SURAT TUGAS

Nomor: 1344-R/UNTAR/PENELITIAN/IV/2022

Rektor Universitas Tarumanagara, dengan ini menugaskan kepada saudara:

1. **LAMTO WIDODO, S.T., M.T., Dr.**
2. **I WAYAN SUKANIA, ST., M.T.**
3. **YENITA, Dr., Dr., S.E., M.M., M.Si., M.T.,**

Untuk melaksanakan kegiatan penelitian/publikasi ilmiah dengan data sebagai berikut:

Judul	:	Ergonomic Intervension to Improve Work Efficiency (Case Study: Small and Medium Enterprise of Tofu Industry)
Nama Media	:	JOURNAL OF MODERN MANUFACTURING SYSTEMS AND TECHNOLOGY (JMMST)
Penerbit	:	Universiti Malaysia Pahang
Volume/Tahun	:	VOL.6, ISSUE1,32?40
URL Repository	:	https://journal.ump.edu.my/jmmst/article/view/6928/1511

Demikian Surat Tugas ini dibuat, untuk dilaksanakan dengan sebaik-baiknya dan melaporkan hasil penugasan tersebut kepada Rektor Universitas Tarumanagara

08 April 2022
Rektor

Prof. Dr. Ir. AGUSTINUS PURNA IRAWAN

Print Security : 9a7df4f369c2097f5c26dd84653b8c14

Disclaimer: Surat ini dicetak dari Sistem Layanan Informasi Terpadu Universitas Tarumanagara dan dinyatakan sah secara hukum.

JOURNAL OF MODERN MANUFACTURING SYSTEMS AND TECHNOLOGY (JMMST)
e-ISSN: 2636-9575
VOL. 6, ISSUE 1, 32 – 40
DOI: https://doi.org/10.15282/jmmst.v6i1.6928

ORIGINAL ARTICLE

Ergonomic Intervension to Improve Work Efficiency (Case Study: Small and Medium Enterprise of Tofu Industry)

L Widodo[1,3], I Wayan Sukania[1], Yenita[2], and Michael Hendri[1]

[1]Industrial Engineering Department, Faculty of Engineering, Universitas Tarumanagara Jakarta, Indonesia.
[2]Management Department, Faculty of Economic and Business, Universitas Tarumanagara Jakarta, Indonesia.
[3]Work System and Ergonomic Laboratory, Faculty of Engineering, Universitas Tarumanagara Jakarta, Indonesia.

ABSTRACT–The food industry is one of the most important industries in human life. Raimin SME is a form of business engaged in the food sector that produces tofu. The tofu production process at Raimin SMEs is mostly done manually. There are some subjective complaints from workers when they are active on the production floor. This complaint was obtained by conducting an initial survey in the form of filling out the Nordic Body Map. Unnatural posture is one of the problems faced by workers, especially in the process of cutting tofu and in terms of ergonomics, working posture in the process of removing tofu from mold and process of tofu cutting. The purpose of this research is to design a tool based on an ergonomic approach so as to reduce the risk of injury and excessive fatigue. The tool in question is also expected to increase the efficiency of processing time. Based on the results of the Nordic Body Map, the most problematic body parts are known, then the Rapid Entire Body Assessment (REBA) and Workplace Ergonomic Risk Factor (WERA) scores are calculated. The results of the REBA calculation for removing tofu from mold resulted in a score of 11 (very high risk category). The results of calculations using the WERA method in the tofu cutting process resulted in a score of 37 (medium risk category). The results of the heart rate (HR) measurement show that workers need energy of 6.34 kcal/minute (classified in heavy work). Furthermore, tool design, simulation with CATIA software and implementation on the production floor are carried out. Of the 8 design concepts, the best design was selected and a simulation was carried out with CATIA software, the result of the REBA score of the cutting process was reduced to 3 (low risk category). The results of the implementation of the tool show that the REBA score after implementation decreases to 3, the WERA score becomes 27, and the energy consumption rate decreases to 3.98 kcal / min, which is categorized as light work. The standard time for removing tofu from mold decreased by 48% (from 48.05 sec to 24.9 sec), while for tofu cutting process it decreased by 69.2% (from 44.58 sec to 13.70 sec).

