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Human Error Analysis on Steelmaking Process to Reduce Product Defect Rate at PT. RAVANA JAYA Using Sherpa and Heart Methods

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ABSTRACT

PT Ravana Jaya is a general contractor that works on steel fabrication and has several partners from small, medium, and large scale companies. Observations show that errors often occur during the production process, leading to a number of defective products with a defect percentage of 0.12%. The allowable defect percentage ranges between 0.05% and 0.07%, or approximately 1-2 items per month. Therefore, research should be conducted to look at the human errors that cause defective products during the production process. This study utilized the Human Error Assessment and Reduction Technique (HEART) and Systematic Error Reduction and Prediction (SHERPA) methods. According to this study, the highest predicted human error occurred in the welding task with a HEP value of 10.565, and the lowest human error occurred in the welding task with a HEP value of 10.565. To reduce the number of defective products, it is recommended to make improvements, such as conducting strict and regular evaluation and supervision, continuous training, adding dividers between parts, and changes in design.

INTRODUCTION

Companies must produce the best quality products because the industrial world is currently developing rapidly, and competition in local and international markets continues to increase (Yaqin, 2024). Companies that can produce their products well will continue to exist in the modern industrial world (Alatas, 2017). Humans play an important role in everything, including the world of work. While humans are smart, flexible and able to learn over time, they are still prone to making mistakes (Al Ma'aarij, 2022). Repetitive work errors can cause the system to not function properly due to the repetitive nature of human work. Human error is one of the many work errors caused by humans (Zetli, 2021). Human error can come from actions or behaviors that can reduce the effectiveness, safety, and performance of a system. Human error is not only caused by humans, but can also come from errors in design and work procedures (Utama, 2021). Frequent human errors in production activities can interfere with a company's efforts to achieve higher levels of effectiveness. This error rate should be minimized by providing improvements to employees (Alfano, 2021).

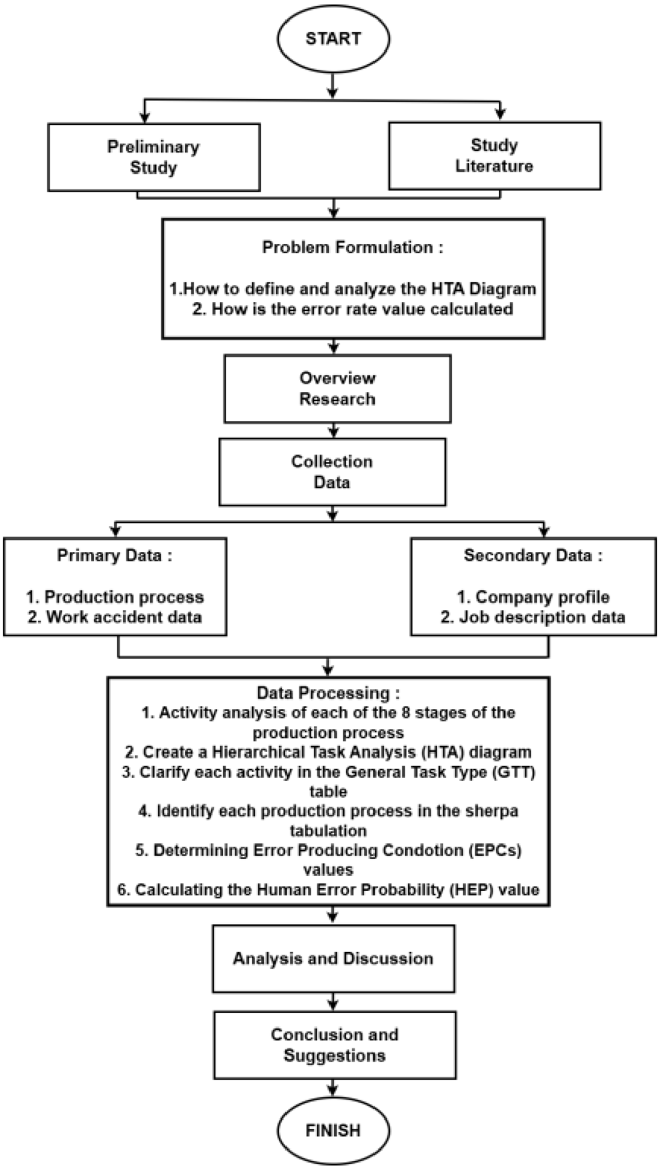
PT Ravana Jaya is a company engaged in steel fabrication construction, general contractor by implementing an outsourcing system that has several partners from small, medium and large scale companies. which has 8 stages of the process, starting from marking, cutting, grinding, drilling, assembling, welding, sandblasting, and painting this company was founded in 2008, led by Mr. H. Musthofa, S.T.. In the iron production process through several processes, including Marking, Cutting, Grinding, Drilling, Assembling, Welding, Sandblasting, and Painting processes. The problem found by the author is that in the steel production process most of them are still done manually and the distance from process 1 to other processes is too close together so that during the production process the focus on work is disturbed by noise which causes human error which has an impact on products becoming defective and in all processes experiencing several potential defects such as: Cutting (the results of the pieces are not suitable), Grinding (uneven surface results), Drilling (hole diameter does not match), Werlding (hollow welding results), Painting (uneven paint results).

