Measurement of operator reliability level using the Human Error Assessment and Reduction Technique (HEART) method

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Abstract. Workers can cause harm to the company caused by human error. Human error has a close relationship with the level of reliability of a worker. One result of the low level of reliability of workers is product defects. PT. X is a company that manufactures engine and molding spare parts and dies, using automatic machinery. There are defective products on production, with an average number of defects of 1.2% per month above the disability tolerance set by the company of 0.2%. The types of defects in the product are corrugated surfaces, rough surfaces, mismatched pieces, inaccurate sizes, and the presence of foreign matter attached to the product. This product defect occurs in the milling machine. This study aims to determine the level of operator reliability at the milling work station that affects production results. This research is a descriptive qualitative research using the Human Error Assessment and Reduction Technique (HEART) method to determine the level of operator reliability. The biggest HEP measurement results experienced by each operator is when the activity is set up and operating the machine by the program, which ranges from 0.7936 to 0.9104. The level of reliability (Rm) for operators 1, 2, 3 has a value of Rm in succession of 0.4350; 0.3627; .2005. Rm value <0.5 indicates the level of reliability which is categorized as low. This low level of reliability is caused by the absence of work procedure standards, lack of supervision of operator performance, low work morale, lack of operator experience, and no effective communication between the operator and programmer when inputting coding on the machine.

1. Introduction
Humans are an important resource in production activities, which can produce value-added products for companies but can also result in losses caused by human error. Human error is defined as a failure to complete a specific task or job so that it can cause disruption to the operating schedule or cause damage to objects and equipment [1,2]. Human error has a close relationship with the level of reliability of a worker (human reliability). The level of reliability of workers (human reliability) is the ability of a person to do a task with success determined by certain requirements [1].

PT. X is a company that produces machinery and molding parts and dies with a very high degree of precision and complicated contours. The production process is carried out using automatic machines that have a high level of accuracy and accuracy. Nevertheless, the role of the operator in setting the machine is very influential in the production results. Production results found defective products, with an average number of defects of 1.2% per month above the disability tolerance set by the company of...
0.2%. The types of defects in the product are corrugated surfaces, rough surfaces, mismatched pieces, inaccurate sizes, and the presence of foreign matter attached to the product. This product defect occurs in the milling machine. Therefore, this study aims to analyze the level of operator reliability at the milling work station to minimize errors.

2. Method
This research is descriptive qualitative research using the Human Error Assessing and Reduction Technique (HEART) method to determine the operator's reliability level. Measurements were made on 3 male operators using CNC Milling with work experience > 3 months, operator age between 18 - 39 years. The milling process is carried out by transferring programs and drawings that have been made, previously set-up the machine, checking the coolant, ensuring the lubrication function is operating properly, cleaning the machine, setting-up of raw materials, set-up and operating the machine according to the program.

The HEART method was first introduced by Williams in 1985 when he worked on the Central Electricity Generating Board [3-6]. HEART is one of the human error quantification methods. This method has proven to be a simple and versatile technique for evaluating human error in various safety studies relevant to complex systems [6-8]. HEART is designed as a method of quantifying the risk of human error that is fast, simple and easily understood by engineers and human factors specialists [6]. This method considers that human reliability is considered to depend on the task performed [2,6,9]. HEART has been used by various organizations for human reliability assessment, cost-effective design, and operational performance decision making. The weakness of the HEART method is that it is subjective so that the results obtained from one researcher to another are not necessarily the same. The steps in conducting the HEART [4,7,10] method are as follows:

- Classify the types of tasks/jobs into Generic Categories contained in the HEART table
- Determine Error Producing Conditions (EPCs)
- Calculate HEP value
- Value of Human Error Probability on HEART as follows:
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- Determine Error Producing Conditions (EPCs)
- Calculate HEP value
- Value of Human Error Probability on HEART as follows:

\[
Assessed\ Effect = ((Total\ HEART\ Effect - 1) \times PoA) + 1 \tag{1}
\]

\[
Assessed\ Nominal\ of\ Failure/HEP = NHU \times \prod_{i=1}^{n} APOE \tag{2}
\]