ARTICLE HISTORY
Revised:9th August 2021
Accepted:15th September 2021

KEYWORDS
Ergonomics,
Nordic Body Map,
REBA,
WERA,
HR,
Standard Time

INTRODUCTION

In Indonesia, soybean (Glycine Max) is the third most important commodity after rice and corn. More than 90% of Indonesian soybeans are used as food ingredients, especially processed food, which is about 88% for tofu and tempeh, 10% for other processed foods and about 2% for seeds [1]. The main principle of the process of making tofu is clumping (precipitation) of soy milk protein. The materials used are tofu block (CaSO4), vinegar (CH3COOH) and MgSO4. The process of making tofu consists of several stages, namely soaking, grinding, cooking, filtering, clumping, printing/hardening and cutting [2].

Small and Medium Enterprises (SME) of Tahu Raimin is an industry engaged in the production of tofu, located in Jakarta, Indonesia. Most of the production process is done manually, including the tofu cutting process. From the initial study found some serious problems with this manual work, which is indicated by the number of subjective complaints from workers. The test parameters used in the initial study were Nordic Body Map (NBM), Rapid Entire Body Assessment (REBA), Workplace Ergonomic Risk Assessment (WERA), and Heart Rate Monitor (HRM).

The Nordic Body Map questionnaire is a questionnaire used to find symptoms and complaints of musculoskeletal disorders in workers [3], [4]. The purpose of filling out the Nordic Body Map questionnaire is to find out the complaints of workers' body parts that feel sick before and after doing work at the work station and are divided into 27 body parts. Nordic Body Map is a development of the Nordic Musculoskeletal Questionnaire (NMQ) which is a questionnaire used to find symptoms and complaints of musculoskeletal disorders in workers [5]. Rapid Entire Body Assessment (REBA) is a method developed in the field of ergonomics that can be used quickly to assess the working position or posture of an operator's neck, back, arms, wrists, and legs. REBA can be used for full body assessment as an evaluation of musculoskeletal load on posture, repetition and force [6][7]. While the Workplace Ergonomic Risk Assessment (WERA) is a survey tool developed for rapid task screening to describe the physical risk factors associated with Work-related Musculoskeletal Disorders (WMSDs). The WERA assessment consists of six physical risk factors including posture, repetition, strength, vibration, contact stress, and duration of work and involves five main body parts, namely

*CORRESPONDING AUTHOR | L Widodo | ✉ lamtow@ft.untar.ac.id

the shoulders, wrists, back, neck, and legs [8], [9][10]. Measurement of heart rate before and after working with a Heart Rate Monitor (HRM) is used to measure the level of energy consumption. The amount of energy expended for a job can be measured by taking into account heart rate and demographic factors and by using regression it can be seen the relationship between heart rate, weight, height and age with energy [11]–[13].

The purpose of this study was to determine the most dominant complaints of workers related to MSDs, to design proposed tools, to carry out ergonomic interventions (with implementation) and to analyze the results of the implementation.

RESEARCH METHODOLOGY

Research begins by conducting a field study by identifying the object of research. Simultaneously, a literature study was conducted to examine ergonomic tools that can be used for analysis and design. The initial analysis was conducted to find out the operator's complaints about the working conditions, especially the dominant complaints. From the results of the complaint analysis, the cause of the complaint is identified, as well as what conditions are desired by the workers. The initial research also carried out time studies to determine the cycle time, normal time and standard time of the tofu production process.

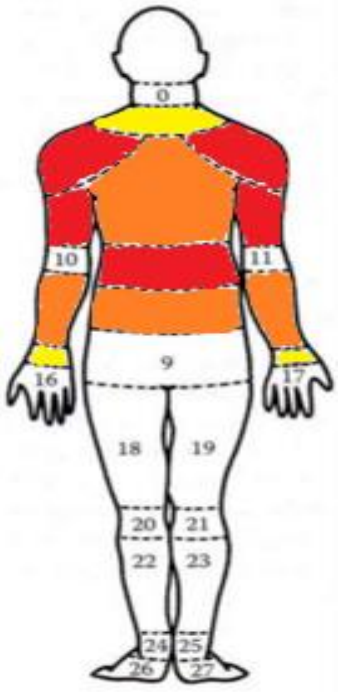
The next stage is to design a tool based on a matrix of complaints, causes, expectations and suggestions of workers. Several alternative proposals are given, then a selection is made to get the best alternative selected. Then an ergonomics simulation was carried out using Catia software to determine the worker's posture so that the REBA value was obtained [14], [15]. These results are then compared with the REBA value of working posture in the existing condition. If the REBA value is reduced, it means that the design is considered capable of reducing ergonomic risks.

