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Design of Shoes Production Tool

Popy Yuliarty[1*], Rezki Ramadan[1], Aulia Naro[1], Reza Afrizal[2]
[1]Department of Industrial Engineering,Universitas Mercu Buana,Jl.Meruya Selatan No.1 Kembangan, Jakarta Barat 11650 Indonesia
[2]Department of Informatic Engineering, Universitas Indraprasta PGRI, Jln. Nangka No 58 Jagakarsa, Jakarta Selatan 12530 Indonesia

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A B S T R A C T

This research was conducted on MSMEs that produce shoes and the like. Some production processes are carried out manually, which has an impact on employee occupational health. The uppersole installation process takes a long time with manual work which is certainly less effective because the position of the shoe changes and produces many unnecessary movements to position the shoe, impacting the condition of workers who experience several complaints such as pain in the thighs, back, and hands. This study aims to design a work aid for installing shoe uppersoles so that they can work effectively and avoid fatigue due to work positions. The design was carried out using the NIDA method. The results of the fixture design show that the fixture is able to withstand 12 directions of object movement, so that the processed upper sole can be maintained in a stationary state and no longer requires repeated positioning efforts. The results of this design can simplify the work process from previously 19 processes with a total time of 62 minutes to 15 processes with a total time of 54 minutes.

*Corresponding Author
Popy Yuliarty
E-mail: popy.yuliarty@mercubuana.ac.id

1. INTRODUCTION

Micro, small and medium enterprises is a general term in the economic world that refers to productive economic enterprises owned by individuals or business entities in accordance with the criteria established by Law no. 20 of 2008 (UUD 1945, 2019). Small and Medium Enterprises (SMEs) in Indonesia are currently growing and play a very important role in supporting the economy in various cities. The Ministry of Cooperatives and SMEs noted that the number of micro, small and medium enterprises (MSMEs) reached 65.47 million units in 2019. This number increased by 1.98% compared to the previous year which amounted to 64.19 million units. This number reaches 99.99% of the total businesses in Indonesia. Meanwhile, large-scale businesses only amounted to 5,637 units or the equivalent of 0.01%. In detail, as many as 64.6 million units are micro businesses. The number is equivalent to 98.67% of the total MSMEs throughout Indonesia. A total of 798,679 units are small businesses. The proportion is 1.22% of the total MSMEs in the country. Meanwhile, medium businesses only had 65,465 units (Mahdi, 2022). This number contributes to 0.1% of the total MSMEs in Indonesia (Adji Sasongko & Purnomo, 2018). This research was conducted at one of the MSMEs that

produces shoes and similar (footwear). To be able to survive in this competition, quality must be improved and one way to do this is to develop a more efficient and effective production process (Yuliarty & Wibowo, 2019),(Wibowo et al., 2023).

The stages of the production process start from cutting the raw material before it is formed into a shoe upper, sewing the raw material into a shoe upper, printing the midsole and bottomsole of the shoe (supplier), combining the midsole with the shoe upper to produce the uppersole, pressing the uppersole and bottomsole using a press machine, and the final stage shoe finishing. In the production process, some processes still use manual labor from workers, due to the capabilities of this shoe production house, which has an impact on employee work health (Amalia Yunia Rahmawati, 2020) (Adji Sasongko & Purnomo, 2018). One of the shoe production processes that takes quite a long time and without using any tools is the process of installing the uppersole. In the process, the upper that will be installed with the midsole is placed on the thigh, and then pulled using a tool in the form of pliers to form the contour of the shoe. This process is certainly less efficient, because the position of the shoes changes and produces a lot of unnecessary movements to position the shoes, this has an impact on the condition of workers who experience several complaints such as pain in the thighs, back pain, pain in the hands (Basager et al., 2020). The working position for installing the uppersole can be seen in Figure 1.

Figure 1. Uppersole placement
Source : Researcher documentation

To solve this problem, an industrial engineering approach is used. The application of industrial engineering systems knowledge is an extension of how the field of industrial engineering knowledge is used in the design, improvement and installation of integrated systems in terms of people, materials, information, equipment, energy (IISE, 2021),(Komara et al., 2019).

