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Human error analysis on production process of door products with SHERPA and HEART method

Nurhayati Sembiring [1], Mangara M Tambunan[2], Miska Febriani[3]
[1,2,3]Department of Industrial Engineering, Faculty of Engineering,
University of North Sumatra
JL. Almamater Kampus USU, Medan 20155
[1]Email: nurhayatipandia68@usu.ac.id
[2]Email: araapul_tambunan@yahoo.com
[3]Email: michafebriani@yahoo.com

Abstract. Company engaged in manufacturing that produces door leaf. This company is a factory whose work is done semi-automatic that man has a role in sustainability of production process. A problem in the production process of the door where there is a defect which is the main cause factor is human (human error). This problem can be solved by performing human error analysis with SHERPA and HEART methods. Systematic Human Error Reduction and Prediction Approach (SHERPA) analyzed occurrence of human error by using a hierarchical task input basic level while Human Error Assessment and Reduction Technique (HEART) part the calculation reliability is defined as how much operator made a mistake in the task that should be done. From the research found the results obtained SHERPA methods work items that have a critical level that is 2.2 (too long), 8.2 (too long), and 11.2 (the flat part of the door yet). Based on the research with HEART method obtained the total value of HEP is 0.4986 where the value is influenced by EPCs factor. Based on the data obtained then possible troubleshooting for item 2.2, 8.2, and 11.2 issues is by improving operator skill.

1. Introduction

Processes in an industry can not be separated from errors (errors). [1] This error can be caused by system error or human error. [2] The system error is an error that is usually caused by the system that controls the process and if it is fixed then the error will not appear again. This is very different from human error. Human error is caused by a lack of awareness of the situation, which is a perception of components in the process environment. [3] Humans can be told the correct procedure and often understand the procedure, but due to the complex system then something that should be done correctly can not be solved. This is called human error. [4] Company engaged in manufacturing that produces door leaf. This company is a factory whose work is done semi-automatic that is human and machine have a role in sustainability of production process. From the results of preliminary observations there are 10 types of doors that are produced in the company, these results can be seen in Table 1.

[1]Lecturer in the Department of Industrial Engineering, University of North Sumatra
[2]Lecturer in the Department of Industrial Engineering, University of North Sumatra
[3]Lecturer in the Department of Industrial Engineering, University of North Sumatra

Table 1. Doors Production in the Company

Door Types	Total Production / year
Contemporary	965
Conventry	907
DX	1102
Salerno	801
Louis	745
Malton	745
Monza	570
Mexicano	2352
Novara	390
Pesaro	645

From the above data, it is known that the defect in the production process that often happens is on the production process of mexicano doors with the largest number of production and number of defects so that mexicano doors are observed. Some types of defects that occur are the cracked door, the carving is not appropriate, the glue given a little, etc. This happens entirely because the operator (human error) is like working in a hurry, work attitude error, and lack of operator skills at work. Disability in the production process is causing losses for the company that is in the form of material loss and disruption of the production process.

The number of default defects allowed by companies is 3-4% (1-2 defects per process). From the description of the problem is needed an analysis to determine what solutions need to be done to reduce human error that can cause the occurrence of disability in the production process using SHERPA and HEART method [5] because both of these methods discuss the job description in a systematic so get proposed improvement.

2. METHODS

Research conducted in PT "XYZ" which is engaged in manufacturing. The type of research conducted at PT "XYZ" is classified as descriptive research in which the type of research aims to describe systematically, factually and accurately about the facts and the nature of a particular object or population. [6]

The method used in this research is SHERPA (Systematic Human Error Reduction and Prediction Approach) and HEART (Human Error Assessment and Reduction Technique). The SHERPA method is used to predict the human error which would have caused the event to occur. [7-8] While the HEART method is used for the possibility of human error throughout the completion of maintenance tasks.[9]-[10]

This research was conducted with several stages of preliminary research, collecting data, performing data processing, analyzing the results of data processing and finally concluded the research results.