The final stage is to make a prototype of the selected alternative tool, and carry out its implementation in the industry. The results of the implementation were analyzed including body posture, subjective complaints, and standard time. These results are compared with the existing conditions as a conclusion and this research.

INITIAL STUDY - EXISTING CONDITION

Worker Complaints Based on NBM and REBA/WERA Score

Evaluation of the existing condition of the tofu production process using the Nordic Body Map shows the physical complaints experienced by workers in several parts of the body while doing their work.The level of complaints of sick (S) and very sick (VS) from body parts can be seen in Figure 1.



Where:
Red Color: Very sick (VS)
Orange Color: Pain (S)
Yellow Color: Somewhat Sick (SS)

The highest complaints are on the *left shoulder, waist, back, upper and lower arms, lower neck, and left and right wrists.*

Figure 1. Physical Complaints to Workers

After analyzing the physical complaints, the Rapid Entire Body Assessment (REBA) score was then calculated based on body posture images (Figure 2 and Figure 3) when doing work. Likewise, the Workplace Ergonomic Risk Assessment (WERA) was calculated, and the results can be seen in Table 1.

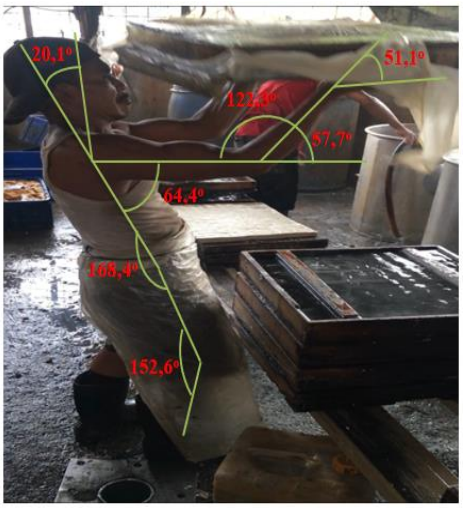


Figure 2. Process of removing tofu from mold.

Figure 3. Process of tofu cutting.

Table 1. Calculation results of REBA and WERA.

No.	Activity	REBA score	Risk Level	WERA Score	Risk Level
1	Process of removing tofu from mold	12	*Very High Risk*	36	*Medium Risk*
2	Process of tofu cutting	11	*Very High Risk*	37	*Medium Risk*

The next test is a physical workload test by calculating the Heart Rate. Measurements are made during the tofu cutting process. The average heart rate during work is 119. The level of energy consumption of workers in the process of cutting tofu with the formula [16]:

$$\mathbf{VO_2 = 0.019HR - 0.024h + 0.016w + 0.045a + 1.15}$$
$$= 0.019(116) – 0.024(162) + 0.016(55) + 0.045(31) + 1.15$$
$$= 2.033 – 4.008 + 1.04 + 1.17 + 1.15$$
$$= 1.268 \text{ litre/min}$$
$$= 6.34 \text{ kcal/min}$$

and is categorized of medium work (5.0 - 7, 5 kcal / min).A graph of the heart rate measurement results during the tofu cutting activity can be seen in Figure 4.