The scope of the research is viewed from 3 sides, namely human, method, and machine. From the human side, in terms of workers' positions that are not ergonomic, it can cause workers to suffer injuries to the thighs due to holding the uppersole for too long on the thigh, the back due to bending for too long and the hands due to holding the shoe work for too long. In terms of method, the process of installing the uppersole is carried out manually, namely by placing it on the worker's body (Badoozadeh et al., 2021). Furthermore, the installation process can be seen from Figure 1. In terms of machine, the process of installing the uppersole, which currently does not use tools. The aim of this research is to reduce the risk of worker fatigue in the back due to poor working positions and to design work aids. Results of the research are design of a table tool for uppersole instalation activities.

2. LITERATURE REVIEW

The NIDA (Need, Idea, Decision, Action) method was used in this study. The NIDA method stands for need, idea, decision, and action (Nurrachman et al., 2023). The use of the NIDA method aims to find information related to things that are needed by workers in order to reduce existing problems, and then develop innovative ideas to produce new tools that are different from existing tools (Kaban et al., 2021). After designing the tool, then determining alternative designs is carried out, and designing the actual tool based on the data that has been collected previously. The NIDA method is used to design products so that they can provide convenience and comfort to their users (Wibowo et al., 2023). From the results of the product design, an analysis is then carried out regarding the needs of each component used to become a tool that is ready to use. Then collecting alternatives that are suitable and in accordance with the needs in the work environment, and designing is carried out using

design software, namely Autodesk Inventor (Ali Ashgar et al., 2025), (Dawson & Aparicio, 2018).

The stages in the NIDA method are as follows (Elandri, 2022), (Soekarta & Suharsono, 2021): (1) Identifying Customer Needs (Need). Interviews are conducted to obtain information from workers regarding complaints experienced during the uppersole installation process. The main point of this stage is to identify needs in the uppersole installation process and elaborate on those identified needs. (2) Generating Ideas for Design (Idea). This stage is conducted to generate design ideas based on operator needs and complaints in accordance with ergonomic principles. (3) Product Design Decision (Decision). In this stage, an assessment is conducted by deciding on the work facility design concept to be used. By developing several ideas, alternative designs emerge that can meet the work facility design needs. (4) Creating the Work Facility Design (Action).

3. RESEARCH METHOD

A research approach is a scientific method, arguably a pursuit of truth governed by logical considerations (Nazir 2014). The benefit of a research approach is that it can assist researchers in answering or defining problem formulations. The research approach must align with the needs of defining and answering research questions. This research approach uses a combination of qualitative methods to gather information directly from workers about their experiences during the work process. This study uses an ergonomics approach to assess worker complaints (Fadli Arsi, Gayuh Lemadi, Resy Kumala Sari, Dian Eko Adi Prasetio et al., 2025), . Figure 2 below shows the research stages.

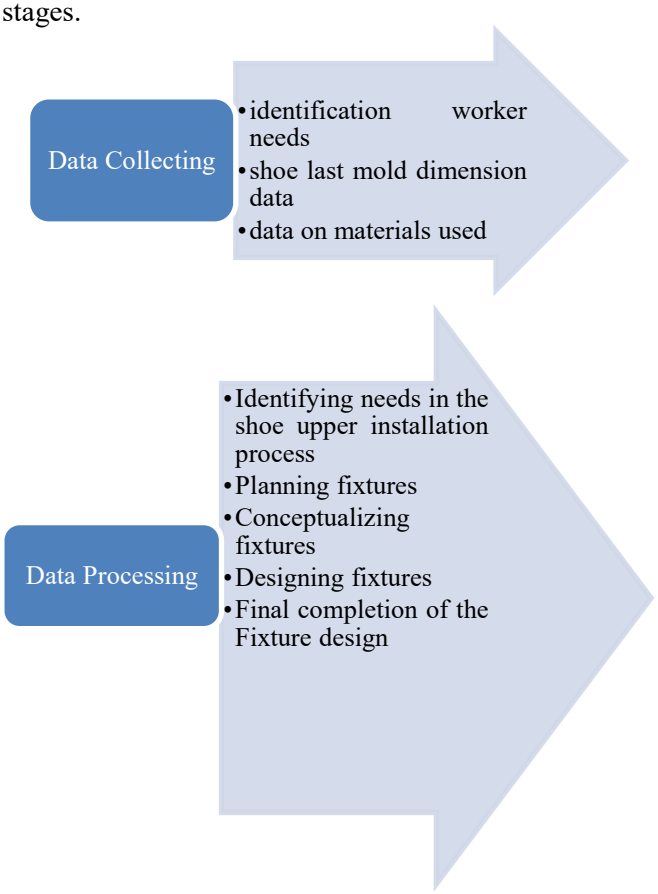

Figure 2. Research framework

4. RESULT AND DISCUSSION

Step 1. Data collection in the form of identifying worker needs for the shoe production process. Table 1 below shows the results of the identification of worker needs.

