Design of work facilities using quality function deployment (QFD) and macro ergonomic analysis design (MEAD)

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Abstract. XYZ is a company engaged in the manufacturing of doors. XYZ process consists of 7 work stations, such as sorting of raw material, the unification of the core material, reaping, laminating, manufacture of components, finishing, and packing. Among 7 work stations, only 1 work station to work while standing still during work (8 hours) and do not have other work that supports the position that the work station finishing work. The purpose of this study is to make improvements to the facilities at the finishing work desk. Facility design work is done by using quality methods to obtain technical characteristics in accordance with the desires of works. Furthermore, the results of the design tool socialized to all component companies use macro ergonomic analysis and design (MEAD). From the result of the design was found that the workbench is design to have the specification table legs fixed, material frame of iron, base material of foam, base material of leather, color frame brown, place mats of blue, the durability of the table at least 3 years, and additional function where the laying equipment. Result are discussed with the company designing and disseminated to the component companies.

1. Introduction

A good work system is one of the most important factors in the company's progress, and is the main key to success in order to improve the efficiency of the company, and can reduce the risk of injury. At first the design of the work system began with an analysis on a micro scale. Along with the development of technology as well as the occurrence of global competition in all aspects, micro ergonomics assessment is difficult to implement, even many failures in solving problems in complex environments so that a holistic approach is needed. work tools and work posture.

The study of MEAD has been conducted on Small Medium Enterprises tofu which discusses the results of variance from MEAD to design printing tools and tofu presses. The variant is used as a basis for repairing tools that refers to body dimensions to get ergonomic tools, ease of use of tools and safety in their use [1].

The same thing is also found in PT. XYZ, which is a company engaged in the industry of leaf doors manufacturing, has 7 work stations, like sorting the raw materials, integrating core materials, securing, laminating, component manufacturing, finishing and packing. Among the 7 work stations, only 1 work station works with a standing position during work (8 hours) and does not have other work facilities that support work positions, namely finishing work stations. Workload emphasizes the operator to the maximum position standing against the work desk. The existence of a work chair will make the distance between the operator and work desk so it makes it uncomfortable to work. This stated the need to design and improve existing work facilities. This problem can be solved using the Macro Ergonomic Analysis and Design (MEAD) method.

MEAD is a method that related to designing, analyzing, and evaluating work systems in organizations so they can be effective and efficient. The MEAD methodology can guide the data collection and analysis to determine the risks and causes of problems that lead to experiments with new design.
strategies and interventions. The study of macro ergonomics studies covered include organizational structure, interaction between people in the organization and motivational aspects of workers [2].

2. Methodology
The research was conducted at PT. XYZ which is a company engaged in the manufacture of door leaf. This company is located in Medan. The general objective of this research is to get a design of a work desk facility with the Macro Ergonomic Analysis and Design (MEAD) method so as to reduce complaints of finishing part workers, and get a good working method design to provide comfort in work and reduce the pain during work. The steps in the data processing are:
1. The anthropometric data of the operator obtained from measurements.
2. Study of literature, as the initial foundation for the problem as well as the constituent variables of the questionnaire.
3. Data collection of Macro Ergonomic Analysis and Design is carried out with the following steps:
   a. Distribution of SNQ to find out operator complaints.
   b. The distribution of the questionnaire was carried out through two stages, as:
      1) The distribution of semi-open questionnaires
      2) The distribution of closed questionnaires
   c. Production Process in the company
   d. Organizational Structure in the company.
   e. The vision and mission of company, obtained through the results of interviews with the management of company.
   f. The Variance Matrix of QFD, obtained through the results of QFD data processing
   g. The opinions from the personnel on the design of existing facilities are obtained through interviews with the production personnel section at the company.
   h. Stakeholder opinion on the design of existing facilities, obtained from the results of interviews with the owner of the company.

3. Results and discussion
3.1. Distribution of the SNQ questionnaire
The first step is to disseminate the SNQ questionnaire to the finishing part operator to find out the complaints experienced by the operator. The results of the identification of musculoskeletal complaints indicate that the complaints most often felt by workers are in the limbs of the thighs, knees, calves, ankles and soles of the feet. Then it is proposed a work desk design that is appropriate for the operator.

3.2. The distribution of semi-open questionnaires and closed questionnaires
The second step is to disseminate a semi-open questionnaire to find out how operators want the work tools to be designed. The results of an open questionnaire were included in a closed questionnaire to find out the most wishes from consumers. From the closed questionnaire, 10 work table attributes were found.

a. Table Shape : Steady Table Leg
b. Table Frame Material : Iron
c. Material for kneeling : Foam
d. Placemats kneeling : Leather
e. Table Frame Color : Brown
f. The color of the knees : Blue
g. Color of the base of the knee : Blue
h. Table Durability : 3 years
i. Additional Functions : Equipment’s Place
j. Additional Work Facilities : Glove
3.3. Deploy the assessment questionnaire and build technical characteristics

The next step is to build technical characteristics and find relationships with consumer desires. Based on the technical characteristic, will get the result of QFD in Figure 1.