Based on the results of the description above, it is known that the cause of the defect factor in each steelmaking process is an error caused by operator error (human error). According to Mr. Sutrisno as Site Manager of PT Rafana Jaya, this is certainly very detrimental to the company considering that the company also has a production target which is also part of the target client request. One of the theoretical and empirical approaches used to determine the causes of errors and how to calculate the value of the error rate in each process and provide improvement solutions from the largest error rate value is the Human Error Assessment And Reduction Technique (HEART) method and Systematic Human Error Reduction And Prediction (SHERPA). (Rizky, 2022). This study aims to find human errors that can occur during the production process of steel making, determine the value of the probability of human error in the steel production process, and provide suggestions for reducing human errors in production operators, it is hoped that the results will improve product quality and reduce costs (A'yun Hafisyah Wafi, 2020).

RESEARCH METHODS

Research Scenario

The initial step in this research process is data collection related to the error rate, in collecting data for the number of respondents itself refers to the number of production processes, namely eight people. In filling out the questionnaire, each section fills in the value of the error rate in its own section by referring to the standard table of general provisions of the hearth method and the sherpa method, after all the data has been collected, the data is processed in accordance with the sequence as shown in the flow chart below.



Picture 1 Research Process Flowchart

Sherpa Method

Systematic Human Error Reduction and Prediction (SHERPA) is a method used to evaluate human errors that occur using task-level hierarchical inputs (Kusumantoro, 2017). These tasks will be thoroughly evaluated first, and then, from each basic level level, the prediction of human errors that may occur (Rohmadhon, 2023). The SHERPA method is used to make the answers of the HEART method better and to find solutions to existing problems (Rammadaniya, 2022). The steps taken to implement the SHERPA method are as follows:

1) Apply the analysis to the task to be investigated.
2) Identify potentially major errors from each basic level of the task.
3) Identify the consequences of the error and the next task that can be anticipated if an error occurs. If the error is considered critical (resulting in unacceptable loss), a note will be made and the criticism will be written in binary form. If the error causes product damage, it will be indicated with a critical asterisk (!). If the error does not cause the product to be damaged, it will be indicated with a dash (-). If the error has never occurred before, the probability is low (0). If it has occurred before, the probability is medium (more than 0 to 0.49), and if the error occurs frequently, the probability is high (0.5 to 1) (Irawan, 2024).
4) Enter the error into the SHERPA table.

