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Human error analysis to reduce production defects with Sherpa method and Heart method in PT XYZ

Ayu Puspitasari, Ginda Safitri, Yolanda Efionita
Department of Management and Business, Politeknik Negeri Batam, Batam, Indonesia

ABSTRACT

This study aims to analyze Human Error to Reduce Defects in Production with the Sherpa Method and the Heart Method at PT XYZ. Sherpa method to identify errors and Heart method to calculate the probability of errors. The results of data processing show a total of 9 tasks and descriptions of errors where errors are divided into 2 types of errors classified based on Sherpa error modes, namely errors in implementation (action errors) as many as 7 errors, errors in checking (Checking errors) as many as 2 errors. The results of the calculation of the HEP value in the production process of automation goods. The probability of error in production with the heart method where the highest HEP value is 0.16. The production process of automation goods at PT XYZ which often occurs in the mounting process with the highest HEP value of 0.1856.

Keywords: Human Error, SHERPA Method, HEART Method

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***Penulis Korespondensi:**
ayupuspitasari@polibatam.ac.id

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INTRODUCTION

In today's modern era, human error is a phenomenon that is inseparable from daily life activities, especially in the world of work and industry. Human error is defined as an action or failure to act that exceeds a predetermined system tolerance (Kirwan, 2017). In an industrial context, these errors can lead to a decrease in product quality, financial losses, and work accidents. Decreased product quality due to deviations from standard work procedures and operator negligence in the production process (Dwiyanti, D. O., Gucci, R., & Abdul, R. 2023; Sembiring, N., Tambunan, M. M., & Febriani, M. 2019).

To minimize the risk of human error, various analysis approaches have been developed. One of them is the combination of SHERPA (Systematic Human Error Reduction and Prediction Approach) and HEART (Human Error Assessment and Reduction Technique) methods. To minimize the risk of human error, various analysis approaches have been developed. One of them is a combination of SHERPA (Systematic Human Error Reduction and Prediction Approach) and HEART (Human Error Assessment and Reduction Technique) methods.

This method has proven effective in identifying types of errors as well as measuring the probability of human failure in complex work systems. In practice, PT XYZ, which is engaged in the manufacturing industry, continues to strive to maintain product quality. Through the application of human error analysis using the SHERPA (Systematic Human Error Reduction and Prediction Approach) and HEART (Human Error Assessment and Reduction Technique) methods (Hantara, E.R., & Susanto, N. 2022). SHERPA is used to predict possible errors based on work activities, while HEART is applied to identify the probability of operator failure under various working conditions (Utama, A. S. P., Tambunan, W., & Fathimahhayati, L. D. 2020). This is very relevant considering that the synergy between machines and humans in the production process often faces obstacles, such as errors in the PCB mounting process or negligence during the aging stage which results in excessive temperature and product damage. Even minor defects such as dead LEDs or dented cases are still categorized as failed products.

Similar research has also been conducted in various other industrial sectors Zetli, S. (2021) used SHERPA and HEART methods to reduce errors in brick molding and firing processes, suggesting regular inspection as a mitigation measure. Mauluddin, Y., & Azzahra, F. (2022) applied similar methods in the convection industry and found that significant errors require systematic quality improvement and prevention. Hantara, E.R., & Susanto, N. (2022) analyzed borong workers in the tobacco sector and recommended specific solutions based on the results of error cause identification. These studies show that the SHERPA and HEART methods can be applied across industries and produce recommendations that are contextualized according to the type of work and operator characteristics.

Taking into account the high contribution of human error to product failure, as well as the proven effectiveness of the SHERPA and HEART methods in various sectors, this study was conducted to deeply analyze the factors that cause human error in the production process at PT XYZ. The goal is to develop a data-driven and systematic mitigation strategy, which not only reduces product defect rates, but also improves operational reliability and company competitiveness.

LITERATURE REVIEW

Human Error

In a fast-paced and complex modern work environment, human error is unavoidable and has great potential to cause serious impacts on overall system performance, ranging from financial losses, decreased company reputation, to occupational safety threats. Therefore, it is important for every organization to implement strategies that minimize the occurrence of human error and build a safe, efficient, and sustainable work culture. Human error itself is defined as an inappropriate action or decision that has the potential to reduce the effectiveness, safety, or performance of a system (Sanders & McCormick, 1993 in Sihaloho, Mende, & Rondonuwu, 2023).

