Analysis of Human Reliability on Work Casting Operators Using Systematic Human Error Reduction and Prediction Approach (SHERPA)

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Abstract

Metal Casting XYZ is engaged in manufacturing souvenirs and household appliances from aluminum. The production process begins with smelting raw materials to make the finished product. Based on the initial observations of the process of making the frying pan, it was found that the reject product was 3-5%, while the tolerance limit for the reject product in the company was 2%. One of the causes of product rejection is human error which causes quality deviations and has an impact on the quality of the foundry products. The purpose of this study was to identify the causes of errors in the casting wok operator. This study uses the Systematic Human Error Reduction Prediction and Approach (SHERPA) to identify errors that occur by knowing the cause and suggesting improvement strategies. Fault identification is carried out based on Hierarchical Task Analysis (HTA) task analysis with an error taxonomy to identify credible errors related to the casting process activity. Based on the results of the study found that 37 tasks of work activities are divided into 4 sub-tasks with error identification found in 10 work tasks. The ordinal probabilities found were 5 tasks for high level, 3 tasks for medium level, and 2 tasks for low level. Suggestions for improvement given to minimize or reduce the occurrence of errors are in the form of making Standard Operating Procedures (SOP) equate work implementation guidelines and making checklist forms as checking tools for operators in checking and preparing tools and materials needed in the production process.

Keywords: Human error; HTA, SHERPA

1. Introduction

The XYZ metal casting factory is a small and medium business with activities including casting, smelting, making aluminum souvenirs and household appliances, such as a pan, pan, soblok, kendil, etc. 90% marketing has spread throughout Indonesia through The Wholesale Lotte Mart, and 10% of product marketing is carried out for exports to several Southeast Asian countries such as Malaysia, Thailand, and other countries. The company has two production factory units located in the Yogyakarta Umbulharjo area, the first factory unit is used as an aluminum smelting and casting unit, printing, and product selection and packing. While the second factory is used for finishing processes such as product thinking, turning and polishing.

The product manufacturing process begins with the fusion of raw materials into finished products. The number of employees owned by approximately 150 people working on 6 workstations. The casting workstation has approximately 32 workers divided into 4 people at the smelting workstation, 4 people at the pouring workstation, and 24 people at the printing work.

The casting process is the initial stage in the product formation process where all processes are still carried out manually, namely by using human power without using automatic machines. The main raw material used is the form of a mixture of 70 % aluminum stems and 30 % of other materials in the form of used aluminum collected from craftsmen such as used cans, used pans, motorcycle plates, and so on.

The production process carried out manually will be more frequent errors, which can be an error or error system caused by humans (human error). Error caused by the system is what occurs in the system that controls the process, and after the error is repaired, it does not repeat. While, human error (human error) is an inappropriate human decision or action that can potentially endanger the security or performance of a system. (Rahmania et al., 2013)

In the preparation phase of the production process, workers are required to make preparations correctly so that the production process can run smoothly and there are no errors when the production process begins. Workers at the Workstation Casting have a task consisting of several parts, namely the smelting workstation which has the task of removing raw materials, adjusting the temperature, and draining the stove, the workplace is assigned to filter the metal liquid and pour on each of that mold That is the one that is the one that is the one is the one that is the one that has been prepared, the station printing work is assigned to prepare a mold for the process pour a ready metal liquid.

Every worker has different abilities and skills so not all workers can work on the prin Based on the observations, several things occur that cause a decrease in the quality of metal casting results such as unstable combustion temperature because there is no fixed temperature regulator, causing the molds to be too soft or too hard, carelessness before pouring metal fluids so that there are still fragments of impurities in In molds, it is less thorough during the pouring process in the mold channel, causing metal fluid to spill outward and cause the product not to match the standard size, and when the process of processing the cooling water is often too much so that the temperature in the mold becomes too cold, this results in the results The printed products become holes.

