Human Reliability Assessment Analysis with Human Error Assessment and Reduction Technique (HEART) Method on Sterilizer Station at XYZ Company

Chalis Fajri Hasibuan, Yudi Daeng P, Reza Rinaldi Hasibuan
Industrial Engineering Department, Faculty Of Engineering, Universitas Medan Area, Indonesia
chalisfajri@yahoo.co.id

Abstract. The matter of human reliability is a subject that has great influence on work-related accident levels or productivity levels of a product. Work-related accidents at XYZ company has 3 types of accidents that occur at boiling station and most of it are caused by human error from work operators, such as boiling overtime, lorry that went off track, inputting inaccurate boiling pressure standards, low discipline levels, not using protection equipment. XYZ company is one of many companies that processes palm oil. Human Reliability Assessment is done using HEART (Human Error Assessment and Reduction Technique) method. At first, an analysis is done on work operator’s tasks by organizing HTA (Hierarchical Task Analysis). The resultant description of tasks at boiling station reveal that there is 11 tasks being handled by operator. Based on the calculation, the value of HEP (Human Error Probability) is highest on setting boiling time task with the value of 0.5324. The second highest is 0.5251 on setting steam pressure task. Researcher has analysed which task with the highest HEP value using Fishbone diagram, and continues to compile prevention methods for human error based from EPC, HEP, and Fishbone diagram.

1. Introduction
The HRA method that is being used in this research is HEART (Human Error Assessment and Reduction Technique) which is a part of quantifying human reliability method developed by Williams on 1985. HEART is proven to be more advantageous due to its flexible implementation in various situation or industry such as chemical, aviation, oil, medical field and so [1]. HEART method describes the task that should be done by an operator and its difficulty well and detailed [2]. This method has also been tested for its validity [3], where his research results claims that HEART method has an acceptable level of accuracy. Human Reliability Assessment done with HEART method is a technique aiming to evaluate the possibility of human error that occurs during completing a certain task, with the basis that each time a task is completed, there is a chance of failure that is being influenced by one or more EPC (Error Producing Condition) such as fatigue, unstable work place, etc. These factors that has significant influence to performance is graded with the highest HEP value. These conditions then can be implemented to “best-case scenario” then calculating the probability of failure under the ideal condition to receive the final chances of errors.

The calculated result will help in communicating the chance of error in analysing higher risks or safety cases. HEART method also has an indirect effect on how to increase reliability from ergonomic stand point.
HEART method is a technique aiming to evaluate the possibility of human error that occurs during completing a certain task, with the basis that each time a task is completed, there is a chance of failure that is being influenced by one or more EPC (Error Producing Condition) such as fatigue, unstable work place, etc. These factors that has significant influence to performance is graded with the highest HEP value. HEART method is built upon several subjects, which are:
1. Human reliability depends on generic nature of the tasks that should be completed.
2. In ideal conditions, reliability levels that is reached tends to be consistent with nominal probability in probabilistic limit.
3. Considering that ideal conditions cannot be reached in every situation, human reliability can be predicted to decrease as the identification of EPC increase.[4]

2. Methods of Research:
The type of research that is being used in this journal is descriptive research. This research is done at XYZ company that moves in palm oil production. This research is done at Boiling Station. First, researcher identifies tasks done by operator at boiling station using HTA (Hierarchical Task Analysis). And then researcher will identify failure or human error at boiling station. Afterwards, researcher will grade Human Error Probability (HEP) with HEART method. This method is done in several stage by classifying tasks into generic task. Subsequently identifying conditions that cause errors with EPC (Error Producing Conditions). In the end, predicting the effect of every EPC with value of Assessed Proportion, Assessed Proportion value can be obtained from interview experts to list tasks at boiling station. The final stage is calculating Assessed effect and HEP (Human Error Probability) value.

In HEART method, there a several stages to be completed am the first stage is HTA (Hierarchy Task Analysis). According to Mandal, et al. The First Stage is the identification work process which is crucial to do. If the process does not divide into sub-processes, it would result in unidentified cause when drafting alternative solutions and would leave errors unchecked in those processes.

The second stage of this method is to classify the tasks that has been analyzed into nominal levels according to tasks unreliability. Classifying the tasks into its general categorization and inputting the nominal value of its level of human unreliability corresponding to table 1

| Code | Task Category                                                                 | Nominal Human Unreliability |
|------|-------------------------------------------------------------------------------|------------------------------|
| A    | Totally unfamiliar, performed at speed with no real idea of likely consequences | 0.55                         |
| B    | Shift or restore system to a new or original state on a single attempt without supervision or procedures | 0.26                         |
| C    | Complex task requiring high level of comprehension and skill                   | 0.16                         |
| D    | Fairly simple task performed rapidly or given scant attention                 | 0.09                         |
| E    | Routine, highly practised, rapid task involving relatively low level of skill | 0.02                         |
| F    | Restore or shift a system to original or new state following procedures, with some checking | 0.003                        |
3. **Result and Discussion**

Form calculation human error probability in XYZ company can see in Table 2.
Based on figure 1, it could be seen the highest rated HEP type of task to the lower one.