According to a journal written by Alfano, V. A., & Rusindiyanto. (2021), work accidents are events that cause harm to people and assets, and basically do not occur by chance, but have causes that can be identified and prevented. One of the dominant causes of work accidents is human error, which arises from deviations from established operational procedures or standards. This is in line with the mandate of Article 86 of Law of the Republic of Indonesia Number 13 of 2003 concerning Manpower, which states that every worker/laborer has the right to obtain protection for occupational safety and health, morals and decency, and treatment in accordance with human dignity. The factors that cause human error include lack of knowledge and information, violation of work rules, and ineffective communication. In addition, human error can also take the form of delay or failure to respond to tasks due to technical glitches, work pressure, or unfavorable environmental conditions, all of which can increase the risk of workplace accidents.

Human Error Assessment And Reduction Technique (HEART)

The HEART (Human Error Assessment and Reduction Technique) method, first developed by Williams in 1985, is a simple and flexible quantitative approach to estimating Human Error Probability (HEP) in various types of tasks, and can be applied in various industrial sectors such as construction, aviation, and chemistry (Cahyani et al., 2022). HEART is designed to evaluate the probability of human error in the execution of a task, starting with classifying the task type into Generic Task Types (GTT), then identifying Error Producing Conditions (EPC) such as fatigue, distraction, or workspace limitations that can trigger errors (Alfano, V. A., & Rusindiyanto. 2021). The main principle of this method is that every task has a failure potential that is affected by one or more EPCs. The next steps include calculating the Assessed Proportion of Effect (APOE) and Assessed Effect (AE) of each EPC, then determining the HEP value to assess the risk level of human error. With this systematic approach, the HEART method enables the identification of the most critical tasks and helps in prioritizing risk control more effectively.

Systematic Human Error Reduction and Prediction Approach (SHERPA)

The SHERPA (Systematic Human Error Reduction and Prediction Approach) method developed by Embrey in 1986 is a qualitative method designed to analyze human error based on individual habits and skills (Cahyani et al., 2022). SHERPA works by breaking down a task into detailed steps through the task hierarchy, then evaluating potential errors at each step systematically (Alfano, V. A., & Rusindiyanto. 2021). This method is very effective for identifying errors related to routine procedures and personnel skills, and providing improvement recommendations to reduce potential errors. In addition, SHERPA is also able to analyze the impact of errors, identify critical actions, and develop mitigation strategies. Another advantage of SHERPA is that it is structured, comprehensive, easy to implement, and more efficient than observation methods, with acceptable inter-rater reliability (Hughes et al., 2015, in Patradhiani et al., 2022).

METHOD

The method applied in this study is to use human error analysis with the Sherpa and Heart methods with respondents in this study were 3 people, consisting of supervisors, leaders and production operators. The data collection method is done by direct observation by looking at the flow of the production process. the area observed is the Production Department. Another step is to conduct interviews with the respondents concerned to obtain data on rejected goods during production.

The Sherpa (Sys-tematic Human Error and Reduction Approach) method (Zetli, S. 2021) performs human error analysis consisting of general questions and answers that distinguish similar errors at each step of the job task analysis. The stages of the process carried out in applying the Sherpa method are:

1. Use the Sherpa table to tabulate errors. In this technique, the error model is reviewed through the forms of errors in Sherpa.
2. Identify the risk of error and the next task to anticipate if an error occurs.
3. Identify potential errors at the bottom of each task level.

The HEART method is a human reliability assessment technique to help identify risks, possible errors, and key influences in human performance, in a repeatable and systematic way. HEART is an additive factor method that is relatively fast and can be more easily used in any industry that uses human reliability. The method is used to derive the essence of known influences in human performance at work. Meanwhile, the stages carried out in HEP with the HEART method (Zetli, 2021):

1. Use Generic Categories as a classification of job types in the HEART table.
2. There are 8 groups of Generic categories HEART (from A - H) then equipped with the value of human unreliability in each group.
3. Determine the Error Productions Conditions (EPCs) value.
4. Determine the proportion value (PoA)

Results from 0 - 1 (0 = Low, 1 = High). A result of 0 means that the measured EPCs have no influence on the possibility of errors, a value of 1 gives a very large influence on the possibility of errors in EPCs. The proportion of assessments carried out by experts is subjective.

RESULTS AND DISCUSSION

a. Prediction of Human Error with the SHERPA Method (Systematic Human error and Reduction Approach)

Human Error Identification (HEI) aims to determine the error modes in the Sherpa table based on the descriptions of the errors that occur. An ordinal analysis of the likelihood of human error is carried out by categorizing the types of human errors that arise in the production process of automation products, where a “High” category indicates a high potential for errors. Consequence Analysis identifies the errors and their subsequent consequences, making it possible to predict potential failures. Meanwhile, the Improvement Solution Strategy Analysis on the production process of automated goods is aimed at preventing human errors and production defects. In this context, Hierarchical Task Analysis (HTA) is applied based on the concept that task execution can be described in a hierarchical structure that includes goals, procedures, and planning. Hierarchical Task Analysis (HTA) is a method used to analyze complex tasks by mapping human and system interactions in a structured manner. HTA is considered effective because it is easy to use, detailed, and focused on the core of the task, and describes the work process of each station in the form of a hierarchical chart (Findiastuti, 2000 in Pradipta, N. S., & Susanto, N. (2023,).