Apart from this, when removing the printed product using tools in the form of hooks, the product often falls because it is not held properly, so the product becomes a dent, and the last is the incident during the process of taking the print, often late lifting or taking the product, causing results The mold becomes hard and sticks, in the end, the hail of the mold cannot be lifted.

For the finished product in the casting process, a printing result selection will be carried out where the product that has defects and cannot be repaired will be returned to the smelting process. If the product can still be corrected, it will continue in the next process, namely thinking and turning. Before entering the next stage of production, checks will be carried out one by one to find out the location and type of disability of each product. The percentage limit of rejected goods in the casting process determined by the company is 1% - 2%. Determination of the percentage is based on considerations made to reduce the rework cost and composition of the material mixture because it will affect the final quality of the products made.

The results of the measurement of product defects in 2022 in January an average of 33.087%, February averaged an average of 31.6%and March an average of 28.44%. So that the average product disability for 3 months is 31.044%, with the policy that the product has been repaired, but the disability is still visible, the product cannot be continued at the next stage. Product disability that cannot be tolerated affects quality so it must be returned to the smelting section for fusion.

The number of products repaired back in January averaged 3.875%, February 3.33%, and March an average of 3.6%. So that the average number of products returned in 3 months is 3.61%. Based on the percentage of product disability and the percentage of the repaired product shows that the company's quality targets cannot be achieved. It is necessary to identify the cause of product defects from the worker side because all the work carried out is still dependent on the worker's energy and skills.

The production process that is carried out manually will result in more frequent errors, which can be in the form of system errors or errors caused by humans (human error). Errors caused by the system are those that occur in the system that controls the process, and after being corrected the error does not recur. Meanwhile, human error is an inappropriate decision or human action that can potentially endanger the security or performance of a system (Rahmania et al., 2013)

XYZ Metal Casting is a small and medium business engaged in foundry, smelting, manufacturing of aluminum souvenirs and household appliances, such as pots, pans, solok, kendil, etc. The production process at the SP Aluminum UKM has reached 90% of the products spread throughout Indonesia through the Lotte Mart wholesale system, and 10% of other products are exported to several Southeast Asian countries such as Malaysia, Thailand, and other countries. UKM SP Aluminum has two production factories in the Umbulharjo area of Yogyakarta. One factory is used for aluminum smelting and casting processes, mold making, and product selection and packing. At the same time, the second factory is used for finishing processes such as product filing, turning, and polishing.

1.1 Objectives

The purpose of this study is to identify and analyze operator errors that cause quality deviations in the metal casting process and provide recommendations for appropriate improvements to reduce the occurrence of human errors that have an impact on quality deviations.

2. Literature Review

Production process activities in the industry that are carried out manually tend to experience errors often. Errors can be in the form of system errors or errors caused by humans (human error). Errors caused by the system are those that occur in the system that controls the process but after being corrected the error does not recur. Meanwhile, human error is an inappropriate human decision or action that can potentially endanger the security or performance of a system. (Rahmania et al., 2013)

Human error can be defined as human behavior that is not only caused by humans but can also be caused by design errors or work processes. Human error occurs due to inappropriate human behavior or decisions or can potentially reduce system effectiveness, safety or performance." (Sanders & McCormick, 1993). Human reliability and human error are two things that cannot be separated. Human Reliability is a person's probability of carrying out work according to the goals set. Human reliability is used to model human activities in their work" (Kirwan, 1994).

Domestic container loading and unloading companies experienced accidents from 2015 to 2016 as many as 44 incidents where the most accidents occurred in loading and unloading activities at 52.27% with 83.3% of these accidents caused by human error. The loss experienced by the company in terms of human error is quite large, both material and non-material losses. the results of the study that have been carried out have proven that for loading and unloading activities at full TL in hold there are 55 jobs with a total of 4 jobs having a "high" error probability. Improvement strategies or recommendation proposals in the form of administrative controls to reduce errors. (Basuki et al., 2017).