The steps of data processing using SHERPA method are as follows:[11]

1. Step I : Hierarchical Task Analysis (HTA)
2. Step II : Job Classification
3. Step III : Identification of *Human Error*
4. Step IV : Consequences Analysis
5. Step V : Ordinal Error Probability Assessment
6. Step VI : Critical Analysis
7. Step VII : Remedy Analysis Strategy

The steps of data processing using HEART method are as follows:[12]

1. Identify all types of work to be performed by the operator.
2. Categorize each work item into one of the 8 categories in the Generic Task Type (GTT) table.
3. Identify error producing conditions (EPCs) according to the scenario in the EPCs HEART table.

4. Determine the proportion of the effects (APOE) and calculate the value of the assessed effect (AE) of each identified EPCs.
5. Calculate the total value of AE.
6. Calculate the value of human error probability (HEP).

The variables in this study consist of dependent variable and independent variable.

a. Dependent Variables
   Dependent variable on the research is disability in production process
b. Independent Variables

The independent variables in this research are work errors, work procedures, and operator inaccuracy.

3. RESULT AND DISCUSSION

Human Error Prediction Happened with Method of SHERPA (Systematic Human Error Reduction and Prediction Approach)

1. Hierarchical Task Analysis (HTA)
   The first stage to use the SHERPA method in analyzing human error is to compile the entire job list into the HTA diagram so that the work to be analyzed becomes more detailed and systematic.
2. Job Classification
   Each job list that has been described in the HTA diagram is further classified into several types of errors. List of jobs for the mexican door making process in detail can be seen in Table 2.

Table 2. Job Classification in the Mexican Manufacturing Process Works

Code	Description	Classification
1.1	Bringing the partical board to the table	*Action*
1.2	Bringing *liping steal*	*Action*
2.1	Sticking liping steal manually against board the particle place	*Action*
2.2	Making a press with the moulder machine	*Action*
3.1	Bringing assemblies to the rooter machine	*Action*
3.2	Doing engraving with rooter engine	*Action*
4.1	Bringing the door to the assembly table	*Action*
4.2	Bringing the planting lipet to the assembly table	*Action*
4.3	Perform assembly manually	*Action*
5.1	Inspect all the doors	*Checking*
5.2	Performing pelhulan on the perforated part	*Action*
6.1	Flatten the result of the blow with a crank engine	*Action*
7.1	Choosing the color of the piner matches the color of the door	*Selection*
7.2	Doing piner gluing on door	*Action*
8.1	Bring the door to the hot press machine	*Action*
8.2	Doing pressing against the door	*Action*
9.1	Bring the door to the assembly table	*Action*
9.2	Cutting the piner more	*Action*
10.1	Bring the door to the rooter machine	*Action*
10.2	Do the engraving	*Action*
11.1	Smoothing the surface of the carvings with sand paper	*Action*
11.2	Inspection of the entire door	*Checking*
11.3	Pack the door with plastic	*Action*
11.4	Pack the door with cardboard	*Action*

3. Human Error Identification (HEI)
   The procedure for identifying errors is to compile a list of jobs that have been classified into several types of errors in the previous stage according to the appropriate category in the error category table according to the SHERPA method.

4. Consequences Analysis

At this stage, a list of consequences is most likely to occur if an operator's work is included in the type of error. Consequences can be the consequences that will occur in humans, machines, equipment, environment, and even affect the overall work system in case of human error. Here are the results of the identification of the consequences of work.

Table 3. Work Consequences Analysis in Mexicano Manufacturing Process

Error Categories	Consequences
A5	*Partical board is peeling off*
A5	Steal lip that was carried rubbed and not fit anymore
A4	The assembly is not perfect and must be repeated
A1	The pressed door will crack
A7	The job gets long because the operator has to sort again
A7	More putty is used
A5	The job gets long because the operator has to sort again
A5	The assembly is not running
A6	Occurrence of discrepancy against the door
C2	There is a hole door that is not caulked
A4	There is an empty cavity on the door
A6	The door is running low

5. Ordinal Error Probability in Mexicano Manufacturing Process

The ordinal probability values used in the SHERPA method are low, medium, and high. The following table is the ordinal error probability of mexicano door making process.

