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Integration of the HEART and SHERPA Approach to Evaluating Human Errors in the Refinery Salt Production

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Abstract. Human error can be prevented by measuring human reliability through the Human Reliability Assessment approach. PT A is a national scale salt producer that produces salt. The quality division identifies human error problems made by operators in the salt refining process. This study aims to identify, calculate probability values, and provide recommendations for improvement to reduce human error in salt refining production operators. HEART and SHERPA are research approaches used because they are considered the most suitable for this study. The results showed that the most visible human error for the error mode category was C2, incomplete checking, and 42 error modes because the operator infrequently did a complete check. The process with the highest Human Error Probability value is the drying process 1, with a value of 7.49. In contrast, the process with the most minor Human Error Probability value score of 0.085 is the bagging process 2. Human error prevention efforts are carried out for each process based on the highest score on the Human Error Probability Index, including Personal Protective Equipment, Standard Operating Procedures, and training to improve operator skills.

Keywords: Ergonomic, Error, Human, HEART, Reliability, SHERPA, Salt

Abstrak. *Pada suatu aktivitas produksi di industri manufaktur atau jasa memungkinkan terjadi sistem error atau Human error. Human eror dapat dicegah dengan mengukur keandalan manusia melalui pendekatan Human Reliability Assessment. PT A adalah produsen garam skala nasional yang memproduksi garam. Divisi kualitas mengidentifikasi permasalahan Human error yang dilakukan operator pada proses pemurnian garam. Tujuan penelitian ini mengidentifikasi, menghitung nilai probabilitas, dan memberikan rekomendasi perbaikan untuk mengurangi Human error pada operator produksi pemurnian garam. HEART dan SHERPA merupakan pendekatan penelitian yang digunakan karna dinilai paling cocok dalam penelitian ini. Hasil penelitian menunjukkan human error yang paling terlihat untuk error mode paling banyak kategori C2, pengecekan tidak lengkap, sebanyak 42 mode error karena operator jarang melakukan pengecekan secara lengkap. Proses yang memiliki nilai Human Error Probability paling tinggi yaitu proses pengeringan 1 dengan nilai 7,49 dikarenakan kurangnya keahlian dan keterampilan operator dalam menjalankan mesin pada area pengeringan 1. Sedangkan proses yang memiliki nilai Human error Probability paling kecil yaitu proses bagging 2 dengan nilai 0,085. Upaya pencegahan human error antara lain lebih memperhatikan kepatuhan pada pemakaian Alat Pelindung Diri, dan kelengkapan template Standar Operasional Prosedur dan mengadakan pelatihan guna meningkatkan keterampilan operator*.

Kata Kunci: Ergonomi, Error, Garam, HEART, Keandalan, Manusia, SHERPA

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1. Introduction

In an industrial process, every activity will lean towards understanding faults. The fault can be a system error or human error. System error is caused by the system that controls the process [1]. Human error is accountability that happens by humans as operators of the system [2]. On the one hand, system fault will be improved if maintenance is done. On the other hand, the complexity of the human system may be possible to repeat the same mistakes, be told the correct procedure, and understand the procedure but repeat the same inaccuracies [3]. PT A is a prominent salt enterprise in Indonesia. The salt production process starts from washing to bagging. Raw Material Salt provides from the company's fields throughout Indonesia. Raw Material Salt is transported by trucks in 50kg bags and stored in Gresik Plant. Raw Material Salt from the warehouse is then loaded using a loader to the production hopper. Belt Conveyor transfers raw Material Salt to the milling station to reduce salt particle size using Roller Mill Crusher. Once the grinding process is finished, the Raw Material Salt is transferred using a Screw Conveyor to the washing machine. The raw material salt is separated between salt and grime through an agitator's stirring system. The grime settles on the bottom, and the salt floats on the top. The washing uses Brine water with a viscosity level between 240-250 Be. Then the Washer Classifier machine processes the salt above to remove the foam. The foams are sprayed using Brine water.

In addition, the salt is transferred using a screw conveyor to the centrifuge to separate the salt and water until the moisture content reaches < 3.5%. Salt is added with a solution of Iodine and then transferred using a Screw Conveyor to the Vibrating Dryer to be dried using hot air from CNG Gas. The CNG gas is transferred to the Burner for the discharge process. The heat generated by the Burner is propelled and transferred using an ID Drying Fan to the Vibrating Dryer to dry the salt. The temperature for drying in the Vibrating Dryer is 1300-1600 degrees Celsius. After drying, the salt is transferred to the Screw Conveyor to the Vibrating Screen to be separated between pr process that meets specifications, namely < 20 mesh. Suppose the resulting product has particles > 20 mesh. In that case, it will be ground using a Roller Mill to convert a product that meets specifications. Proper refinery salt transfer using a screw conveyor to the Silo. The salt in the Silo is then transferred using a screw conveyor for the bagging into 50kg sacks.