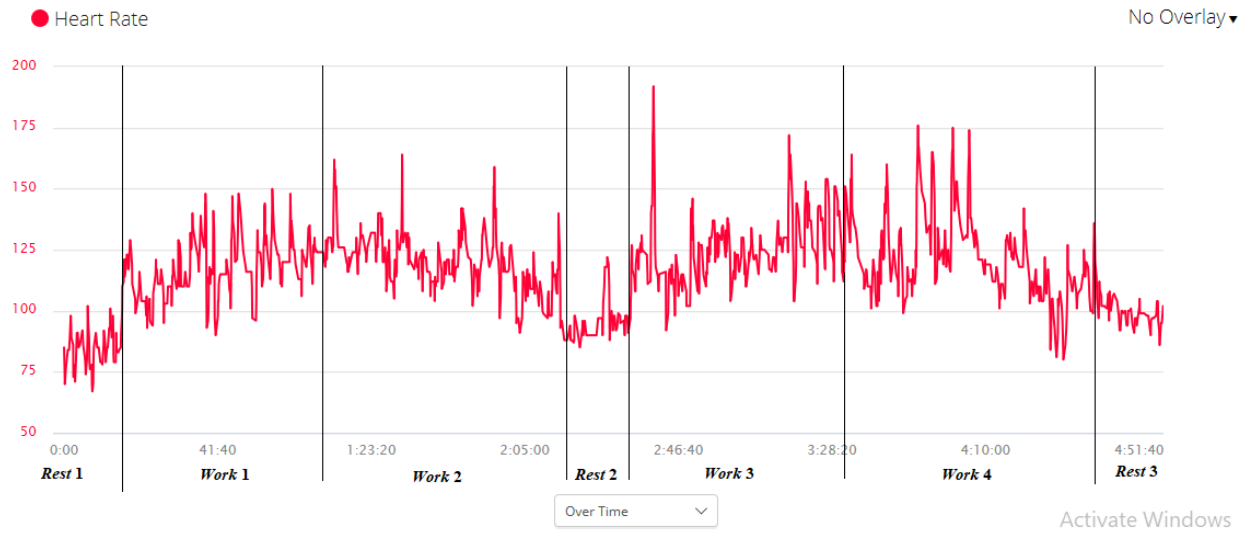


Figure 4. Heart Rate during tofu cutting process

Standard Time

Standard Time Calculation of the standard time for the existing process, is done by calculating the cycle time, normal time with the existing allowance factor.The following is a standard time calculation which can be seen in Table 2 below.

Table 2. Calculation of Standard Time

No	Activity	Cycle Time (sec)	Rating Factor	Normal Time (sec)	Allowance	Standard Time (sec)
1	Process of removing tofu from mold	34,6	+0,01	34,946	37,5%	48,05
2	Process of tofu cutting	32,3	+ 0,03	33,269	34%	44,58

Based on the table above, it is known that the standard time obtained is 48.05 seconds for Removing the Tofu from mold, and 44.58 seconds for Tofu Cutting.

TOOL DESIGN

Before designing tools as a solution to the problems faced by workers, an analysis of Complaints, Causes, Expectations, and Proposed Improvements (worker version) is carried out. Complaints from the NBM questionnaire were analyzed, so that the causes of these complaints were obtained. Then interviews were also conducted to find out the expectations desired by workers to minimize existing complaints. Then the best design proposals/solutions are made in order to meet expectations and reduce worker complaints. The results of the analysis of complaints, causes, expectations, and design proposals can be seen in Table 3.

Table 3. Analysis of Complaints, Causes, Expectations, and Proposed Improvements (worker version).

No.	Complaint	Cause	Expectation	Proposed Improvement
1	Pain in the neck, back, shoulders, and arms	A working position that is bent over and lifting weights repeatedly for a long period of time	A tool that can improve the posture of workers so as to reduce complaints	The design of the assistive device is adjusted so that the worker does not perform the job in a stooped position
2	Pain in the waist	Workers must bend down after removing the tofu from the box to proceed to the cutting process	A tool that has a design that can reduce the frequency of workers bending during the tofu cutting process	The size of the tool that is in accordance with the position of the worker when doing the tofu cutting process
3	Pain in the wrist	The tofu cutting process requires workers to repeatedly cut vertically and horizontally	There are cutting tools that are practical to use and can reduce vertical and horizontal movements in the tofu cutting process	Cutting tool design that can reduce vertical and horizontal cutting movements in the tofu cutting process
4	The tofu print box is slippery during the process of removing the tofu from the print box	Inadequate hand grip when removing tofu from the print box	There is a tool for removing tofu from the printed box	Provided a suitable handle or hand grip on the design of the tool

After analyzing complaints, expectations, and needs, the next step is to translate these analyzes into alternative designs that can overcome the complaints that occur. Making alternative designs is done by conducting interviews with SME of Raimin Tofu in order to find out the selected and considered characteristics in a design, as well as to filter and simplify the design of tools using product design and development methods. The design is made so that workers no longer need to bend over for a long time, turn the box of tofu using both hands, and do not need to do repetitive movements in the process of cutting tofu.After determining the alternatives and conducting concept selection, there are 3 concepts from 8 alternative concepts.The concept screening matrix for tools can be seen in Table 4 below.

Table 4. The concept screening matrix for tools.

