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SIX SIGMA IMPLEMENTATION IN "MONOSODIUM GLUTAMATE" PRODUCTION SYSTEMS

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ABSTRAK

Sebagai upaya untuk menjadi perusahaan yang kompetitif, PT GCK Indonesia sebagai salah satu produsen Monososium Glutamat di Indonesia, harus terus melakukan peningkatan sistem di segala sektor. Termasuk sistem produksi. Penelitian ini melakukan analisis perbaikan sistem produksi dan menelusuri produk cacat dengan penerapan metode Six Sigma. Data yang digunakan berasal dari hasil produksi selama enam bulan. Berdasarkan tahapan pengukuran, cacat produk memiliki nilai sigma sebesar 3,23 dengan nilai DPMO sebesar 275.586,22. Faktor manusia dan mesin adalah penyebab utama cacat. Perbaikan dilakukan dengan memperbaiki sistem perawatan mesin dan melengkapi prosedur operasi standar untuk setiap aktivitas kritis di lini produksi.

Kata Kunci: *Monosodium Glutamat, Six Sigma, DPMO, DMAI*

ABSTRACT

In order to gain competitive advantages, PT GCK Indonesia, as one of the Monosodium Glutamate producers in Indonesia, must continuously improve the system in all fields. Including the production system. This study used the Six Sigma method, which analyzed product defects. Data used comes from production results for six months. Based on the measurement stages, the product defect had a sigma value of 3.23 with a DPMO value of 275,586.22. Human and machine factors are the leading causes of defects. Improvements are made by correcting the machine maintenance system and completing standard operating procedures for each critical activity.

Keywords: *Monosodium Glutamate, Six Sigma, DPMO, DMAI*

INTRODUCTION

Industry development in Indonesia is very fast, giving rise to competition between one industry and another. It encourages companies to have an excellent strategy to continue competing and developing to survive (Nayak et al., 2022). One of the strategies that can be chosen is to increase the efficiency of the process by reducing the level of product defects (Nurcahyo et al., 2021).

PT. GCK Indonesia is a company that strives to continuously improve the quality of the products produced due to any product defects that occur in the production process. It impacts decreased production results which have a detrimental effect on the company. The problem of high defective products is a problem in the production process, including the number of defective products due to dirty, damp products, inappropriate product sizes, and yellow colors. The high value of the percentage of defects from the three factors of the problem makes companies need to minimize product defects that still occur frequently with this problem, here trying to apply the six sigma quality calculation method to destroy the defective product.

The Six Sigma method was chosen because, in previous research in various fields, it could provide improvement through the stage of recommendations and proposed improvements for companies in suppressing defective products. In this study, the stages used were "defined, measure, analyze, and improve." These stages will analyze the factors that cause high product defects. The six sigma method is also expected to provide solutions to reduce product defects and improve product quality standards. It is what the company hopes to continue to get benefits to develop its business by continuously being able to make high-quality products according to customers' needs.

RESEARCH METHODS

Definitions of Quality

Quality is desired and expected by customers attached to the products of goods and services (Montgomery, 2019). Quality is often considered a relative measure of the goodness of a product or service, a function of the conformity of product specifications, and a measure of how far a product meets the requirements or quality specifications set (Kusuma, 2021; Santoso &

Fudhla, 2018). The following is the notion of quality according to experts: (Kiran, 2017)

- According to A.V. Feigenbaum, quality can be interpreted as factors in an item or result that causes manufacturing and maintenance that make the products and services used to meet customer expectations.
- According to Crosby, quality is conformance to requirement, which is following what is required or standardized. A product has quality if it is under the quality standards that have been determined. Quality standards include raw materials, production processes, and finished products.
- According to Deming, quality conforms to the market's or consumers' needs. The company must understand what consumers need for a product that is produced.
- According to Garvin, quality is a dynamic condition related to products, people or labor, processes and tasks, and an environment that meets or exceeds consumer expectations. Consumer tastes in a product are constantly changing, so the quality of the product must also change or be adjusted. With the change in product quality, it is necessary to change or improve the workforce's skills and change the production process.

Six Sigma

Six Sigma is a philosophy of dramatic quality improvement applied by Motorola since 1986. Currently, Six Sigma is widely developed and widely accepted by the industrial world because Six Sigma can dramatically improve quality towards a zero-defect rate. (Narasimhan, 2002).