- Calculating the level of reliability
- After the HEP value is obtained, it then determines the operator's reliability level. It is known that the level of reliability can be calculated by the following equation

\[
R (Reliability) = 1 - HEP \tag{3}
\]

The above calculation applies to subsequent tasks that have possible errors. So the value of system reliability is the result of multiplication of each value of reliability

\[
Rm = \prod_{i} R_i \tag{4}
\]

If \( Rm \leq 0.5 \), the operator's reliability in carrying out work instructions falls into the low category, if \( Rm \geq 0.5 \), the operator's reliability can be categorized high.
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\[ Rm = \prod_i R_i \]  \hspace{1cm} (6)

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3. Result and discussion

The stages of the HEART method to determine the level of reliability of operators/workers: (a) classification of types of jobs/jobs generic Categories, (b) determine Error Producing Conditions (EPCs), (c) determine the value of proportion (PoA), (d) calculate the value of HEP, and (e) calculate the level of reliability. Human error probability calculation is done by observing the generic job by paying attention to the level of errors that occur and adjusted to the EPC table. Proportion values range from 0-1 (0 = low / low and 1 = high / high).

Recapitulation of the calculation of human error probability (HEP) and the level of reliability of respondents from each stage of the machine operation process can be seen in Table 1.

| Machine Operation Process Description                  | 1st Respondent | 2nd Respondent | 3rd Respondent |
|--------------------------------------------------------|----------------|----------------|----------------|
| Reset the machine to the origin position               | 0.0230         | 0.0095         | 0.0152         |
| Conduct coolant checks                                | 0.0874         | 0.0874         | 0.0978         |
| Ensure the lubrication function is operating properly | 0.0874         | 0.0874         | 0.1083         |
| Ensuring guaranteed engine cleanliness                | 0.0721         | 0.0721         | 0.0657         |
| Set up of raw materials                               | 0.0097         | 0.0128         | 0.0193         |
| Set up and operate the machine according to the program| 0.7936         | 0.8711         | 0.9104         |
| Total Reliability \( Rm \)                            | 0.1543         | 0.0974         | 0.0650         |

Based on the calculation results, the largest HEP experienced by each operator is set-up and operating the machine under the program, namely the 1st HEP Respondent is 0.7936, the 2nd HEP Respondent is 0.8711 and the 3rd HEP Respondent is 0.9104. If the HEP gets bigger, the value of human reliability (\( R_i \)) will have a small value and if the HEP gets smaller, the value of human reliability (\( R_i \)) will be even greater.

| Respondent | \( Rm \) | Information |
|------------|----------|-------------|
| 1          | 0.1543   | low         |
| 2          | 0.0974   | low         |
| 3          | 0.0650   | low         |

Based on the recapitulation results of the level of reliability of each respondent in carrying out work instructions are categorized as low, the value of each \( Rm \) of each respondent <0.5. These results indicate...
that there needs to be an increase in the operator's level of reliability when carrying out work activities at the milling work station.

Low reliability is due to the absence of tools or work procedures that explain the working procedures, lack of supervision, lack of experience and lack of communication between operators and programmers in the input coding activity on the machine. Therefore it is necessary to improve the work system of the company, namely the proposed design of work methods in the form of training and supervision called (on the job training), improvement of work instructions that can improve the reliability of the operator in working and design standard operating procedures (SOP) to facilitate the operator in carrying out activities at the milling work station.

4. Conclusion
The conclusions from the results of this study are as follows:

- The current work methods carried out by the company can cause conditions for errors caused by the operator when carrying out work instructions. This is because it takes good skills and experience to be able to operate a CNC milling machine.
- The operator's level of reliability when operating the machine has a low category because of $R_m < 0.5$. This is affected because the conditions experienced by the operator can produce errors (EPCs), so it is necessary to increase operational reliability by eliminating the error conditions (EPCs).

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