and information move through existing production systems. The VMS process begins by mapping the initial conditions, identifying the associated waste, and then designing a map of future conditions. This approach often results in cycle time reductions, optimal workforce utilization, process improvements, and financial savings (J. Singh et al., 2020).

Spaghetti Diagram

Spaghetti diagrams, also known as Spaghetti charts, models, or plots, are methods used to visualize the movement of objects in a system using lines. Tracked moving objects can include workers, materials, and others. The name "Spaghetti diagram" comes from the resulting visualization, which often resembles a tangled spaghetti intertwined. Such diagrams are an established tool that seeks a more effective layout. When transportation routes are plotted, it is often easy to see opportunities to reduce waste in the movement (Tanco et al., 2013).

METHODS

Research design is the framework of research methods and techniques chosen by a researcher to conduct a study. General types of research designs are qualitative research and quantitative research. A mixture between qualitative and quantitative research is also possible. The Lean Six Sigma approach was chosen to improve production capacity that did not reach the target. The DMAIC (Define, Measure, Analyze, Improve, and Control) technique will be used as a methodical framework in this study. The data collection methods that will be used are interviews and participatory observation.

RESULTS

Define Phase

Define phase is a stage carried out to define problems in the plastic injection process carried out by the production department at PT Indonesia TRC Industry. The problem that occurs is that there is a request that cannot be met or does not reach the desired target amount.The series of plastic injection production processes will be described through a table containing the identification of suppliers, inputs, processes, outputs, and customers (SIPOC) at PT Indonesia TRC Industry. As presented by the researcher in table.

Table 1. SIPOC

Element	Detail
Suppliers	- Internal Supplier: Division that supplies raw materials or internal supporting materials.
	- External Supplier: External vendors providing plastic resins, additives, or mold components.
Inputs	- Plastic raw materials (resin, additives).
	- Mold (mold).
	- Machine parameters (temperature, pressure, cycle time).
	- Production schedule and working documents.
Process	**1. Material Handling:**The material handling team brings raw materials from the warehouse to the production area.
	2. Machine Setup: The injection machine team prepares the machine (sets parameters, installs mold).
	3. Injection Molding: Production operators carry out the molding process (clamping, injection, cooling, ejection).
	4. QC Patrol: The QC team checks product quality in real-time on the production line.
	5. Packing: Products that pass inspection are packed according to standards.
Outputs	- Plastic products according to customer specifications (eg electronic housing, automotive components).
	- Inspection result data (pass/fail).
	- Production waste (scrap, flash).
Customers	- Internal Customers: Internal divisions such as OQC Team (Internal Quality Control) for final inspection before shipment.
	- External Customers: External clients (OEMs or end users) who receive the

	final product.
	- Delivery Team: Division responsible for final packaging and delivery of products to customers.

The SIPOC identification table shows the flow and parties involved in the production of PT Indonesia TRC Industry. At the definition stage, researchers identify the parties involved and also the problems related to the production flow. As has been explained, the problem that always arises is the product not being achieved. Regarding the product produced, the problem lies in the "process" element. Where process parameters are inconsistent, resulting in defective products. The product not achieved data is in the period April-September 2024 (24 weeks).

Table 2. Unchieved Injection Data

Period	N	Not Achieved		Achieved		Total	Total Per Month	Target Amount	Percentage of Achievement
		n	%	n	%				
April	Week 1	262	51%	251	49%	**513**	**1471**	**3410**	**43%**
	Week 2	0	0%	0	0%	**0**			
	Week 3	153	44%	193	56%	**346**			
	Week 4	277	45%	335	55%	**612**			
May	Week 5	180	45%	220	55%	**400**	**2161**	**4003**	**54%**
	Week 6	223	50%	222	50%	**445**			
	Week 7	264	49%	273	51%	**537**			
	Week 8	368	47%	411	53%	**779**			
June	Week 9	365	58%	266	42%	**631**	**2231**	**3731**	**60%**
	Week 10	275	47%	306	53%	**581**			
	Week 11	220	54%	190	46%	**410**			
	Week 12	311	51%	298	49%	**609**			
July	Week 13	239	53%	214	47%	**453**	**2068**	**3959**	**52%**
	Week 14	191	50%	190	50%	**381**			
	Week 15	231	49%	238	51%	**469**			
	Week 16	354	46%	411	54%	**765**			
August	Week 17	295	48%	322	52%	**617**	**2765**	**4609**	**60%**
	Week 18	368	52%	337	48%	**705**			
	Week 19	270	45%	326	55%	**596**			
	Week 20	359	42%	488	58%	**847**			
September	Week 21	233	22%	821	78%	**1054**	**4248**	**4629**	**92%**
	Week	235	21%	897	79%	**1132**			