Six Sigma is a vision of quality improvement towards the target of 3.4 failures per million opportunities (DPMO) for every product transaction (goods and or services) (Ikumapayi et al., 2020). Therefore, Six Sigma can be said to be an active effort towards perfection (zero defect). Six Sigma is a clever way to manage a business or department. Six Sigma puts customers first and uses facts and data to get better solutions (Wang et al., 2021).

The stages of implementation of six sigma quality improvement consist of five steps, namely using the DMAIC method or define, measure, analyse, improve, and control. (Harmon, 2019)

1. (Define) Defining the problem is the first operational step in Six Sigma's quality improvement program. In this stage, it is necessary to define several things related to the six sigma project selection criteria. The roles and responsibilities of the people who will be involved in the Six Sigma program, the training needs for the people involved in the Six Sigma project, the critical processes in the Six Sigma project and its customers, the specific needs of the customer, and the six Sigma project objective statement. So, the essence of this stage is to identify the problems and objectives of the Six Sigma project.
2. (Measure) Measuring is the second operational step in six Sigma's quality improvement program. At this stage, there are three main things to do: selecting or determining key quality characteristics (CTQ) that are directly related to the specific needs of the customer; developing a data collection plan through measurements that can be done at the process, output, and/or outcome level; and measuring current performance at the process, output, and or outcome level to be set as a performance baseline at the beginning of the Six Sigma project. So, the measure is a logical follow-up to the defined step and is a bridge to the analysis step. The measuring step has two main objectives, namely:
   - Get data to validate and quantify issues/opportunities.
   - Getting started touching on facts and figures that provide clues about the root of the problem.
3. (Analyze) Analyzing is the third operational step in the Six Sigma quality improvement program. At this stage, it is necessary to do the following: determine the stability and capability/capability of the process, set performance targets of the critical quality characteristics (CTQ) to be improved in the Six Sigma project, identify the sources and root causes of defects or failures, and convert multiple failures into the cost of failing n quality. So, the analysis step is used to find the "root cause."
4. (Improve) Improving is the fourth operational step in Six Sigma's quality improvement program. After knowing the sources and root causes of the quality problem, it is necessary to determine action plans. The action plans will describe the allocation of resources and the priorities and/or alternatives in implementing the plan. So, at this stage, it will be decided what to achieve (relating to the targets set), the reasons for the usefulness (why) the action plan should be carried out, and where the action plan will be implemented or carried out. When it will be carried out, who will be in charge of the action plan, how to implement it, how much it will cost to implement that action plan, and the positive benefits received from implementing that action plan. The 5W-2H method can be used at this stage.
5. Control is the last operational step in the Six Sigma quality improvement project. At this stage, the results of quality improvement are documented and disseminated. Successful best practices in improving processes are standardized and disseminated. Procedures

are documented and used as standard work guidelines, and ownership or responsibility is transferred from the Six Sigma team to the owner or person in charge of the process. This stage aims to ensure that the modified process allows the critical variable to remain within the predetermined acceptance range.

Some Terms in the Six Sigma Concept

Some of the terms in the Six Sigma concept that will be used to make it easier to understand are:

1. Critical to Quality (CTQ) are essential attributes to pay attention to because they are directly related to customer needs and satisfaction. CTQ is a product, process, or practice element that directly impacts customer satisfaction (Cohen et al., 2020).
2. Defect is a failure to deliver what the customer wants (Montgomery, 2019).
3. Defect per million opportunities (DPMO) is a measure of failure in Six Sigma's quality improvement program, which shows failures per million chances (Ikumapayi et al., 2020). The target of 3.4 DPMO should not be interpreted as 3.4 defective output units out of a million output units produced but as a single product unit. An average chance of failure of a CTQ characteristic is only 3.4 failures per million occasions.

$$DPMO = \frac{defect}{unit\ inspected \times defect\ opportunity} \times 1\ million \quad (1)$$

Where:

Defect is the number of defects found

Inspected units is the number of units inspected

Defect opportunity is a possible error.

As for the calculation of Sigma, it is as follows.

$$sigma = normsinv\left(1 - \frac{DPMO}{1.000.000}\right) + 1.5 \quad (2)$$

4. Process capability is the ability of the process to produce or submit the output by customer expectations and needs. *Process capability* is a critical performance measure showing the process could produce following product specifications set by management based on customer needs and expectations (Pawar et al., 2021).