Table 4. Ordinal Error Probability in Mexicano Manufacturing Process

Code	Ordinal Error Probability	Code	Ordinal Error Probability
1.1	M	**7.1**	L
1.2	L	**7.2**	M
2.1	M	**8.1**	L
2.2	H	**8.2**	H
3.1	L	**9.1**	M
3.2	H	**9.2**	L
4.1	L	**10.1**	L
4.2	M	**10.2**	H
4.3	M	**11.1**	L
5.1	L	**11.2**	M
5.2	M	**11.3**	M
6.1	L	**11.4**	M

6. Critical Analysis

If the resulting error consequences are critical (ie, result in an intolerable loss), then the work item being analyzed should be marked as a critical work item. The sign used as an indication that the error of the analyzed job item is critical is an exclamation point (!), Whereas for non-critical errors it is marked (-).

7. Remedy Analysis
   The next stage is to develop strategic plans and actions that need to be done in order to reduce errors. Strategic plans must be tailored to the consequences, critical levels and probabilities of error. The strategy plan can be seen on Table 5.

Table 5. Remedy Analysis Strategy in Mexicano Manufacturing Process

Code	Critical Level	Strategies	Code	Critical Level	Strategies
1.1	-	Modify or redesign the equipment	**7.1**	-	Operators must be thorough
1.2	-	Conducted training of operators	**7.2**	-	Operators must be thorough
2.1	-	Operators must be thorough	**8.1**	-	Operators must be thorough
2.2	!	Improve skill / skill operator	**8.2**	!	Improve skill / skill operator
3.1	-	Operators must be thorough	**9.1**	-	Operators must be thorough
3.2	-	Operators must be thorough	**9.2**	-	Operators must be thorough
4.1	-	Operators must be thorough	**10.1**	-	Add assembly table
4.2	-	Improve skill / skill operator	**10.2**	-	Operators must be thorough
4.3	-	Operators must be thorough	**11.1**	-	Operators must be thorough
5.1	-	Operators must be thorough	**11.2**	!	Improve skill / skill operator
5.2	-	Redesigned the equipment used so far	**11.3**	-	Conducted training of operators
6.1	-	Operators must be thorough	**11.4**	-	Conducted training of operators

Human Error Assessment and Reduction Technique

1. Identify All Types of Work to Be Carried By Operator
   The job description to be performed by the operator on the processing of mexicano door products can be seen in the data collection.[14]
2. Categorize Each Work Item Into One Of The 8 Existing Categories In Tables Generic Task Type (GTT)
   Following are the categories of each work item in the Generic Task Type (GTT) category followed by Nominal Human Error Probability**.**

Table 6. Category of Work Item and Nominal Value of Human Error Probability on Processing Process of Mexicano Door Products

No Task	Generic Task Type (GTT)	Nominal Human Error Probability	No Task	Generic Task Type (GTT)	Nominal Human Error Probability
1.1	G	0.0004	**7.1**	E	0.02
1.2	G	0.0004	**7.2**	E	0.02
2.1	E	0.02	**8.1**	G	0.0004
2.2	D	0.09	**8.2**	D	0.09
3.1	G	0.0004	**9.1**	G	0.0004
3.2	F	0.003	**9.2**	F	0.003
4.1	G	0.0004	**10.1**	G	0.0004
4.2	G	0.0004	**10.2**	F	0.003
4.3	E	0.02	**11.1**	F	0.003
5.1	D	0.09	**11.2**	D	0.09
5.2	F	0.003	**11.3**	E	0.02
6.1	G	0.0004	**11.4**	E	0,02

3. *Error Producing Conditions* (EPCs) Identification In accordance with Existing Scenarios in Table HEART EPCs