In the production of bricks, errors often occur in workers which results in the safety of their workers. Some mistakes often occur both from the side of workers, administration, and an unstable work environment. This causes the average brick produced to experience defects, which is around 5,000-15,000 pieces per month. Proposed improvements to critical activities that have the potential for human error to occur are to conduct thorough and routine checks on each process and provide training to workers on a regular basis. (Zetli et al., 2021).

Based on the point of view of the risk of work accidents, human error problems are carried out in stages to minimize work accidents, starting with identifying the initial problem, then making a hierarchical task analysis and the next step is determining the task, production error effects, assessed effects, human error probability, and human error reliability. Workers who do not focus on their work are more often the cause of the human error, so it is necessary to evaluate work and fulfill work safety facilities. (Al Ma'aarij, et al., 2021)

3. Methods

Main observation objects in all production process activities that have the potential to result in product disability or decreased product quality. All production poses will be identified in detail to facilitate the determination of the source of events that results in product quality disappearance. Observations are only made at one company location where the production process takes place.

This study uses the Systematic Human Error Reduction Prediction and Approach (SHERPA) method to identify the error of the process made by humans (human error) through the analysis of the task hierarchy in relation to the taxonomy of errors to identify credible errors related to human activity. The Sherpa method has a structured and comprehensive technique that can be easily taught and applied, substantially saves more time compared to the observation method, and can produce reliability values between acceptable appraisers (Hughes et al., 2015).

Sherpa is designed to help analyze manufacturing processes such as conventional and nuclear power plants, petrochemical processing, oil and gas extraction, and power distribution (Embrey, 1985). The Sherpa method can also be applied to oil and gas exploration companies can be found in Stanton and Wilson (2000). The procedure for applying the Sherpa method is carried out through several stages in sequence as follows: 1) Hierarchical Task Analysis (HTA); 2) Task classification; 3) Identification of human error; 4) consequences of analysis; 5) Ordinal probability analysis; 6) critical analysis; and 7) improvement analysis.

4. Data Collection

Based on the results of observations, a series of work operators was obtained in the process of making a pan. The series of work is arranged into a Hierarchical Task Analysis (HTA). HTA is a method for arranging the overall work steps into a decomposition diagram or HTA table to make it easier to identify the series of work to be analyzed. The description of the task in the casting area can be seen in Table 1.

Table 1. Assignment and Deskispsi Task

No. *Task*	Task description
1.1	*Set-up tools and materials*
1.1.1	Furnace preparation
1.1.1.1	Burner machine preparation
1.1.1.2	Prepare oil for the smelting process
1.1.1.3	Prepare aluminum raw materials
1.1.1.4	Prepare a supporting tool (dipper/shovel, filter)
1.1.1.5	*Setting the furnace temperature regulation for the smelting process*
1.1.2	Preparation of printing equipment
1.1.3	Preparation of the casting process (in this task can be done randomly and at the same time because the work is carried out with all operators)
1.1.3.1	Prepare cooling water
1.1.3.2	Prepare a place to lay the product
1.1.3.3	Prepare a tool supporting the casting process (hook, brush, scrap)
1.2	Skoking casting process (The pan casting process is carried out sequentially)
1.2.1	Press the top mold tool with body weight
1.2.2	The two sides of the mold
1.2.3	Tilt the mold
1.2.4	Penuangan cairan logam kedalam cetakan (proses penuangan cairan dilakukan secara berurutan)
1.2.4.1	Take a metal liquid using a shovel
1.2.4.2	Bring the liquid to the mold
1.2.4.3	Point the shovel to the mouth of the mold
1.2.4.4	Ensure that the metal liquid is clean from the fragments of other objects
1.2.4.5	Pour the liquid into the mold
1.2.5.5	Enforce the mold to its original position
1.3	Print results
1.3.1	Press the top mold tool with body weight
1.3.2	Open the lock on the side of the molding tool
1.3.3	Lift the top mold
1.3.3.1	Apply the top molding tool with cooling water using a brush
1.3.3.2	Put back the top mold to its original position
1.3.4	Cut the flow using scrap
1.3.5	Lift the mold using a hook
1.3.6	Place the printout to the finished product
1.4	Checking the printout (the process of checking the printout can be done if the Task 1.3 has been completed and the process is carried out in sequence)
1.4.1	Check product labels
1.4.2	Take a frying pan sample
1.4.3	Measure the weight of the pan
1.4.4	Note the overweight or thickness of the pan

