Prototype Plate Bending Tool 1 mm Size in the Process of Making a Fence with an Anthropometric Approach in the Pasuruan Regency Welding Workshop

Subchan Asy’ari, Leo Virgi Setyawan, Abdul Wahid, Miftahul Huda, Achmad Misbah
Yudharta University of Pasuruan, Indonesia

*subchan_07@yudharta.ac.id, leovirgi@gmail.com, wahid@yudharta.ac.id, miftahulhuda@yudharta.ac.id, achmadmisbah@yudharta.ac.id

Abstract. In the process of bending the plate making fence workers have difficulty because the process of bending the plate is still done in a conventional way as well as the absence of bending tools that correspond to the posture of the welding workshop bending in Pasuruan district area. The condition of the workers that occurred in welding workshop bending in Pasuruan district at the time of bending the plate is considered not ergonomic, because with the position of the dimensions of the body is not suitable. Among them the head bends, the back bends, the legs bend, the hands bend and the production results are less maximal. In the design of this bending tool uses an anthropometric approach in determining the design of ergonomic bending tools and providing worker comfort, samples used from 20 workers. Based on research conducted in welding workshop in Pasuruan Regency area, researchers proposed the idea of an ergonomic bending tool designed based on an anthropometric approach. With this bending tool, it is expected to be a solution to get comfort and security while working so as not to interfere with the work process. The presence of this product is expected to encourage innovation in the field of designing work systems and ergonomics.

1. Introduction
Work accidents often occur as a result of tools or machines, from less effective machines making it difficult for workers to process work.[1] In the process of bending the plate making fence welding workshop workers have difficulty because the process of bending the plate is still simple. The absence of bending equipment that corresponds to the posture of welding workshop workers in Pasuruan district. The risk of work accidents is common such as hands being scratched sharp objects, feet can be pinched and production results are not maximal. Therefore, the design of bending tool bending plate that is adapted to the body of welding workshop workers is highly blinded to suppress the number of work accidents and to produce maximum products.

Bending head, bending back, bending feet, bending hands and less maximum production are the conditions of welding workshop workers in various areas of Pasuruan district when bending plates. It is considered not ergonomic because of the inappropriate position of the body dimensions. These problems are against the backdrop of the need for ergonomic work tool repair, so researchers try to solve it by designing a bending tool bending bending plate that can help workers to produce quality products and suppress the number of work accidents in welding workshop in Pasuruan district area. The purpose of
making this tool is to help reduce complaints of Musculeskeletal Disorders resulting from bending plate bending activity of 1mm size.

2. Methodology
This study uses experimental research design. The design of the experiment is an experimental design with every step of the action defined, so that information related to or necessary an issue to be examined can be collected in factual.[3] This research sample is a plate bending tool in the bending process. Methods of data collection by methods of literature, observation and experimentation. While the method of analysis uses anthropometric calculation and the design of worker tools.

Identification and Data Collection Stage
The initial stage of this research is to identify welding workshop workers in Pasuruan district to look for problems that are then used as the basic material of tool design. The research site was conducted in several welding workshop in Pasuruan district area in the bending tekuk plate process.

Data Processing Stage
The data processing in this study includes anthropometric data used to determine the size of the design.

1. Test the adequacy of the data that serves to know if the data that has been obtained is sufficient

\[ N' = \left( \frac{K}{s} \right) \sqrt{\frac{N(X_i^2) - (\Sigma X_i)^2}{\Sigma X_i}} \]

2. Data uniformity test is performed to make the data within the control limit [6].

\[ \sigma = \sqrt{\frac{n(\sum X^2) - (\sum X)^2}{n^2}} \]

3. Calculation of BKA and BKB to ensure the data is within the control limit.

4. Calculation of anthropometric data percentile data. In the concept of the existing population percentile is divided into 100 percentage categories, sorted from the smallest value to the largest value for a given body size.[7]

5. Determination of design solutions based on complaint and desire data.

6. Bending Plate Tool Design in Bending Process:
   a. Calculation of elbow length dimension data (X1)
   b. Calculation of forward hand range dimension data (X2)
   c. Calculation of high dimension Data of standing position feet (X3)

![Figure 1. Systematic review diagram](image-url)
The method used in data collection is to retrieve work dimension data for workers bending bending plate and interview at the same time. The required data is the worker's complaint on the bending process of bending the plate and the anthropometric data of the dimensions of the worker's body in the process of bending the bending of the plate. Data processing is carried out based on the literature used. After data collection, data adequacy tests are carried out, data uniformity tests and percentile calculations to obtain the anthropometric size of the plate bending tool in the bending process.

### Result and Discussion

Welding workshop is a business in the field of welding and manufacturing metal products spread in various regions in Pasuruan district. Welding workshop is able to produce hundreds of products both individual and mass orders consisting of fences, metal doors, tralis, metal balconies, canopies, stainless gate, railing stairs and service.