In the production process at PT XYZ, all stages have been automated, and the application of HTA allows estimating the possibility of human error during task execution at each stage of production.

Table 1. Sherpa Data Processing

No	Task	Mode Error	Deskripsi Error	Konsekuensi	Perbaikan	Analisis *Ordinal*	Analisis Strategi
1.1	Manual Insert Process	A8	Forgot to insert a component on the pcb	In the process function goods become fail / error	Reprimanded the operator for forgot to insert the component	Low	Perform routine checks
1.2	Manual insert process	A8	Components on the pcb are not soldered	Process function becomes a fail/error	Give a warning to the operator to double-check what has been done.	Low	Conduct Training
2.1	Manual insert process	A3	Not putting the pcb in the machine according to the priority which results in components not being soldered.	Process function to fail/error	Reprimanded the operator to look at the work guide properly.	Low	Conduct Training
2.2	Manual insert process	A7	Incorrect use of components on the pcb	Process function to fail/error	Reprimanded the operator to look at the work guide correctly	Low	Conduct routine checks
3.1	Mountig Process	A8	Missing Screw on pcb due to not using kitset	Part-parts inside the case such as pcb with bracket/heatsink not connected	Rechecking after finishing the product	High	Conduct regular check-ups
3.2	Mountig Process	A6	Broken pcb led because when closing the pcb with the case did not use a jig	When in process function led number does not light up	Reprimanded the operator to use the jig that have been provided.	High	Conduct Training
3.3	Mountig Process	A8	Using the wrong screw because of not looking at the worksheet/work guide	Cannot enter the function slot because the thread is different	Instructed the operator to recheck the equipment set.	High	Conduct Routine Check-ups
3.4	Item checking process	C1	When in the aging process forgot to press the start button on the machine	The item will be hot and the case will melt due to too high temperature	Create a warning next to the engine start button as a reminder to the operator	Low	Conduct Routine Check-ups
4.1	Item checking process	C2	In the final monting process forgot to attach the sheet to the cover.	The battery gets shaken because there is no sheet support	Made a warning to the operator not to forget to install the sheet.	Low	Conduct Training

Table 1 shows that Data processing using SHERPA shows a total of 9 tasks and error descriptions where the error is divided into 2 types of errors that are classified based on Sherpa mode, namely errors in implementation (action errors) as many as 7 errors, errors in checking (Checking errors) as many as 2 errors. based on Sherpa error mode, namely errors in implementation (action error) as many as 7 errors, errors in checking (Checking error) as many as 2 errors.

b. Probability of Human Error with Heart method (System-atic Human Error and Reduction Approach)

At this stage, the classification of activity types is carried out using the Generic Task Types (GTT) table. This classification is based on the type of work performed by workers. Tables 2, 3, and 4 classify the types of work and the resulting probability of human error at each stage of production.

No. Task	Generic Task Type (GTT)	Nominal *Error* Probability
1.1	C	0,16
1.2	E	0,02

Table 2 shows the classification of human error probability values and job types during the manual insert stage. The highest human error probability is 0.16 in Task 1.1. This is because the worker needs a certain level of understanding and skills regarding circuit boards/PCBs and must understand the polarity of the board where components must be installed.

Tabel 3. Kategori Pekerjaan Proses Mounting

No.Task	Generic Task Type (GTT)	Nominal *Error* Probability
1.1	E	0,02
1.2	C	0,16
1.3	E	0,02

Table 3 presents human error probability values and job types during the mounting stage. The highest human error probability is 0.16 in Task 1.2. Workers need specific knowledge and skills about PCBs and their casing or cover, depending on the product model ordered by customers, the parts used, and the PCB code used. This requires comprehension and skill.

Tabel 4. Kategori Pekerjaan Proses Pengecekan Barang

No.Task	Generic Task Type (GTT)	Nominal *Error* Probability
1.1	C	0,16
1.2	E	0,02

Table 4 classifies the probability values of human error and work type during the inspection stage. The highest probability is 0.16 on Task 1.1. This is due to the need for worker competence in understanding which products are worth sending based on PT XYZ standards.
Error Producing Conditions (EPC) are calculated based on factors that contribute to errors or mistakes in the workplace. The Proportion of Effect (POE) is determined through interviews with individuals who are considered knowledgeable and experts in the production process. POE has a scale of 0 to 1, where higher values indicate greater Human Error Probability (HEP). The EPC and POE values lead to the Assessed Proportion of Effect (APOE), which correlates with the HEP. The higher the APOE, the greater the HEP value and the likelihood of error.