Validation of decomposition or validation of the HTA table is done by conducting discussions with the head of the casting area, casting operator, and pouring operator. Validation is done by showing the results of the decomposition that has been made and checked the steps of work activities that have been made to adjust whether it is in accordance with the work activities that are in the same.

The research implementation using the Sherpa method was conducted by the Focus Group Discussion (FGD) approach. FGD is done to gather information and data that is done by interacting directly. Information or data obtained based on the results of the discussion conducted. The following are steps in the preparation of the Sherpa method outlined as follows:

1. Hierarchical Task Analysis (HTA)
   HTA is one method to describe a series of activities using an analysis task to describe work steps. The results of the HTA output will be input for the Sherpa method. Based on the task description table, then a decomposition diagram is made to see the sequence of the process of prostitution in detail from the set-up to testing product quality. Figure 1 shows the stages and description of the task in the metal recording process for the pan product.

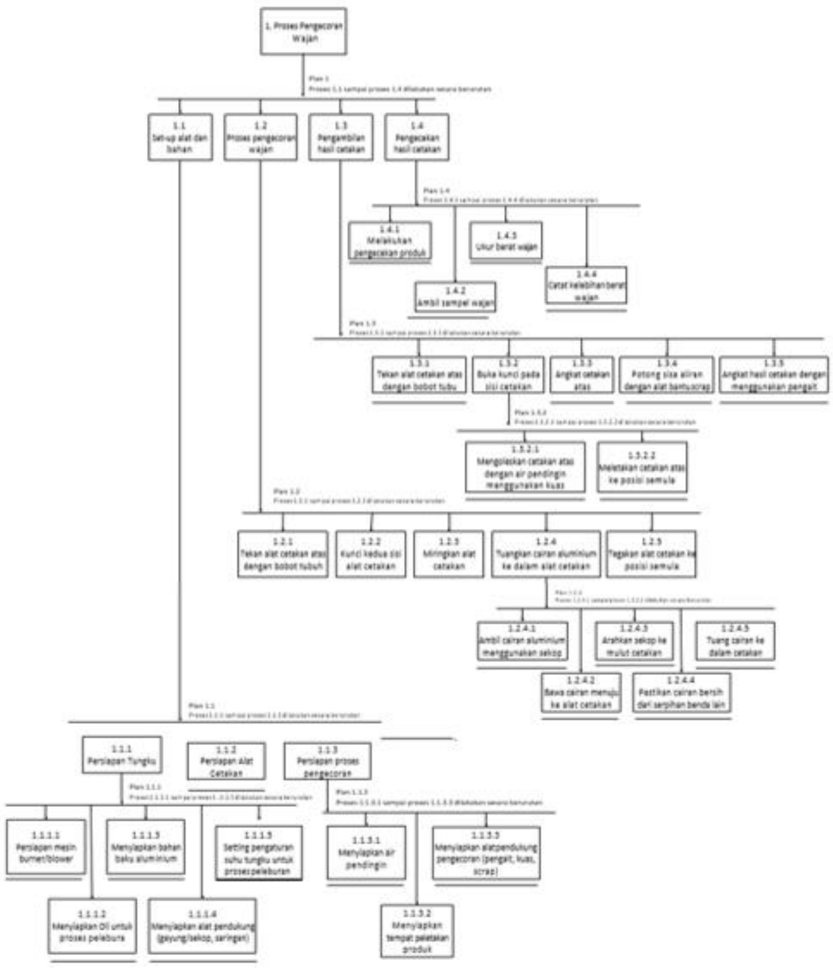

Figure 1. Hierarchical Task Analysis (HTA) The process of casting the pan

2. Job classification (task classification)
   Job classification is used to determine the categories of types of work carried out on each task. Job classification is carried out on a low-level task from the HTA table. There are 5 categories, namely action (action), checking (examination), retrieval (a receipt of information), communication (communication), and selection.

Based on the results of the discussion conducted with the head of the casting area and several operators determined several classifications of work in the skillet casting process. Table 2 shows the work classification in the process of casting the pan.

Table 2. Classification of Jobs in the Skill Casting Process

No. *Task*	Deskripsi *Task*	*Task Classification*
1.1.1.1	Blower/Burner Machine Preparation	Action
1.1.1.2	Prepare oil to prepare for the smelting process	Action, Checking
1.1.1.3	Prepare raw materials	Action
1.1.1.4	Prepare a supporting tool (dipper/shovel, filter)	Action
1.1.1.5	Setting the furnace temperature regulation for the smelting process	Action
1.1.2	Preparation of printing equipment	Action
1.1.3.1	Prepare cooling water	Action
1.1.3.2	Prepare a place to lay the product	Action
1.1.3.3	Prepare a casting support tool (hook, brush, scrap)	Action
1.2.1	Press the top mold with body weight	Action
1.2.2	The two sides of the mold	Action
1.2.3	Tilt the mold	Action
1.2.4.1	Take metal liquid using a shovel	Action
1.2.4.2	Bring a metal liquid to the mold	Action
