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Defect Type Analysis to Minimize the Occurrence of Product Defects in the Cast Iron Production Process

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***Abstract* - The metal casting industry cannot be separated from the occurrence of product defects. Because of this, the quality of the products produced will decrease and will cause the company's funds to be greater. Four types of defects occur in the product, including porous defects, cohesive defects, incomplete defects, and deformation defects. The purpose of this research is to find out the causes of the defects that occur and find out what prevention can be done to reduce the number of funds used but still produce quality products. The production data showed that the cohesive defects were the most common defects, then observations and analyses were carried out. From the results of the analysis, the causes of defects are divided into two factors, namely general factors such as human error and special factors such as errors that occur during the casting process. Prevention efforts that can be done are conducting job training, conducting performance appraisals, and increasing supervision of worker activities.**

Keywords: Metal casting, product quality, product defects, and human error.

I. INTRODUCTION

The development of industry in this modern era is very fast. This development must be accompanied by consumer demands regarding product quality. Companies that produce low-quality products will surely lose their market. This happens because the product cannot win the hearts of consumers. Resulting in low sales volume, so the company's profit decreases. In the market, usually, consumers will use products that provide satisfaction according to their needs. So maintaining consumer loyalty is mandatory if you want the product to existing in the market. For this reason, if the company wants its products to sell well in the market, it must maintain their quality. [1]

Quality is the overall characteristics and features of a product or service resulting from the ability of the product or service to partially or completely satisfy the needs of consumers. Consumers as product users are increasingly critical in choosing the products to be used, resulting in an increasingly important role of quality [2].

The production results achieved by each company are largely determined by the resources they have, including technological capital and labor. In the production process, the technology used (i.e machines) is combined and replaced each other with labor. Labor is a resource that drives other resources [3].

The objectives to be achieved in this study are to determine the causes of defects in the product and determine the improvements that must be made to minimize the number of product defects to reduce the amount of company spending.

II. MATERIAL AND RESEARCH METHOD

Material

Cast Iron is an iron-carbon alloy with a carbon content of more than 2%. Iron alloys with a carbon content of less than 2% are referred to as steels. The main alloying elements that make up the character of cast iron are carbon (C) between 3-3.5% and silicon (Si) between 1.8-2.4%. The difference in levels of C and Si causes the melting point of cast iron to be lower than that of steel, which is about 1150 to 1,200° C [4]. The alloying elements contained therein affect the color of the fracture; White cast iron contains elemental carbides while gray cast iron contains graphite flakes [5].

Ductile cast iron is known in the automotive industry as nodular cast iron [6]. This cast iron is cast iron that has been treated in a molten state to create graphite from carbon into spheroids or nodules under as-cast conditions [7]. Nodular cast iron contains small amounts of magnesium or rare earth metals such as cerium [8]. Nodular cast iron is the most easily welded cast iron of all existing cast-iron types. The lower the tensile strength, the easier it is to weld [9]. Nodular cast iron has the spherical shape of graphite. The addition of magnesium and cerium (Fe-Si-Mg alloy) when the cast iron is in a liquid state causes the graphite to become spherical (Nodularisation) [10]. Nodular cast iron has better strength, ductility, and toughness

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than gray cast iron, due to the spherical shape of the graphite, the lower the strain concentration [11-13].

III. RESULTS AND DISCUSSIONS

Types of Defects

4 types of defects occur in the product, more clearly in the following explanation.

Porous Defects

This type of porous defect is characterized by-products that are easily brittle, checked by hitting them with a hammer.

Figure 1: Example of Porous Defect

Incomplete Defects

Types of incomplete defects are defects that are characterized by the presence of incomplete parts of the product.

Figure 2: Example of Incomplete Defect

Cohesive Defects

Cohesive defects are product defects that have small holes both on the surface and on the inside of the product.

Figure 3: Example of Cohesive Defect

Deformation Defects

This type of tablet defect is seen with product characteristics that are not symmetrical or bent which does not match the expected results.

Figure 4: Example of Deformation Defect

Identification of Causes of Defects

There are 2 kinds of factors that cause defects in cast iron products, namely general factors and special factors. Here's the explanation.

General Factors

In general, five sub-factors are consisting of humans, machines, environment, methods, and materials, which can be seen more clearly in Table 1.

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Table 1: Causes and Corrective Actions on Common Factors

No	Factor	Cause	Effect	Correction
1	Human	Careless workers	The resulting product is not as it should be	Improve worker accuracy and focus more at work
		workers are less concentrated	The product is not as it should be and allows accidents to occur	Remind workers to concentrate more while working
		Lack of attention to instructions from the operations manager	Product error or machine failure may occur	Improve supervision and advise the workers
		Lack of experience	The product is not as it should be	Provide training and instructions to workers
		Not neat in making molds	The shape and size of the product are not what they should be	Improve worker accuracy
2	Machine	The machine is damaged	Machine performance is reduced or the machine cannot be used	Perform maintenance on production machines so that the machines are always in optimal condition
		There is dirt on the machine	Disturbing the uncomfortable working of machines and workers	Carry out regular machine cleaning
		Loose machine parts	Reduced engine performance	Perform periodic checks on production machines
		The machine used is less stable	Affect product results such as inappropriate size and shape	Checking the stability of the place where the machine is located
3	Environment	Dirty workplace	Workers are not comfortable	Cleaning the workplace after work
		Heat and smoke from the smelting process	Workers are not comfortable and breathing is disturbed	Added air ventilation and it is recommended that workers wear masks
4	Method	Not following the applicable Standard Operating Procedure (SOP)	An error occurred during production and in the resulting product	Supervise so that work is carried out according to SOPs
		Inappropriate casting technique	The product is not as it should be	Provide advice to workers and improve supervision
5	Material	An incorrect mix of raw materials	The product is not as it should be	Improve supervision in the selection of better raw materials
		Raw material mixed with dirt	The product is not as it should be	Sorting raw materials with dirt so they don't get mixed up when they are going to be used
		The moldings and is still rough	The surface of the resulting product is uneven and still rough	The sand is filtered before use

Special Factors

Prevention of special factors is carried out according to the types of defects found, namely porous, spruce, incomplete, and tablet. Here's the explanation. For types of porous defects can be seen in Table 2.