RESULTS AND DISCUSSION

The data that is successfully collected will be processed using the six sigma method. Data collection is carried out through observation or observation directly at where production occurs. This research was conducted to find out the problems with msg products and find solutions to control the quality of these products.

Define

"Define" is the stage of defining quality problems in the final product, monosodium glutamate (MSG). At this stage, the product experience a defect defined as the cause of the defect. Based on existing problems, the defects' causes can be seen in the table below. The following in Table 1 explains the quality standards that the company has set.

Table 1. Product Quality Standards

Product Quality Standards	Explanation
Product hygiene	The product must be avoided from contaminated by dirt or foreign objects.
The moisture content of the product	The moisture content of the specified product is < 0.2%
Product size	Product sizes should be divided according to the size of each type according to the standard L, M, S, and SS.
Product color	The color of the product must follow the color standards set, namely having a crystal value of > 97%
Product form	The shape of the product should not be any lumps

The product can be said to be of high quality if it meets five elements of quality standards, namely product hygiene, the product's water content, product size, product color, and product shape. Suppose one of the five elements is not fulfilled. In that case, it can be said that the product is defective and must be reprocessed or dissolution of the crystals so that they become liquid again and reprocessed.

Tabel 2. Examples Of Product Images That Conform To The Standards And Are Not

Examples of standardized product images	Examples of defective product images	Name type of defect
		dirty
		humid
		Mixed size

Examples of standardized product images	Examples of defective product images	Name type of defect
		yellow
		Clump

Potential causes of producing the final product msg and from table 2 above can be identified as follows:

1. Dirty
   Contaminated MSG often causes this problem with dirt on the floor because MSG spilled from production machines, so it becomes non-standard to be sent to the packing plant.
2. Humid
   This problem is in the form of a condition of MSG that has not dried or a high water content caused by the non-maximum drying process so that the product becomes no longer standard.
3. Mixed size
   This type of defect is MSG size that does not match the size that should be separated in the Vibro machine but is not separated so that the product size is mixed, which results in the MSG becoming a non-standard product size.
4. Yellow
   This defect is usually caused because the product is exposed to water droplets or ML liquid dripping from the counter back machine or the heater; also caused by a turbid liquid color so that the color of the MSG is not standard.
5. Clump
   This defect is caused during the crystallization process; at the time of the beginning of the production process, the crystal tank is not cleaned before, so that it can make small lumps of residual crystals that are still in the tank and mix with products that have been processed in the tank.

Table 3. The percentage of defects for six months

Period	Production (Tons)	Number of defects (Tons)	Percentage of defects per month (%)
July	5. 104	916	17,94
August	4. 954	1. 402	28,30
September	4. 986	928	18,61
October	5. 092	1. 415	27,78
November	5. 386	827	15,35
December	5. 209	1. 131	21,71
Total	**30. 731**	**6. 619's**	**21,53**

Table 3 above shows the most defects found in august with 1. 402 Tons, 28.30% of product for one month, and the least is in November with a 15.35% defect rate.

Table 4. The percentage of each type of defect to the total amount of production for six months

Types of defects	Total production (Tons)	Number of defects (Tons)	Percentage %
Dirty	30. 731	2328	7,57
Humid	30. 731	2188	7,12
Mixed size	30. 731	1351	4,40
Yellow	30. 731	527	1,71
Clump	30. 731	225	0,73

The "dirty" is the most significant type of defect with a percentage of 7.57% with a total defect of 2328 tons of the total production for six months. The "clump" defect has the smallest percentage with a percentage of 0.73 with a total defect of 225 tons.

Measure

The output performance measurement can be done by calculating the data on the results of the production process inspection and calculating DPMO and sigma values. Here are the results of calculating output performance on the system.

Table 5. Sigma and DPMO values of the production process

Period	DPMO	Sigma
July	35.893,42	3,30
August	56.600,73	3,09
September	37.224,23	3,28
October	46.314,48	3,18
November	30.709,25	3,37
December	43.424,84	3.21
Rata-rata	275.586,22	3,23

Based on Table 5 above, It can be stated that in November, the company achieved a good value with a sigma value of 3.37 with a DPMO of 30.709,25. In August, the company got the worst sigma value with a sigma value of 3.09 and a high DPMO value of 56.600,73. From July to December, the average company had a sigma value level of 3.23 with an average DPMO score of 275. 586,22 per one million products. An average sigma value of 3.23 indicates that it is included in the average industry group in the country. From the data obtained above, it can be analyzed that the company can make output measurements about the type of disability specified to know the capabilities of Sigma and DPMO. The company must make improvements to reduce the number of defects in the product.

