Design of Work Facilities in Magetan Leather Shoes SMEs

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Abstract

Magetan leather shoes are one of the leather industries in Indonesia that produce quality and durable products. One of the stations in Magetan leather shoes, namely the upper sole assembly station, shows a hunched posture of workers and the operator's hands hanging. This project aims to assist the operator of the upper sole assembly station to adjust its position with the design of work facility. The design of work facilities begins with distributing Nordic Body Map (NBM) and Quick Exposure Check (QEC) questionnaires to operators, Calculation of Quick Entire Body Assessment (REBA), Anthropometry and using NIDA (Need, Idea, Decision, Action) Method. As a result, based on the results of the NBM, there are complaints of musculoskeletal disorders in the back as the most complaints. Then, at QEC it was found that further research is needed and implement changes. In the REBA method, a score of 8 is obtained, which means high risk, investigate, and implement changes. Because of these problems, a work desk and chair are designed using NIDA method and Best-Worst Method. An alternative comparison was made on the design materials of work desks and chairs, namely aluminum, wood, and iron to obtain the best criteria as materials for making work desks and chairs. The criteria considered in each alternative are strength, price, availability, durability, and aesthetics. By using the Best-Worst Method, aluminum is obtained as the best alternative material that best meets the criteria as a material for making work desks and chairs.

Keywords

Leather Shoes, Nordic Body Map, Quick Exposure Check, Quick Entire Body Assessment and Need, Idea, Decision, Action.

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1. Introduction

In an industry, there are many workers who contribute directly to the company, especially in the production line sector. Data from the Ministry of Industry of the Republic of Indonesia until the third quarter of 2021, the total export value of Indonesian footwear (leather and non-leather) reached USD 4.3 billion. Meanwhile, the total GDP of the leather, leather goods and footwear industry reached IDR20 trillion or grew 7% (year-on-year) until the third quarter of 2021. This value is very large and is the economic revival of the shoe industry.

In 2020, according to the Ministry of Industry, the industrial development in Indonesia was 5.3%. However, with the increasing productivity of the shoe industry, this is not accompanied by an increase in the health and safety of its workers. In small and medium scale industries there are still workers who do their work with unhealthy postures. This can cause musculoskeletal health problems both in the short and long term. If this can be overcome, then work productivity will increase and there are no complaints of pain in certain parts of the body caused by the wrong working position. These conditions result in an unergonomic work system, which will result in risks to aspects of comfort, safety and occupational health and result in the achievement of work productivity. Ergonomic work systems pay attention to five aspects, namely, workers, materials, machines used, work methods and support for a qualified physical work environment. The results of the identification of these five aspects are in the form of standardization of the work system for the observed object, so that it is hoped that the achievement of productivity can be achieved safely, comfortably and healthily. It is necessary to apply ergonomics in this case to be able to overcome the problems experienced by workers.

This research was conducted in a small-medium scale shoe industry in Magetan, Central Java, Indonesia. Observations and interviews were conducted with workers there, especially on the upper sole assembly line. The interviews were conducted to find out the complaints experienced by the operators during work. Based on the results of the interviews, it was found that operators work for 8 hours a day, and often complain of body aches due to poor work posture during the work process. This research is important to do in order to support the health of shoe industry workers during their work and reduce physical complaints at work.

2. Literature Review

2.1 Actual Situation in the Magetan Leather Shoes SMEs

Magetan is a part for leather craftsmen starting from raw materials to ready-to-use finished merchandise, one among that is shoes, and sandals. Animal skin shoes and sandals are superior products in Magetan, in Magetan there are production centers for leather shoes and sandals, one of which is the "Praktis" company. The "Praktis" company could be a leather craftsman in Magetan that has been around for a protracted time, its products have conjointly been legendary by shoppers from varied regions in Indonesia, because it's attention-grabbing to check the way to create shoes in Magetan leather Shoes SMEs.