	22								
	Week 23	221	21%	818	79%	**1039**			
	Week 24	361	35%	662	65%	**1023**			
Accumulation Period							**14944**	**24341**	**61%**

Source: Processed by researchers (2024)

As presented in the table, during the period of April-October 2024, it shows that the injection production process was not achieved in meeting demand, which can be seen from the percentage of achieving demand fulfillment of only 61 percent. Thus, it is known that 39 percent of PT Indoensia TRC Industry has not been able to produce plastic injection according to the desired production target.

Measurement Phase

In the Measure Phase, researchers will measure the level of defects that occur in the plastic injection production process at PT Indonesia TRC Industry through Defects per Million Opportunities (DPMO), Sigma Level, control chart, and process capability.

DPMO Calculation

$$DPMO = \left(\frac{Number\ of\ Defects}{Number\ of\ Units\ x\ Number\ of\ Opportunities}\right) x\ 1.000.000$$

Noted that:
Number of defects : 6.225
Number of Units : 24 weeks
Number of Opportunities : 0.4281
So the DPMO value obtained is:

$$DPMO = \left(\frac{6225}{24\ x\ 0{,}4281}\right) x\ 1.000.000 = 179.186$$

This shows that there are 179,186 defects per million opportunities in the plastic injection manufacturing process at PT Indonesia TRC Industry.

Sigma Level

The sigma level based on the DPMO value obtained is:

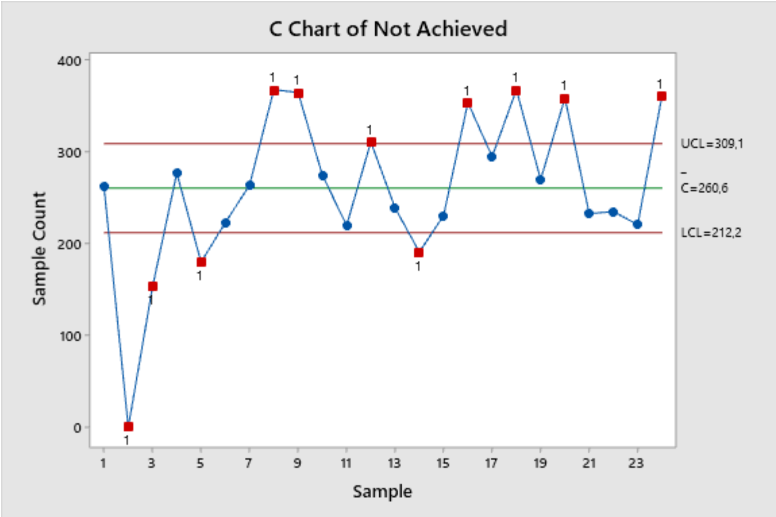
$$Sigma\ Level = \frac{ln\frac{DPMO}{1.000.000}}{\ln(1.5)} + 6$$

$$Sigma\ Level = \frac{ln\frac{179.186}{1.000.000}}{\ln(1.5)} + 6 = 4{,}5$$

The achievement of this sigma level illustrates that the plastic injection production process at PT Indonesia TRC Industry shows quite good quality, but there is still room for improvement towards the 6 Sigma level (DPMO < 3,400).In essence, the smaller the DPMO value, the better the process performance, so improvements are needed in the plastic injection production section.

Control Chart

Figure 1. C-Chart Map of Not Achieved Product Data for 24 Week Period

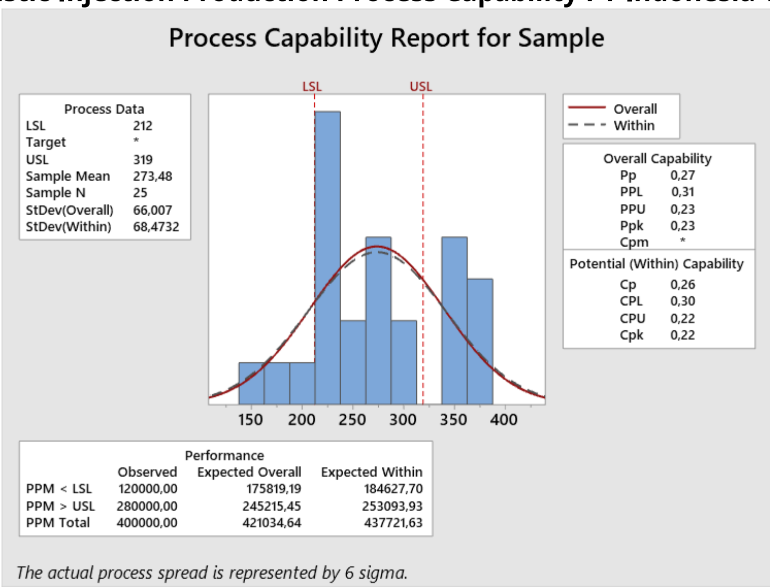


Source: Processed by researchers (2024)

