http://jurnal.yudharta.ac.id/v2/index.php/jkie

Journal Knowledge Industrial Engineering

E-ISSN: 2541-4461 | P-ISSN: 2460-0113

Design of Soybean Dregs Separator Tool for Tempe Production in MSMEs Pasuruan Regency Using Pulse Method and Rula Method

Ayik Pusakanongwati[a], Achmad Misbah[b], Muhammad Hermansyah[c]
[a,b,c] Department of Industrial Engineering, Universitas Yudharta Pasuruan, Indonesia
Corresponding Author: ayik@yudharta.ac.id

Article Info

Article history
Received : November 07, 2022
Revised : November 16, 2022
Accepted : December 17, 2022
Published : December 31, 2022

Keywords:
Soybean Separator Tool;
Pulse Method;
RULA;
Anthropometry;
Ergonomics.

Open Access license
CC-BY-SA

ABSTRACT

Micro small and medium enterprises (MSMEs) are a source of the regional and national economy. MSMEs have many roles in the social economy including being the main actor in economic activity, providing employment, playing a role in local economic development and community empowerment, a source of innovation, and creating new markets. Pasuruan Regency is one of the tempe centers in East Java. More than 200 families are engaged in Tempe production, including those in the Bangil sub-district, Purwodadi sub-district, Kejayan sub-district and Sukorejo sub-district. The main problem faced by Tempe Production SMEs is the machine or soybean dregs separator used, still using traditional tools (humans) which are less effective and efficient so that it takes a long time and there are working positions for workers who lack ergonomics, causing workload which is more. The purpose of this activity is how to make or design a design tool and work aid test for soybean dregs separator machines from soybean seeds to reduce the workload of making soybeans into tempeh and to be able to reduce the portion of the workload on tempe making workers with anthropometric calculations.

DOI: https://doi.org/10.35891/jkie.v9i3.3505

1. Introduction

Micro, Small and Medium Enterprises producing tempeh are no longer foreign to us. Pasuruan Regency is one of the tempeh centers in East Java. More than 200 families are engaged in Tempe production, including those in the Bangil sub-district, Purwodadi sub-district, Kejayan sub-district and Sukorejo sub-district. The tempe they produce is quality tempeh. It tastes savory and delicious without any sour (sour) or bitter taste that is often found in traditional markets and modern markets in general. In the daily production process, Tempe production SMEs are able to consume as much as 100- 150 kg of soybeans. All stages of the soybean production process into tempeh are still carried out in a traditional and semi-manual manner. Starting from: The raw material for soybean seeds is poured into a cauldron and water is added to cook (warming up) which aims to develop the soybean seeds and lasts for approximately 2 hours and this process is still done manually.

At this time the tempe production process still uses simple tools using human power. The results of the research based on interviews and observations of the author can decide to make changes to speed

up the process of separating the soybean dregs from the soybean seeds by making a dregs separator that is no longer used manually (peel off with human hands). So that this machine will help speed up the tempeh production process, which previously required a relatively long time.

Design plan This tool is designed by considering the processing time of soybeans into tempeh, an assessment of the effectiveness of the process of turning soybeans into tempeh. This is done to shorten the production time of soybeans into tempeh. The tool for separating soybean dregs from soybean seeds is designed in the form of a mixer with the following dimensions:

The driving force for the tool is a 0.5pk electric motor with a source of electrical energy. This tool for separating soybean dregs from soybean seeds is only to make the processing time for making soybeans into tempeh shorter and has been tested. but in this study the design of the tool for separating soybean dregs from soybean seeds from the old design did not guarantee that the tool was ergonomic and in accordance with the anthropometry of the worker's body.

2. Literature Review

a. Ergonomic Studies Ergonomics

Comes from the Latin, namely ergon which means work and nomos which means natural law. In the United States, ergonomics is referred to as "human factors engineering". Ergonomics is related to optimization, efficiency, health, safety and human comfort in the workplace. In general, the objectives of ergonomics are:

- Improving physical and mental well-being through efforts to prevent work-related injuries and illnesses, reduce physical and mental workload, seek promotion and job satisfaction.
- Improving social welfare through the quality of social contacts, managing and coordinating work appropriately in order to improve social security both during productive and non-productive periods.
- Creating a rational balance between various technical, economic, anthropological, and cultural aspects of each work system that is carried out so as to create a high quality of work and quality of life

b. Nordic Body Map (NBM)

Nordic Body Map (NBM) is a simple ergonomic measurement tool that can be used to identify the causes of musculoskeletal the nordic body map.