1.2.4.3	Point the shovel to the mouth of the mold	Action
1.2.4.4	Ensure the liquid is clean from the fragments of other objects	Checking
1.2.4.5	Pour the liquid into the printing device	Action, Checking
1.2.5	Re -enforce the printing equipment	Action
1.3.1	Press the top mold tool with body weight	Action
1.3.2	Open the lock on the mold side	Action
1.3.3.1	Apply the top molding tool with cooling water using a brush	Action
1.3.3.2	Place the mold in its original position	Action
1.3.4	Cut the flow side using a scrap tool	Action
1.3.5	Lift the printout with	Action, Checking
1.3.6	using hooks	Action
1.4.1	Put the printout to the finished product	Action,Check ing
1.4.2	Check product labels	Selection
1.4.3	Take a frying pan sample	Action
1.4.4	Measure the weight of the pan	Retrieval

3. Human error identification
   The preparation stage of human error identification determines the type of error. Each task will be identified based on the type of error and mode in accordance with the category. Determination of errors is carried out with discussions that refer to the HTA table. The results of the discussion of determining error modes and error explanations that occur can be seen in Table 4.

Table 4. Identification of Human Error in the Panjan Casting Process

No *Task*	Work steps	*Mode Error*	Error explanation that might occur
1.1.1.5	Setting the furnace temperature regulation for the smelting process	A7	Operator error in the stove setting process for the smelting process
1.1.2	Preparation of printing equipment	C2	Lack of accuracy of the operator so that the mold is not clean or uneven

No *Task*	Work steps	*Mode Error*	Error explanation that might occur
1.2.4.3	Navigate the shovel to the mouth of the mold	A6	Pouring aluminum fluid that is not right in the mold channel hole
1.2.4.4	Make sure the liquid is clean from the fragments of other objects	C2	Foreign objects enter the mold because of the lack of accuracy of the operator
1.2.4.5	Pour the liquid into the mold	A2	The operator is too slow to pour the liquid into the mold
		C2	Excessive use of molding tools by operators
1.3.3.1	Apply the top mold with cooling water using a brush	A4	Operators do not do the processing of cooling water on the molding tool
		A4	equally
1.3.5	Lift the mold using a hook	A9	Operators do too much cooling water on the mold
		A2	Lack of accuracy of the operator so that the printout falls on the floor

4. Consequence analysis
   At the analysis stage, the consequences are identified by the error consequences that may occur in the task from the results of the error identification that has been carried out. In the preparation of the analysis, the consequences are carried out by considering the impact that occurs from the identification of errors. Table 5 shows the results of the consequence analysis of the pan-casting process.