Analyze

The frequency of defects from Table 4 is then compulsively processed to obtain a Pareto diagram.

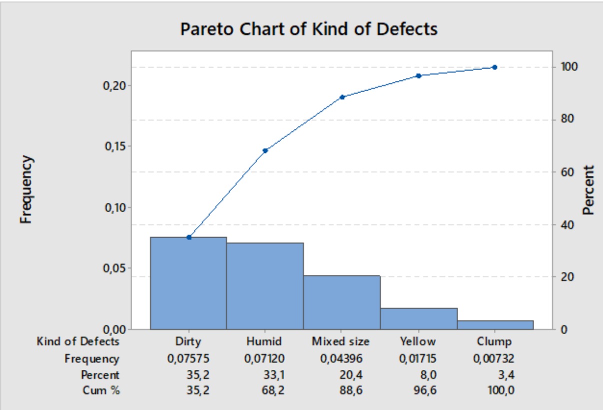

Figure 1. Pareto of MSG defects

Pareto in Figure 1 shows that Dirty, Humid, and Mixed Sizes are accumulated to 88.6% of defects in the MSG production process, so these three defects are the top priority for further analysis.

Fishbone Diagram of "Dirty"

Figure 2 shows a fishbone diagram of the Msg production process with a "dirty" type of defect. The root causes can be explained as follows:

1. Method

   The method applied to this defect problem is only limited to incomplete supervision of the entire production process flow so that many things are not controlled, which results in product defects.

2. Personal

   Operators often forget to run a series of machines because many buttons on the panel must be turned on. Sometimes there are electro motors that have not been turned on, resulting in product defects. It could happen because there are no work instructions to run the machine. The operator's primary job is maintaining the machine's cleanliness (self-checking) and controlling the valves related to the machine process flow to avoid valve jams during the production process. The lack of operator control over machines running, if there is damage to the machine, the operator does not know this, could result in product defects.

3. Machine

   The machine's rarely cleaned condition can cause dirt from the remaining MSG left in it to become a contaminant in the next production. Improper machine settings can also cause product defects. The distribution between slurries is not balanced; it makes the outlet capacity unstable, resulting in defective products. Checking the Vibro machine's screen that is only performed once at the beginning of the shift could increase the probability of machine disruption in the next part of the shift. If the screener breakdown, much product will fall to the floor and be contaminated with dirt.

4. Material

   Too soft materials can also cause product defects. The rate of material at the counter back speed machine runs slowly and accumulates on the conveyor and vibrates so that it falls to the dirty floor. Hence, the product is not suitable for packaging.