   Error Producing Conditions (EPCs) have become much easier to quantify information has become available. [15]-[18] Based on the results of observations and direct interviews it can be described EPCs that affect the failure rate of operators in the process of mexicano door product processing are as follows:

a. Category I
   - EPCs number 7, ie there is no clear procedure in correcting unintentional errors of work.
   - EPCs number 9, which is required a technique (way) that is different from usual in doing the job.
   - EPCs number 15, ie inexperienced operators (new operators who have been qualified in performing their work but not yet experts). Based on the results of interviews, operators do understand the procedure but still slow in terms of workmanship.
   - EPCs number 17, ie independent checks of output little or may not be checked.

b. Category II
   - EPCs number 20, ie the education level of the operator is not in accordance with the needs of work that should be.
   - EPCs number 25, ie allocation of duties and responsibilities is not clear. At the time of the observation, often the operators working in the inspection section do work that is not his job..

4. Determining the Proportion of Effects (APOE) and Calculating the Assessed Effect (AE) Value of Each EPCs that Have Been Identified

Assessed Proportion of Effect (APOE) value and Assessed Effect (AE) value calculation for processing of mexicano door products can be seen on Table 7.

Table 7. Securities Proportion Value (APOE) and AE Calculation in the Door Product Processing Process Mexicano

Serial Number (Table EPCs)	Max. Effect	APOE	AE ((Max. Effect-1) x APOE)+1)
7	8	0.6	((8-1) x 0.6) + 1) = 5.1
9	6	0.3	((6-1) x 0.3) + 1) = 2.5
5	3	0.4	((3-1) x 0.4) + 1) = 1.8
17	3	0.4	((3-1) x 0.4) + 1) = 1.8
20	2	0.2	((2-1) x 0.2) + 1) = 1.2
25	1.6	0.2	((1.6-1) x 0.2) + 1) = 1.32

5. Calculating the Total AE Value

   The total AE value is calculated using the equation:

   Total AE = AE1 x AE2 x AE3 x ... x AEn

   where n is the number of AEs identified as EPCs factors.

   The calculation of the total value of AE for the operator on the processing of mexicano door products is:

   Total AE = 5,1 x 2,5 x 1,8 x 1,8 x 1,2 x 1,32 = 65.435

6. Calculating *Human Error Probability* (HEP)

   Human Error Probability (HEP) is calculated using the equation **:**

   HEP = Nominal HEP x Total AE

   The HEP value for each mexicano door product processing task can be seen in Table 8.

Tabel 8. Nominal Human Error Probability of Mexicano Manufacturing Process

Generic Task Type (GTT)	Nominal Human Error Probability	HEP	Generic Task Type (GTT)	Human Error Probability	HEP
G	0.0004	0.0261	**E**	0.02	1.3087
G	0.0004	0.0261	**E**	0.02	1.3087
E	0.02	1.3087	**G**	0.0004	0.0261
D	0.09	5.8891	**D**	0.09	5.8891
G	0.0004	0.0261	**G**	0.0004	0.0261
F	0.003	0.1963	**F**	0.003	0.1963
G	0.0004	0.0261	**G**	0.0004	0.0261
G	0.0004	0.0261	**F**	0.003	0.1963
E	0.02	1.3087	**F**	0.003	0.1963
D	0.09	5.8891	**D**	0.09	5.8891
F	0.003	0.1963	**E**	0.02	1.3087
G	0.0004	0.0261	**E**	0,02	1,3087

4. CONCLUSION

The conclusions that can be obtained from the research conducted are as follows:

1. Based on the results of qualitative research with the SHERPA method, the critical work item is the activity of pressing with the moulder machine (2.2), Doing the door pressing (8.2), inspection of the whole door (11.2)
2. Based on the assessment by the HEART method, the total value of HEP for the operator is 0.4986.
3. Based on the results of the analysis with qualitative and quantitative methods then the improvement that can be done is to improve skills / skill operator and operator more thoroughly in mexicano door production process.

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