![Figure 1. Workbench’s QFD.](image)

### Table have Steady for Table Leg
- Table’s Frame Using Material Iron
- Kneeling Table Material Using Material Foam
- Placemats Kneeling Using Material Foam
- Table’s Frame Color is Brown
- Kneeling Space Color is Blue
- Base Kneeling Color is Blue
- Table Durability Minimal 3 Years
- Additional Function is Space for Laying Equipment

| Characteristic                        | Importance Weight | Degree of Difficulty | Degree of Importance | Estimate Cost |
|---------------------------------------|-------------------|----------------------|----------------------|---------------|
| Table have Steady for Table Leg       | 95                | 5                    | 23                   | 23            |
| Table’s Frame Using Material Iron     | 99                | 3                    | 14                   | 16            |
| Kneeling Table Material Using Foam    | 45                | 3                    | 3                    | 15            |
| Placemats Kneeling Using Foam         | 60                | 4                    | 3                    | 23            |
| Table’s Frame Color is Brown          | 9                  | 1                    | 0                    | 0             |
| Kneeling Space Color is Blue          | 9                  | 3                    | 2                    | 5             |
| Base Kneeling Color is Blue           | 15                 | 5                    | 0                    | 5             |
| Table Durability Minimal 3 Years      | 81                 | 3                    | 3                    | 3             |
| Additional Function is Space          | 55                 | 5                    | 3                    | 23            |

| Material Quality                  | 95                |                         |                      |               |
| Material Endurance                | 78                |                         |                      |               |
| Thickness of Material              | 45                |                         |                      |               |
| Cutting Accuracy                   | 60                |                         |                      |               |
| Assembly Accuracy                  | 95                |                         |                      |               |

**Degree of Difficulty**
1 = Not hard
2 = Average
3 = Hard
4 = Very Hard
5 = Absolute Very Hard

**Degree of Importance**
1 – 10 = Not too important
11 – 20 = Important
21 – 31 = Very important

**Estimate Cost**
1-20 = Cheap
21-40 = Average
41-60 = Expensive

3.4. Macro ergonomic analysis and design (MEAD)
The steps in MEAD, are:
Step 1: Define the organizational subsystem.
At this stage a description of the vision and mission of PT. XYZ. Vision and Mission of PT. XYZ is as follows:
a. The vision of PT. XYZ is a door leaf company that produces high quality doors for customers in the world with various innovations.
b. The mission of PT. XYZ:
   1) Making a superior company by paying attention to quality by dedicating service.
   2) Making companies that have competitiveness with other door industries.
3) Improve the welfare and comfort of work for all personnel at XYZ.

Step 2: Define the type of tool and set the desired level of performance.

Determination of work facilities at XYZ refers to the design of facilities based on the needs and body dimensions of its users. In accordance with the mission of XYZ to improve the welfare and comfort of work for the operators who work, the achievements are determined.

The level of performance you want to achieve is:

1) Reducing work fatigue felt by finishing operators at XYZ
2) Increase the work comfort of production operators at XYZ

Step 3: Define work processes and work analysis

The process of making doors at XYZ has 7 parts of work, namely sorting raw materials, uniting core materials, securing, laminating, component making, finishing and packing. The operator works in the position of the body standing and bending. Work is also done for a long time, which is 8 hours per day.

Based on the identification of the work processes that exist at the XYZ, the work analysis is carried out using SNQ. The SNQ results show that the complaints most often felt by workers are on the limbs of the thighs, knees, calves, ankles and soles of the feet.

Step 4: Define actual variance and expectations

Based on information obtained from XYZ through interviews and distributing SNQ questionnaires to workers in the finishing section of XYZ, it is known that workers experience complaints in parts of the thighs, knees, calves, ankles and soles of the feet. Complaints of pain are caused because the work position and work desk facilities are not ergonomic, causing work risks to the operator. Based on these data, it is necessary to do an ergonomic workbench design by using workers’ body dimension data in order to reduce work complaints experienced by workers, and provide occupational safety and health and be able to comfort members of workers at XYZ. To obtain variance, semi-open and closed questionnaires were conducted to determine the variance needed in designing the existing work desk.

Step 5: Create a variance matrix

The assessment results obtained from the assessment questionnaire are related to the characteristics of the technique to obtain a variance matrix. The variance matrix can be seen in Figure 2.