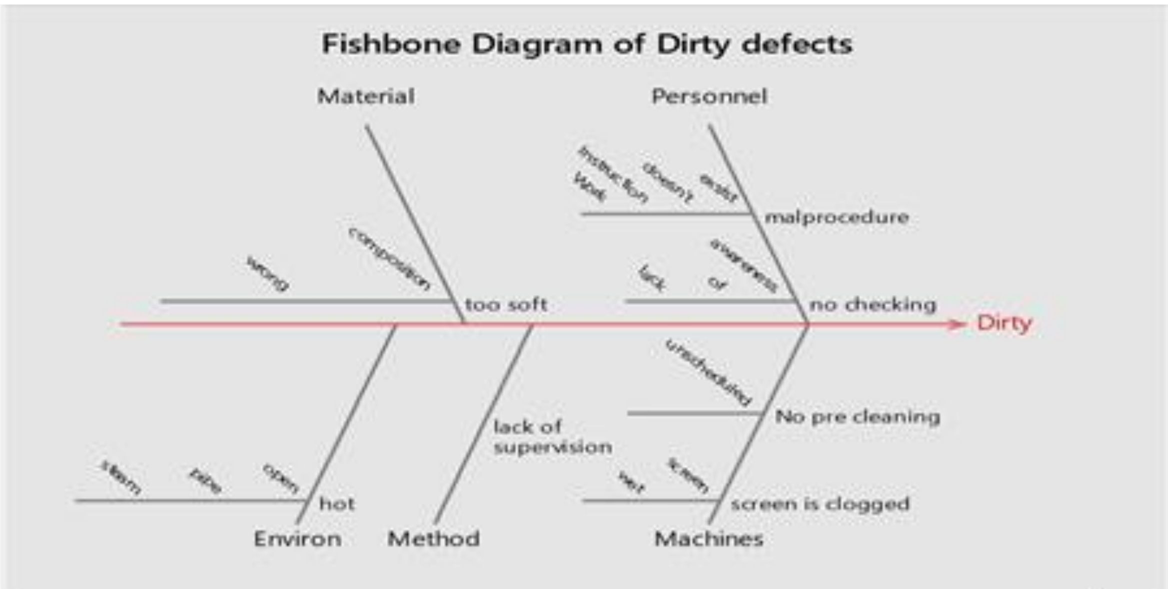

Figure 2. Defect of Dirty Cause and Effect Diagram

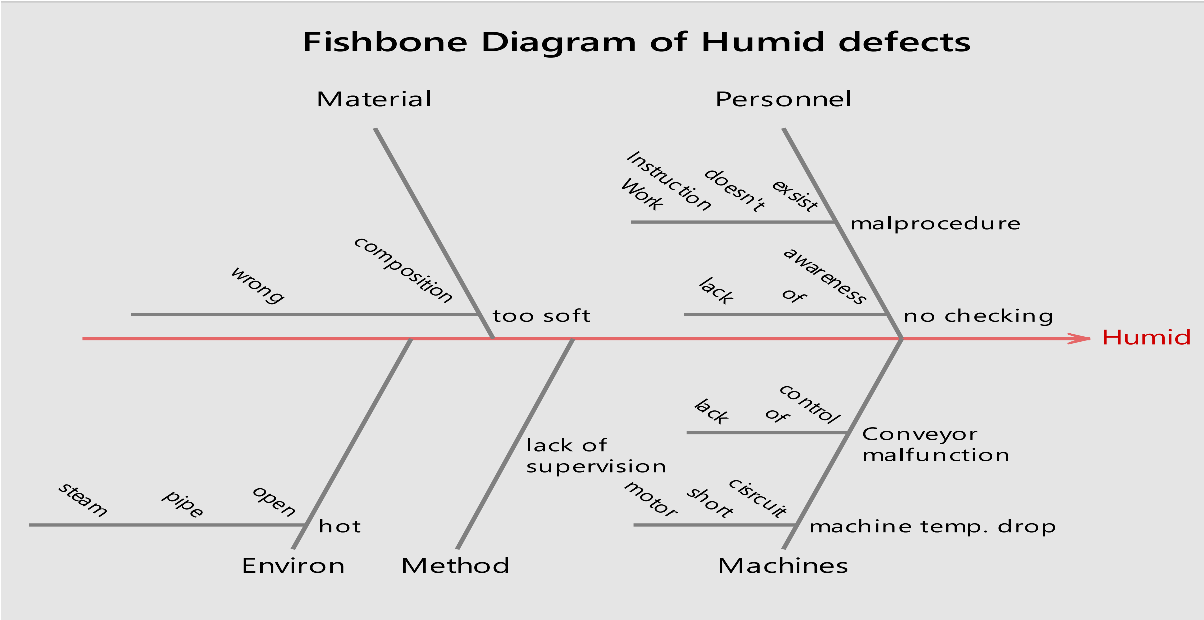

Figure 3. Defect of Humid Cause and Effect Diagram

5. Environment

The hot workspace makes the workers uncomfortable and lacks concentration in running the machine, so they could feel rushed in carrying out their responsibilities at work.

Fishbone Diagram of "Humid"

Figure 3 shows a fishbone diagram of the Msg production process with a "Humid" type of defect. The root causes can be explained as follows:

1. Method

Incomplete supervision at the stages of the ongoing production process makes many parts uncontrolled, which results in product defects.

2. Personal

Lack of control and operator discipline in running the machine cause defects. There is no inspection from the machine operator, so if there is a problem or machine breakdown, the operator does not know.