	Concept Proposed							
Selection Criteria	1	2	3	4	5	6	7	8
Suitable Size	+	+	-	+	+	+	-	-
Reduce Time	+	+	+	+	+	+	+	+
Raw Material	+	+	+	+	-	-	-	-
Easy to Operate	+	+	-	+	-	+	-	+
More practical cutting tool	+	+	+	+	+	+	+	+
A Tool for Removing Tofu	+	+	+	+	+	+	+	+
Total (+)	6	6	4	6	4	5	3	4
Total (0)	0	0	0	0	0	0	0	0
Total (-)	0	0	2	0	2	1	3	2
Final Score	6	6	2	6	2	4	0	2
Rank	1	2	5	3	6	4	8	7
Be Continued?	Yes	Yes	No	Yes	No	No	No	No

The results of the concept screening stage obtained 3 concepts that have the same ranking. Then the assessment stage for the 3 selected concepts is carried out. This stage is the stage of assigning relative importance weights to each selection criteria and focusing on better comparison results with an emphasis on each criterion. An example of a calculation to get a weight on the selection criteria for an ergonomic working method is by dividing the value by the number of the weights, namely 5/24 x 100% = 20.83%. After determining the weights for each selection criteria, the weighted score is calculated. The value of the weighted score is obtained from the multiplication between the rating and the percentage of weight that has been determined in the table above. The weighted scores of each concept are summed and a ranking is determined for each concept [11] The concept assessment matrix for tools can be seen in Table 5.

Table 5. The concept assessment matrix.

		Concept					
		1		2		4	
Selection Criteria	WeightedFactor(%)	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Suitable Size	20.83	5	1.04	5	1.04	4	0.83
Reduce Time	16.67	4	0.67	5	0.83	3	0.5
Raw Material	12.5	5	0.63	5	0.63	4	0.5
Easy to Operate	16.67	4	0.67	5	0.83	4	0.67
More practical cutting tool	20.83	4	0.83	4	0.83	3	0.62
A Tool for Removing Tofu	12.5	4	0.5	4	0.5	4	0.5
	Total Score	4.34		4.66		3.62	
	Be Continued?	No		Yes		No	

From the results of the calculation of the weighted score, the highest alternative value is decided as the chosen alternative for development and implementation. From the calculation results, concept 1 has a final score of 4.34, concept 2 has a final score of 4.66, and concept 4 has a score of 3.62. Thus concept 2 was chosen as the concept to be developed and implemented. The three alternative design can be seen in Table 6.

Table 6. The three tool alternative design.

Alternative	1	2	4
3D Drawing			
Description	Concept 1 is designed with a rectangular table shape. The table is divided into 2 parts that can be folded. The left is for inserting the tofu mold box and the right is for the tofu cutting place. The material for inserting the tofu mold box is designed in full parts. The tofu cutter uses a lever that can be raised and lowered to carry out the cutting process.	Concept 2 is designed with a rectangular table shape. The table is divided into 2 parts that can be folded. The left is for inserting the tofu mold box and the right is for the tofu cutting place. The material for inserting the tofu mold box is designed in the form of a framework. The tofu cutter uses a lever that can be raised and lowered to carry out the cutting process.	Concept 4 is designed with a rectangular table shape. The table is divided into 2 parts that can be folded. The left is for inserting the tofu mold box and the right is for the tofu cutting place. The material for inserting the tofu mold box is designed in the form of a framework. Tofu cutting tools use hinges that can be folded to carry out the cutting process.

Tool Dimension

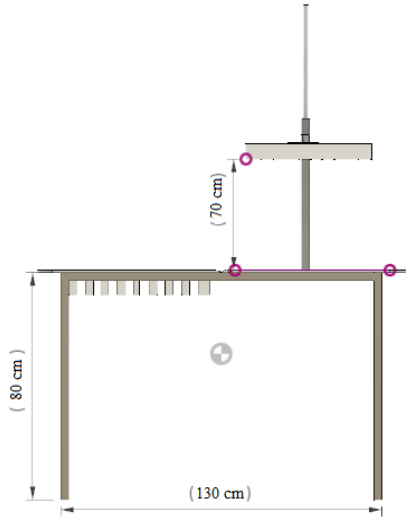
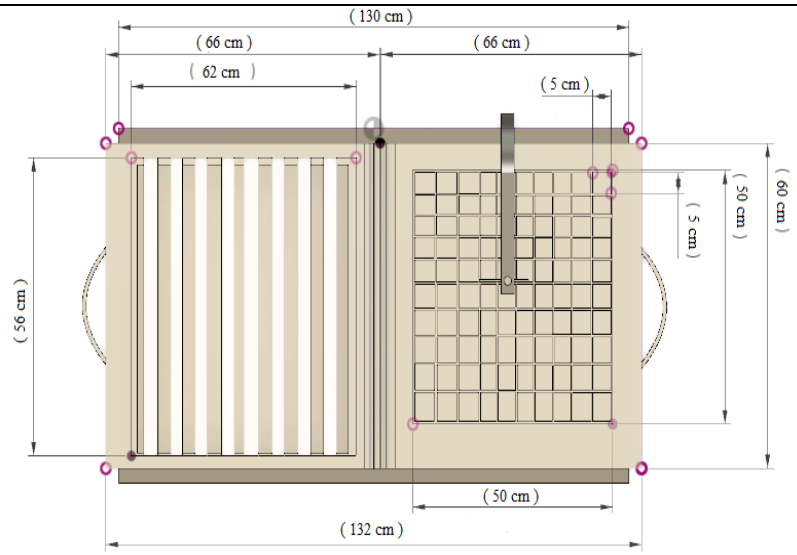
The dimensions of the tool are determined based on the anthropometric data of workers, the size of the tofu mold box, and the size of the tofu on the Tofu Raimin SME. Because all workers are male, the data used is anthropometric adult male. The body dimensions used are the latest Indonesian male body dimensions. The anthropometric data used can be seen in Table 7.

