Human error analysis using sherpa and heart method in Batik Cap production process

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Abstract. The batik industry is one of the creative industries which development keeps increasing every year. Almost all of Batik Cap production process activities are done manually. Therefore, production operators play an important role in influencing the quality of Batik Cap. This research was conducted to identify the human error factor that happened in the Batik Cap production process using SHERPA and HEART method. The potential for human error that occurs is described with SHERPA tabulation. The human error assessment is calculated using the HEART method of human error probability value that occurs in the production process operator. The result of this research is 26 potential errors of overall activity in 6 work stations divided into 19 error in action error, 5 error on checking error and 2 error in selecting error. The highest probability of human error value in stamping the work station on the fabric stamping activity.

Keywords: Batik Cap, Human Error, SHERPA, HEART

1. Introduction
Human Reliability is the probability of human success in carrying out his work elements. The goal is to identify high-risk areas, identify the factors that lead to human error and how to repair an existing system so as to reduce adverse human error and pose a hazard. The most commonly used method is Systematic Human Error Reduction and Prediction (SHERPA) because it is suitable for errors related to human skills and habits, more detailed and consistent in error identification. The next method is Human Error Assessment and Reduction Technique (HEART) is a method designed as a method of quantifying human error risk quickly, simply and easily understood by engineers and human factors specialists [1]. Small businesses Batik Supiyarso in the District Laweyan Surakarta, where the process of making Batik done with the stamping known as Batik Cap. Stages of the production process are the process of cutting the fabric, the process of stamping, the coloring process, the "penglorodan" process, the process of drying, and the process of arrangement of batik fabric [2]. Produced batik quality is determined by the quality of the process being undertaken and also the quality of raw materials. The most influential production process of batik quality in outline occurs in the stamping and coloring. In the coloring section, the most common defects are in the form of uneven color gradations (5%), curved fabric (2%), and uneven dyeing (3%) [3]. Research in the textile industry with the highest Human Error probability results in Dyeing Department at occupation number 6, human error probability value 54.4% [4].

Humans have limitations in their work to make mistakes. Analysis of the occurrence of human error associated with skills and habits more detailed and consistent in the identification of errors using
the input hierarchy of the basic level task is the method of SHERPA \cite{5}\cite{6}. While the HEART method is used in determining the chances of error in every job activity \cite{7}. The HEART method is based on the principle that every time a task is performed there is a possibility of failure and this possibility is affected by one or more EPC (Error Producing Condition), the factors that have a significant effect on performance are indicated by the largest HEP value. This condition can then be applied to the best-case scenario of the estimated probability of failure under ideal conditions to then get a chance of final error \cite{8}.

This study attempted to find an alternative quality improvement of batik produced by identifying the possibility of human error that occurs in the process of Batik Cap so that it can be searched way to reduce the existence of the error.

2. Method

This study was conducted to identify the type of error operator/human error that contribute to the occurrence of defective products. Also to know the magnitude of operator error probability in every product defect event.

The data was collected through interviews directly to the person in charge of production and 9 operators by giving a questionnaire to determine the frequency of factors causing the error to occur, ie 0 to 1 value for each of the driving factors. The assessment range is the range of the probability value of the contribution to the occurrence of human error in order to assess the value of APOA (Assessed Proportion of Affect) by determining the probability value of error for each factor that has been identified.

After the data successfully collected proceed to the stage of data processing, namely:

1) Hierarchical Task Analysis (HTA). Error identification data is then performed breakdown task into sub-task using HTA which is used as reference determination identification of the work failure operator.

2) Data Processing SHERPA

   a) Human Error Identification (HEI), HTA Data is used to identify errors related to human error using SHERPA Error Mode table reference.
   b) Consequence Analysis, which occurs due to human error that may occur.
   c) Ordinal Analysis Probability, indicated by low, medium, and high.
   d) Analysis of Strategy, explains remedial solutions to overcome human error which may occur.

3) HEART Data Processing

   a) Classify the task type to one of 8 GTT categories. HTA data used for the identification of errors related to human error using the reference table owned by GTT HEART.
   b) Determine EPCs and APOA. The result of error identification is translated into EPCs language to determine EPC value and used as a reference for a questionnaire to determine APOA value.
   c) Calculates the HEP value. To determine the highest error probability level of each work station.