The Production and Quality Control Division has established the working procedures for the salt refining process. However, errors still occur, which result in delays in the stages of the salt purification process. Problem identification can be found from the washing process to the finishing process. There is damage caused by operator negligence in the washing process, namely chain screw loss, jammed output hopper, block roll mill, and stuck hopper. In salt and water separation, the damage caused by human error is centrifuge error, chain screw loss, and blocking centrifuge. There are errors in drying area 1, namely burner error and dryer block. There are blocking mesh errors, torn mesh, and roll mill blocking in the sizing area. In bagging area 1, there are errors, namely bagging errors, screw jams, and chain loss. In drying area 2, there are errors, namely frozen gas, blocking salt 2. In the bagging two areas, there is an error.

Namely, the sewing machine is jammed. In the 500gr bagging area, there are errors caused by human error. Namely, the bagging cycle is jammed, the blade is blunt or broken, salt blocking.

Moreover, research has been conducted to evaluate human error implemented in various manufacturing and service businesses [4]–[7]. The Systematic Human Error Reduction and Prediction Approach (SHERPA) and Human Error Assessment and Reduction Technique (HEART) are acknowledged as robust approaches to evaluate human error [8], [9]. SHERPA is effectively used to evaluate the probability of human error in the type of activity, time to do work, and rest time in various work shifts. The SHERPA method also effectively predicts human errors during working activities [1], [6]. The HEART method can determine the probability of the occurrence of human error. The HEART method was also used to distinguish human error probability in Serbian power plant [3].

Moreover, this method is also coherent to analyze the human error in marine transportation accidents [10]. In addition, the HEART method is accurately implemented to analyze human errors related to information security incidents [11]. Integration of SHERPA and HEART methods study on welding works of conveyor and used in the human error analysis of ceramic and welder production processes in manufacturing businesses in two medium-sized companies [9], [12]. This study uses the SHERPA and HEART methods the same as previous studies. However, this study is implemented in a big scale business's salt purification production process. Furthermore, this study improves previous studies by evaluating accumulation risk and severity examination to improve the level of human error operators in the salt purification production process. This study aims to evaluate and identify the human error, calculate probability levels, and recommend improvement scenarios to minimize human error in the salt refining production process.

2. Related Work

2.1. Overview of Systematic Human Error Reduction and Prediction

SHERPA is a Human Reliability Assessment (HRA) Technique that analyzes the work in a structured manner and solves errors [1], [3], [6]. Hierarchical Task Analysis (HTA) is a core in implementing HRA [6]. Moreover, HTA represents a job and achieves a goal in daily activity. HTA can analyze errors during working activity. In addition, error mode is determined based on the error type in SHERPA [1]. There are five types of SHERPA errors: action, recovery, inspection, selection, and information communication [1], [6], [13].

2.2. Overview of Human Error Assessment and Reduction Technique

HEART can be used to give the probability that an error will occur [5], [7], [11]. HEART is known as both an analytical and structured human error analysis tool. One of the characteristics of this analysis tool is a mechanism to see how much the factors that cause errors contribute to errors and the ability to mitigate these errors. HEART determines the dominant factors that cause an error was introduced by Williams in 1985 [5] [7]. As one of the Human Reliability

Analysis methods, the HEART approach is a comprehensive method for quantitatively calculating the risk of human error [5], [13], [14]. In addition, this method has been applied in both manufacturing and service enterprises in developing and developed countries in terms of human reliability assessment [5], [13], [14]. This study aims to identify human errors, calculate human errors' probability value, and provide recommendations for improvement to reduce human errors in salt production operators. The improvement recommendations are expected to improve product quality and reduce human errors [5], [13], [14].

3. Methodology

3.1. Sampling

The type of research used in this research is descriptive research. Descriptive research is a research method that describes the phenomenon studied to elucidate the object of research [15]. This descriptive study includes a walkthrough survey on the refinery salt production process in 2020. Instrument tools include a questionnaire design, recording device, and note sheet. Furthermore, additional data through a thorough walk survey included work processes and tasks and job descriptions of the operators [16].

3.2. Procedure

This study follows the implementation of the SHERPA method [17]. The first stage is to determine Hierarchical Task Analysis (HTA). The second is to classify tasks and then decide on Human Error Identification (HEI). Furthermore, the next stage is a Consequence Analysis and determines the Consequences Analysis. The fifth and sixth activities include in the following order: Recovery and Ordinal Probability Analysis. The two last stages include Critical Analysis and proposed improvement. In addition, HEART implementation follows [10], [18]: the first is to classify tasks based on Generic Task Types (GTTs), and the second is to determine the unreliability value of the job. In addition, the third is to assess the value of Error Producing Condition (EPC), and the fourth is to determine the Assessed Proportion of Effect (APOE). The next stage calculates the Assessed Effect (AE) value with the formula. The sixth calculates the Human Error Probability (HEP) with the procedure. The seventh calculates the Total Human Reliability formula [18]. The determination of the probability value is carried out to determine the value of the Assessed Proportion of Effect (APOE) of the EPC with a formula as follows [19]:

$$\text{APOE} = ((\text{total HEART effect} - 1) \times \text{Probability Rating}) + 1 \qquad (1)$$