Table 7. Anthropometric data (Indonesian's Adult Male).

Component	Related anthropometric data	Percentile	Dimension (cm)	Tolerance (cm)	Final dimension (cm)
Table Height	Elbow Height	5 %tile male	88.6	-8.6	80
Tofu Cutting Tool Height	Body Height (Standing Upright)	5 %tile male	146.4	+3.6	150
Table Length	Adapted to Working Conditions	-	-	-	130
Table Width	Distance from Grip to Back in Front Hand Position (Horizontal)	5 %tile male	61.0	-1	60
Tofu Cutter Tool (Length, width, height)	Adapted to the Size of Tofu	-	-	-	(50 x 50 x 3)
Tofu Extraction Tool (Length, width, height)	Adapted to Tofu Box Size	-	-	-	(62 x 56 x 15)

Table height is determined based on 5% percentile elbow height data, given a tolerance of -8.6 cm so that when folding the table, part of the table does not exceed the position of the worker's head. The height of the Tofu Cutting Tool is adjusted based on body height data in the 5% percentile standing upright position, a tolerance of +3.6 cm is given so that when folding the table, the table part does not collide with the tofu cutting tool. The table width is adjusted based on the data from the grip distance to the back in the forward (horizontal) 5% percentile position, a tolerance of -1 cm is given to make it easier for workers to reach the width of the table. Then, for the dimensions of the Table Length, Tofu Cutting Tools, and Tofu Removing Aids are adjusted to the sizes that apply to Raimin Tofu SME. The complete dimensions of the tool can be seen in Table 8.

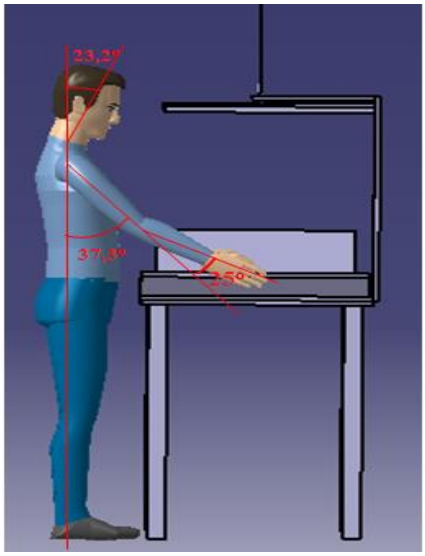
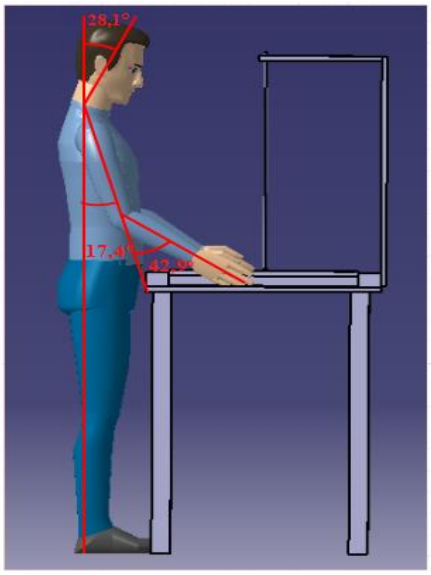
Table 8. Tool dimension (final).