Table 5. Analysis of Consequences in the Skill Casting Process

No *Task*	Work steps	*Mode Error*	Error explanation that might occur	Consequence
1.1.1.5	Setting the furnace temperature regulation for the smelting process	A7	Operator error in the stove setting process for the smelting process	Error settings or inappropriate
1.1.2	Preparation of printing equipment	C2	Lack of accuracy of the operator so that the mold is not clean or uneven	Print results do not match the specified standards because they have the same thickness
1.2.4.3	Navigate the shovel to the mouth of the mold	A6	Pouring aluminum fluid that is not right in the mold channel hole	Metal liquid that spills out of the mold and causes the product not according to the specified standards
1.2.4.4	Make sure the liquid is clean from the fragments of other objects	C2	Foreign objects enter the mold because of the lack of accuracy of the operator	The quality of the printed product does not meet the standard and will enter the product
1.2.4.5	Pour the liquid into	A2	The operator is too slow to	disabled

No *Task*	**Work steps**	***Mode Error***	**Error explanation that might occur**	**Consequence**
	the mold		pour the liquid into print	
		C2	Excessive use of molding tools by operators	Uneven liquid throughout the mold cavity
1.3.3.1	Apply the top mold with cooling water using a brush	A4	Operators do not do cooling water polishing on the molding equipment evenly	The printout of the bumpy or there is a thicker or thinner side
		A4	Operators do too much cooling water to the tool print	The results of printed products are still soft
1.3.5	Remove the printout	A9	Lack of accuracy of the operator so that the printout falls on the floor	The results of the product printed into holes because the temperature is too low
		A2	The operator takes too long to take the printout so that the product is stuck in the mold below	The results of the product printed into dents and must be leaned back

Information:

a. Task 1.1.1.5
Errors in the stove setting process for the smelting process can have an impact on the results of the metal liquid combined. Operators often make this error and wrongly adjust the temperature of the valve playback on the burner machine. This causes the temperature produced to be too hot and will have an impact on the metal liquid to be sought and will affect the mold. Conversely, if the resulting temperature is too low, the metal liquid does not melt perfectly.

b. Task 1.1.2
In the preparation of the molding tool, the operator does not carry out the inspection properly on the molding device before use so that there is a mold used is not clean or uneven which causes the results of the product that is printed will not to be the same thickness. This will have an impact on the quality of the product to be continued in the next process.

c. Task 1.2.4.3
In the process of pouring aluminum fluids that are not right in the mold channel hole, the operator poured the metal fluid that is not right in the mold channel hole so that it causes metals that do not enter as a whole in the mold and will flow to the side of the mold. The results of the mold do not match the printing equipment and also the liquid will spill on the floor.

d. Task 1.2.4.4
Foreign objects entering the mold can occur because the operator does not filter the dirt first, causing dirt into the mold and hardening the results of the printed product. This causes the results of the mold to become rough or arise lumpily and there are dirty spots on print products.

e. Task 1.2.4.5
Genesis 1 is too slow in pouring metal liquid into the mold. In this process, the operator does not pour metal fluids quickly so it has an impact on the print. The metal liquid that is poured does not spread evenly so the product produced will be covered or not formed perfectly.