The APOE value has then calculated the value of the possibility of the operator making an error and the value of the operator's state. The equation for calculating the error probability value (Assessed Nominal Likelihood of Failure) is as follows [19]:

$$\text{Assessed Nominal Likelihood of Failure} = \_i\hat{\ }n = 1 \text{ APOE} \qquad (2)$$

This study uses a modification of the two methods [17]. Therefore, there are differences in analyzing it compared to previous research. Data analysis is breakdown into 12 stages as follows [17]. The first is to determine Hierarchical Task Analysis (HTA), the second to classify tasks, and the third to categorize each job according to the Generic Task Types (GTTs) table. In addition, the next stage is to order each task according to the Generic Task Types (GTTs) table and determined by Human error Identification (HEI). The fifth and sixth stages include Consequence Analysis. The next step is determining the value of the Error Producing Condition (EPC). The seventh determines the Assessed Proportion of Effect (APOE) following phase includes the eighth calculates the value of the Assessed Effect (AE). Nine steps are related to calculating the value of Human error Probability (HEP). The tenth calculates the value of Human Reliability Total. The eleventh is a risk analysis, and the last is an improvement analysis. Risk analysis combines ordinal probability analysis and criticality analysis on the SHERPA method. Risk analysis is done by multiplying likelihood, exposure, and severity. Risk analysis based on the AZ/NZS 4630 standard was used to validate the degree of the risk level. After assessing the level of risk based on AZ/NZS, 4630, the last stage is determining the risk level, as shown in Table 1 [17].

Table 1 Risk Assessment

Risk Level	Risk Description	Action	Rank
>350	Very high	Activity is initiated until risk can be reduced to an acceptable or acceptable limit	5
180-350	Priority 1	Need control immediately	4
70-180	Substantial	Requires technical improvement	3
20-70	Priority 3	Needs to be monitored on an ongoing basis	2
<20	Acceptable	Intensity that inquires minimal risk	1

This risk assessment method is brainstormed with respondents from the Operation and Quality Control Division. The respondent includes the Machine Maintenance Staff, Supervisor, and Production and Quality Manager. After the risk assessment, the calculation is carried out by multiplying the HEP and the risk level weight. The multiplication results are used to determine the priority of human error prevention based on the order from the highest to the lowest.

4. Result and Discussion

4.1. Description of Sub Task of Refining Salt Production Process and Hierarchy Task

The study results showed eight tasks in doing work for the salt refinery production process. the first was salt washing (sub-tasks: salt sorting, salt to rolling mill crusher, salt to pre washer), and the second was salt and water separation (sub-tasks: pre washer to centrifuge). , centrifuge), the third one is drying 1 (sub-tasks: dryer, Burner, exhaust), the fourth is sizing (sub-tasks: screen, dry roll mill), the fifth is bagging 1 (sub-tasks: cyclone output, power output, product output), the sixth is drying 2 (sub-tasks: rotary dryer, rotary dryer motor, combustion gas), the seventh is bagging 2 (sub-tasks: product output), the last is bagging 500gr (sub-task: product output). Once identifying tasks are done, Hierarchical Task Analysis (HTA) is carried out. Figure 1. depicts the HTA of refinery salt production.