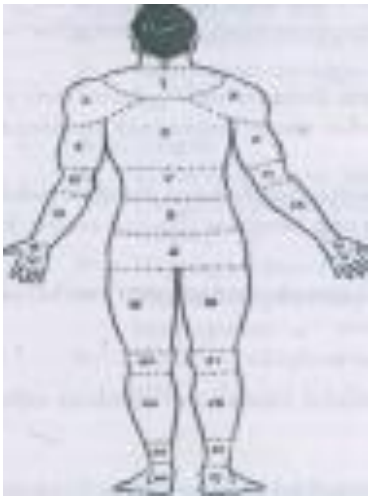


Figure 1. Nordic Body Map
Source: Corlett, 1992 in Tarwaka et al., 2004

Assessment of Physical Workload is the measurement method is indirectly carried out by using heart rate or pulse while working.. Posture is a setting of attitude when the body is doing work. Work

attitude at work should be done normally so as to prevent musculoskeletal events, including:

- Shoulder Correction
- Shoulder Joints
- Elbow Joints
- Wrist Joints

c. Rapid Upper Limb Assessment (RULA)

The RULA method was developed as a method to detect work posture which is a risk factor designed to assess workers and determine musculoskeletal that may cause disturbances in the upper limbs. The risk factors investigated as external load factors, namely:

- Amount of movement
- Static muscle work
- Power/strength
- Determination of working posture by equipment
- Working time without rest

Assessment using the RULA method has 3 stages of development, namely: 1. Identification and recording of working posture. The body is divided into two parts that form two groups.

Group A

1. Figure Upper arm

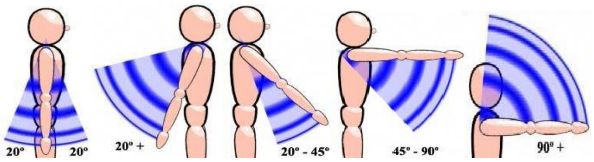


Figure 2. Posture of the upper arm (upper arm)
Source: www.rula.co.uk, 2010

Table 1. Upper armSource

Locate Upper Arm Position	Score	Adjustment
20° forward or backward of body	1	+1 if shoulders are up
> 20° backward or 20°- 45°	2	+1 if arms rotated/bent
40°- 90°	3	
> 90°	4	

Source: www.humanics-ef.com, 2010

2. Figure Lower arm

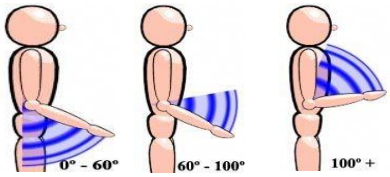


Figure 3. Posture of thelower arm
Source : www.rula.co.uk, 2010

Table 2. Score for the lower arm

Locate Lower Arm	Score	Adjustment
40° - 90 °	1	+ 1 if the forearm works past the midline or out of the side of the body
> 90°	2	

Source: www.humanics-ef.com, 2010

3. Wrist (Wrist)

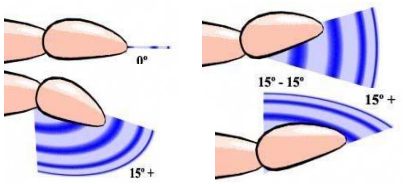


Figure 4. Posture of the wrist (wrist)
Source: www.rula.co.uk, 2010

Table 3. Score wrist (wrist)

Locate Wrist Position	Score	Adjustment
Neutral position	1	+1 if the wrist is away from the center
0 - 15 °	2	
> 15°	3	

Source: www.humanics-ef.com, 2010

4. Wrist *Twist* Source

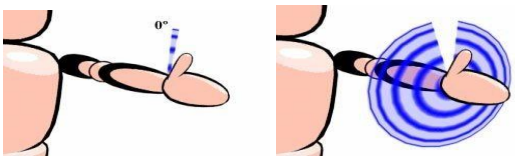


Figure 5. Body posture for thewrist
Source:twistwww.rula.co.uk , 2010

For a wrist*twist*in a neutral posture, the score is:
1 = midpoint of the twist.
2 = position at or near the turn.