Tabel 1. APOE and AE Values for Item Insert Manual Process

No. Task	Nomor Urut (Tabel EPCs)	*Max.Effect*	APOE	AE ((Max.Effect -1)x APOE) + 1
1.1	17	3	0,8	2,6
1.2	1	17	1	1

Tabel 2. APOE and AE Values for the Item Mounting Process

No.Task	Nomor Urut (Tabel EPCs)	Max Effect	APOE	AE (Maxx.Effect -1) x APOE) + 1
1.1	17	3	0,8	2,6
1.2	26	1,4	0,4	1,16
1.3	10	5,5	0,3	2,35

Tabel 3. APOE and AE Values for the Goods Checking Process

No. Task	Nomor Urut (Tabel EPCs)	Max.Effect	APOE	AE ((Max.Effect – 1) x APOE) + 1
1.1	12	4	0,9	3,7
1.2	26	1,4	0,7	1,28

Tables 4.5, 4.6, and 4.7 show the values obtained for EPC and APOE for the Manual Assembly, Installation, and Inspection processes, respectively. Some tasks have an EPC number of 4.6, which refers to independent checking i.e., where the output is not or only minimally checked. Other tasks have an EPC number of 26, which indicates the absence of a clear method to maintain or improve supervision during the task, leading to ineffective supervision and potential quality issues. Human Error Probability (HEP) values are calculated to determine how likely errors are when workers perform their tasks. HEP values are derived from the GTT table and APOE values.

Tabel 4. HEP Value for Manual Insert Process

No Task	Nominal *Error* Probability	Assessed Proportion of Effect (APOE)	*Human error* Probability (HEP)
1.1	0,16	2,6	0,416
1.2	0,02	1	0,02

Table 4.8 shows that the highest HEP value in the manual insert process is 0.416 (Task 1.1), indicating that the worker did not recheck the processed PCB, resulting in missing components and function failure.

Tabel 5. HEP Value for Mounting Process

No.Task	Nominal *Error* Probability	Assessed Proportion of Effect (APOE)	*Human error* Probability (HEP)
1.1	0,02	2,6	0,052
1.2	0,16	1,16	0,1856
1.3	0,02	2,35	0,047

Table 4.9 shows that the highest HEP value in the mounting process is 0.1856 (Task 1.2), indicating negligence in securing the LED PCB, causing breakage or detachment.

Tabel 6 HEP Value for Checking Process

No Task	Nominal *Error* Probability	Assessed Proportion of Effect (APOE)	*Human error* Probability (HEP)
1.1	0,16	3,7	0,592
1.2	0,02	1,28	0,0256

Table 4.10 shows that the highest HEP value in the inspection process is 0.592 (Task 1.1), indicating the worker failed to verify whether the power-on button of the aging machine was active, leading to overheating and product rejection.

Discussion

a. SHERPA (Systematic Human Error Reduction and Prediction Approach): 9 errors were found in the Manual Insert, Mounting, and Check Item processes. Errors were most common in the Manual Insert process and were critical because they involved forgetfulness or faulty components that could cause product damage. In Mounting, errors generally involved forgetting or using the wrong screw. In Check Item, errors include forgetting to press the button or not installing the sheet protector.
b. HEART (Human Error Assessment and Reduction Technique): Human Error Probability (HEP) values were calculated as follows: Manual Insert: 0.416 (high) Mounting: 0.1856 (medium), Check Item: 0.592 (very high). The high HEP is influenced by the complexity of the work and the error triggering conditions (EPC).
c. Combined SHERPA and HEART Analysis Results: 7 activities with error risk were found, where task 1.2 Mounting was categorized as High due to repetition. The highest HEP value is 0.1856 in the mounting process because it does not use jigs. Proposed improvements include making clear worksheets, using jigs, and retraining operators in every production process.
d. Production Defect Reduction Strategy. Improvement efforts include: Root cause analysis (5 Why), Strict quality control, Employee training, Implementation of SOP, Machine maintenance, Use of production aids (jigs).

CONCLUSION

a. From the results of data processing using the SHERPA and HEART methods, several conclusions can be obtained from this study: Based on the measurement of errors with the HEART method, the highest HEP is obtained for all tasks in the production process with the highest task being the mounting process. The problem that often occurs in the task is that the Led pcb does not light up in the function process because the pcb is broken / falling out due to not using a jig. The Human Error Probability value for this task is 0.1856.
b. Recommendations for improvement are given to the manual insert process, the mounting process and the process of checking goods according to the existing conditions in the production department, especially those that affect human error.

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