In the process of designing bending tools bending plate size 1 mm required anthropometric data such as elbow length dimensions, bending head dimensions, foot height dimensions sampled by as many as 20 workers to ensure that the size of the designed tool can suit the needs of workers in the process of bending the plate appeal at a size of 1 mm

### Elbow Length Anthropometric Calculation

| No | Name  | Xi (Elbow length) cm | Xi^2 (Elbow length) cm | Xi (Hand reach) cm | Xi^2 (Hand reach) cm | Xi (Foot height) cm | Xi^2 (Foot height) cm |
|----|-------|----------------------|------------------------|------------------|---------------------|---------------------|----------------------|
| 1  | Khoiri | 31                   | 961                    | 58               | 3364                | 91                  | 8281                 |
| 2  | Minto  | 27                   | 729                    | 56               | 3136                | 85                  | 7225                 |
| 3  | Leo    | 32                   | 1024                   | 53               | 2809                | 95                  | 9025                 |
| 4  | Jainuri| 31                   | 961                    | 52               | 2704                | 95                  | 9025                 |
| 5  | Hadi   | 32                   | 1024                   | 58               | 3364                | 95                  | 9025                 |
| 6  | Dedik  | 32                   | 1024                   | 58               | 3365                | 86                  | 7396                 |
| 7  | Antok  | 32                   | 1024                   | 58               | 3365                | 85                  | 7225                 |
| 8  | Japar  | 27                   | 729                    | 56               | 3136                | 85                  | 7225                 |
| 9  | Kholik | 27                   | 729                    | 55               | 5025                | 95                  | 9025                 |
| 10 | Mandra | 31                   | 961                    | 53               | 2809                | 95                  | 9025                 |
| 11 | Arip   | 28                   | 784                    | 56               | 3136                | 91                  | 8281                 |
| 12 | Rokim  | 28                   | 784                    | 58               | 3365                | 86                  | 7396                 |
| 13 | Khoirul| 27                   | 729                    | 56               | 3136                | 86                  | 7396                 |
| 14 | Riyan  | 31                   | 961                    | 56               | 3136                | 85                  | 7225                 |
| 15 | Hari   | 27                   | 729                    | 56               | 3136                | 85                  | 7225                 |
| 16 | Hudi   | 31                   | 961                    | 52               | 2704                | 92                  | 8464                 |
| 17 | Yusril | 32                   | 1024                   | 53               | 2809                | 91                  | 8281                 |
| 18 | Vicki  | 32                   | 1024                   | 53               | 2809                | 91                  | 8281                 |
| 19 | Khakim | 32                   | 1024                   | 54               | 2916                | 95                  | 9025                 |
| 20 | Sule   | 31                   | 961                    | 56               | 3136                | 92                  | 8464                 |
|    | Total  | 601                  | 18147                  | 1107             | 63360               | 1801                | 162515               |

![Figure 2. Mind map research](image-url)
### Table 1. Data Domain Size Worker Process Bending Plate

| Elbow Length Percentile Data | Hand reach Percentile Data |
|-----------------------------|---------------------------|
| Biggest data = 32           | Biggest data = 58         |
| The smallest data = 27      | The smallest data = 52    |
| Range = 5                   | Range = 6                 |
| Many Interval Classes       | Many Interval Classes     |
| \( K = 1 + 3.3 \log n \)    | \( K = 1 + 3.3 \log n \)  |
| \( K = 1 + 3.3 \log 20 \)   | \( K = 1 + 3.3 \log 20 \) |
| \( K = 5.2 = 5 \)           | \( K = 5.2 = 5 \)         |
| Interval Class Length       | Interval Class Length     |
| \( \frac{R}{K} = \frac{5}{5} = 1 \) | \( \frac{R}{K} = \frac{6}{5} = 1.2 \) |

#### Percentile Frequency Distribution

| No | Interval Class | Cumulative Frequency (f) | Cumulative Frequency (F) | Cumulative Frequency (%) |
|----|----------------|--------------------------|--------------------------|-------------------------|
| 1. | 27 – 28        | 7                        | 7                        | 35%                     |
| 2. | 28 – 29        | 0                        | 0                        | 0%                      |
| 3. | 29 – 30        | 0                        | 0                        | 0%                      |
| 4. | 30 – 31        | 6                        | 13                       | 30%                     |
| 5. | 31 – 32        | 7                        | 20                       | 35%                     |

#### Percentile Location

Setting \( P_i = \frac{(n+1)}{100} \)

\( P_5 = \frac{5}{20+1} = 0.25 \)
\( P_{50} = \frac{50}{20+1} = 2.5 \)
\( P_{95} = \frac{95}{20+1} = 4.75 \)

#### Percentile Calculation (Elbow Length)

\( P_i = b_i + \frac{(n+1-F)}{f} \times \frac{R}{K} \)

\( P_5 = 27 + 1 \left( \frac{20}{100-7} \right) \)
\( P_{50} = 30 + 1 \left( \frac{20}{100-7} \right) \)
\( P_{95} = 32 + 1 \left( \frac{20}{100-7} \right) \)