b. Group B

1. Neck Figure

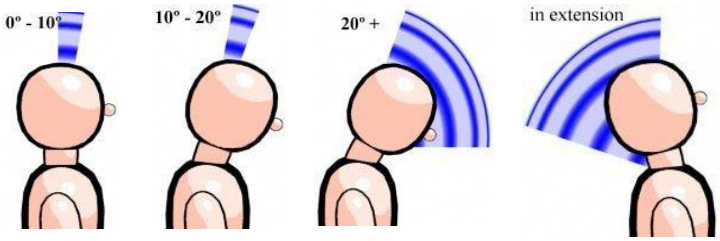


Figure 6. Body posture of the neck
Source: www.rula.co.uk, 2010

Table 4. Score of the neck

Locate Neck Position	Score	Adjustment
0° - 10°	1	+ 1 if neck rotates/bent
10° - 20°	2	
> 20°	3	
Extension	4	

Source: www.humanics-ef.com, 2010

2. Trunk Source

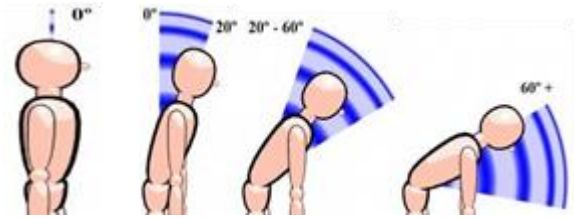


Figure 7. Body posture of thetrunk.
Source : www.rulaco.uk, 2010

Table 5. Score of the trunk (trunk)

Locate Trunk Position	Score	Adjustment
Normal position 90°	1	+1 if the shoulders are up
0° - 20°	2	+1 if the rotating arms are bent
20° - 60°	3	
> 60°	4	

Source : www.humanics-ef.com, 2010

3. Legs (Legs)

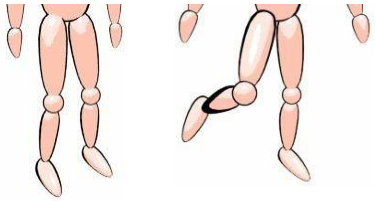


Figure 8. Posture of the legs (legs)
Source: www.rula.co.uk, 2010

Table 6. Score of the legs (legs)

Locate Legs Position	Score
Normal or balanced position	1
Unbalanced	2

Figure 9. Posture of the legs (legs)
Source: www.humanics-ef.com, 2010

4. Scoring a score
   For each movement in work is given according to existing provisions.
   a. Giving value (score) for Group A Group A
      Value = Posture + Muscle use + Force/Load
   b. Giving value (score) for Group B Group B
      Value = Posture + Muscle use + Force/ Load

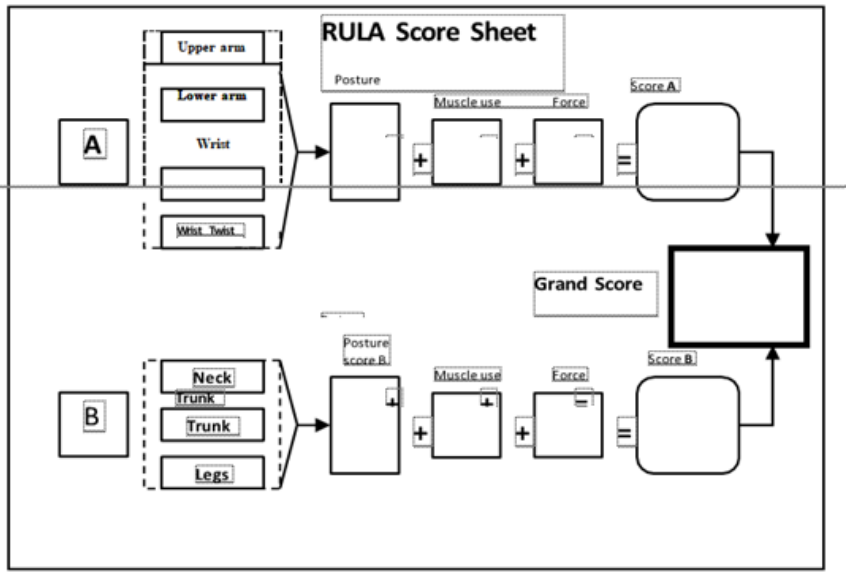


Figure 10. RULA scoring system
Source: www.humanics-ef.com, 2010

c. Final assessment (final score), namely score C
Score C can obtained by looking at the values A and B in the *Grand Score* table