Field observations were carried out on October 9, 2021 at the 'Praktis' Shoe Store, Magetan, East Java. Observations focused on the assembly line, especially on the upper sole assembly station. Interviews were conducted to find out the complaints experienced by operators during work. Based on the results of the interview, it was found that the operator worked for 8 hours a day, and often complained of body aches due to poor work posture during the work process (see Fig. 1).

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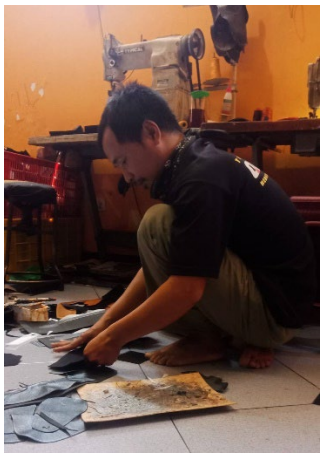

Figure 1. Operator work posture at the upper sole assembly station

3. Methods

3.1 Nordic Body Map (NBM) and Quick Exposure Check (QEC) Questionnaires

Making this design begins with the distribution of the Nordic Body Map (NBM) and Quick Exposure Check (QEC) questionnaires. The Nordic Body Map questionnaire could be a type of ergonomics list questionnaire that's accustomed to confirm the workers' discomfort as a result of its standardized and showing neatness arranged. The points that become the focus of the Nordic Body Map are twenty seven points scattered throughout the body (Briansah 2018). The NBM questionnaire often shows that a part of the muscle incorporates a downside with the number of complaints starting from No Pain, Some Pain, Pain, and Significantly Pain. The results of the form are often accustomed to estimate the kind and level of complaints, fatigue, and pain within the muscles felt by workers by viewing and analyzing the analyzed body map (Dewi 2020).

The QEC is a risk exposure measuring tool that has physical, organizational, and associated psychosocial factors. it had been developed by Li and Buckle (1998) and changed by David et al. (2003). The tool is employed by an observer to assess the postures and movements of 4 main body areas; the back, wrist/arms, shoulder/hand, and also the neck. The discovered worker provides input concerning the quantity of weight handled, time to complete the task, and level of hand force exertion (Oliv S et al. 2019).

The following is the calculation of the Exposure Level Score formula and the Exposure Level Score percentage table (See. Table 1).

$$\mathrm{E}\,(\%) = \frac{\mathrm{X}}{\mathrm{X}max} \mathrm{x}\,100\%$$

Table 1. Persentage total exposure level

Total Exposure Level	Action
< 40%	Safe
40 – 49%	Need more research
50 – 69%	Further research is needed and changes are made
≥ 70%	Conduct research and changes as soon as possible

3.2 Calculation of Rapid Entire Body Map (REBA)

The REBA methodology in applied science is employed to quickly assess the posture of a worker's neck, back, arms, wrists, and legs. REBA is a lot general, in summary, one in every of the new systems within the analysis which incorporates dynamic and static factors (Wibisono, 2017). The appliance of the REBA method is used to forestall the chance of injury to figure postures, particularly in skeletal muscles. Therefore, this method is incredibly helpful for

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risk hindrance and may be used as a warning that there are inappropriate working conditions in the work environment (Rinawati, 2016).

Table 2. Risk level based on REBA method (Astari 2017)

Rapid Entire Body Map (REBA)			
Score	**Level**	**Category**	**Action**
1	0	Ignore	No changes needed
2-3	1	Low	Change may be required
4-7	2	Medium	Change of work posture is required
8-10	3	High	Changes implemented soon
11+	4	Very high	Implementation is implemented right then and there

3.3 Anthropometric Calculation

Anthropometry is that the measure of body dimensions and alternative physical characteristics, it's more classified into 2 types: structural and functional. Structural measuration is the measurement of body dimensions during a series of static postures and dynamic anthropometry is the measurement of body dimensions once the body is moving. Anthropometry has been considered an important issue for product design, hand tools, and work environments to extend the operator's comfort, efficiency, and safety (Lee, Y.C et al. 2019). The measurement data of the worker's body dimensions are used as the basis for determining the design of work facilities. There are 10 body dimensions that are measured to help design work facilities as measured by structural measurement that are closely related to determining the shape and dimensions of a work facilities, namely normal sitting height, thigh height, popliteal height, popliteal length, sitting elbow height, hip width, forward arm reach, shoulder width, forearm length, and inward turning angle.