Table 1. Identification of worker needs

Complaint	Needs
Workers experienced difficulty and pain in their backs, hands, and feet due to pinching the material when installing shoe uppers (The uppersole installation process is still done manually, using a human thigh to clamp the uppersole. This is considered ineffective because it involves a lot of unnecessary movement while constantly positioning the uppersole, which can lead to muscle injuries in workers).	Work aids/fixtures to make work easier and prevent pain due to work positions (A fixture is needed to position the uppersole to reduce unnecessary movements and speed up the process time and maintain the quality of the shoe).

Step 2. Generating ideas in design (Idea).This stage is carried out to generate ideas in design based on the needs and complaints of operators in accordance with ergonomic principles. The

development of ideas can be developed from the demands for the desired assistive devices which can be seen in Table 2.

Table 2. Ideas/ideas for designing a fixture tool

No.	Complaint	Need
1.	The positioning of the aligner function can be adjusted to suit various shoe last sizes.	The fitting function can be adjusted to fit shoe sizes ranging from 39-45.
2.	The user's height can be adjusted while sitting on the chair.	The base height of the device is equivalent to a sitting position, 75-90 cm (according to adult male anthropometric standards).
3.	Sturdy and lightweight frame.	Uses a hollow frame.
4.	Economical.	Made of stainless steel.
5.	Corrosion-resistant.	Reduced cost to manufacture.
6.	Easy repair.	Requires no special tools for component or machine repair and maintenance.
7.	Easy assembly.	Can still be installed by hand with simple tools.

Step 3. Product Design Decisions. At this stage, an assessment is conducted by deciding on the design concept for the work facility to be used. By developing several ideas, alternative designs emerge that can meet the work facility design requirements. Determining the Overall Function of the Tool: At this stage, a problem-solving process is carried out using a flowchart of the overall functional structure of the fixing tool design for the shoe uppersole installation process. The overall function of the fixing tool design can be see as Figure 3 .

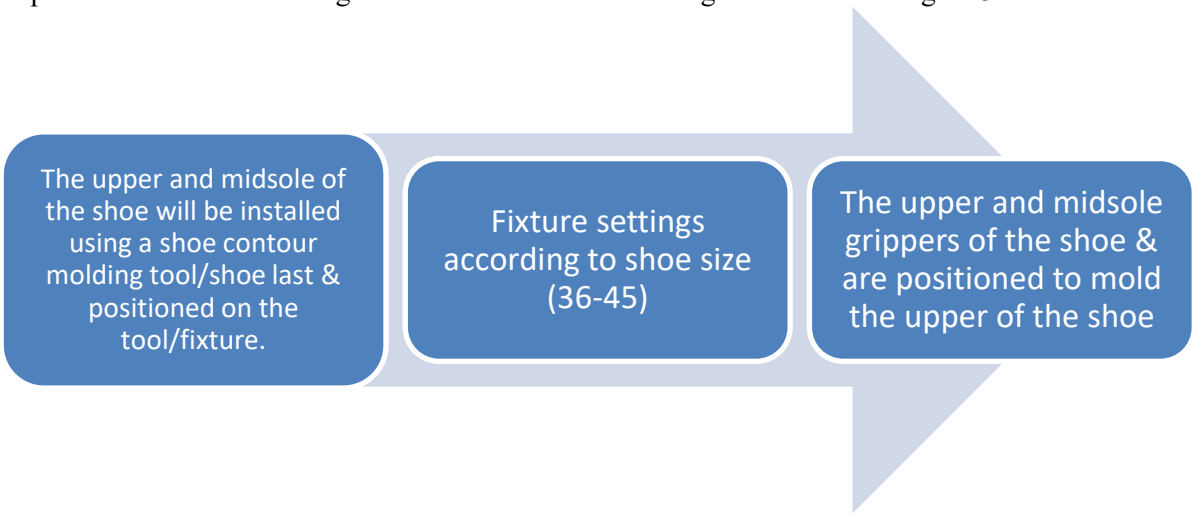

Figure 3. Overall function diagram of the fixtures in the shoe uppersole installation process

Furthermore, the division of sub-functions of the design of the auxiliary tools (fixtures) in the shoe uppersole installation process is shown in Figure 4.