3. Results and Discussion

Making HTA for 6 work stations making Batik Cap. Mori Cutting Working Station with 2 female workers, 35-40 years old. Stamping Working Station with 5 male workers, age 48-60 years old. Coloring Working Station with 2 male workers, 35-37 years of age. Penglorodan Working Station, with 1 male worker, age 55 years. Drying Working Station, with 1 male worker, 37 years old. Batik Stacking Working Station with 1 female worker, age 56 years.
Table 1. Hierarchical Task Analysis In “Batik Cap” making Process

| Working Station           | Hierarchical Task Analysis                                                                 |
|---------------------------|-------------------------------------------------------------------------------------------|
| 1. Mori Fabric Cutting    | 1.1. Measuring Fabrics                                                                   |
|                           | 1.2. Cutting Fabrics                                                                     |
|                           | 1.3. Stacking Fabrics on Hangers                                                         |
| 2. Stamping               | 2.1. Cutting the Wax                                                                      |
|                           | 2.2. Setting up the work table                                                           |
|                           | 2.3. Installing Fabrics on the Work Desk                                                 |
|                           | 2.4. Taste the Fabrics                                                                   |
|                           | 2.5. Folding Fabrics that have been stamped                                              |
| 3. Coloring               | 3.1. Color mixing                                                                        |
|                           | 3.2. Pouring colors into Peder Machine                                                    |
|                           | 3.3. Installing a fabric                                                                 |
|                           | 3.4. Coloring and Color Locking Process                                                   |
| 4. Penglorodan            | 4.1. Boiling Fabrics                                                                     |
|                           | 4.2. Washing Fabrics                                                                     |
| 5. Drying                 | 5.1. Lifting Fabrics to the Dryer                                                         |
|                           | 5.2. Pulling Fabrics from the Dryer                                                       |
| 6. Stacking Batik Fabrics | 6.1. Sorting Fabrics                                                                     |
|                           | 6.2. Packing Fabrics                                                                     |

The data of work failure identification was obtained from an interview and brainstorming with Batik business owners and also with a total of 9 employees (Table 2).

Table 2. Identification of Operator’s Working Failure

| Activity Description | Failure Description | Cause of Failure                                                                 | Failure Effect                  | Corrective action |
|----------------------|---------------------|----------------------------------------------------------------------------------|---------------------------------|-------------------|
| 1.1 Measuring Fabrics| Incorrect size of fabric | The operator forgot to count the size The operator is not focused due to the intervention of the other party | The wrong size of fabric / missed | Repeat again       |
| 1.2 Cutting Fabrics  | Fabric is hard to cut Pieces of fabric are not symmetrical | The cutter/scissors are not sharp The operator is not used to cutting The operator is not focused due to the intervention of the other party | Cain defects                  | Cutting the defect fabric |
| 1.3 Stacking Fabrics on Hangers | There are pieces of fabrics that are still folded / not tidy | The operator did not inspect the fabric after it was laid out The operator hurried when setting the fabric | Fabric is not tidy, hard to taste | Repeat again       |
| 2.1 Cutting the Wax  | The operator did not cut the wax | Cutlery can not be used | It will not fit in the frying pan | Sharpen the cutting tool |
| 2.2 Preparing the Work Desk | Plastic cover of wet foam torned | The operator did not check the desk when it’s going to be used The operator is less aware because of their age | Wet fabric can not be stamped | Drain the fabric |
| 2.3 Stacking Fabrics on the Work Desk | There are pieces of fabrics that are still folded | The operator missed to check the fabric The operator hurried when setting up the fabric | Fabric is not tidy, hard to taste | Repeat again       |
| No   | Task                          | Activity Description                  | Failure Description          | Cause of Failure                                                                 | Failure Effect                      | Corrective action |
|------|-------------------------------|---------------------------------------|------------------------------|---------------------------------------------------------------------------------|-------------------------------------|-------------------|
| 2.4  | Stamping the Fabrics          | Wrong stamping                       | The stamping tool can not be used | The operator hurriedly stamping the fabric                                      | The tasting does not fit the motive | Can not be fixed |
|      |                               |                                       |                              | Operators are less aware because of their age                                   |                                     |                   |
| 2.5  | Folding the stamped fabrics   | The operator folds the fabric imperfectly | The operator hurried while folding the fabric | Damage the wax on the fabric                                                      | Repeat again                      |                   |
| 3.1  | Color mixing                  | Incorrect color                       | The operator did not check the results | Less experienced operators                                                      | Caint defects                      | Repeat            |
| 3.2  | Pouring Color into Peder Machine | The operator pours the color with a less precise dose | The operator hurries when pouring colors | Spilled color solution                                                           | Can not be fixed                  |                   |
| 3.3  | Laying the Fabrics            | The operator puts the fabric in the wrong position | The operator is not accustomed to installing the fabric to the peder | Fabric wrinkled                                                                  | Can not be fixed                  |                   |
| 3.4  | Coloring and Color Locking Process | Uneven or dirty staining results     | Did not do color testing on fabric | Fabric color does not match                                                     | Can not be fixed                  |                   |
|      |                               |                                       | Inexperienced operator         | Peder machine not cleaned                                                        |                                     |                   |
| 4.1  | Boiling Fabrics               | The color of the fabric is faded      | Boiling too long               | The color of the fabric is faded                                                | Can not be fixed                  |                   |
|      |                               |                                       | Too much starch solution       |                                                                                  |                                     |                   |
|      | Washing Fabrics               | Waxes are still attached              | Boiling is not stirred continuously | Waxes are still attached                                                          | Repeat again                      |                   |
|      |                               |                                       | Too little starch solution     |                                                                                  |                                     |                   |
| 5.1  | Lifting Fabrics into Dryer    | Uneven drying                        | The operator does not level the fabric in the dryer | Inhibits work                                                                  | Repeat again                      |                   |
| 5.2  | Pulling Fabrics from the Dryer| Uneven drying                        | The operator did not pull the fabric on the dryer | Inhibits work                                                                  | Repeat again                      |                   |
| 6.1  | Sorting Fabrics               | False sorting of good/bad quality fabrics | The operator did not check thoroughly | Incorrect placement of fabric sort                                               | Complete check                     |                   |
| 6.2  | Packing Fabrics               | The packaging is not strong           | The operator hurriedly packs batik fabric | The packaging results are easily removed                                        | Re-checking                       |                   |