Figure 1 illustrates that the plastic injection production process at PT Indonesia TRC Industry which is at the outer limit of control, namely the Upper Control Line (UCL) is in the 7-week period, especially in June, July and August. Also, it is known that in the period of April and May it is at the outer limit of control, namely outside the Lower Control Line (LCL). This indicates that there are many causes of the occurrence of products that are not in accordance with or not achieved.

Process Capability

Figure 2. Plastic Injection Production Process Capability PT Indonesia TRC Industry



Source: Processed by researchers (2024)

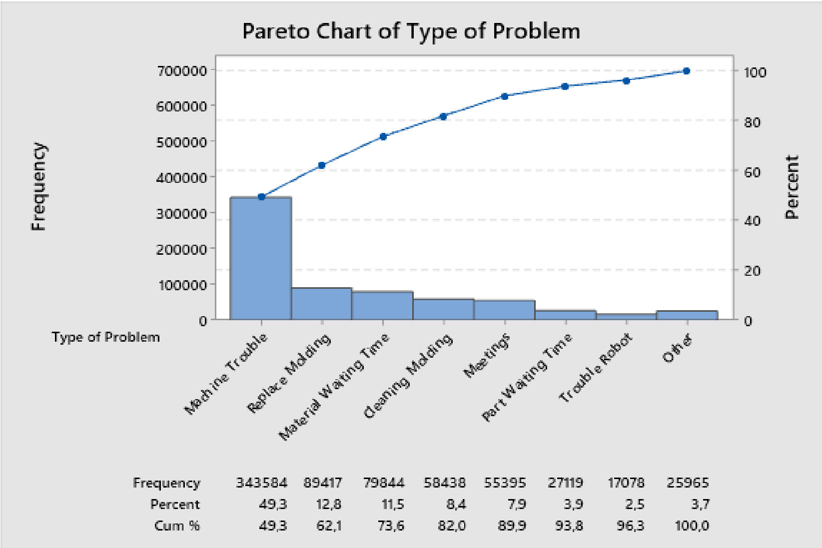
Based on the image, it is known that the USL (Upper Specification Limit) value is 319, while the LSL (Lower Specification Limit) is 212. Furthermore, the Cp value is 0.26 and Cpk is 0.22. So it can be concluded that the plastic injection production process at PT Indonesia TRC Industry is in a condition that is unable to produce products in specifications with good consistency. Thus, an analysis is needed to improve the plastic injection production system in order to be able to produce appropriate products.

Analyze Phase

Determining Sources of Process Variance

Pareto diagram is used to determine the priority level of defects that occur in a work section. This tool helps visualize data stating that 80% of results usually come from 20% of the main causes.

Figure 3. Pareto Diagram



Source: Processed by researchers (2024)

Pareto diagram explains the cause of loss time at PT Indonesia TRC Industry caused by 49% machine trouble.

1. Machine Trouble (49%)
   The main cause of the decline in productivity at PT Indonesia TRC Industry based on Pareto analysis is the existence of trouble machines that hinder the production process. Data findings reveal that the machines used are old or have expired. However, they have not been replaced, making the machines work less than optimally. Trouble machines also occur due to mechanical damage, component failure, machine setting errors and unscheduled maintenance. This indicates that human factors also influence the occurrence of trouble machines. Interview data findings also reveal that the temperature in the room also causes the machine to be damaged. The existence of trouble machines has an impact on production activities, namely downtime.
2. Replace Molding (12.8%)
   Replace molding is the second most common problem, which is 12.8 percent. This is influenced by both human and machine factors. Where, the mold replacement process becomes inefficient due to operator error in setting the mold and operating errors. In addition, the replace molding problem also occurs due to damage to the mold due to machine trouble.
3. Material Waiting Time (11.5%)
   Material Waiting Time is known to be caused by internal process delays, namely in the production line. The findings also show that machine trouble causes downtime and has an impact on the delay of available materials, which should be used for the next production. In addition, material waiting time also occurs because production planning and scheduling are not well coordinated, causing materials to pile up in the storage area. Improper scheduling

causes longer waiting times, especially when production is disrupted by machine trouble that causes production activities to be hampered.