Table 7. *Grand Score*

Table C		**Group B scores**						
		1	**2**	**3**	**4**	**5**	**6**	**7**
Scores Group A	1	1	2	3	3	4	5	5
	2	2	2	3	4	4	5	5
	3	3	3	3	4	4	5	6
	4	3	3	3	4	5	6	6
	5	4	4	4	5	6	7	7
	6	4	4	5	6	6	7	7
	7	5	5	6	6	7	7	7
	8+	5	5	6	7	7	7	7

5. Determination of the level of action Action
Level scale that provides a guideline on the level of existing risk and is needed to encourage a more detailed assessment related to the analysis obtained.

Table 8. Category of action based on grand score

Category of action	**level risk**	**Action**
1 – 2	Minimum	Safe
3 – 4	Small	Required for some time in the future
5 – 6	Moderate	Action in the near future
7	High	Action right now

d. Anthropometry and its application in the design of human work tools

In general will vary in terms of shape and dimensions of body size. There are several factors that will affect the size of the human body:

- Age
- Gender (*sex*)
- Tribe (*ethnic*)

- Body position (*posture*)

An explanation of the anthropometric dimensions of the body required in the design is explained.

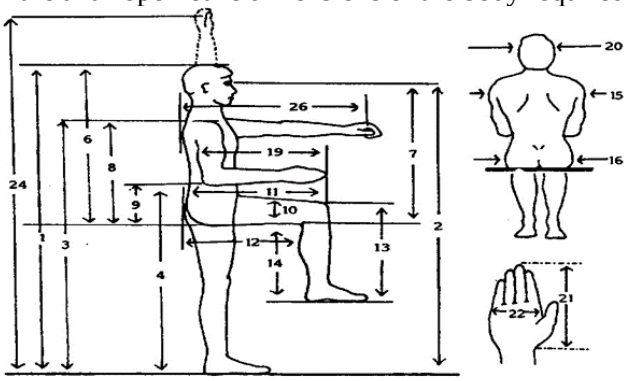
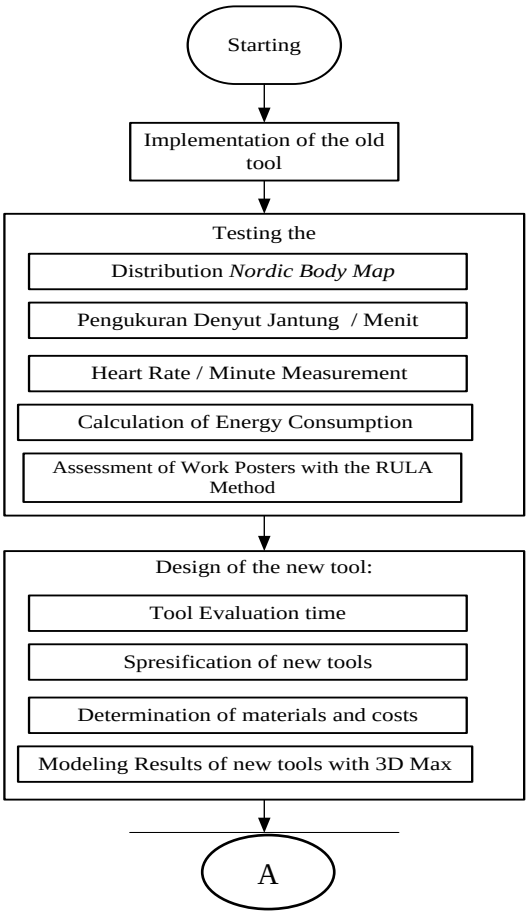


Figure 11. Anthropometry for Product Design
Source: Wignjosoebroto, 199

3. Methodology

Stage Problem identification in this study aims to identify whether the old design tool has been able to contribute to the comfort of the workers and according to the needs of workers. Trial of the old tool was carried out at UMKM Tempe Production, and the trial of the old tool included distributing the **Nordic Body Map**, measuring heart rate/minute, calculating energy consumption, assessing work posture using the RULA method, and anthropometric measurements workers.