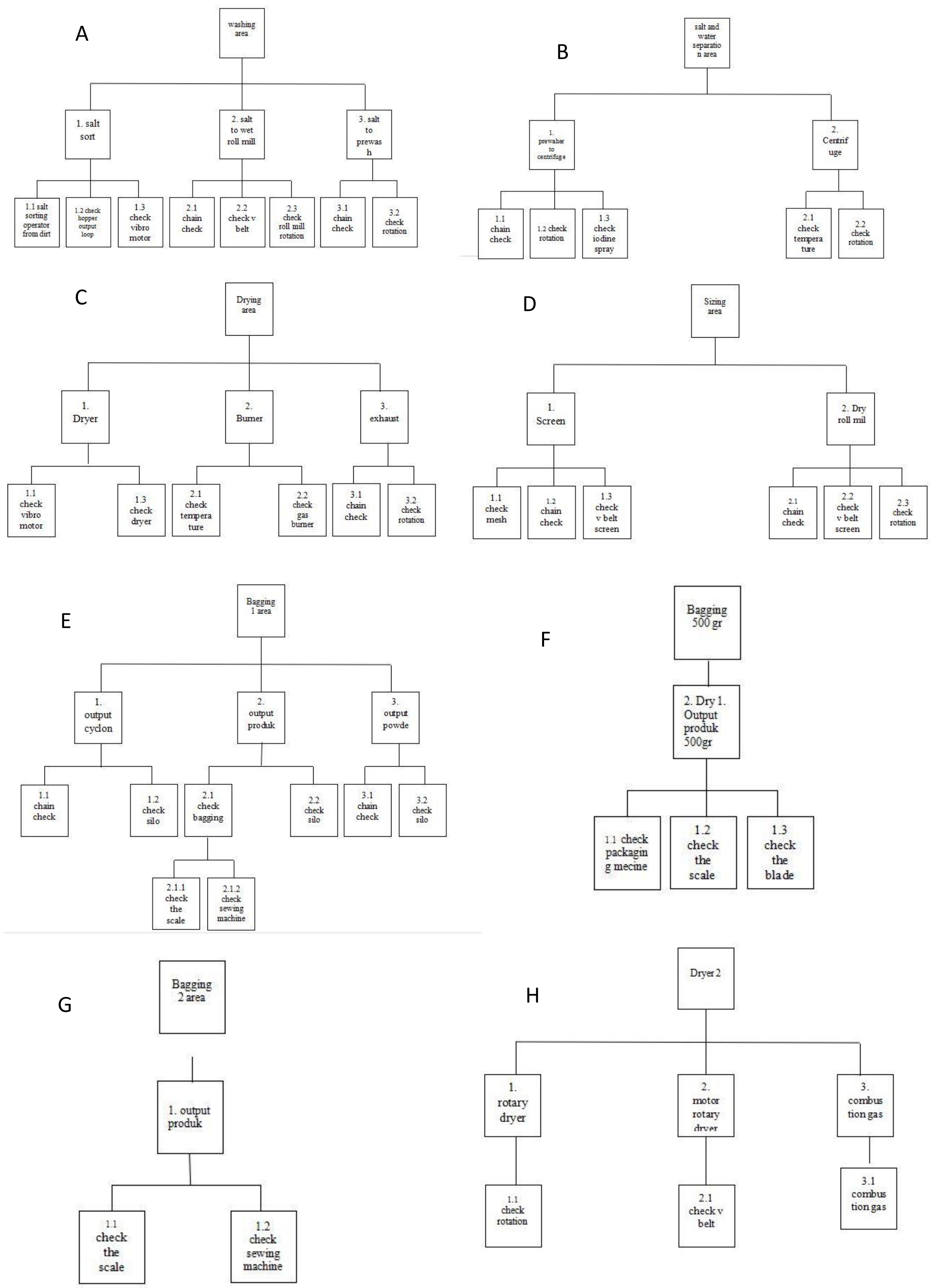

Figure 1 Hierarchical Task Analysis of Salt Refinery Process

Figure 1. shows the Hierarchical Task Analysis of the refinery salt production process. In addition, HTA A configures the washing production process, and HTA B illustrates the salt and

water separation process. The drying and sizing process of HTA are illustrated in C and D. HTA of Bagging one and Drying process two are shown in E and F. The last HTA, G, and H illustrate Bagging process two and Bagging 500gr process production. Furthermore, The HTA consists of several tasks. For illustration, the first task is to sort the salt. The second task is to salt to the moisture roll mill. The third task is salt going to the washer. After that, determine the subtask on each job. The salt sorting task consists of three sub-tasks: the operator sorting the salt from the grime, the operator inspecting the output hopper rotation, and finally, the operator inspecting the Vibro motor. Sub-task sequence of wet roll mill consisting of chain inspection, v-belt examination, and roll mill inspection. The subtasks of prewashed consist of a chain and a loop inspection.

4.2. Human error identification results

Once the HTA process is done, the next step is to analyze Human Error Identification in each production process. Moreover, further evaluation is performed about human errors during tasks activity. This HEI analysis of the salt refinery production process depicts in Table 2.

Table 2 Hierarchical Error Identification in Salt Refinery Production

Hierarchical Error Identification in the washing production process				
No	**Subtask**	**Code**	**Description Error**	**Consequence**
1.1	Operators sorting	C4	Operators are not vigilant in sorting	Salt waste enters the production of end-goods
1.2	Operator checks output rotation	C2	Operator overlooks to check Vibro motor	Motor rotation Turns off, and salt does not come out
1.3	An operator checks the Vibro motor	C2	Operator overlooks to check Vibro motor	There is no vibration and salt dock in the hopper
2.1	Operator checks chain	C2	The operator overlooks to patterned the chain	the chain is broken and cannot rotate
		A9	Operators infrequently elasticity oil	Chain is crack and slog
2.2	An operator checks the v bet	C2	The operator overlooks to check the v belt	The V belt is broken and cannot rotate
2.3	Operator check roll rotation	C2	Operator overlooked to check roll mill	Unstable rotation
		A9	Operators infrequently perform refinement for treatment	The round will strain
		A7	The operator has set the gap roll mill incorrectly	The salt that comes out does not match the size
		A9	Operator infrequently cleans roll mill	Blocking of roll mill caused by salt build-up
3.1	The operator checks the chain	C2	The operator overlooks to check the chain	the chain is broken and cannot rotate
		A9	Operators infrequently transfer engine lubricating oil	Chain is challenging to turn
3.2	Operator checks cycle	C2	Operator overlooks to check rotation	Agitator is stuck
		A7	The operator inaccurately set the water pressure	Blocking salt due to too much water
HEI Salt and Water Separation Process				
No	**Subtask**	**Code**	**Description Error**	**Consequence**