3. Machines

The lower vibrating temperature causes the drying process not to run optimally. Hence, the product becomes moist due to the absence of regular maintenance. The electro motor often breakdown while the process is running. Likewise, because of the conveyor power outage, the lack of control of the motor technician at this time is only carried out once a day in the morning. While the motor runs for 24 hours, this results in the condition of the motor being unchecked in the afternoon and evening, whether there is overheating, fanbelt almost broke, ran out of lubricant, or others which could cause the motor to jam or power outage and the machine broken down.

4. Material

The soft material caused by the unbalanced liquid composition during the crystallization process makes the drying process take longer than normal, so the product is still moist.

5. Environment

The hot workspace makes the workers less comfortable running the machine, making them feel rushed.

Fishbone Diagram of "Mixed Size"

Figure 4 shows a fishbone diagram of the Msg production process with a "Mixed Size" type of defect. The root causes can be explained as follows:

1. Personal

The operator could make a mistake when choosing and installing the mess size on the machine. There was no appropriate work standard, and the operator only estimated the mess size. Operators rarely check product results if superiors are not on site. During the sifting process, many products are mixed in size due to a lack of checking, making the product defective.

2. Machines

A clogged Vibro screen could make the MSG sizes mixed, and product defect occurs. It can be caused when the installation is still in a less dry condition so that the hole in the screen so quickly gets stuck. Lack of checking when the screen is already installed in the machine, so they do not know if the screen is hollow.

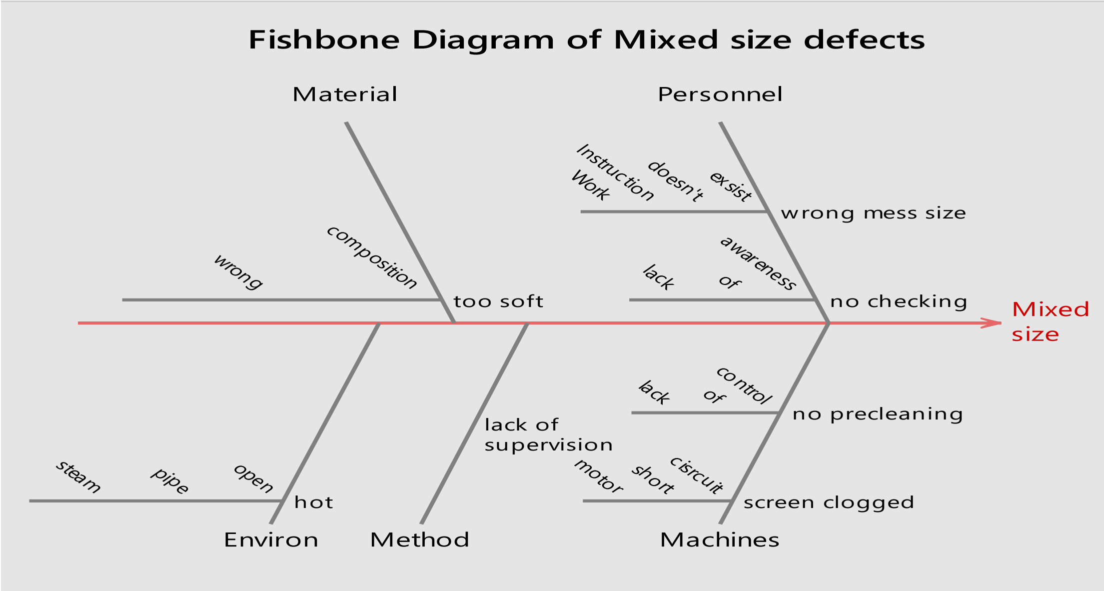

Figure 4. Defect of Mixed Size Cause and Effect Diagram

3. Method
   The method of supervision that is only brief at the beginning of the shift makes the performance of machines and employees less than optimal.
4. Material
   The soft material and the less than optimal drying process will also hamper the sifting process, resulting in the MSG's size not quickly separating according to its size.
5. Environment
   The stuffy work environment makes workers less optimal in maintaining the machine and often leaves the machine area.