Hearth Method

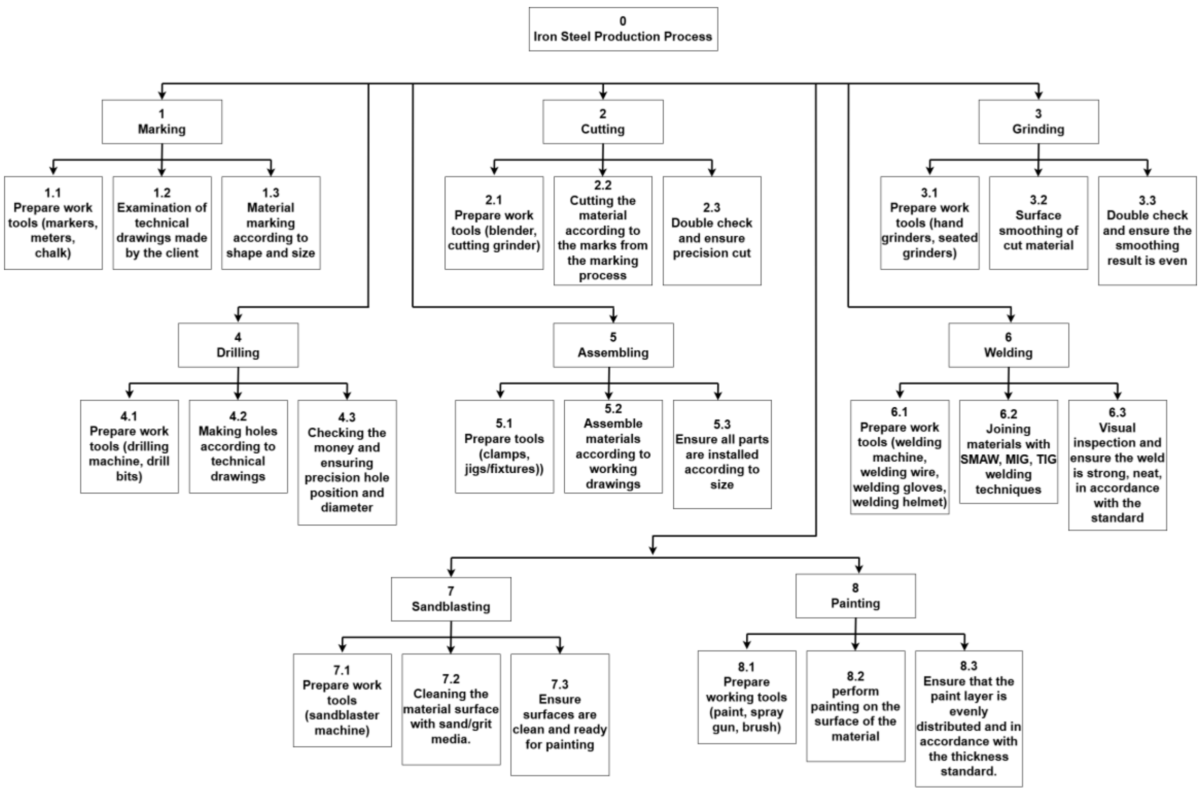
The purpose of the HEART quantification method is to assess the likelihood of human error by translating it into generic categories and error conditions that cause errors (EPCs) (Rosyidah, 2023). Leaving aside smaller factors, HEART can be used to look at the main factors that cause errors (Julianto, 2021). To find out the possibility of human error, the data is processed using the HEART method. The steps to identify human error with HEART are as follows:

1) Analyzing tasks using HTA.
2) Identify the set of tasks for the operators and indicate what tasks they need to complete.
3) Determine the GTT for the types of work commonly performed by steel operators based on the degree of likelihood of sub-work causing human error.
4) Determining the EPC and its value and identifying the determinants that cause faults in the analyzed sub-jobs. making maximum predictions about the unreliability of steel operators, which can change from good conditions to bad conditions (Sihaloho, 2023).
5) Determine the APOA value to calculate the assumption of the proportion of errors affecting the EPC to the HEP of the steel operator selected by the expert between 0 and 1 (Riset, 2024).
6) Calculating the evaluated effect to calculate the probability value determined during the distribution of questionnaires filled out by each division of the production department. To determine the assessed effect (AE) of the EPC (Conditions that cause errors), the probability value is calculated (Istiqomah, 2021).
$$EPCS^{n} = (EPCs - 1) \times PoA + 1) \quad (1)$$
7) Calculating HEP is used to calculate the probability of human error for each task.
$$HEP = GC \times EPCs^{1} \times EPCs^{2} \times EPCs^{3} \times EPCs^{4} \times \ldots dst \quad (2)$$

RESULTS AND DISCUSSION

Human Task Analysis (HTA)

One of the most popular methods for analyzing complex tasks is hierarchical task analysis (HTA). HTA is a formal method that describes and analyzes human interactions with systems, consisting of physical activities performed to achieve system goals (Cahyani, 2022). HTA is easy to use, detailed, and to the point, hierarchical task analysis is done to determine the work process of each work station into operations or actions, this is depicted visually through a structure chart (Zaelani, 2024). HTA in the steelmaking process there are 8 tasks and each task has 3 subtasks, which is a total of 8 tasks and 24 sub-tasks.



Picture 2 HTA Diagram of Steelmaking Process
Source: Job Description of Production Operator PT. Ravana Jaya

Classification of Operator Tasks in the GTTs Table (General Task Type)

From the results of the HTA diagram above, it is then classified in the form of a GTTs table as shown in the table below which later for Sub Tasks with categories that are not critical or can be called there is no potential for error, the Sub Task will not be continued to the Sherpa tabulation and calculation of the Human Error Probability (HEP) value.