Worker's elbow length is 32,03

### Table 2. Percentile Frequency Distribution

| No | Interval Class | Cumulative Frequency (f) | Cumulative Frequency (F) | Cumulative Frequency (%) |
|----|----------------|--------------------------|--------------------------|-------------------------|
| 1. | 52 – 53.2      | 6                        | 6                        | 30%                     |
| 2. | 53.2 – 54.4    | 1                        | 7                        | 5%                      |
| 3. | 54.4 – 55.6    | 8                        | 15                       | 40%                     |
| 4. | 55.6 – 56.8    | 0                        | 15                       | 0%                      |
| 5. | 56.8 – 58      | 5                        | 20                       | 25%                     |

#### Percentile Location

Setting \( P_i = \frac{(n+1)}{100} \)

\( P_5 = \frac{5}{20+1} = 0.25 \)
\( P_{50} = \frac{50}{20+1} = 2.5 \)
\( P_{95} = \frac{95}{20+1} = 4.75 \)

#### Percentile Calculation (Hand reach)

\( P_i = b_i + \frac{f}{n+100} \times \frac{R}{K} \)

\( P_5 = 52 + 1 \left( \frac{20}{100-6} \right) \)
\( P_{50} = 55.6 + 1 \left( \frac{20}{100-6} \right) \)
\( P_{95} = 58 + 1 \left( \frac{20}{100-6} \right) \)

The worker's hand reach length is 58,08
Foot height Percentile Data
Data terbesar = 95
Data Terkecil = 85
Rentang = 10

Many Interval Classes
K = 1 + 3,3 log n
K = 1 + 3,3 log 20
K = 5,2 = 5

Interval Class Length
\[ K = \frac{\text{range}}{\text{many classes}} \]
\[ K = \frac{10}{5} = 2 \]

Percentile Frequency Distribution

| No | Interval Class | Cumulative Frequency (f) | Cumulative Frequency (F) | Cumulative Frequency (%) |
|----|----------------|--------------------------|--------------------------|--------------------------|
| 1. | 85 – 87        | 8                        | 8                        | 40%                      |
| 2. | 87 – 89        | 0                        | 0                        | 0%                       |
| 3. | 89 – 91        | 4                        | 12                       | 20%                      |
| 4. | 91 – 93        | 2                        | 14                       | 10%                      |
| 5. | 93 – 95        | 6                        | 20                       | 30%                      |

Table 4. Percentile Frequency Distribution

Percentile Location
Setting \( P_i = \frac{i}{n+1} \)

\( P_5 = \frac{5(20+1)}{100} = 1,05 \)
\( P_{50} = \frac{50(20+1)}{100} = 10,5 \)
\( P_{95} = \frac{95(20+1)}{100} = 19,5 \)

Percentile Calculation (Foot height)
\[ P_i = b_i + p \left( \frac{n/100 - P_i}{20/100 - 6} \right) \]

\( P_5 = 85 + 2 \left( \frac{100 - 1,05}{20 - 6} \right) = 85.05 \)
\( P_{50} = 91 + 2 \left( \frac{100 - 10.5}{4} \right) = 91.1 \)
\( P_{95} = 95 + 2 \left( \frac{100 - 19,5}{6} \right) = 95.08 \)

Worker Foot Height is 95.08

Figure 3 shows the average result of the calculation of elbow length with a percentile value of 32.3.

Figure 4 shows the mean result of the outreach calculation with the percentile value is 58.08

Figure 5 shows the mean of the calculated leg height in a standing position with a percentile value of 95.08

Figure 3. Elbow length in standing position

Figure 4. Reach Hand standing position

Figure 5. Standing Foot Height
After the data collection and processing results are obtained, the calculation of dimension size for the selected design based on anthropometric results is obtained namely: The length of the standing position elbow is 32.03 cm, the hand range of the standing position is 58.06 cm and the height of the standing position foot is 95.08 cm. The wide size design of the bending tool uses 95 percentiles of the population who are expected to use this bending tool using the results of the calculation of hand range and elbow length which is 58.06 and 32.03. Thus obtained the width value of the bending tool is 58.06 - 32.03 = 26.03 cm.

In the design of the length of the bending tool the population is expected to use this bending tool using the calculation results of hand range and elbow length which is 58.06 and 32.03. So obtained the length value of the bending tool is 58.06 + 32.03 = 90.09 cm. In the design of the high size of the bending tool the population is expected to use this bending tool using the calculation of the height of the standing position foot which is 95.08 cm.

4. Conclusion
Conclusions that can be drawn from the results of research on the design of bending tools bending welding workshop plates in Pasuruan regency area with this anthropometric approach, namely the result of Prototype bending tool bending plate on the manufacture of fence in accordance with the anthropometry of the body of the worker welding workshop Pasuruan district area. Based on the results of the calculation of anthropometry namely the length of the elbow standing position 32.03 cm, hand length standing position 58.06 cm and foot height standing position 95.08 cm and result of body measurement dimensions workers bending bending plate with anthropometric approach in welding.
workshop in Pasuruan district area using 95th percentile result namely Bebding tool width 26 cm, bending tool length 100 cm and bending tool height 95.09 cm

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