1.1	The operator checks the chain	C2	The operator Fail to recall to check the chain	The chain is broken and cannot turn
		A9	Operators infrequently transfer engine lubricating oil	Chain is hard to turn
1.2	the operator checks centrifuge rotation	C2	The operator Fail to recall to check the centrifuge rotation	*Blocking* centrifuge
1.3	operator checking iodine spray	C2	The operator Fail to recall to check the iodine spray	*Spray* stuck, not spraying
		A7	The operator set the iodine spray wrong	Too much/lack of Iodine
2.1	operator checks temperature	C2	The operator Fail to recall to check the temperature of the centrifuge motor.	Centrifuge error motor heat
		C2	The operator Fail to recall to check the centrifuge cooler	Centrifuge error motor heat
		A9	Operators infrequently transfer engine lubricating oil	Unstable rotation centrifuge
2.2	the operator checks motor rotation	C5	The operator Fail to recall to check the centrifuge rotation	*Blocking* centrifuge
		A3	The operator set the water pressure wrong, and the salt enters	*Blocking* centrifuge
		A1	Operator infrequently cleans centrifuge	*Blocking* centrifuge
			HEI Drying Process	
No	**Subtask**	**Code**	**Description Error**	**Consequence**
1.1	an operator checks the Vibro motor	C2	The operator Fail to recall to check the motor Vibro	Salt does not work, and blocking the dryer
1.2	operator checking dryer	C2	The operator Fail to recall to check the dryer	Blocking dryer
		C2	Failed to recall to turn on the dryer	Blocking dryer
		A1	Infrequently cleans the dryer	Blocking dryer
2.1	operator checks temperature	C2	The operator Fail to recall to check the temperature	Salt is not dry caused blocking dryer and blocking screen
2.2	operator checking gas burner	C2	The operator Fail to recall to check the gas burner	Salt is not dry caused blocking dryer and blocking screen
		A3	Operator wrong on setting	Salt is not dry caused blocking the dryer and blocking the screen.
3.1	operator check chain	C2	The operator Fail to recall to check the chain	The chain is broken and cannot turn
		A9	Operators infrequently transfer engine lubricating oil	Chain is hard to turn
3.2	operator check rotation	C2	The operator Fail to recall to check the rotation	Cyclone salt unstable rotation does not come out
		A9	Operators infrequently clean exhaust fan	Blocking and not rotating

HEI Sizing Process

No	Subtask	Code	Description Error	Consequence
1.1	operator checks mesh	C2	The operator Fail to recall to check the mesh	Torn mesh
		A1	infrequently cleans the screen	Blocking mesh
		A2	Operator delays in performing mesh-machine maintenance	Product quality is not up to standard
1.2	operator check chain	C2	The operator Fail to recall to check the chain	The chain is broken and cannot turn
		A9	Operators infrequently transfer engine lubricating oil	Chain is hard to turn
1.3	an operator checks the v belt screen	C2	The operator Fail to recall to check the V belt screen	V-belt broke
2.1	operator check chain	C2	The operator Fail to recall to check the chain	The chain is broken and cannot turn
		A9	Operators infrequently provide oil	Chain is hard to turn
2.2	an operator checks v belt	C2	Operator Failed to recall to check the V belt	V-belt broke
2.3	operator check rotation roll mil	C2	The operator Fail to recall to check the roll mill rotation	Unstable spine
		A3	Operator incorrectly set gap roll mill	The salt that comes out is not according to size
		A9	Operators infrequently clean the rolling mill	Blocking roll mill caused by salt pile

HEI Bagging 1

No	Subtask	Code	Description Error	Consequence
1.1	operator check chain	C2	The operator Fail to recall to check the chain	The chain is broken cannot turn
		A9	Operators infrequently transfer engine lubricating oil	Chain is hard to turn
1.2	checks Silo	C2	The operator Fail to recall to check Silo	Full Silo causes a trip
		A9	Operators infrequently clean silos	End goods do not meet the specifications
2.1	operator checks bagging	C2	The operator Fail to recall to check bagging	Baggage error
		A1	Operator Failed to recall to clean bagging	End-goods do not meet specification
2.1.1	the operator checks the scales	C2	The operator Fail to recall to check the scale	Weighing scales do not match
		A3	The operator set the scales wrong	Weighing scales do not match
2.1.2	operator checking sewing machine	C2	The operator Fail to recall to check the sewing machine	Sewing machine error, broken needle n tread
		A1	Infrequently clean sewing machine	Sewing machine stuck
		A9	Operators infrequently transfer engine lubricating oil	Silo overload