Table 1 Table GTTs of Steelmaking Process

No	Task	Subtask	Task Category	Description
1	Marking	1.1Preparation of working tools (permanent marker, chalk, meter, and steel ruler)	-	Not included in critical activities
		1.2 Checking technical drawings	G	Familiar, known and well-designed tasks
	-	1.3 Material marking according to size and shape	E	Ordinary, skilled work does not require high skills.
2	Cutting -	2.1 Preparation of working tools (blender, cutting grinder)	-	Not included in critical activities
		2.2 Cutting the material according to the marks from the marking process	C	The work is complex and requires excellent skills and understanding
		2.3 Re-check and ensure cuttings are within specifications	E	Ordinary, skilled work does not require high skills
3	Grinding	3.1 Preparation of work tools (hand grinders, sitting grinders)	-	Not included in critical activities
		3.2 Surface smoothing of the cut material	G	Familiar and recognizable, well-designed, tasks are the usual ones
		3.3 Re-check and make sure the surface is smooth and flat	E	Ordinary, skilled work does not require high skills
4	Drilling	4.1 Preparation of working tools	-	Not included in critical

		(drilling machine, drill bit)		activities
		4.2 Making holes in materials according to technical drawings	G	Familiar, familiar and well-designed tasks
		4.3 Re-check and ensure precision hole diameter position	D	This job is rather easy, done quickly, and requires little attention
5	Assembling	5.1 Tool preparation (clamps, jigs/fixtures)	-	Not included in critical activities
		5.2 Assembly of components according to working drawings	G	Familiar, familiar and well-designed tasks
		5.3 Ensure all parts are installed in the correct order and size	D	This job is rather easy, done quickly, and requires little attention
6	Welding	6.1 Preparation of work tools (welding machine, welding wire, welding helmet)	-	Not included in critical activities
		6.2 Joining materials with SWAW, MIG, TIG welding techniques	C	The work is complex and requires excellent skills and understanding
		6.3 Re-check and ensure that the weld result is not hollow, neat according to the standard	C	The work is complex and requires excellent skills and understanding
7	Sandblasting	7.1 Setup of working tools (sandblaster machine)	-	Not included in critical activities
		7.2 Cleaning the surface of the material using sand/grit media	G	Familiar, familiar and well-designed tasks
		7.3 Ensuring the surface is clean and ready for the painting process	E	Ordinary, skilled work does not require high skills
8	Painting	8.1 Penyiapan alat kerja (cat, spray gun, kuas)	-	Not included in critical activities
		8.2 Painting the surface of the material to protect against corrosion	G	Familiar, familiar and well-designed tasks
		8.3 Ensure that the paint layer is evenly distributed and in accordance with the thickness standard	D	This job is rather easy, done quickly, and requires little attention

Source: PT. Ravana Jaya Production Operator Questionnaire Data Processing

Sherpa Tabulation

After determining the general task type table processed from the results of the next HTA diagram, namely tabulating / describing each operator activity as an implementation of the Sherpa method, where each operator activity is investigated for the cause of the error and given an improvement solution.

Table 2 Sherpa Tabulation Recapitulation

Sub Task	Error Mode Code	Explanation of Possible Errors	Due to	Probability Error	Solution Breeding
1.2	C2	The operator checks the work drawing less carefully and the operator takes too long to check	May result in process failure at a later stage and may reduce production time	0,1368 Medium	Conducted guidance socialization and need more checking supervision by the Leader before production starts
1.3	A3	Operators do not understand the working drawings so that they are negligent when marking the	Can result in the size of the material marking results not in accordance with	0,1477 Medium	Regular and continuous training and training are conducted for operators

		material, the size of the material and the working drawings do not match	the technical drawings		
2.2	A1	Operators are less focused during cutting so that the cut results are poor and feel disturbed by noise.	The result of the cut becomes defective and fails to process at the next stage and can disrupt the production process	8,4054 High	Redesigned the production layout and improved the production environment for employee comfort
2.3	C1	Operators check the cut results less carefully and make decisions too quickly	Can result in rejected pieces and have an impact on the failure of the process at the next stage	0,14 Medium	Conducted guidance socialization and need more checking supervision by the Leader when production starts.
3.2	A8	Operators operating the grinder are less careful and hesitant about the grinding settings and the operator is not strong enough to withstand the vibration of the grinder	Can result in uneven smoothing results and have an impact on process failure at the next stage	0,1727 Medium	Regular and continuous training and training are conducted for operators
3.3	C2	Operators are less thorough in re-checking and hasty in making decisions	May result in process failure at a later stage and reduce production time	0,18 Medium	Conducted guidance socialization and need more checking supervision by the Leader when production starts
4.2	A1	Operators lack focus during punching so that the results of the hole diameter are bad	Can result in diameter holes that cannot be utilized optimally and disrupt the production process	0,2096 Medium	Regular and continuous training and training are conducted for operators
4.3	C2	Operators are less careful in re-checking and in a hurry in making decisions	May result in process failure at a later stage and may reduce production time	0,117 Medium	Conducted guidance socialization and need more checking supervision by the Leader when production starts
5.2	A5	Operators are too hasty in assembling and less precise in assembling other parts	May result in components not being installed properly and disrupt the production process	0,0233 Low	Regular and continuous training and training are conducted for operators
5.3	C1	Operators are less thorough in re-checking and hasty in making decisions	May result in process failure at a later stage and may reduce	0,6156 Medium	Conducted guidance socialization and need more checking supervision by the