Data of **Nordic Body Map** obtained by giving a **Nordic Body Map** to 1 worker, the data contains complaints that workers who make soybeans into tempeh feel when using old tools at work. The method used to measure heart rate is the 10 pulse method**using**a **stopwatch.**



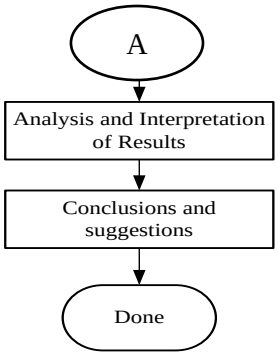


Figure 12. Flow of Research Methods Flowchart

4. Results and Discussion

a. Questionnaire Nordic Body Map (NBM)

The questionnaire was given to 1 worker who had tested an old tool with the aim of finding out the complaints workers experienced during or after making tempeh into soybeans.

Table 9. Questionnaire Data Nordic Body Map

No Image	Body Parts	Worker						Total	Percentage
		5	15	30	45	60	75		
0	Upper								
1	Lower Neck				√	√	√	3	50%
2	Left								
3	Right Shoulder								
4	Left Upper Arm								
5	Back		√	√	√	√	√	5	83%
6	Right Upper Arm								
7	Waist Back		√	√	√	√	√	5	83%
8	Hips Back								
9	Buttocks						√	1	17%
10	Left elbow						√	1	17%
11	Right elbow						√	1	17%
12	Left								
13	Forearm								
14	Left								
15	Right Wrist								
16	Left								
17	Palm Right								
18	Left Thigh					√	√	2	33%
19	Right Thigh					√	√	2	33%
20	Left Knee								
21	Right Knee								
22	Left								
23	Right Calf								
24	Left Ankle								
25	Right Ankle								
26	Foot								
27	Right Foot								

Leftand after work using a separator a soybean pulp from soybean seeds. The results of measuring a worker's heart rate per 10 beats are shown in, then an example of calculating heart rate before work (DN0) and after work (DN1) is shown using a soy dregs separator design tool from soybean.

Table 10. Data on measuring heart rate of workers per minute

Day	Time 10 beats (seconds)		Time 10 beats (seconds)	
	Before	After	Resting Heart Rate (Beats/minute)	Heart Rate after work (Beats/minute)
1	8.16	7.42	73.52	80.86
2	8.25	7.86	72.72	76.33
3	8.46	7.31	70.92	71.51
4	8.39	7.52	71.51	79.78
5	8.32	6.80	72.11	88.23
6	8.29	6.92	72.37	86.70

Source: Processed data for MSMS tempe blessing

. The results of measuring the heart rate per 10 beats will then be calculated for the heart rate per minute. An example of calculating heart rate per minute for worker number one is as follows:

- Resting Heart Rate (DN0)
  Heart Rate / minute = 10 beats x 60 / Calculation time = 10 beats x 60 / 8.16 = 73.52 beats/minute
- Heart Rate after work (DN1)
  Heart rate/minute = 10 beats x 60 / Calculation time = 10 beats x 60 / 7.42 = 80.86 beats/minute

b. Calculation of Energy

Consumption Energy consumption of workers when implementing old design tools determined based on the results of heart rate calculations. An example of calculating energy consumption for worker number one is as follows:

- Calculation of energy needed at rest (E0)
  E0 = (1.80411 – (0.0229038 x X)) + 4.71733 (10^{-4}(X^2) x 60
  = (1.80411 – (0.0229038 x 73.52)) + 4.71733 (10^{-4}x $(73.52)^2$ x 60
  = (1.80411 – (1.68388 + (4.71733 x 0.7352))x 60
  = (1.80422 – (1.68388 + 3.46818)) x 60
  = 3.35 x 60
  = 201 Kcal/hour
- Calculation of energy needed when working (E1)
  E1 = (1.80411 – (0) .0229038 x X)) + 4.71733 (10^{-4}(X^2)x 60
  = (1.80411 – (0.0229038 x 80.86)) + 4.71733 (10^{-4}x $(80.86)^2$ x 60
  = (1.80411 – (1.85200 + (4.71733 x 0.8086))x 60
  = (1.80422 – (1.85200 + 3.81443)) x 60
  = 3.86 x 60
  = 231.6 Kcal/ hours
- Calculation of the amount of energy consumption (KE)
  KE = E1 – E0
  = 231.6 – 201
  = 30.6 Kcal/hour