4. Cleaning Moldings (8.4%)
   Cleaning Moldings that affect the decline in productivity at PT Indonesia TRC Industry are caused by human factors, where the cleaning procedure is inefficient. In addition, the machine is also a contributing factor because it is difficult to clean related to the mold design itself.
5. Meetings (7.9%)
   Meetings also affect the decline in plastic injection production productivity. Data findings reveal that much time is wasted on meetings that are considered ineffective. So this involves the organization that holds meetings.
6. Part Waiting Time (3.9%)
   Part Waiting Time is the time needed to wait for components needed in the production process. This is known to be influenced by machines that cannot process certain parts on time. This also indicates that the occurrence of part waiting time is also triggered by production obstacles due to machine trouble.
7. Trouble Robot (2.5%)
   Trouble robots are also known to be caused by trouble machines. In addition, another factor is human, where there is operator error in operating improper settings.

Thus, the major problems indicate that they involve machine trouble (such as machine problems, mold changeovers, mold cleaning, partial waiting time and robot problems) and human (such as operator errors in operating the machine, mold changeovers and organizing the cleaning process). However, it is known that there are other factors such as logistics (material waiting time) and organization (meetings) that affect productivity but are not directly related to machines or humans. Therefore, in order to improve efficiency and production capacity, it is important to identify the root causes of each factor and implement improvements at the machine, human and related production process levels.

This is in line with the findings of interview data which revealed that machine problems cause waiting times that are too long so that PT Indonesia TRC Industry's product side is unable to produce plastic injection according to the expected target. This analysis section also researchers conducted by reviewing the number of defects or "NG" products that occurred with machine trouble in a 24-week period through statistical regression analysis.

Figure 4. Effect of Machine Trouble on Defective Products

Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	108,0	34,7	3,11	0,005	
Machine Trouble	0,01016	0,00215	4,72	0,000	1,00

This finding shows that the intercept value is 108.0, which means that 108 is the number of plastic injection product defects that will occur without any interference to the machine. Where this shows the default value or normal condition of the production process when the machine is functioning properly. Meanwhile, the slope value of 0.01016 shows that each unit increase in machine trouble will increase the number of product defects by 0.01016 units. This also indicates that the more machine problems there are, the greater the number of defects in the plastic injection production process that will occur.

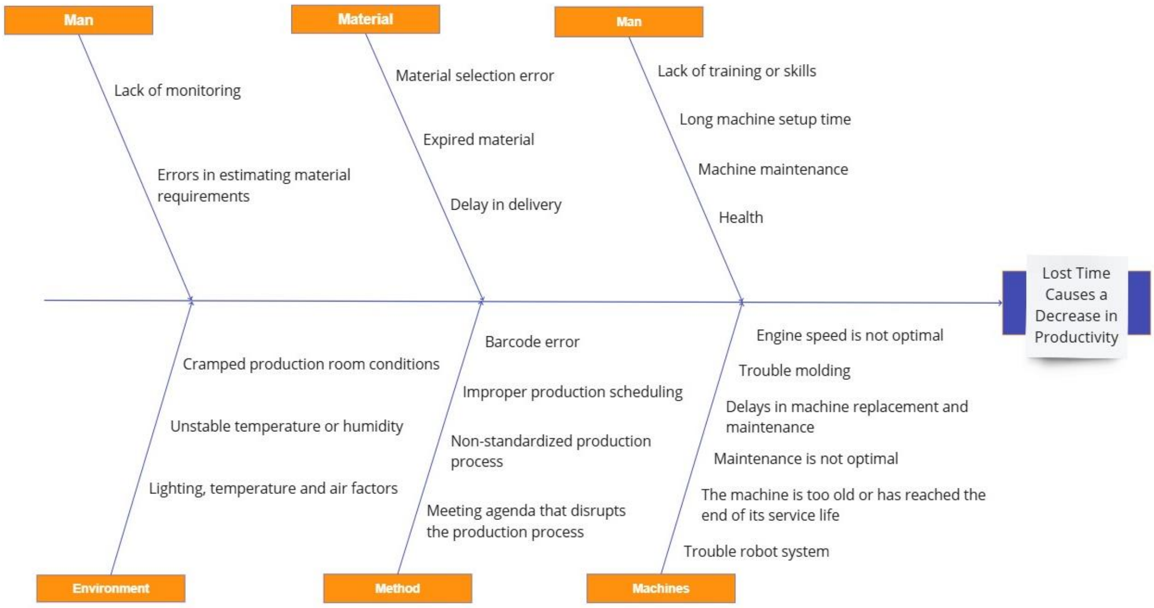
Identify Potential Root Cause using Fishbone