Figure 1. Order of HEP values from high to low.

Based from measurement from the HEART method, the biggest HEP (Human Error Probability was on the task which set the boiling time, which at the value of 0.5324, where the failure
deemed from a very small or too much amount of time spending on boiling. The second highest HEP value was on the task which putting in and out steam (setting steam pressure), at the number 0.5251. Then the total HEP would be analysed using the fishbone diagram to determine the cause and factor which contributes to the operator failure in performing the task.

Figure 2. Fishbone Diagram for Stew/Sterilizer Time Settings

Based on HEP data, researchers would analyze the factor which contributes into failure of the task using fishbone diagram.

a. Human

Related causes from the human side were education background, where in performing the task, knowledge and skill is needed. Age of the operator would contribute a critical aspect on the endurance of the operator, the older they get, the lower the productivity rate, and at a risk of faster rate in getting tired and lower the concentration. Low concentration would increase the failure rate. Hot environment causing dehydration and unavailability of drinks play a critical role also in the rate of failure.

b. Machine

Figure 3. Fishbone Diagram for Regulator Steam Pressure
Rarity of checking up the boiling control machine causing failure of the machine. When there is malfunction of the machine and can’t be used, operator forced to do the task manually, leading into higher human error rate when performing the task, such as setting the steam pressure which didn’t meet the standard, or wrongly setting the boiling time, etc.

c. Environment

Environment in the boiling station isn’t suitable as a working environment, caused by steam leaking out of pipes from steam turbine to boiler, causing distraction to operator and making the work environment hotter, thus lowering concentration. Temperature also affect operator at various degree (Wignjosoebroto, 2008);

1. ± 49° C: Operator could endure it at least for 1 hour, even though it exceeds the physical and mental endurance.
2. ± 30 ° C: mental and concentration lowers, and tend to make mistake in performing the task, and causing physical fatigue.
3. ± 24 ° C: optimum condition.
4. ± 10 ° C: extreme weird physical behavior would be apparent.

Temperature at the boiling station would range between 30 ° C - 34 ° C, causing fatigue on physical mental state and increasing the tendency of making mistake. In the hot environment it also increases injury or work accident related to dehydration.

d. Equipment

The broken boiling control machine forcing the operators to manually setting the boiling time cycle which had 3 peak boiling time. When there’s unavailability of the boiler setting machine, operator would assume and count the boiling time with the working clock at the working space, leading to a very short amount or exceed the boiling time, inaccuracy in putting in steam, etc. The mistake committed by operators would contribute into lowering the productivity in the boiling station or lowering the desired oil result from boiling.

Broken Thermometer and Rototherm would impact the performance of operator who can’t determine the exact temperature or pressure fit for boiling thus using manual means by feeling and assuming it, thus lowering the productivity of TBS (Tandan Buah Segar) from boiling.

e. Rules

The faulty company management in organizing the operators contribute into less disciplined operator. A lot of reports not using the protective equipment, thus causing work accident. Operator working on the boiling station reports of getting injured by steam caused by leaking pipe, opening hose or the steam pressure regulating pipe without protective equipment such as gloves, which lead into injury and work accident.

4. Conclusion

Factors which contributes into the rate of operator failure in performing the task in boiling station are as follows. Age of operator plays an important role into stamina and endurance of the operator, the older they get the lower the productivity and the faster getting tired thus causing low concentration which increasing the high rate of human error. Education plays an important role because in performing the task knowledge, discipline and skill in performing the task. Operators in the boiling station still haven’t the required amount of discipline, caused by unused Protection Equipment, Equipment and Machine, plays a critical role in the rate of human error, due to broken machine and equipment in the boiling station forcing the operators using manual means and feeling without the help of the equipment/machine, leading to mistake in the boiling time, too much steam pressure, etc., The type of task also become a contributing factor an operator commits a mistake or not. Harder tasks need more people to finish it, and it counts on the age of operator, equipment/machine, and operator’s education. And Based on the result of HEART (Human Error Assessment and Reduction Technique),
the task with the highest HEP is setting the boiling time, at the number 0.5323, then followed by putting in and out the steam, at the number 0.5251.

5. References
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