The results of calculating the energy consumption of workers from day one are classified into moderate workloads.

c. RULA method

- **Group A**

1) Upper arm, code RULA = 2.
   Description: Based on the rules for scoring, upper arm is 35 ° is given a score of 2 because it is located between positions 20° - 45°.
2) Forearm (lower arm), code RULA = 1.
   Note: according to the rules for a score of 25° the forearm is given a score of 1 because it is located between the positions from 0^o – 60^o.
3) Wrist *position*, code RULA = 2.
   Note: based on the rules for the wrist, wrist 10^o is given a score of 2 because it is located between the positions 0^o – 15^o.
4) Wrist *twist*, code RULA = 1.
   Note: based on the rules for wrist twists, wrist twists are given a score of 1 because the wrist is in the middle position during the twist.

Table 11. Determination of group score A RULA

Upper arm	Lower Arm	Wrist							
		1		2		3		4	
		Wrist Twist		Wrist Twist		Wrist Twist		Wrist Twist	
		1	2	1	2	1	2	1	2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	2	3	3	3	4	4
2	1	2	2	2	3	3	3	4	4
	2	2	2	2	3	3	3	4	4
	3	2	3	3	3	3	4	4	5
3	1	2	3	3	3	4	4	5	5
	2	2	3	3	3	4	4	5	5
	3	2	3	3	4	4	4	5	5
4	1	3	4	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	3	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	7	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

- **Group B**

1) Neck (*neck position*), code RULA = 2.
   Description: according to the rules for a neck score of ^{15o} is given a score of 3 because it is located between ^{10o}- 20° position.
2) Back (*trunk position*), code RULA = 4.
   Note: based on the rules for a back score of 70° it is given a score of 4 because it is located between positions 60° - 90°.
3) Legs *(legs position)*, code RULA = 1.
   Description: based on the rules for the feet score is given a score of 1 because the feet do not move when standing with an average balanced weight.

The results of determining the score for group B use table B which can be seen in table 4.4 below. Use of muscles or (muscle), code RULA = 1.

Table 12. Determination of group B scores RULA

	1	**2**	**3**	**4**	**5**	**6**
	Legs	**Legs**	**Legs**	**Legs**	**Legs**	**Legs**
Neck	1	2	1	2	1	2
1	1	3	2	3	3	4
2	2	3	2	3	4	5
3	3	3	3	4	4	5
4	5	5	5	6	6	7
5	7	7	7	7	7	8

Based on the rules for the use of muscles the activity of separating soybean dregs from soybean seeds is given a score of 1, because this activity is maintained within 1 minute and repeated.

Score for load *(force)* Load, code RULA = 0

Based on the rules for the load lifted by the worker is given a score of 0 because the load lifted is less than 2 kg. The next step is to add scores for muscle use *and* force . The score of group A is 2, plus the score of muscle (1) and the score of load (0) becomes 3. The score of group B is 5, plus the score of muscle (1) and load (0) becomes 6. The total score for the soybean dregs separation process from soybean seeds is done by combining the scores of group A and group B scores using table.

Table 13. Determination of group C score RULA

1		2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

From the coding above, the total score is 5 the total score is 5, meaning that the risk level is moderate with corrective action needed in the near future.

Worker Anthropometric Measurements

In the design of this ceramic makers tool, frame dimensions and reach are determined by using artisan anthropometry data. The anthropometric data of the workers obtained and shown are as follows:

TPO : Plopiteal Height = 42cm.
PP : Plopiteal buttocks = 44cm.
LP : Hip Width = 40cm.
LPG : Waist Width = 33cm.
JTD : Forward Hand Reach = 66cm.
TPG : Waist Height = 50cm.
SKJT : Elbow to Middle Fingertip = 38cm

5. Conclusion

Based on the calculation of heart rate and energy consumption, from the initial average of 1800 kilo calories it decreased to an average of 1500Kkl using the rula method with a score of group A score is 2, plus a muscle score (1) and the load score (0) becomes 3. The score for group B is 5, plus the score for muscle (1) and load (0) becomes 6. The total score for the process of separating soybean dregs from soybean seeds is carried out by combining the scores of group A and group B scores by using table C so that the value in group C is 5 which means the risk level is moderate and improvement is needed in the near future. Based on research on the design of a new working tool for removing soybean dregs from soybean seeds in the form of work chairs with anthropometric data of workers as chair Seat Width (LP) = 41cm, backrest height (TPG) = 40cm, backrest width (LPG) = 35cm, So that work chairs made based on these data can reduce the workload of workers.