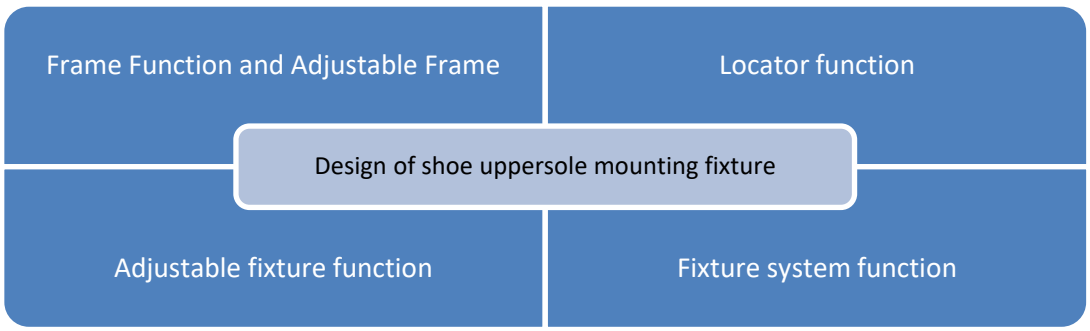

Figure 4. Sub-function division diagram

A description of each sub-function section can be seen in Table 3.

Table 3. Description of sub-function sections

No	Function of Parts	Deskription
1	Frame Function	As the main frame supporting the tool
2	Adjustable Frame Function	As a component of the tool frame positioning that can be adjusted to the employee's working position
3	Locator Function	As a component for positioning fixtures on the tool
4	Fixture System Function	As a fitting function to position the upper and midsole for processing
5	Adjustable Fixture Function	As a fixture positioning system component to accommodate shoe size variations

Step 4. Preparation of Fixture Design
Based on Table 3, alternatives are developed for each section function. After completing the planning and conceptualization stages, the design of the fixture aid for the shoe uppersole installation process will be outlined based on the design concept assessment. The initial draft of the fixture design is then drawn using CAD software, as shown in Figure 5.

Figure 5. Fixture design

Based on the design above, several analyses were conducted. The following analyses were conducted on the fixture design: locator analysis, fixture system analysis, and processing time analysis. The results showed that the design performed well in blocking 12 directions of object movement that caused the object to remain stationary and facilitated the uppersole processing process without continuously positioning the uppersole. To further improve the design quality, optimization was performed on one of the component functions, the locator, by changing the shape of the front locator from a slanted plate to a rounded shape to achieve better positioning, following the curve of the shoe. The processing time analysis by creating a map of operations (Pratiwi et al., 2020) before and aftershowed a simplification of the process to 15 processes with a total time of 54 minutes, down from 19 processes with a total time of 62 minutes.

The implication of this research is the achievement of its objective, which is to reduce worker fatigue by adding fixture that are suitable for the work position of attaching shoe uppers. The quality of the results can be improved because the use of fixtures can hold the workpiece in place, resulting in more precise work. However, this research is not yet optimal due to limitations in that it takes time to train employees to use this tool proficiently. Measurement of the results of shoe upper sole installation operations needs to be carried out at a later date to re-evaluate the use of this fixture.

5. CONCLUSION

The design is intended to simplify the shoe uppersole manufacturing process, which is considered less effective because it uses the thigh to position the uppersole using the NIDA method which outlines 4 process stages, namely; planning, conceptualizing, designing, and finishing. The results of the fixture design analysis show that the fixture is able to withstand 12 directions of object movement, so that the processed uppersole can be held in a stationary state and no longer requires repeated positioning efforts. The design results can simplify the manufacturing process from the previous 19 processes with a total time of 62 minutes to 15 processes with a total time of 54 minutes. The recommendation for this research is to conduct an audit of all work processes to make them more effective and efficient so that the company can achieve better productivity.

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