Table 3. Identification of Problems Found

Type of Problem	Causes of Problems	Impact on Production Process
Machine Trouble	Production using robotic systems experiences problems due to overheating of machine components such as gears and bearings.	The machine will become slow, unresponsive and even stop in the middle of the process. This causes high waiting times.
	There is an incorrect synchronization time, where to smooth the production process there must be a time between the injection machine and the robot that is synchronized.	The production process is hampered
	Maintenance is not optimal	Overheating of the engine and shortening of the engine life
	No engine replacement was carried out	Causing operational failure
	Unstable engine temperature	The plastic injection products produced are inconsistent, where temperatures that are too high or too low will change the properties of the plastic material and affect the injection process.
	Suboptimal cycle time	Causes of defective products
	The machine is too old or has reached the end of its service life	Machine is not optimal
Trouble Molding	Leakage in the mold	Defective product
	The mold is worn out	Damaged products such as cracks or scratches
	Unstable temperature	Damaged product
	The mold cooling system is not working properly	Causes longer production times and causes plastic injection products to be damaged.
Waiting Time	Delay in delivery	Production process is hampered
	Incorrect barcode material	Production process is hampered
	Expired material	Production process is hampered
	Long machine setup time	Production process is hampered
Meetings	Meeting time is too long	The production process is delayed
	Hold meetings during main working hours	The production process is delayed
	Lack of production team involvement	Eliminates opportunities for better improvement
Production Preparation	Long machine setup time	The production process is delayed
	An error occurred during the mold installation process.	The production process is delayed
	There are staff who do not attend training	Errors in handling machines, materials and slowing down the production process
	Incorrect stock of materials	The production process is delayed
	Narrow production area	The production process is delayed

Based on this, the fishbone diagram that is formed will contain an analysis of the problems or sources of problems in the plastic injection process of PT Indonesia TRC Industry.

Figure 5. Fishbone Diagram of PT Indonesia TRC Industry's Plastic Injection Production Process



Source: Processed by researchers (2024)

Identify Specific Root Cause using Value Stream Mapping (VSM)

Data findings reveal that there is a waste of time in the plastic injection production flow that is carried out, namely in the machine section to the taking out parts stage. The accumulation of time targeted by PT Indonesia TRC Industry at the Machine-Taking Out Parts stage is 15 minutes 15 seconds. However, it is known that based on observations made by researchers over a period of 24 weeks, there was a very significant waste of time, namely an average of 3-4 hours. This is caused by the set up time being too long and the machine trouble that occurs, thus hampering the expected production time.

Identify Specific Root Cause using Spaghetti Diagram

Spaghetti diagram analysis is used by researchers to identify inefficiencies. This analysis found that at PT Indonesia TRC Industry there were unnecessary movements, waiting times, and delays caused by problems such as machine trouble and mold replacement. The production space was too narrow, slowing down the movement of workers in moving materials. In addition, materials that were moved back and forth between several points indicated that the production flow was not well organized. Interviews with production revealed that workers had to move too far from one point to another, indicating that the flow of materials and workers was not optimized.

In addition, it is found in the material room and mold maker. Where, material must wait to be processed and the machine must wait for mold replacement. This also increases lead time and reduces production speed. Furthermore, mold cleaning after the production cycle shows inefficiency.

Improvement Phase

Table 4. Improvement Phase

Aspect	Repair Steps	Objective	Methods/Tools Used
Machine	- Integrate IoT sensors for real-time monitoring of machine parameters. - Implement predictive maintenance.	Reduce unexpected downtime and increase operational efficiency.	IoT Sensors, Machine Learning Models, TPM (Total Productive Maintenance)
Man	- Use the Kaizen approach to empower operators to provide process improvement feedback. - Provide training to read IoT data.	Improve operator skills, participation and ownership.	Kaizen Boards, Training Modules, Continuous Feedback Loops
Material	- Monitor material usage using IoT-based inventory systems. - Conduct regular waste material analysis.	Increase material efficiency and reduce production waste.	IoT Inventory Systems, Material Flow Mapping, 5S Analysis
Method	- Implement IoT-based automation processes for critical steps. - Standardize processes through Kaizen Events.	Reduce process variability and improve result consistency.	Automation Software, SOP Standardization, Lean Kaizen Events
Measurement	- Use IoT devices for real-time measurement of critical parameters. - IoT-based automatic calibration for measuring instruments.	Ensure measurement accuracy and product quality consistency.	IoT-enabled Measurement Devices, Statistical Process Control (SPC)
Environmental	- Use IoT to monitor machine energy consumption. - Identify potential emission reductions through Kaizen Projects.	Reducing environmental impact and increasing sustainability.	IoT Energy Management Tools, Green Kaizen Programs