Mechanical Drawing	Description
	Table Height and Tofu Cutting Tool Height
	Length, and Width of the Table, as well as Cutting and Removing Tofu

SIMULATION

After the selected concept design (concept 2) is completed with dimensions, the next step is to simulate the worker's posture using CATIA software. The goal is to find out if there are changes in body posture when using assistive devices. The simulation model used is a male mannequin with 5% percentile. The simulation is done by positioning the mannequin according to the position of the worker when doing the job using the designed tool. Based on the image of the mannequin in the software, then the angle measurement of the mannequin posture is carried out to calculate the change in the REBA score. The comparison of the results of REBA scores before and after implementation using CATIA software can be seen in Table 9.

Table 9. The comparison of the results of REBA scores before and after implementation using CATIA software.

No.	Activity	CATIA Simulation	REBA Score (existing condition)	REBA Score (by using CATIA Simulation)
1	Process of removing tofu from mold		12	4
2	Process of tofu cutting		11	3

IMPLEMENTATION

Comparison of REBA and WERA Analysis Before and After Implementation

The final stage of this research is prototyping and implementation. The prototype is made according to the dimensions that have been determined based on the selected concept, and the implementation is carried out at the Raimin Tofu SME Industry. After the implementation of the tofu cutting process, REBA and WERA scores were obtained. The comparison of REBA and WERA scores before and after implementation can be seen in Table 10 and Table 11.

Table 10. The comparison of REBA score before and after implementation.

No.	Activity	Worker Body Posture	REBA Score (existing condition)	Risk Level	REBA Score (after imple-mentation)	Risk Level
1	Process of removing tofu from mold		12	*High Risk*	4	*Medium Risk*
2	Process of tofu cutting		11	*High Risk*	3	*Low Risk*

Table 11. The comparison WERA score before and after implementation.

No.	Activity	WERA Score (existing condition)	Risk Level	WERA Score (after implementation)	Risk Level
1	Process of removing tofu from mold	36	*Medium Risk*	26	*Low Risk*
2	Process of tofu cutting	37	*Medium Risk*	27	*Low Risk*

Comparison of Energy Consumption Levels Before and After Implementation

Based on the measurement of the worker's heart rate after using the tool, the operator of the tofu cutting division experienced a decrease in the level of energy consumption. The following is a comparison of the energy consumption level before and after implementation which can be seen in Table 12.

Table 12. The comparison of energy consumption level before and after implementation.

Before Implementation (Existing Cpondition)		After Implementation	
Average Heart Rate (bpm)	Energy Consumption (kkal/menit)	*Average Heart Rate* (bpm)	Energy Consumption (kkal/menit)
116	6,34	91	3,98

Comparison of Standard Time Before and After Implementation

Based on the measurement of cycle time, normal time and standard time, it was found that the processing time decreased after implementation. The following is a comparison of the time before and after implementation of the process of Removing Tofu from the Printed Box and Cutting Tofu which can be seen in Table 13 and Table 14.

Table 13. The comparison between the time before and after implementation (Process of removing tofu from mold).

No	Time	Before Implementation /Existing Cpondition (sec)	After Implementation (sec)	Reduce Percentage (%)
1	Cycle Time	34.6	20.2	41.6
2	Normal Time	34.9	20.8	40.5
3	Standard Time	48.05	24.9	48

Table 14. The comparison between the time before and after implementation (Process of tofu cutting).

No	Time	Before Implementation /Existing Cpondition (sec)	After Implementation (sec)	Reduce Percentage (%)
1	Cycle Time	32.3	11.3	65
2	Normal Time	33.27	11.53	65.4
3	Standard Time	44.58	13.71	69.2

CONCLUSION

1) Based on the results of the Nordic Body Map questionnaire, there were 12 physical complaints experienced by workers during the tofu cutting process. Then by assessing body posture using the REBA and WERA methods and measuring heart rate, it can be concluded that the work done by workers in the tofu cutting division of SME Raimin is not ergonomic.
2) Based on the analysis, complaints, and expectations, 8 alternative design tools were obtained which were then filtered using the Product Design and Development method into 3 alternative tools in the form of a workbench with tools for removing and cutting tofu. Then concept 2 was chosen as the best concept and according to the needs of workers.
3) The results of the simulation using CATIA software obtained a lower REBA score than the REBA score before implementation, namely for the process of removing tofu from the printed box it decreased from 12 to 4, while for the tofu cutting process it decreased from 11 to 3. tool, the posture of workers in the tofu cutting division will be better than before using tool.
4) After implementation, there was a decrease in the REBA score for the activity of removing and cutting tofu to 4 and 3, respectively, then the WERA score for these activities became 26 and 27 respectively. The calculation of the total energy consumption of tofu cutting operators decreased to 3, 98 kcal/min.The standard time for removing tofu from mold decreased by 48% (from 48.05 sec to 24.9 sec), while for tofu cutting process it decreased by 69.2% (from 44.58 sec to 13.70 sec).