2.2	operator checks Silo	C2	The operator Fail to recall to check silo bagging	The chain is broken and cannot turn
3.1	Check chain	C2	Fail to recall to check chain	Chain is hard to turn
		A9	Operators infrequently transfer engine lubricating oil	Full Silo causes a trip
3.2	operator checks Silo	C2	The operator Fail to recall to check Silo	End-goods do not meet specification
		A9	Operators infrequently clean silos	

HEI Drying Process 2

No	Subtask	Code	Description Error	Consequence
1.1	the operator checks dryer rotation	C2	The operator Fail to recall to check the dryer rotation	Salt is not dry blocking dryer and blocking screen
2.1	an operator checks v belt	C2	The operator Fail to recall to check the condition of the v belt	V belt broke / V belt wrapped
		A1	Operators infrequently change the v belt	V-belt is loose / V-belt is broken
3.1	the operator checks gas combustion	C2	The operator Fail to recall to check the temperature	Salt is not dry blocking dryer and blocking screen
		C2	The operator Fail to recall to check combustion gas.	Salt is not dry, blocking the dryer and blocking the screen.
		A3	Operator wrong setting of combustion	Salt is not dry blocking dryer and blocking screen

HEI Bagging process 2

No	Subtask	Code	Description Error	Consequence
1.1	the operator checks the scales	C2	The operator Fail to recall to check the scale	Weighing scales do not match
		A3	The operator set the scales wrong	Weighing scales do not match
2.1	operator checking sewing machine	C2	The operator Fail to recall to check the sewing machine	Sewing machine error, broken needle, broken thread
		A1	Operators infrequently clean sewing machines	Sewing machine stuck
		A9	Operators infrequently transfer engine lubricating oil	Sewing machine stuck

HEI Bagging process 500gr

No	Subtask	Code	Description Error	Consequence
1.1	operator check machine	C2	The operator Fail to recall to check the packing machine	Packaging machine error
		A3	The operator set the packaging machine wrong	Scale error
		A9	Operators infrequently clean the packaging	Dirty and rusty packaging machine
1.2	the operator checks the scales	C2	The operator Fail to recall to check the scale	Weighing scales do not match
		A3	The operator set the scales wrong	Weighing scales do not match
1.3	operator checking	A9	Operators infrequently	The blade is overcast and

blade	clean blades	rusty

Table 2. shows the subtask, error code, description of the error made by the operator, and the consequences that occur if the operator makes an error in the salt washing process. It can be seen in table 3 that the most error code is C2. Once HTA and HEI are identified, the next stage is graphing Human Error Identification mode the error mode. The graph calculation result is a walkthrough survey and brainstorms with respondents. The human error identification graph is illustrated in Figure 2.

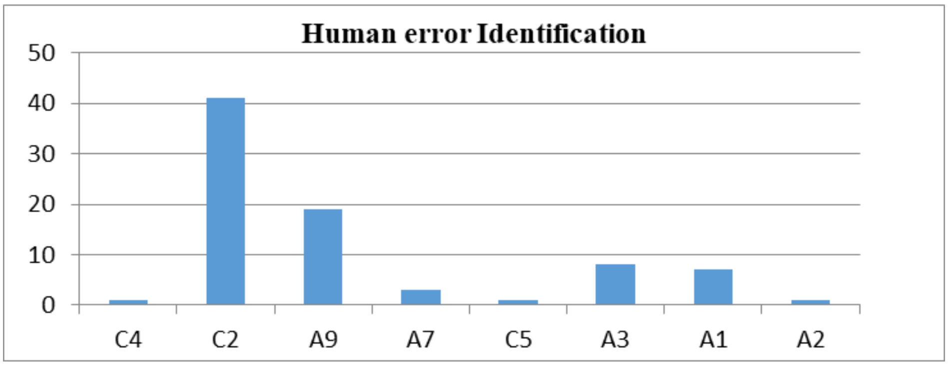

Figure 2 Human Error Identification Rank of Salt Refining Process

Based on data analysis in Figure 2, the identification of the highest human error was C2, namely 41 preliminary inspections. Such activity includes overlooking the motor rotation and inspection. Worker errors occur because of, in nature, the complexity of the human system. Low work morale creates insubordination towards guidelines. Moreover, an excellent example of complying with SOPs is needed to create good habitual action and then voluntarily change toward good working performance. The next stage determines Human Error Probability (HEP) by performing calculations based on a predetermined formula. Table 3. shows HEP Value.