Machine is the main focus that is the source of improvement in this study, because machine trouble is known to be the main problem that causes waste in plastic injection production carried out by PT Indonesia TRC Industry. Interview data findings reveal that machines using a robot system will be difficult to repair if the machine is not replaced based on the old age of the machine. The age of the machine has an impact on the machine used not being able to work optimally. Furthermore, machine trouble is also triggered by a robot system that has an automatic system. So that the improvement phase in machine trouble can be done through the implementation of the Internet of Things (IoT). Where IoT is considered capable of increasing efficiency and productivity through features such as real-time monitoring, predictive maintenance and data-based quality control. As this was also revealed by research conducted by Hernandez-Vega et.al (2024) that technology such as IoT has a significant impact on the efficiency, quality and sustainability of the production process, contributing to the competitiveness of the sector and the development of innovative products. The implementation of the IoT system allows early identification of problems with machine components by analyzing data patterns and detecting anomalies. Thus, this can reduce unexpected downtime obstacles in production.

Control Phase

Table 5. Control Phase

Managed Aspects	Action Steps	Objective	Tools
Machine Maintenance	Implementing Predictive Maintenance using IoT data.	Prevent undetected machine damage.	IoT sensors, Maintenance scheduling software
Process Standardization	Update and standardize SOPs (Standard Operating Procedures).	Ensures every step of the process is carried out in the same way.	Procedure documentation, SOP training
Product Quality Control	Implement quality control with automatic measurements and visual inspection.	Maintain product quality according to standards.	Automated Inspection Systems, Inspection tools
Parameter Control	Perform monitoring on critical parameters (temperature, pressure, cycle time) in real-time.	To ensure process stability	Real-time Monitoring Systems, IoT devices
Process Monitoring	Using Control Charts to monitor process variability.	Ensuring process stability and consistency.	SPC (Statistical Process Control), Control Charts
Corrective Action	Implement procedures for correction if deviations occur.	Return the process to normal conditions as quickly as possible.	Root Cause Analysis, Corrective Action Plans
Performance Audit	Conduct periodic internal audits to assess process performance.	Ensuring processes remain efficient and sustainable.	Audit schedules, Performance review meetings
Team Training and Development	Advanced training program for operators and production managers.	Improve team skills in operating machines and solving problems.	Training programs, Workshops
Key Performance Indicator (KPI) Evaluation	Monitor production cycle time, product defect rate, machine downtime, and employee productivity, as well as compare data before and after repairs.	Measuring the success of implementing improvements	IoT Sensors
Security and Sustainability	Implementing measures to reduce waste and improve energy efficiency.	Increasing sustainability and reducing environmental impact.	Energy management systems, Waste reduction programs

DISCUSSION

Based on the data analysis that the researcher has described, it shows that the decline in productivity experienced by PT Indonesia TRC Industry was caused by the amount of production time lost due to loss time and downtime due to machine disruptions which hampered actual production and had a direct impact on the products produced experiencing damage (defects). Pareto analysis shows that 49% of the problems that often occur are trouble machines. Data findings show that the occurrence of material waiting time problems is caused by delays in the production line, namely trouble machines. The downtime that occurs causes delays in available materials, which should be used for the next production. The DPMO value obtained is known to be 179,186 with the Sigma Level value obtained being 4.5. The achievement of this sigma level illustrates that the plastic injection production process at PT Indonesia TRC Industry shows quite good quality, but there is still room for improvement towards the 6 Sigma level (DPMO <3,400). In essence, the smaller the DPMO value, the better the process performance, so improvements are needed in the plastic injection production section.