			production time		Leader when production starts
6.2	A1	Operators are less skilled in the welding process and do not know about the correct welding techniques	May result in perforated welds resulting in process failure at the next stage	10,565 High	Regular and continuous training and training are conducted for operators
6.3	C3	Operators check the cut results less carefully and make decisions too quickly	May result in components not being installed properly and disrupt the production process.	0,829 Medium	Regular and continuous training and training are conducted for operators
7.2	A2	Operators are less skilled in the cleaning process and do not know about the correct cleaning techniques	May result in unclean material surfaces	0,0039 Low	Conducted guidance socialization and need more checking supervision by the Leader when production starts
7.3	C3	Operators rushed through the inspection and were not decisive in their decision-making	May result in process failure at a later stage and may reduce production time	0,0942 Medium	Conducted guidance socialization and need more checking supervision by the Leader when production starts
8.2	A1	Operators are less skilled in the painting process and do not know about the correct painting techniques	May result in bubbly paint and different color contrast	0,032 Medium	Regular and continuous training and training are conducted for operators
8.3	C1	Operators rushed through the inspection and were not decisive in their decision-making	May result in final product rejects and disrupt the storage of goods in the warehouse	0,684 Medium	Conducted guidance socialization and need more checking supervision by the Leader when production starts

Source: Sherpa Method Data Processing

Calculation of Error producing Condition (EPC), Assessed Proportion of Effect (ApoA), Human Error Probability (HEP)

The Error-Producing Circumstances (EPC) value is calculated based on the factors that determine the cause of some errors or mistakes that occur on the job. In addition, the Proportion of Effect (POE) value is obtained from interviews with individuals who are considered to understand and be proficient in the steelmaking process. The Error Producing Condition (EPC) value and the Proportion of Effect (POE) value each indicate the Assessed Proportion of Effect (APOE) value. A higher APOE value indicates that there is an increased likelihood of an error occurring. Thus, a higher APOE value indicates that there is an increase in error density.

Table 3 EPCs, APOa and HEP Calculations

Task	**Steelmaking Operator of PT. Ravana Jaya**							
Subtask	**Value of GTTs**	**EPCs and APoA values**						**HEP**
1.2 Checking technical drawings	G (0,0004)	EPCs	No. EPCs	2	6	16		0,137
			No. EPCs	11	8	3		
		APoA		0,4	0,4	0,4		
1.3 Material marking according to size and shape	E (0,02)	EPCs	No. EPCs	6	16	32		0,148
			No. EPCs	8	3	1,2		
		APoA	0,4	0,4	0,4	0,4		
2.2 Cutting the material according to the marks from the marking process	C (0,16)	EPCs	No. EPCs	2	14	23	32	8,405
			No. EPCs	11	4	1,6	1,2	
		APoA	0,4	0,8	0,8	0,8	0,8	
2.3 Re-check and ensure cuttings are within specifications	E (0,02)	EPCs	No. EPCs	2	19			0,14
			No. EPCs	11	2			
		APoA	0,4	0,4	0,4	0,4		
3.2 Surface smoothing of the cut material	G (0,0004)	EPCs	No. EPCs	15	23	33		0,173
			No. EPCs	3	1,6	1,15		
		APoA	0,4	0,8	0,8	0,8	0,8	
3.3 Re-check and make sure the surface is smooth and flat	E (0,02)	EPCs	No. EPCs	2	17			0,18
			No. EPCs	11	3			
		APoA	0,4	0,4	0,4			
4.2 Making holes in materials according to technical drawings	G (0,0004)	EPCs	No. EPCs	15	20	33		0,21
			No. EPCs	3	2	1,15		
		APoA	0,4	0,8	0,8	0,8		
4.3 Re-check and ensure precision hole diameter position	D (0,09)	EPCs	No. EPCs	2	5			0,117
			No. EPCs	11	8			
		APoA	0,4	0,4	0,4			
5.2 Assembly of components according to working drawings	G (0,0004)	EPCs	No. EPCs	6	14	16		0,023
			No. EPCs	8	4	3		
		APoA	0,4	6	14	16		
5.3 Ensure all parts are installed in the correct order and size	D (0,09)	EPCs	No. EPCs	5	16			0,616
			No. EPCs	8	3			
		APoA	0,4	0,4	0,4			
6.2 Joining materials with SWAW, MIG, TIG welding techniques	C (0,16)	EPCs	No. EPCs	6	15	16	23	10,57
			No. EPCs	8	3	3	1,6	
		APoA	0,4	0,8	0,8	0,8	0,8	