Appropriate measurement data is required to appreciate product styles that have the flexibility and are "capable of conformance" to a particular size range. Therefore, it's necessary to check anthropometric data to seek out the reality of the data. the subsequent are the stages of testing anthropometric data:

1. The level of confidence and therefore the level of accuracy the boldness level is that the confidence is worth that the calculation results obtained to meet the accuracy requirements. whereas the level of accuracy describes the best deviation from the measurement results.
2. Test data uniformity the information uniformity test could be a step in statistics that aims to get a particular level of confidence within the data and shows that everyone is within the management limits. The information uniformity test serves to reduce the variety of existing data by eliminating extreme data or data that are outside the control limits. The steps in the data uniformity test are to see the mean, normal deviation, higher control limit (UCL), and lower control limit (LCL).
3. Data adequacy test during this project, a data adequacy test is employed to check whether or not the data taken is comfortable or not by knowing the worth of N'. If the worth is $N' \leq N$, then the mensuration information is alleged to be comfortable and no additional data assortment is needed.
4. Verify the grade value the quality deviation and mean are done initially to see the percentile value because the basis for planning this ergometer; is the 95th percentile for the large, the 50th percentile for the typical, and therefore the 5th percentile for the small (Kempe 1996).

3.4 Methods of Need, Idea, Decision and Action (NIDA)

There are 4 stages in the NIDA method, namely Need, Idea, Decision, and Action.

1. Need
   At this stage, identification of the need for designing work facilities at the shoe uppersole assembly station is carried out based on the Nordic Body Map Questionnaire, Quick Exposure Check Questionnaire, and Rapid Entire Body Assessment Calculations. In the QEC Questionnaire, it was found that the operator's exposure level was at level 3 in the range of 50 - 69%. The REBA calculation results in a score of 8, which means high risk activities that must be investigated and changes are implemented.
2. Idea
   This section is an idea that will be carried out in a work facility.
3. Decision

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The final idea generated is a work tool in the form of a work desk and chair with a table height based on the results of the worker's body posture percentile. This tool aims to improve the posture of workers while working and also to be a storage place for tools and materials when doing work at work Magetan Leather Shoe IKM assembly station (Praktis Shop).

4. Action
   The design of work facilities in the form of work desks and chairs for workers at the shoe uppersole assembly station. Its features are equipment pockets (storing tools and materials), top drawers (temporarily storing assembly results), drinking places, and footrests.

3.5 Material Selection by Calculating the Weight of the Best-Worst Method Criteria (BMW)

Through alternative proposals, evaluation of material selection in the design is used the Best-Worst Method (BMW).

1. The first stage is to determine the number of decision criteria. The following is a number of decision criteria.

Table 3. Table of Criteria

Criteria Number = 5	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5
Names of Criteria	Strength	Price	Availability	Durability	Aesthetics

2. The second stage is determining the best criteria and the worst criteria based on the opinion of the decision maker

Table 4. Table of the Best Criteria

Criteria Number = 5	Criteria 1
Names of Criteria	Strength

3. The third stage is determining the preferences of decision makers between the best criteria against other criteria with a scale of 1-9. The following is a scale of 1-9 and its meaning.
   1) **Equal** importance
   2) Somewhat between Equal and Moderate
   3) **Moderately** more important than
   4) Somewhat between Moderate and Strong
   5) **Strongly** more important than
   6) Somewhat between Strong and Very strong
   7) **Very strongly** important than
   8) Somewhat between Very strong and Absolute
   9) **Absolutely** more important than

4. The fourth stage is determining the preferences of decision makers between all criteria against the worst criteria on a scale of 1-9. The following is the result of determining the preferences of decision makers between all criteria against the worst criteria.
5. The fifth stage is to use a solver to solve the problem.
6. The last stage is the selection of the selected material. In this stage, the advantages and disadvantages of each material are translated into the scale contained in the conversion rules. After that, the value of each criterion is multiplied by the weight of each criterion.