The improvement phase in Lean Six Sigma in the plastic injection production process is used as a tool to optimize every aspect of production. Based on the findings of the fishbone diagram analysis data, improvements that can be made by PT Indonesia TRC Industry are by utilizing Internet of Things (IoT) technology and the Kaizen philosophy. As stated by Nangia et.al (2020), IoT technology has the ability to predict failures in advance which will help organizations increase productivity, reduce equipment costs, improve working conditions and work environment safety, better product quality, reduce waste in terms of consumables and energy savings. Thus, PT Indonesia TRC Industry can create continuous improvements, increase operational efficiency and achieve production sustainability.

In terms of machinery, the application of IoT sensors allows real-time monitoring of critical parameters such as injection pressure, temperature, and cycle time. This data is used to predict failures through predictive maintenance, which reduces downtime by up to 25%. On the other hand, Selcuk (2017) stated that IoT technology can help industries reduce downtime by up to 70-75%. In addition, the Kaizen philosophy involves operators in routine maintenance activities to maintain optimal machine conditions. Thus, the combination of IoT and Kaizen significantly increases machine life and operational efficiency.

In the human aspect, IoT supports occupational safety through wearable devices that monitor environmental conditions and employee health. Kaizen complements technology by encouraging continuous training that improves employee skills and engagement. This approach has proven effective in reducing human error and creating an innovative work culture. The combination of technology and training contributes to increased employee productivity (Pitjamit, et.al, 2024) In addition, standardization of operating procedures (SOPs) through Kaizen can create process consistency, reduce variability and minimize human error.

The IoT system for the material aspect facilitates the movement of materials from the warehouse to the production stage, reducing consumption by up to 30%. The Kaizen approach supports in-depth analysis of the logistics process to make the material flow more efficient than standardization. This optimization also shows the quality of the final product due to poor production due to material damage.The combination of IoT and Kaizen systems allows workers to see problems directly and immediately provide feedback for improvement (Patel and Kiran, 2022)

In addition, in the layout method, IoT allows companies to use real-time data to improve production cycles. Adjustments to process parameters such as cooling time and injection speed can be made precisely to reduce cycle time without compromising product quality. Kaizen supports this effort by standardizing operating procedures that prevent variability in the manufacturing process. A study conducted by Rusli et al (2024) showed that Kaizen, an optimized IoT-based method, resulted in increased cycle time efficiency and had a direct impact on increased productivity. Maintaining a large enough workspace and optimal temperature is very important to prevent machine problems and improve operator comfort. This condition can increase speed and accuracy in the production process, as well as reduce the possibility of machine damage (Aminabadi et.al., 2022).

Finally, in the Environmental aspect, IoT covers energy consumption and environmental emissions generated during the production process. This data helps companies identify opportunities to save energy and thus support retirement efforts. The Kaizen philosophy integrates this technology by promoting waste management initiatives and material reuse.

Poyyamozhi, et.al (2024) revealed that IoT technology can reduce energy consumption by 30% and operational costs by 20%. Overall, integrating IoT and Kaizen in the Lean Six Sigma improvement phase provides a holistic and effective solution. IoT technology provides real-time data for better decision making, while Kaizen allows these innovations to be implemented collaboratively and sustainably. The combination of the two not only increases productivity and quality, but also creates processes that respond to future changes and challenges.

CONCLUSION

Based on the analysis data findings that have been described to answer the problem formulation, the researcher concludes that:

1. The gap between the 90% production target and the 75% plastic injection production realization is caused by a combination of technical, human resource, and production environment issues. A number of key factors such as frequent machine breakdowns, inadequate maintenance processes, production variability, and lack of employee training contribute to the reduced efficiency. Improvements in machine maintenance, employee training, and the implementation of automated monitoring technology can help close this gap and drive production levels to higher targets.
2. Production shortages in the plastic injection industry can increase operating costs and delay delivery schedules. Operating costs increase due to additional labor, maintenance, energy, and raw material waste. At the same time, production delays will impact on-time delivery, and potentially damage customer relationships.
3. Strategies that can be implemented to improve production efficiency and align actual production levels with company targets in plastic injection production can be done by implementing an improvement phase that includes addressing problems in machines, man, measurement, method and environment. In addition, integrating advanced technologies such as IoT with the Kaizen approach to monitoring and automation and implementing Lean and Six Sigma principles will improve efficiency and ensure smoother production, leading to more consistent target achievement.

LIMITATION

This research is limited to the plastic injection production operations at PT Indonesia TRC Industry and does not cover other production processes within the company. The study focuses solely on internal factors affecting production output, excluding external variables such as market condition changes or disruptions in the external supply chain.