6.3 Re-check and ensure that the weld result is not hollow, neat according to the standard	C (0,16)	EPCs	No. EPCs	16	17	18	0,829
			No. EPCs	3	3	2,5	
		APoA	0,4	0,4	0,4	0,4	
7.2 Cleaning the surface of the material using sand/grit media	G (0,0004)	EPCs	No. EPCs	6	23		0,004
			No. EPCs	8	1,6		
		APoA	0,4	0,8	0,8		
7.3 Ensuring the surface is clean and ready for the painting process	E (0,02)	EPCs	No. EPCs	5	24		0,094
			No. EPCs	8	1,6		
		APoA	0,4	0,4	0,4		
8.2 Painting the surface of the material to protect against corrosion	G (0,0004)	EPCs	No. EPCs	3	6	24	0,032
			No. EPCs	10	8	1,6	
		APoA	0,4	0,8	0,8	0,8	
8.3 Ensure that the paint layer is evenly distributed and in accordance with the thickness standard	D (0,09)	EPCs	No. EPCs	5	18		0,684
			No. EPCs	8	2,5		
		APoA	0,4	0,4	0,4		

Source: PT. Ravana Jaya Production Operator Questionnaire Data Processing

Comparison Results with Previous Research

In the process of preparing the above research, it refers to several sources of reference both from articles, final assignments and others. Author Itang Manthofani years 2021 sourced from the final project report of Sutan Agung Islamic University with the title analysis of human error in the manufacture of guadrail part beam coil cutting parts at PT. Tosan Mash with sherpa and hearh methods for proposed improvements in the form of a coil cutting table design where the highest human error value is obtained from the process of operating the roll machine so that the most appropriate proposal to reduce the level of disability by making the coil cutting track in the form of a conveyor track. Author Sri Zelti years 2021 sourced from the Journal of Intech Teknik Inudustri Serang raya Vol 7 No 2 with the title of human error analysis with the approach of the sherpa and hearth methods in the production of UKM yasin bricks from three brick making processes, the results of the highest human error value in the brick laying process with proposed improvements in the form of tightening checks during the process and conducting regular training.

From the explanation of previous research comparisons, there are some differences, especially in the proposed improvements where each proposed improvement refers to how many kinds of processes are calculated related to the value of human error, the more complex the research, the more diverse the proposed improvements. For the results of the above research covering 8 steelmaking processes which to determine the level of error value is much more complex by calculating the value of each process and after that making improvement proposals for the highest error rate value in the form of regular training, socialization of guidance with tightened supervision, and changes in production layout for comfort at work.

CONCLUSIONS

In the process of making steel at PT Ravana Jaya through 8 processes, namely (marking, cutting, grinding, drilling, assembling, welding, sandblasting and painting) the process that has the highest probability and has the potential to cause defective products is 6.2 Material connection with SWAW, MIG, TIG welding techniques which have a HEP (Human Error Probabiloty) value of 10.565 (High), and for the lowest probability process that causes potential defective products, namely 7.2 Cleaning the surface of the material using sand / grit media of 0.0039 (Low). The impact of this research is to find out the root cause of problems due to product defects during the production process by further evaluating regular training for operators and strict supervision. Recommendations for improvement in accordance with the conditions in the production department, namely socialization and strict supervision and competency training programs on an ongoing basis, especially in matters affecting human error in operators. The improvement recommendations given are expected to help the company in reducing human error and improving operator performance. The suggestion for further research is that the research focuses more on one section so that the evaluation of the improvement suggestions given creates more of an innovation (either in the form of design, or system) that is very impactful in that one section.

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