Step 6: Analyze the role of personnel

In the sixth stage in MEAD it aims to identify how the variance obtained from the previous step is related to the role of personnel responsible for the existing work unit.

Step 7: Allocate functions and merge designs

From the results of discussions with the head of production at XYZ can be made 2 alternative products based on the questionnaire mode and the opinion of the head of production. This alternative will later be given to stakeholders of XYZ to determine what variance is the choice for designing work desk products.
## Table 1. Analysis of the role of personnel.

| No | Variance                  | Questionnaire Modus          | Watch third Party          | Personal Opinion          |
|----|---------------------------|------------------------------|---------------------------|---------------------------|
| 1  | Table’s Form              | Steady Table Leg             | Head of production        | Steady Table Leg          |
| 2  | Table’s Frame Material    | Iron                         | Head of production        | Iron                      |
| 3  | Material for Kneeling     | Foam                         | Head of production        | Foam                      |
| 4  | Placemats kneeling        | Leather                      | Head of production        | Leather                   |
| 5  | Table’s Frame Color       | Brown                        | Head of production        | Brown                     |
| 6  | Space Color for Kneeling  | Blue                         | Head of production        | Blue                      |
| 7  | Base Color for Kneeling   | Blue                         | Head of production        | Blue                      |
| 8  | Table Durability          | 3 Year                       | Head of production        | 5 Year                    |
| 9  | Additional Function       | Equipment Laying Space       | Head of production        | Equipment Laying Space    |
| 10 | Other Work Facilities     | Gloves                       | Head of production        | Gloves                    |

**Figure 2.** Variance matrix.
Step 8: Analyze Stakeholder Perceptions and Responsibilities
From the results of interviews with XYZ company then alternative 1 is chosen as the specification of work facilities for the finishing part operator of XYZ company. The reason for choosing alternative 1 is because the alternative cost is cheaper than alternative 2 so that it has a smaller impact on the company.

| Table 2. Weighting. |
|---------------------|

| Alternative 1 | Reach for Organization | Risk Occurrence in Success | Facilities Benefit | Alternative Cost Estimate |
|---------------|------------------------|----------------------------|--------------------|--------------------------|
| 1. Improve Firm Profit | 1. Improve Firm Profit | Work facilities | Operators become slower | Rp. 350,000.00 |
| 2. Cheaper Firm Expenses to buy Facilities | 2. Adaptation with new Facilities | No need for | Improved comfort of the operator |
| 3. Improving operator productivity |

| Alternative 2 | Reach for Organization | Risk Occurrence in Success | Facilities Benefit | Alternative Cost Estimate |
|---------------|------------------------|----------------------------|--------------------|--------------------------|
| 1. Improve Firm Profit | 1. Improve Firm Profit | Work facilities | Operators become slower | Rp. 550,000.00 |
| 2. Higher Firm Expenses to buy Facilities | 2. Adaptation with new Facilities | No need for | Improved comfort of the operator |
| 3. Improving operator productivity |

Step 9: Redesign the support and merge subsystems
After obtaining an alternative that will be used for product design, work facilities can be designed that have the following specifications:

a. Table Shape : Steady Table Leg
b. Table Frame Material : Iron
c. Material for kneeling : Foam
d. Placemats kneeling : Leather
e. Table Frame Color : Brown
f. The color of the knees : Blue
g. Color of the base of the knee : Blue
h. Table Durability : 3 years
i. Additional Functions : Equipment’s Space
j. Additional Work Facilities : Gloves

3.5. Comparison of actual and proposed workbench
The actual work table consists of two parts arranged to support the door. The actual work desk does not have a part that can hold the foot during the working process so that the worker must stand up during the finishing process.

The proposed work table is rectangular in shape that is adjusted to the shape of the door. The proposed work desk has a place to support the legs, which is a kneeling place that can be used if the worker experiences fatigue in the leg. Where to kneel has a design that can be put under the table (as folded) so as not to interfere if the worker works in a standing position. If the worker wants to use a kneeling place, the worker reverses the position of the kneeling place, and kneels while working in order to minimize the pressure on the foot. The proposed work table also has a place for laying equipment to facilitate the movement of workers in using equipment.
4. Conclusion
Conclusions from the results of observations and data processing are proposed work facilities in the form of work desks for finishing operators at XYZ company. The proposed work table has specifications in the form of a fixed foot table, iron frame material, foam base material, leather base material, brown frame color, blue pedestal color, blue base color, minimum durability of 3 years table and additional function as a place to lay equipment.

Acknowledgement
The author would like to thanks to the Universitas Sumatera Utara who has provided financial support to publish this paper. The authors express their gratitude to the owner of company who are willing to be the object of research. We appreciate the efforts of all those who have cooperated in conducting this study.

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