References

Alfatiya, R. M. (2017). Redesign Kursi Dan Meja Perkuliahan Dengan Metode Quality Function Deployment (QFD) Secara Ergonomis Di Program Studi Teknik Industri Universitas Pamulang. Proceedings Universitas Pamulang, (p. 2(1).).

Antoni, S., & Hidayat, T. . (2016). Perancangan Meja Konveyor Sebagai Media Pembelajaran Untuk Mempertimbangankan Faktor Antropometri Di Laboratorium Analisa Perancangan Kerja Fakultas Teknik. Engineering. Jurnal Bidang Teknik, , 7(1).

Asy'ari, S. &. (2019). Pembuatan mesin pengayak tepung jagung dengan pendekatan antropometri . Journal of Industrial Hygiene and Occupational Health , Vol, 4(1).

Asy'ari, S. S. (2021, February). Prototype Plate Bending Tool 1 mm Size in the Process of Making a Fence with an Anthropometric Approach in the Pasuruan Regency

Welding Workshop. In Journal of Physics. Journal of Physics: Conference Series, IOP Publishing, (Vol. 1783, No. 1, p. 012093).

Asy'ari, S. (2019). Pengukuran Antropometri Pekerja Cut Open Pada Proses Pengolahan Susu Di PT. XYZ. JKIE (Journal Knowledge Industrial Engineering). JKIE (Journal Knowledge Industrial Engineering), 6(3), , 128-135.

Azmi, A., Fitra, F., & Suroso, M. . (2021). Penerapan Data Antropometri Dalam Perancangan Alat Pengupas Sabut Kelapa Ekonomis. Jurnal ARTI (Aplikasi Rancangan Teknik Industri), 16(1), 94-99.

Bintang, A. N. (2017). Analisa postur kerja menggunakan metode owas dan rula. Jurnal Teknik Industri, 18(1), , 43-54.

Bora, M. A. (. (2017).). Usulan Desain Laboratorium Perancangan Sistem Kerja & Ergonomi di Program Studi Teknik Industri STT Ibnu Sina Batam. . J. Tek. Ibnu Sina, , 2(2), 1-7.

Izzhati, D. N. ((2010).). Pengembangan alat pemotong tahu yang ergonomis dengan menggunakan metode RULA. Prosiding SNST Fakultas Teknik, 1(1).

Kholili, N., Hindratmo, A., & Nugroho, A. (2021). Perancangan Mesin Cacah Sampah Organik Dan Nonorganik Yang Otomatis Berbasis Ergonomis Dengan Metode Qfd Dan Antropometri.

Pratama, P., Tannady, H., Nurprihatin, F., Ariyono, H. B., & Sari, S. M. . (2017). Identifikasi risiko ergonomi dengan metode quick exposure check dan nordic body map. J. PASTI, , 11(1), 13-21.

Taryat, T., & Nurwathi, N. (2021). Perancangan Mesin Perajang Singkong Yang Ergonomis Menggunakan Data Antropometri. Rekayasa Industri dan Mesin (ReTIMS), 2(1), 27-32.

Prayogo, I. A. (2017). Sistem Monitoring Denyut Jantung Dan Suhu Tubuh Sebagai Indikator Level Kesehatan Pasien Berbasis Iot (Internet Of Thing) Dengan Metode Fuzzy Logic Menggunakan Android. . Jurnal Teknik Elektro dan Komputer TRIAC, , 4(2), 33-39.

Supriyanto, S. &. (2020). Pengembangan Produk Meja Laptop Lipat Dengan Pendekatan Ergonomi Dan Antropometri. Jurnal Aplikasi Ilmu Teknik Industri (JAPTI), 1(1).

Setiawan, R., Mulyono, S., & Yuhas, D. (2021, December). Perancangan Adjustable Welding Table yang Ergonomis Berdasarkan Pertimbangan Antropometri Di Bengkel Teknik Mesin. In Seminar Nasional Teknik Mesin 2021 (pp. 641-650)