Table 2: Causes and Prevention of Porous Defects

Defect Shape	Cause	Prevention
• Fragile • Easy to break	1. Design of castings that do not take into account the freezing process, such as differences in the thickness of the walls of the castings that are not uniform 2. The mold expands, and the core resists the expansion of the casting. 3. The insufficient size of drain and riser.	- Uniform metal freezing process by using small amounts if necessary. - Liquid metal filling from multiple places. - The pouring time should be as short as possible. - Avoid castings that have sharp corners - Avoid sudden changes to the walls of the castings.

For types of porous defects can be seen in Table 3.

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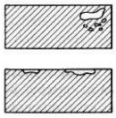
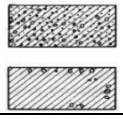
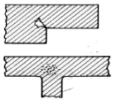
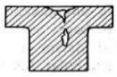
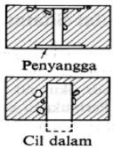
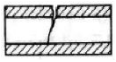
Table 3: Causes and Prevention of Cohesive Defects

Defect Shape	Cause	Prevention
• Air cavity  • Pinhole 	1. Oxidized molten metal 2. The drain and ladle are not dry enough 3. The pouring temperature is too low 4. Pouring is too slow 5. The mold is less dry 6. The permeability of molding sand is less than perfect 7. Too much is coming out of the mold 8. Insufficient vent 9. The pressure above is too low	- Efforts are made when melting the coke base so that the metal is not in the oxidation zone - The temperature of the metal casting before casting is ensured to be appropriate and the casting is fast - Careful mold making, good permeability, sufficient compaction, sufficient ventilation - Try to make the pressure above high
• Internal shrinkage  • External shrinkage  • Shrinkage cavity 	1. Oxidized molten metal 2. The pouring temperature is too low 3. The load material has a lot of dirt and rust 4. Planning and laying of the adder are not perfect 5. The booster height is too low 6. Mold swell 7. Sand molds from sharp corners 8. Too small casting radius 9. Difficult filling of the booster	- The temperature of the metal casting before pouring, ensure that it is appropriate and pouring quickly - Careful planning and laying of adders - Eliminates sharp corners in prints - Designing castings with radius - Careful planning of the channel system
• Small cavity because of cil 	1. Evaporation of oil ingredients 2. Rusty cil material 3. Surface condenses of cil	- Using cil ingredients that do not evaporate - Removes rust on cil materials - Ensure the surface of the cil is completely dry before pouring

For types of porous defects can be seen in Table 4.

Table 4: Causes and Prevention of Incomplete Defects

Defect Shape	Cause	Prevention
• Incomplete product section • Does not fill the entire mold 	1. Casting is too thin 2. The pouring temperature is too low 3. The pouring rate is too slow 4. The non-uniform flow of molten metal due to poor channel system 5. The vent on the mold is lacking 6. Imperfect addition system	- The pouring temperature must be high enough - The pouring speed must be high enough - Good channel system planning - The vent must be added - Improved the boost system

For types of porous defects can be seen in Table 5.

Table 5: Causes and Prevention of Deformation Defects

Defect Shape	Cause	Prevention
• Swell 	1. The compressive strength of sand is less 2. Compaction of molding sand is not uniform	- Increase the compressive strength of the molding sand - Compaction of molding sand is made uniform

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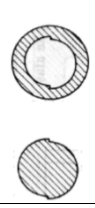
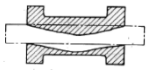
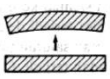
• Shift 	1. Shift the midpoint of the pattern 2. Shift pen and core box 3. Shift the midpoint of the mold 4. Shift after mold installation	- Careful and thorough at the time of making the mold - Careful and thorough at the time of core installation - Be careful when installing the coup and drag
• Core displacement 	1. Floating core 2. Core retainer is not strong	- Reinforced core palm - Using supports on core mounting
• Flexing 	Tension difference during cooling and shrinkage	Carefully calculate the shape of the casting

IV. CONCLUSION

Based on the results of the research that has been done, some conclusions can be drawn as follows:

1. The types of product defects that exist are porous defects (easily fragile products), cohesive defects (there are small holes both on the surface and on the inside of the product), incomplete defects (there are parts of the product that are incomplete), and deformation defects (asymmetrical or bent products that do not match the expected results).
2. The factors that cause defects in cast iron products are divided into two, namely general factors and special factors, where the general factors consist of humans, machines, environment, methods, and materials used, while special factors consist of the form and causes of the type the defects already discussed.
3. Corrective actions that can be given to the company to reduce the number of defects in the production process are conducting job training for workers who are still beginners, conducting performance appraisals, and supervising every worker's activity. Perform regular machine maintenance, inspect mold sand, and raw materials, and test specifications for raw materials.

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