3.6 Formulation of Alternative Solutions

The concept of an alternative solution in this project is the manufacture of work facilities in the form of a table and operator chair at the upper sole assembly station. The manufacture of this work facility has several uses, namely as a place for storing tools and materials, temporary storage of assembly results, making it easier for workers to reach when drinking, as well as safe and comfortable work facilities with three alternative materials used.

4. Data Collection

The data collection process is conducted by doing an interview, questionnaire, and taking a picture of the upper sole assembly operator to analyze the work posture. An interview is conducted to investigate the problems that the operator

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experienced during work hour. From the interview, can be concluded that the operator works for 8 hours/day and their often feels sore in their arms and feet. These problems is caused by a bad work posture in upper sole assembly station.

A questionnaire given to the operators consist of Nordic Body Map (NBM) and Quick Exposure Check (QEC). NBM is used to identify musculoskeletal disorder caused by repeated workload in a long time. QEC is used to analyze the condition of upper sole assembly station.

Table 5. Respondent Criteria

Criterion	**Result**
Job Description	Upper Sole Assembly
Number of Workers	6
Sex	Male
Age	34 – 39 yrs old
Weight	58 – 63 kg

Table 6. QEC Exposure Score Recapitulation

Exposure Score Recapitulation	
Part of the Body	**Score**
Back (Manual Handling)	46
Shoulder / Arm	34
Arm Wrist	34
Neck	18
Total	**132**

The picture of the operator is used to analyze the angle of the body parts. The lines and the angles are drawn using CorelDraw. Then, the angles will be analyzed with the Rapid Entire Body Map (REBA) method.

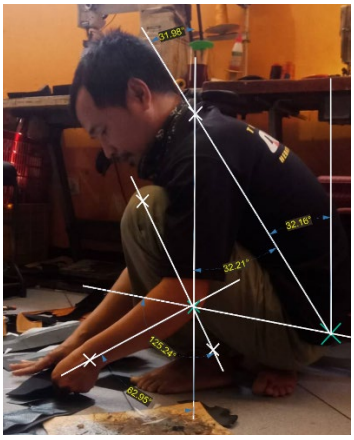

Figure 2. Work Posture Analyzed by Coreldraw

5. Results and Discussion

5.1 Nordic Body Map (NBM) and Quick Exposure Check (QEC) Results

Based on the results of the NBM questionnaire conducted on 6 workers at the shoe uppersole assembly station. So, it can be seen in Graph 1 sbelow.

Graph 1. Nordic Body Map Recapitulations

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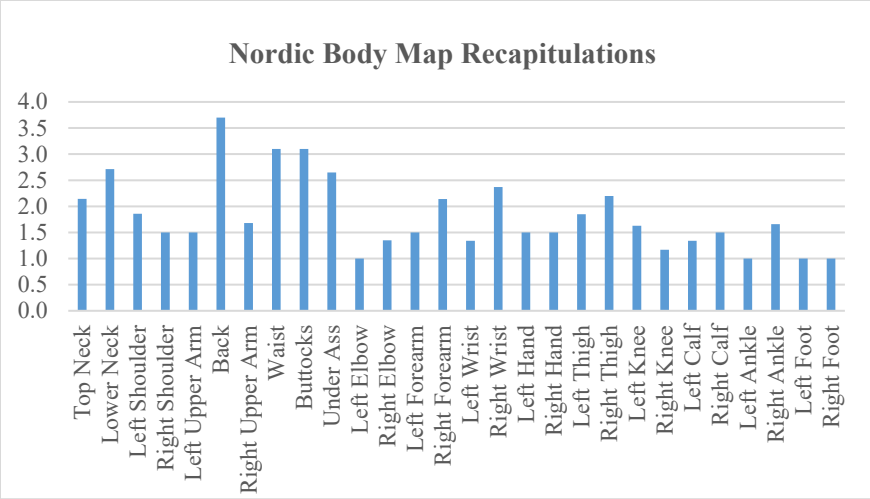