After making HTA and collecting work failure identification data, it is then used as a reference for making a tabulation of SHERPA (Table 3).
| Task number | Task | Error Mode | Error Description | Consequences | Correction | Error Probability |
|------------|------|------------|------------------|--------------|------------|------------------|
| 1.1        | Measuring Fabrics | A8 | The operator did not measure the size of the fabric | Inhibits work | Repeat again | Low              |
|            |      | A2 | The operator wrongly calculates the size of the fabric | Inhibits work | Repeat again | Medium           |
|            |      | A7 | The operator cuts the fabric not straight | Fabric defects | Cut out a defective fabric | Medium           |
| 1.2        | Cutting Fabrics  | C2 | The operator did not check the crumpled fabric | Difficult to be stamped | Repeat again | Low              |
| 1.3        | Stacking Fabric on Hangers | A8 | The operator Did not give the fabric on the wet sponge | Interfere the work | Wetting the sponge | Low              |
|            |      | C2 | The fabric is hollow | Wet fabric can not be stamped | Replace the glass fabric | Medium           |
| 2.1        | Cut out the candle | A8 | The operator Did not cut the wax | It is not fit in the frying pan | Cut out the candle | Low              |
| 2.2        | Prepare the Work Desk | A8 | The operator did not wet the sponge with water | Interfere the work | Wetting the sponge | Low              |
|            |      | A8 | The operator Did not give the fabric on the wet sponge | Interfere the work | Do it again | Low              |
|            |      | C2 | The fabric is hollow | Wet fabric can not be stamped | Wet fabric can not be stamped | Medium           |
| 2.3        | Stacking Fabrics at the Work Desk | A9 | The operator organizes the fabric not straight | Inhibits work | Repeat again | High             |
| 2.4        | Taste the Fabrics | A7 | The Operator wrongly stamped the motive | wrong fabric motive | Can not be fixed | Medium           |
| 2.5        | Folding Stamped Fabrics | A9 | The operator folds the fabric not thoroughly | Damage the wax on the fabric | Can not be fixed | Medium           |
| 3.1        | Color mix | S2 | The operator chooses a wrong mix | Fabric color is wrong | Do it again | Medium           |
| 3.2        | Pouring Color to Water Glass | A6 | The operator pours the colors not on the color box | Color does not appear | Do it again | Low              |
| 3.3        | Laying Fabric | A2 | The operator did not tie the fabric to the clamp | Inhibits work | Do it again | Low              |
| 3.4        | Coloring and Color Locking Process | C1 | The operator did not clean the peder | Color does not match | Can not be fixed | Medium           |
| 4.1        | Boiling Fabrics | A8 | The operator did not pour the starch solution | Waxes stuck together again | Repeat again | Low              |
|            |      | A4 | The dose of starch solution is less | Waxes are still attached | Repeat again | Medium           |
|            |      | A4 | The dose of starch solution is excess | The color of the fabric is faded | Can not be fixed | Low              |
|            |      | A8 | Not stirring at the time of penglorodan | Waxes are still attached | Repeat again | Low              |
| 4.2        | Washing Fabrics | C2 | Checking of fabric is incomplete | Waxes are still attached | Repeat again | Low              |
| 5.1        | Lifting Fabric to Dryer | A9 | Not leveling the fabric in the fabric | Uneven drying | Repeat again | Low              |
| 5.2        | Pulling Fabric from the Dryer | A2 | Not pulling fabric from the dryer | Uneven drying | Repeat again | Low              |
| 6.1        | Sorting Batik Fabric | A4 | Wrong choosing good/bad quality fabric | Incorrect packing location | Recheck | Low              |
| 6.2        | Packing Batik Fabric | A4 | Not folding in the same size | Not tidy | Repeat again | Medium           |
|            |      | A3 | Packaging is not strong | The packaging results are easy to open | Repeat again | Low              |
After making HTA, the lowest level of HTA is used as a reference in HEART data processing (Table 4).