In the incidence of 2 molds into cracks, this can occur because operators who do not use printing equipment to the maximum where the molding device has been used for too long so that the mold durability decreases. Crack molds are characterized by cracks on the surface of the mold so that when the mold is flowed by metal liquid will produce uneven and prominent products.

f. Task 1.3.3.1
In the process of applying the cooling water operator does not do it evenly, resulting in the production of printed product will be soft because the temperature in the top mold is still high, requires time to harden and if it is immediately lifted will give a trace on the product side. Vice versa, the operator also sometimes the cooling water that is too much and makes the temperature in the mold down and resulting in the results of printed product will be hollow.

g. Task 1.3.5
In event 1 the printout falling on this floor occurs because when the process of taking the printout operator does not hold the hook properly or is released from the hand so that the mold falls and hits the floor. Products that have not hardened perfectly will change shape to dent so they must be returned to the smelting process to be merged again.

h. In event 2, it has been long to take the printed product so that the mold will be stuck in the lower printing device. This is related to printing tools and metal liquids. Where when there is a cracked mold device it will cause the flow of metal fluid that enters will become uneven and metal fluids decrease in temperature so that it sticks to the lower mold and is difficult to take.

5. Ordinal probability analysis
At the ordinal probability, the analysis stage is done by determining the scale of error that still occurs. Error assessments are carried out based on low (low), medium, and high (high) scale (high) scales in the work analyzed. If during the production process there is no error found in the probability of the error, and if during the production process there is an error incident some time ago and the event occurs in a low frequency, the probability of the error is moderate (medium), and the Error probability is said to be high (high) if during the production process the incidence of errors was found some time ago and events occur in high frequencies and can cause losses. Table 4.5 shows the results of the ordinal probability that occurs. Metal liquid decreases in temperature so that it sticks to the lower mold and is difficult to take.

6. Results and Discussion

Analysis of data processing results are:

a. Analysis of Hierarchical Task Analysis (HTA)
Based on data processing, 37 work activities were found by the casting operator which were divided into 4 sub-tasks, namely the set of tools and materials, the process of casting the pan, taking the printout, and checking the printout. Each subtask is then divided into several sub-tasks until the task stops at the lowest process. The output generated from the HTA table is the sequence of the work activity task into the work subtask to provide an overview of the sequence of work steps carried out by the pan's casting operator.

b. Systematic Human Error Reduction Prediction and Approach (Sherpa) Systematic Analysis
Based on the data processor conducted, the determination of the classification of work activities carried out by the casting operator is presented in the form of a job classification diagram as referred to in Figure 2.

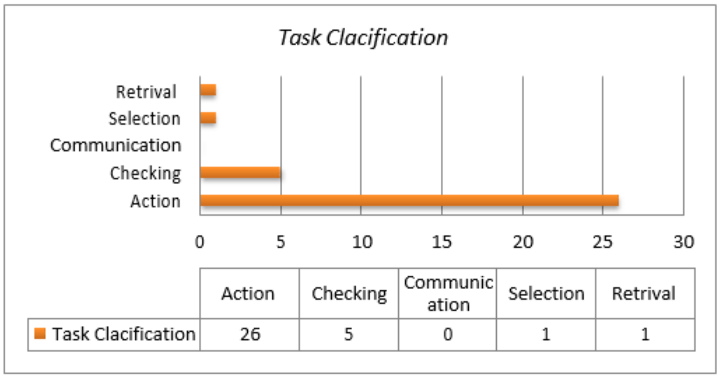

Figure 2. Task Classification Level

From the results of the classification of work that has been done, a more detailed identification will be carried out to determine the possibility of errors in the task based on the error mode.

c. Error Action Mode
In the job classification, the action is divided into 10 error modes which are shown in Figure 3.