Based on the graph there are complaints of musculoskeletal disorders in the back as the most complaints. Furthermore, measurements were made using Quick Exposure Check (QEC) to assess the four areas of the body most at risk for occupational musculoskeletal disorders (WMSDs). The following in Figure 3 is the result of QEC score.

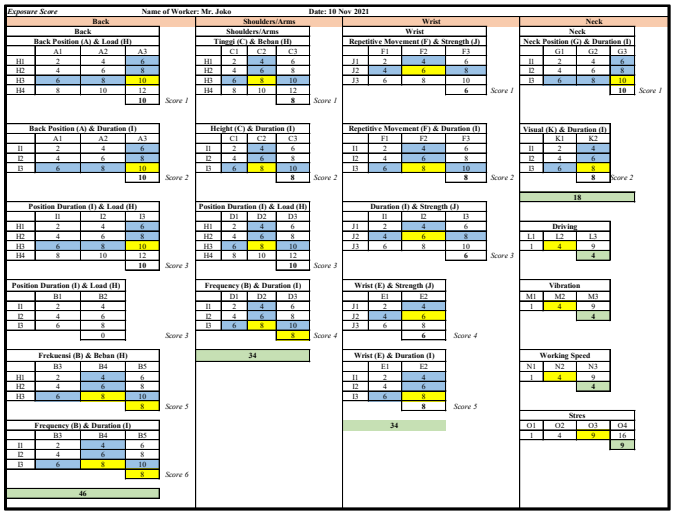

Figure 3. *Quick Exposure Check Score*

$$E(\%) = \frac{113}{176} \times 100\%$$
$$= 64{,}20\%$$

After calculating the score (in Figure 3), the results of the QEC level is 64,20%. This means that more research is needed and implement the changes.

5.2 Calculation of Rapid Entire Body Map (REBA)

Based on observations, it is known that workers tend to do activities in a state of squatting/sitting on the floor (Seen in Figure 4.1) on the floor so that the work rests on the lower part of the body of the thigh. This is because the facilities used are not designed according to the needs of workers. Then it is necessary to calculate REBA to be able to make ergonomic tables and chairs, so as to reduce musculoskeletal complaints that occur.

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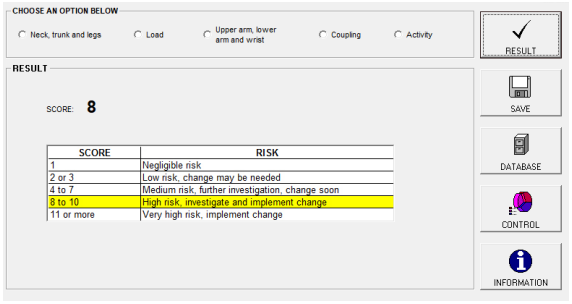

Figure 4. Calculation of REBA by ErgoFellow

Based on the results of the REBA calculation in Figure 4, a score of 8 is obtained, which means the activities carried out are high risk and need to be implement changes.

5.3 Anthropometric calculation results

Anthropometric data is data on measuring the dimensions of the worker's body that is used as a basis for determining the design of work facilities in the form of a work desk at the assembly station and the addition of a decent chair to make it easier for workers to reach the materials to be used. There are 10 body dimensions that are measured to help design work facilities. The following is a recapitulation of the average data and standard deviation of 6 workers at the assembly station.