Table 3 Human Error Probability Value of Refinery Salt Production Process

Areas of Potential Human error	**Salt and Water Separation Area**		
General Task Types (GTTs)	Trained regular jobs that require expertise		
Nominal Human error Probability		0.06	
Error Production Conditions (EPCs)	Total Effect	Evaluated	Assessed Effect
Prolonged and low mentality doing work	1.1	0.6	1.06
limited time to detect and fix error	11	0.6	7
human error Probability		0.44	
Areas of Potential Human error	**Drying Area 1**		
General Task Types (GTTs)	Transferring the system to the next stage following a procedure completion task		
Nominal Human error Probability		0.02	
Error Production Conditions (EPCs)	Total Effect	Evaluated	Assessed Effect
The need to make definite judgments that are beyond the capabilities of the operator	1.6	0.8	1.48
limited time to detect and fix error	11	0.8	9
Low ratio to signal interference	10	0.8	8.2
Lack of operator experience	3	0.8	2.6
A mismatch between standard and actual	1.4	0.8	1.32

human error Probability	7.49		
Areas of Potential Human error	**Sizing Area**		
General Task Types (GTTs)	Transferring the system to the next stage following a procedure completion task		
Nominal Human error Probability	0.045		
Error Production Conditions (EPCs)	Total Effect	Evaluated	Assessed Effect
There is a discrepancy between the actual and design in implementing SOPs	8	0.8	6.6
The conflict between a quick end goal and an end goal that takes time	2.5	0.8	2.2
There is no record of ongoing progress	1.4	0.8	1.32
Action steps caused by the intervention of others	1.06	0.8	1.048
Unreliability of the equipment	1.6	0.8	1.48
human error Probability	1.34		
Areas of Potential Human error	**Bagging Area 1**		
General Task Types (GTTs)	Trained regular jobs that require expertise		
Nominal Human error Probability	0.06		
Error Production Conditions (EPCs)	Total Effect	Evaluated	Assessed Effect
Equipment unreliability	1.6	0.8	1.48
There is no instrument to conduct rework	8	0.8	6.6
The action caused by the intervention	1.06	0.8	1.048
human error Probability	0.61		
Areas of Potential Human error	**Drying Area 2**		
General Task Types (GTTs)	Trained regular jobs that require expertise		
Nominal Human error Probability	0.06		
Error Production Conditions (EPCs)	Total Effect	Evaluated	Assessed Effect
A mismatch between standard and actual	4	0.6	2.8
There is an urge to use other dangerous ways	2	0.6	1.6
Unreliability of the equipment	1.6	0.6	1.36
There is no record of ongoing progress	1.4	0.6	1.24
human error Probability	0.45		
Areas of Potential Human error	**Bagging Area 2**		
General Task Types (GTTs)	Trained regular jobs that require expertise		
Nominal Human error Probability	0.06		
Error Production Conditions (EPCs)	Total Effect	Evaluated	Assessed Effect
Equipment unreliability	1.6	0.6	1.34
Prolonged mental lowness of doing work	1.1	0.6	1.06
human error Probability	0.085		
Areas of Potential Human error	**Bagging 500gr**		
General Task Types (GTTs)	Trained regular jobs that require expertise		
Nominal Human error Probability	0.06		
Error Production Conditions (EPCs)	Total Effect	Evaluated	Assessed Effect
Equipment unreliability	1.6	0.6	1.34
Prolonged mental lowness of doing work	1.1	0.6	1.06
Ambiguity about performance standards	5	0.6	1.24
human error Probability	0.11		

The HEP value for the washing section shows in Table 3. The HEP value describes the probability of failure when the washing section operator does his job. The HEP value for operator negligence in using PPE and tasks that the operator must carry out is 0.70. After calculating the probability in each production process. The next step is to sort the HEP values from the largest HEP to the smallest HEP value. In order to make it easier to know which value has the greatest HEP in the salt production process, it is presented in table 4.

Table 4 The rank of Human Error Identification

No	Working Area	HEP
1	Drying 1	7,49
2	Sizing	1,34
3	Washing area	0,70
4	bagging area 1	0,61
5	Drying area 2	0,45
6	Salt and water separation area	0,44
7	Bagging area 2	0,11
8	Bagging area 500gr	0,085

After calculating the HEP for each production process, the next step is ordering the highest HEP value to the lowest. The maximum HEP rank score is of 7.49 is found in the drying process 1. Then the second HEP rank is of 1.34 is found in the sizing process. The next rank is the third HEP is equal to 0.70 was found in the washing area, followed by the fourth HEP of 0.61 was in the bagging area. The fifth HEP of 0.45 was in the drying area 2. Rank sixth HEP of 0.44 was found in the salt and water separation area, and then the seventh HEP of 0.11 was in the 500 grams bagging area. The last HEP with a value of 0.085 is in the bagging area.

4.3. Risk Assessment

The risk assessment determines the priority of preventing human error based on the high risk. Table 5. explain risk assessment and determination of human error prevention.