Improve

This stage is an action plan to carry out quality improvement by providing proposed improvements based on the cause of the product defect problem. The following table 6 will explain the causal factors and proposed improvements that will be made:

Tabel 6. Factors causing defects and proposed improvements

Defects	Factor	Cause	Proposed Improvements
Dirty	Personal	incorrect machine operation procedure	create work instructions
	Machine	less machine cleanliness *screen* clogged	Create a hygiene checklist Create *a checklist cleaning screen*
	Material	soft material	more thorough control of liquid raw materials
	Metode	fewer surveillance methods	applying the operator method is the same as QC
	Envi.	hot temperature	closes open and leaking steam pipes
Humid	Personal	incorrect machine operation procedure lack of control	create work instructions make *checklist* control machine
	Machine	machine temperature drop conveyor power outage	control and more optimized machine maintenance
	Material	soft material	more thorough control of liquid raw materials
	Metode	fewer surveillance methods	applying the operator method is the same as QC
	Envi.	hot temperature	closes open and leaking steam pipes
Mixed Size	Personal	misplaced mess lack of machine control	create work instructions create *checklist* control machine
	Machine	*screen* clogged *hollow* screen	make *a checklist cleaning screen* change screen periodically
	Material	soft material	more thorough control of

Defects	Factor	Cause	Proposed Improvements
			liquid raw materials
	Metode	fewer surveillance methods	applying the operator method is the same as QC
	Envi.	hot temperature	closes open and leaking steam pipes

From table 6 above, it can be seen that the causes of defects from machine, human, material, method, and environmental factors can be used as a basis for a proposed improvement to improve quality which can be explained as follows:

In human factors, defects are caused by the absence of work procedures to operate the machine during production. This stage provides a proposal to make work instructions (WI) in each production machine so that the operator is more careful in operating the machine, as in the example of work instructions shown in the figure below.

Intruksi Kerja Pengoprasian Mesin *Counter Back*

Departemen : Produksi

Plant : *Refenarry*

Di buat : Mr XXX

Di laksanakan : Operator mesin *Conter Back*

Prosedur Pelaksanaan:

1. Nyalakan lebih dahulu mesin *vibrating* yang terdapat pada panel *counter back* dan pastikan motor *vibrating* hidup.
2. Buka *valve* steam yang terdapat di samping mesin *vibrating*.
3. Nyalakan mesin rotari yang terdapat pada panel *vibrating*.
4. Nyalakan mesin *conter back*,sebelum di hidupkan pastikan terlebih dahulu mess pada mesin tidak berlubang.
5. Nyalakan mesin *conveyor* atas dan bawah yang terdapat pada panel *conter back*.
6. Pastikan semua *conveyor* atas dan bawah sudah tertutup rapat.
7. Sebelum proses produksi berjalan pastikan suhu di *vibrating* mencapai 70-85 derajat celcius

Demikian intruksi kerja yang di buat, harap di laksanakan sepenuhnya.

Figure 5. Work Instruction for Machine Operator

With clear work instructions, employees in the production department will increase awareness of the importance of quality, which impacts the reduction of product defects, so that they feel responsible for the products they produce.

From the factors of the method applied, which is less thorough supervision, the refinery plant will be able to apply both the operator method and QC so that the operator can maintain product quality. From environmental factors, the room temperature is hot; it could be minimized by closing the open steam pipe or adding a blower. In terms of material, it is expected to be more thorough in checking the incoming material from the recovery plant before processing. Establish operational procedures standards (SOP) in the company.

Product defects caused by machine factors require corrective actions, namely by cleaning every beginning of the process and maintaining the cleanliness of the machine, controlling the machine during every production process at least once every 2 hours, and controlling the operating machine. In addition, the central workshop controller must set the machine regularly, consistently check it, and control the machine motor so there is no short circuit or burning. The importance of machine cleanliness directly impacts product quality; the operator should better maintain the cleanliness of the machine at the beginning of each production. To improve the cleanliness of the machine at this stage, it also proposes a checklist cleaning machine so that the machine is always routinely cleaned by the operator to minimize defects caused by machine cleanliness factors.

CONCLUSION

Factors affecting defects are more caused by machines that lack supervision in operation, machines that are less cleaned, and electro motors that often power outage in connection with less maintenance. The second is the human factor of lack of scrupulousness in machine operation and lack of control during the production process.

In order to minimize defective products that occur, it must be supervised real-time during the process and control them from the initial stage to the finished product. Describing clear work instructions or Standard Operating procedures of any critical production steps should help operators understand their responsibility. The study did not reach the "control" stage. This stage can be carried out in future research.

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