REFERENCES

[1] T. Sudaryanto and D. K. S. Swastika, "Soybean Economy in Indonesia (Original title in Indonesian: Ekonomi Kedelai di Indonesia)," *Kedelai – Tek. Produksi dan Pengemb.*, no. Bps, 2007.

[2] J. Mulyana and L. M. H. Santosa, "Proses Pembuatan Tahu," *Tek. Tata Cara Pembuatan Dan Cara Kerja*, no. April, 2013.

[3] L. Widodo, S. Ariyanti, and J. Octavia, "Peningkatan produktifitas UKM Produk Sugarwax melalui Intervensi Ergonomi," 2019.

[4] S. Ariyanti, L. Widodo, M. Zulkarnain, and K. Timotius, "DESIGN WORK STATION OF PIPE WELDING WITH ERGONOMIC APPROACH," *SINERGI*, vol. 23, no. 2, p. 107, Jul. 2019, doi: 10.22441/sinergi.2019.2.003.

[5] I. Kuorinka *et al.*, "Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms," *Appl. Ergon.*, 1987, doi: 10.1016/0003-6870(87)90010-X.

[6] L. Widodo, A. Adianto, D. Debby, and S. Rohananasution, "Ergonomic portable toilet for women in public facilities," in *IOP Conference Series: Materials Science and Engineering*, 2019, doi: 10.1088/1757-899X/508/1/012052.

[7] S. Hignett and L. McAtamney, "Rapid Entire Body Assessment (REBA)," *Applied Ergonomics*. 2000, doi: 10.1016/S0003-6870(99)00039-3.

[8] M. N. asrull Abd Rahman, M. R. ebi Abdul Rani, and J. M. ohd Rohani, "WERA: an observational tool develop to investigate the physical risk factor associated with WMSDs," *J. Hum. Ergol. (Tokyo).*, 2011, doi: 10.11183/jhe.40.19.

[9] L. Widodo, F. J. Daywin, and M. Nadya, "Ergonomic risk and work load analysis on material handling of PT. XYZ," in *IOP Conference Series: Materials Science and Engineering*, 2019, vol. 528, no. 1, doi: 10.1088/1757-899X/528/1/012030.

[10] M. N. A. Rahman, M. R. A. Rani, and J. M. Rohani, "Investigation of work-related musculoskeletal disorders in wall plastering jobs within the construction industry," *Work*, 2012, doi: 10.3233/WOR-2012-1404.

[11] T. Kuusela, "Methodological aspects of heart rate variability analysis," in *Heart Rate Variability (HRV) Signal Analysis: Clinical Applications*, 2013.

[12] G. Ernst, "Heart rate variability," *Hear. Rate Var.*, 2014, doi: 10.1007/978-1-4471-4309-3.

[13] A. M. Basahel, "Investigation of Work-related Musculoskeletal Disorders (MSDs) in Warehouse Workers in Saudi Arabia," *Procedia Manuf.*, 2015, doi: 10.1016/j.promfg.2015.07.551.

[14] L. Widodo, I. W. Sukania, and R. Sugiono, "RANCANGAN FURNITURE DAN TATA RUANG DENGAN DIMENSI TERBATAS SECARA ERGONOMIS," *J. Ilm. Tek. Ind.*, 2017, doi: 10.24912/jitiuntar.v4i2.491.

[15] A. K. Singh, M. L. Meena, H. Chaudhary, and G. S. Dangayach, "Ergonomic assessment and prevalence of musculoskeletal disorders among washer-men during carpet washing: guidelines to an effective sustainability in workstation design," *Int. J. Hum. Factors Ergon.*, 2017, doi: 10.1504/IJHFE.2017.088416.

[16] S. Adipradana, "Tugas Akhir: Pengembangan Persamaan Prediksi Konsumsi Energi Berdasarkan Denyut Jantung, Faktor Anthropometri, dan Demografi Pekerja Industri Pria," Bandung, 2009.