Table 7. Anthropometric Data

No	Body Dimensions	Mean (6 Workers)	Standard Deviation
1	Normal sitting height	81,72	1,92
2	Thigh thickness	13,25	1,43
3	Popliteal High	41,42	2,38
4	Politeal Length	46,52	0,87
5	Sitting Elbow Height	22,65	2,31
6	Hip Width	34,65	1,94
7	Hand Reach Forward	73,02	3,58
8	Shoulder Width	36,77	2,92
9	Forearm Length	44,43	1,35
10	Inward Rotation Angle	41,67	5,65

5.4 Work Design Facility Results

Based on the results of the analysis using the NIDA method, the design of work facilities in the form of work tables and chairs for workers at the upper shoe assembly station. Its features are a utensil pocket (storing tools and materials), a top drawer (temporarily storing assembly results), a drink holder, and a footrest.

Then the material selection in the design used was carried out using the Best-Worst Method (BMW). There are 3 choices of materials used, namely aluminum, wood and iron. Material selection is carried out by considering the criteria for strength, price, availability, durability and aesthetics of each material.

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Table 8. Material Selection

Alternative	Criteria					Score
	Strength	Price	Availability	Durability	Aesthetics	
Aluminium	1	3	5	5	5	3,6415094
Wood	3	5	5	3	5	3,5283019
Iron	5	1	5	3	1	3,490566

Based on table 8 it can be seen that the selection of materials used for the design of work facilities at the shoe uppersole assembly station is aluminum. The design of work facilities in the form of can be seen in Figure 5 below.

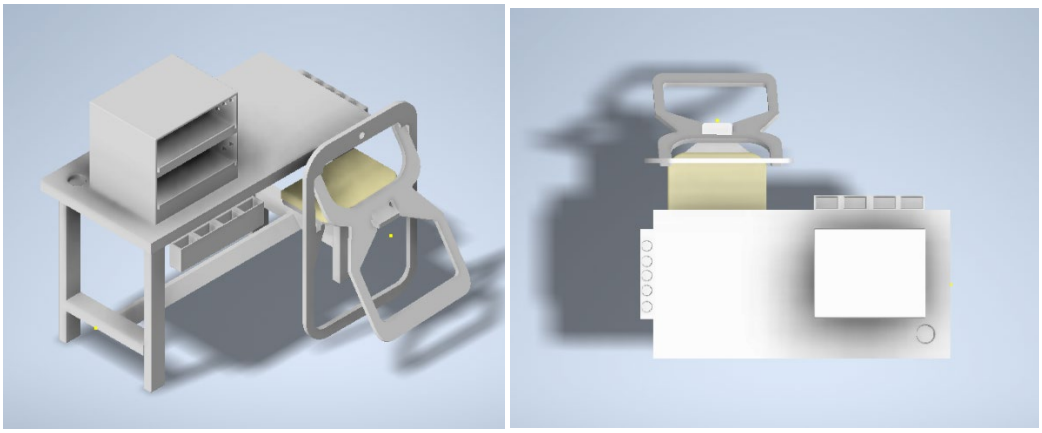

Figure 5. Design of Work Facilities

6. Conclusion

Based on calculations with the methods used, namely Nordic Body Map (NBM), Quick Exposure Check (QEC), Rapid Entire Body Assessment (REBA), Anthropometry, Need-Idea-Decision-Action Method (NIDA), Best-Worst Method (BMW) along with data that has been collected through observations and interviews with workers. Making a design with dimensions that are adjusted to the calculation of the methods used. Thus, a proposed design of work tables and chairs is obtained that will help solve the problem of physical complaints in workers who do their work in the leather shoe industry in Magetan, East Java, Indonesia. This proposed design chair and table are made of aluminum. This proposed design also provides additional features such as equipment pockets to facilitate users in storing and retrieving equipment, drawers for storing temporary assembly results, drink holders, along with foot rests that make workers more comfortable while working.

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