Table 5 Risk Level with HEP and Prevention Priority

Task	Risk Level	HEP	Weight Risk Level	Proposed Multiplication	Result
Drying Area 1	Very high	7,49	5	37,45	Procedure, Equipment, Training
Area Sizing	Priority 1	1,34	4	5,38	Procedure, Equipment
Washing area	Substant	0,70	3	2,1	Procedure, Equipment
Bagging area	Substant	0,61	3	1,83	Procedure, Equipment
Drying area 2	Substant	0,45	3	1,35	Procedure, Equipment
Salt and water separation area	Priority 3	0,44	2	0,88	Procedures, Equipment
Bagging area 2	Priority 3	0,11	2	0,22	Procedure, Equipment
Bagging area 500gr	Priority 2	0,08 5	2	0,17	Procedure, Equipment

Table 5. shows that drying production area 1 is the work area with the highest maximum risk, 4. Furthermore, the sizing work area is ranked the second-highest risk with a score of 4. The washing area, packing area, and drying area 2 with a score of 3 is the third risk rating. The work area for separating salt from the water and area bagging 2 is at risk level 4 with a risk score of 2. Finally, the 500gr packaging area is the work area with the minor risk.

4.4. Discussion

The results of this study are consistent with previous studies evaluating human error using Sherpa and Heart [8], [9], [14], [18]. The findings from SHERPA implementation show that the cause of Human error consists of five factors. There are Action errors, Inspection errors, Retrieval errors, Communication errors, and Selection Errors. In addition, most mistakes were made because of Inspection Errors, which cause errors in the machine and the production process. The previous finding concluded that errors in the human-machine relation were the most significant type of error in human and machine adaption [10], [11].

The probability of the most significant human error in the drying area is a 7.49 score. Furthermore, the drying area encompasses gas and a combustion system with a greater risk of error, and the treatment system takes extensive. The second-largest probability in the sizing process score is 1.34 because the area is inclined to error. If an error occurs, the handling takes enormously long, resulting in a plant shutdown. Furthermore, the washing area score is 0.70 is a lower hazardous error. The salt and water separation area score are 0.44, smaller than the washing area since of the error factor and fewer error consequences. Finally, for the bagging area 1 of 0.61. For drying area 2, the probability of 0.45 is lower than for drying one because the level of risk arising from drying area 2 is lower and human error is the lowest. For bagging area 2, the probability level is 0.0085, and human error is low because the process does not require particular expertise specifications. Lastly, the area of Bagging 500gr has a probability of 0.11. It is considered the lowest human error all over salt refinery production processes.

The result based on risk assessment calculation shows that the salt refining process working area risk score ranges from 2 to 5. Consequently, management in the Production and Quality Divisions should conduct substantial action to mitigate the impact of the human error risk. Efforts can be made by redesigning both work methods and layout to eliminate human errors. The subsequent strategy is to improve the salt refining production process in the affected area. Furthermore, Continuous supervision is the third effort to ensure that the operator has carried out the production process by the established work standards. This result is related to research findings [20] that such action may improve human reliability.

5. Conclusions and Recommendations

The highest human error evaluation based on the SHERPA method is C2, with 41. In addition, the most significant error probability in the drying process is a 7.49 score based on the results of the HEART calculation. The results of the SHERPA identification show that human error occurs due to negligent factors and lack of communication. In addition, human errors are caused by a loss of focus to do the work. It is also caused by operators' lack of reliable skills in doing work, and inaccurately receiving orders count as factors that cause human errors.

The second conclusion is the HEP value obtained from the salt-making process for the washing area. The probability is 0.70. In addition, the probability of the salt and water separation area is 0.44. The probability of drying area of 1 salt is 7.49. For the sizing area, the probability is 1.34. For bagging1 area, the probability is 0.61, drying area 2 is 0.45, and bagging area 2 is 0.085. for 500gr bagging area is 0.11. It displays that the uppermost error arises in the drying area because the drying process requires a high level of expertise to comprehend the working system. The second rank is for the high probability of error in the sizing area of 1.34 because the area is likely faults that result in fatalities.

It is recommended that the firm's management conduct training to minimize operator faults and add SOPs posters in the working area. Furthermore, it is expected to be more in-depth communication among operators and conduct regular meetings involving operators concerned with the production process. Human error in terms of infrequency inspection and routine maintenance may get extra training to improve operators" skills. It is expected that the enterprise will provide a routine schedule for inspection and repairing machines. Operators' deficient awareness during working activities may recommend additional breaks and job rolling to prevent repetitive environments.

This research has several limitations, which are described as follows. The first limitation is the limited time in the data collection process, resulting in incomplete data needed to support research. The drawback of the second research is that it does not consider other factors in determining human error, namely machine reliability and the level of operator fatigue. In addition, this research does not analyze work methods, operator’s posture, and working environment. Further research in the form of validation of the probability level of human error is needed to improve the results of this study. Research-based on an ergonomic risk approach and machine reliability are needed to improve the results of this research.

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