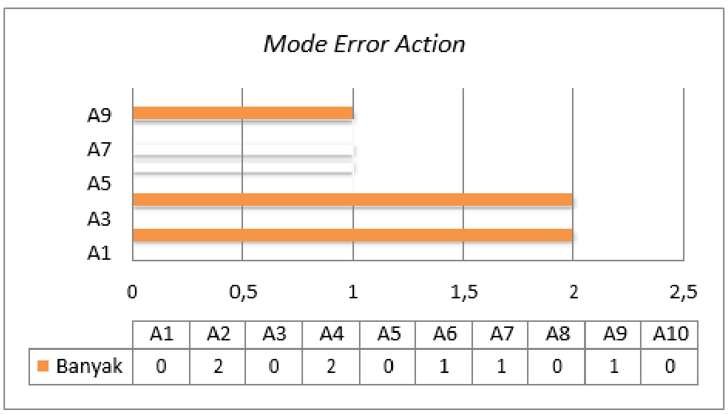

Figure 3. Mode Error Action

In the action job classification, there are 4 types of error modes that may occur, namely 2 tasks with incorrect operation error mode (A2), 2 tasks with too few or too many operating error modes (A4), 1 task with operating error mode that corrects on the wrong object (A6), and as many as 1 tasks with error mode operation not completed (A9). A description of the error action mode can be seen in Table 6.

Table 6. *Mode Error Action*

No Task	*Mode Error*	Explanation of Possible Errors
1.1.1.5	A7	Palmar operator in the process of setting
1.2.4.3	A6	Furnace for the melting process
1.2.4.5	A2	The operator is too slow to pour liquid into the mold
1.3.3.1	A4	The operator does not apply water
	A4	cooling of concrete tools evenly
1.3.5	A9	Operators apply too much cooling water to the mold
	A2	The operator is not careful enough so that the prints fall on the floor.

d. Proposed Improvements
The last stage in to propose improvement strategies to reduce errors. The strategy is given as suggestions or suggested improvements to the work system that can prevent error reduction or at least reduce its consequences.

Table 7. Proposed Improvements

No *Task*	Job Step	*Mode Error*	Explanation of possible errors	Proposed Improvements
1.1.1.5	Setting the furnace temperature setting for the smelting process.	A7	Operator error in setting the furnace for the smelting process	*Checklist Form (Checking tool for operators in preparing tools for the production process*
1.1.2	Printing equipment preparation	C2	Lack of operator accuracy so that the mold is not clean or uneven	
1.2.4.4	Make sure the liquid is clean of debris.	C2	Foreign objects enter the mold due to a lack of accuracy from the operator.	
1.2.4.5	other things	C2	Excessive use of molding tools by operators	
1.2.4.3	Pour the liquid into the mold.	A6	Improper pouring of aluminum liquid in the mold channel hole	Making standard operating procedures (SOP) for the foundry area (to reduce the error rate and operator negligence in working and clarify the duties of each operator)
1.2.4.5	Pour the liquid into the mold	A2	The operator is too slow to pour liquid into the mold.	
1.3.3.1	Applying the top mold with cooling water using a brush	A4	The operator does not apply cooling water to the mold tool evenly.	
		A4	Operators apply too much cooling water to the mold.	
1.3.5	Lift the printout using the hook tool	A9	The printout fell on the floor	
		A2	The operator takes too long to take the printout so that the product gets stuck in the bottom print	

7. Conclusion

Based on the results of data processing and analysis that have been done, conclusions can be drawn:

1. Found 37 work activity tasks with 4 sub-tasks, namely setting tools and materials, casting pans, taking molds, and checking printouts. Based on the identification of errors made, it was found that 10 work tasks that allow errors to occur with error modes that affect quality are action and checking. The ordinal probabilities found were 5 tasks for high level, 3 tasks for medium level, and 2 tasks for low level.
2. The proposed improvement given to the company to minimize or reduce the occurrence of errors is in the form of making a Standard Operating Procedure (SOP) for the foundry area as a guideline to facilitate the implementation of work carried out by operators and making a checklist form as a checking tool for operators in checking and preparing tools. and materials needed in the production process

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