Table 4. Calculation of Human Error Assessment and Reduction Technique

| Task | Generic Task | Human Unreliability Value | Calculation | HEP  |
|------|--------------|--------------------------|-------------|------|
|      | E            | 0.02                     | EPC 16      | 0.032768 |
| 1.1  |              |                          | Total HEART Effect 36 |   |
|      |              |                          | Proportion 0.106 |   |
|      |              |                          | Assessed Effect 1.024 |   |
|      | E            | 0.02                     | EPC 23      | 0.0270766 |
| 1.2  |              |                          | Total HEART Effect 31 |   |
|      |              |                          | Proportion 0.106 |   |
|      |              |                          | Assessed Effect 1.018 |   |
|      | E            | 0.02                     | EPC 31      | 0.0211744 |
| 1.3  |              |                          | Total HEART Effect 36 |   |
|      |              |                          | Proportion 0.106 |   |
|      |              |                          | Assessed Effect 1.018 |   |
|      | E            | 0.02                     | EPC 23      | 0.0236 |
| 2.1  |              |                          | Total HEART Effect 16 |   |
|      |              |                          | Proportion 0.106 |   |
|      |              |                          | Assessed Effect 1.118 |   |
|      | E            | 0.02                     | EPC 17      | 0.04032 |
| 2.2  |              |                          | Total HEART Effect 38 |   |
|      |              |                          | Proportion 0.106 |   |
|      |              |                          | Assessed Effect 1.008 |   |
|      | E            | 0.02                     | EPC 17      | 0.044592 |
| 2.3  |              |                          | Total HEART Effect 36 |   |
|      |              |                          | Proportion 0.106 |   |
|      |              |                          | Assessed Effect 1.018 |   |
|      | E            | 0.02                     | EPC 15      | 0.0513 |
| 2.4  |              |                          | Total HEART Effect 23 |   |
|      |              |                          | Proportion 0.106 |   |
|      |              |                          | Assessed Effect 1.118 |   |
|      | E            | 0.02                     | EPC 31      | 0.0228 |
| 2.5  |              |                          | Total HEART Effect 36 |   |
|      |              |                          | Proportion 0.106 |   |
|      |              |                          | Assessed Effect 1.018 |   |
|      | E            | 0.02                     | EPC 31      | 0.0354 |
| 3.1  |              |                          | Total HEART Effect 17 |   |
|      |              |                          | Proportion 0.106 |   |
|      |              |                          | Assessed Effect 1.024 |   |
|      | E            | 0.02                     | EPC 31      | 0.02036 |
| 3.2  |              |                          | Total HEART Effect 1.06 |   |
|      |              |                          | Proportion 0.106 |   |
|      |              |                          | Assessed Effect 1.018 |   |
|      | E            | 0.02                     | EPC 31      | 0.0228 |
| 3.3  |              |                          | Total HEART Effect 1.06 |   |
|      |              |                          | Proportion 0.106 |   |
|      |              |                          | Assessed Effect 1.018 |   |
|      | E            | 0.02                     | EPC 17      | 0.0354 |
| 3.4  |              |                          | Total HEART Effect 31 |   |
|      |              |                          | Proportion 0.106 |   |
|      |              |                          | Assessed Effect 1.024 |   |
|      | E            | 0.02                     | EPC 31      | 0.02442 |
| 4.1  |              |                          | Total HEART Effect 1.06 |   |
|      |              |                          | Proportion 0.106 |   |
|      |              |                          | Assessed Effect 1.102 |   |
Based on observations and interviews that is tabulated in the SHERPA tabulation (Table 5).