The root cause analysis will be limited to issues that the company can directly control. The implementation of solutions will also be confined to the research timeframe, with other solutions provided as recommendations for future consideration. Additionally, the research period is restricted to data collected from recent operations (April 2024 – September 2024), and historical data outside this timeframe will not be analyzed.

REFERENCES

Alkiayat, M. (2021). A Practical Guide to Creating a Pareto Chart as a Quality Improvement Tool. *Global Journal on Quality and Safety in Healthcare,* 4(2), 83–84, DOI:. https://doi.org/10.36401/jqsh-21-x1.

Aminabadi, Saeidi S., et.al. (2022). Industry 4.0 In-Line AI Quality Control of Plastic Injection Molded Parts. *Polymers,* 14(17), 3551; https://doi.org/10.3390/polym14173551

Bappenas and ERIA. (2021). Kajian Sektor Manufaktur Indonesia 2021.

Coccia, M., & Niversity, A. R. S. T. U. (2018). the Fishbone diagram to identify , systematize and analyze the sources of general purpose technologies. *Journal of Social and Administrative Sciences,* 4(4), 291-303,

Hartono and Fatkhurozi. (2021). Implementation of Kaizen to Reduce Loss Time in Increasing Infrared Welding Machine Productivity (Case Study of PT. Mitsuba Indonesia). *Journal Industrial Manufacturing,* 6(1), 1-18.

Hernandez-Vega, Jose I., et.al. (2024). Plastic Injection Molding Process Analysis: Data Integration and Modeling for Improved Production Efficiency. *Appl. Scie.* 14(22), DOI: https://doi.org/10.3390/app142210279.

Luisi, Gerardo., et.al. 2023. A Hybrid Architectural Model for Monitoring Production Performance in the Plastic Injection Molding Process. *Appl. Sci*., 13(22), 12145; https://doi.org/10.3390/app132212145.

Nandakumar, N., Saleeshya, P. G., & Harikumar, P. (2020). Bottleneck Identification and Process Improvement by Lean Six Sigma DMAIC Methodology. *Materials Today: Proceedings*, 24, 1217–1224. https://doi.org/10.1016/j.matpr.2020.04.436

Nangia, Shikhil., et.al (2020). IoT based Predictive Maintenance in Manfucturing Sector. *International Conference on Innovative Computing and Communication (ICICC 2020).* DOI: http://dx.doi.org/10.2139/ssrn.3563559.

Page, A., Sakdiyah, S. H., Eltivia, N., & Afandi, A. (2022). Journal of Applied Business , Taxation and Economics Research (JABTER) Root Cause Analysis Using Fishbone Diagram *: Company Management Decision Making.* 1(6), 566–576. https://doi.org/10.54408/jabter.v1i6.103.

Pitjamit, Siwasit., et.al. (2024). Enhancing Lean-Kaizen practices through IoT and automation: A comprehensive analysis with simulation modeling in the Thai food industry. *Engineering and Applied Science Research,* 51(3), 286–299. Retrieved from https://ph01.tci-thaijo.org/index.php/easr/article/view/254675.

Poyyamozhi, Mukilan., et.al. (2024). IoT—A Promising Solution to Energy Management in Smart Buildings: A Systematic Review, Applications, Barriers, and Future Scope. *Building*, 14(11). DOI: https://doi.org/10.3390/buildings14113446.

Rusi, Mohd Hazri., et.al. (2024). Development of IoT Kaizen System for Smart Lean Raw Material Inventory Management: A case study at an SME factory in Malaysia. *Jurnal Kejuruteraan*, 36(4), 1585-1598. DOI: DOI:10.17576/jkukm-2024-36(4)-24

Selcuk, S. (2017). Predictive maintenance, its implementation and latest trends. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture,* 231(9), 1670-1679.

Singh, J., Singh, H., Singh, A., & Singh, J. (2020). Managing industrial operations by lean thinking using value stream mapping and six sigma in manufacturing unit: Case studies. *In Management Decision*, 68(6), DOI: https://doi.org/10.1108/MD-04-2017-0332

Singh, M., & Rathi, R. (2019). A structured review of Lean Six Sigma in various industrial sectors. *In International Journal of Lean Six Sigma*, 10(2), DOI: https://doi.org/10.1108/IJLSS-03-2018-0018.

Tanco, M., Santos, J., Rodriguez, J. L., & Reich, J. (2013). Applying lean techniques to nougat fabrication: A seasonal case study. *International Journal of Advanced Manufacturing Technology*, 68(5–8), 1639–1654. https://doi.org/10.1007/s00170-013-4960-7