**Table 5. Classification of Error Types**

| Number | Error Types    | Total |
|--------|----------------|-------|
| 1      | Action Error   | 19    |
| 2      | Checking Error | 5     |
| 3      | Selecting Error| 2     |

Based on Table 5, the total of 18 tasks generated 26 error descriptions which are included in 3 types of errors classified according to SHERPA error mode ie error in action error, checking error and selecting error. The entire error description generated the consequences that have been described so that with the explanation there is a potential error that need to be wary of.

In table 6 HEP values are sorted from the largest to the smallest values to find out which task has the highest probability of operator failure.

**Table 6. The sequence of Human Error Probability On Operator Production of “Batik Cap”**

| No | HEP  | Task                                      |
|----|------|-------------------------------------------|
| 1  | 0.0513 | 2.4 Stamping the Fabrics                  |
| 2  | 0.0448 | 2.3 Organize the Fabric on the Work Desk  |
| 3  | 0.0403 | 2.2 Preparing the Work Desk               |
| 4  | 0.0354 | 3.1 Mixing Color                          |
| 5  | 0.0348 | 3.4 Coloring and Color Locking Process    |
| 6  | 0.0328 | 1.1 Measuring Fabrics                     |
| 7  | 0.0271 | 1.2 Cutting Fabrics                       |
| 8  | 0.0238 | 4.1 Boil the Fabrics                      |
Based on Table 6, the result of the HEP calculation shows the probability of human error in the production process of Batik Cap, which is 0.0204-0.0513. The biggest potential error occurs in the task of stapling the fabric with HEP of 0.0513. This Task has the highest number of EPCs that is 4 EPC, meaning it has the most number of error types where each EPC shows errors contained in this task. Description of the error in the task of stapling the fabric is one of the stapling motives, because the canting stamping tool is less reliable due to some eroded angle, the operator in a hurry to do the stapling, the operator is exhausted due to standing position and exposed to heat radiation from the stove for 7 hours. operators are subject to limitations due to the influence of age and less experienced operators. The errors found did not fully show that the operator is wrong with the stapling motive, it is only the stapling results that are irregular and messy. There is also the effect of stapling sticking less visible so that the wax less attached to the fabric resulting in leakage color during the coloring process.

When compared to the value of HEP obtained, the size of HEP through measurement using the HEART method is determined not only by how much the proportion weighting which is the result of the questionnaire, also determined by the Generic task that is the Human unreliability selection which determines the general characteristics of each job. There are a number of 9 Generic tasks that indicate the level of operator unreliability, and EPC selection that indicates the conditions in the task that may cause errors. The larger the selected EPC number the smaller the EPC value is obtained. EPC is adjusted to the conditions in each job. The type of EPC varies depending on the situation that can lead to human error.

Processes that occurred on the production floor have a risk of accident because when the operator uses the machine, it must be equipped with personal protective equipment used to reduce the risk of accidents [9]. The results of the evaluation and analysis of the work system can provide suggestions for improvement to prevent the occurrence of occupational diseases or decreased productivity [10].

4. Conclusion
There are 26 human error potential descriptions of all Batik Cap production activities at 6 work stations divided into 19 errors during action error, 5 error at checking error and 2 error at the time of selecting error. The result of the probability assessment of human error is indicated by the HEP value of 0.0204-0.0513. The biggest potential error occurs in the task of stapling the fabric with the HEP of 0.0513. This is because the canting stamping tool is less reliable due to several corners that have been eroded, operators in a hurry to stamp, operators who are exhausted due to standing position and exposed to radiation heat from the stove for 7 hours, operators are subject to limitations due to the influence of age and less experienced operators.

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