International Research Journal of Engineering, IT & Scientific Research
Available online at https://sloap.org/journals/index.php/irjeis/
Vol. 8 No. 4, July 2022, pages: 144-151
ISSN: 2454-2261
https://doi.org/10.21744/irjeis.v8n4.2156

Developing a Wood Lathe Machine with Speed Control and Workers' Anthropometry to Increase the Productivity of the Broom Industry

I Gede Santosa [a]

Article history:

Submitted: 18 April 2022
Revised: 9 May 2022
Accepted: 27 June 2022

Keywords:

broom handle production;
skeletal muscle complaints;
workload;
wood lathe machine;
work productivity;

Abstract

A well-prepared abstract enables the reader to identify the basic content of a document quickly and accurately, determine its relevance to their interests, and thus decide whether to read the document in its entirety. The Abstract should be informative and completely self-explanatory, provide a clear statement of the problem, the proposed approach, or solution, and point out major findings and conclusions. The Abstract should be 100 to 200 words in length. The abstract should be written in the past tense. Standard nomenclature should be used and abbreviations should be avoided. No literature should be cited. The keyword list provides the opportunity to add keywords, used by the indexing and abstracting services, in addition to those already present in the title. Judicious use of keywords may increase the ease with which interested parties can locate our article.

Corresponding author:
I Gede Santosa,
Mechanical Engineering Department, Politeknik Negeri Bali, Indonesia.
Email address: gedesantosa@pnb.ac.id

[a] Politeknik Negeri Bali, Indonesia

1 Introduction

The COVID-19 outbreak prompted the Indonesian government to urge the public to limit physical contact, resulting in an economic crisis. This restriction on physical contact has a significant impact on many parties, including entrepreneurs, who must limit their outdoor and indoor activities. Up to this point, the majority of business actors, ranging from small to large-scale Medium Enterprises, have revealed a decline in income (Mulawarman, 2022). Therefore, the COVID-19 pandemic has a significant impact on business continuity and is expected to cause changes in business in the future, particularly in consumer behaviour (Yusuf et al., 2016). To overcome the economic crisis, working and conducting business from home (Work From Home - WFH) is one of the initiatives that must be pursued. Businesses must certainly continue to run effectively to survive, especially during this social distancing period, which can be an opportunity to optimize business strategies. This emphasizes the significance of identifying consumption and consumer behaviour in the production of goods required by the community. Furthermore, it is a driving force for the growth of the creative industry to support the economy (Miyake, 2001; DiDomenico & Nussbaum, 2011).

One of the small entrepreneurs in Besan Village, Dawan District, Klungkung Regency is the production of wooden broom handles that are commonly used in dowels, garden brooms, or fibers brooms. The basis of this production came from the wood waste that is collected from log processing sites which are imported from outside the region. Sengon wood, salam wood, melinjo wood, and other panglong wood waste that can be used are among the wood processed.

The method for producing the broom handle still uses traditional tools such as chisels and hand grinders to cut and rotate wood materials, so the results obtained are not optimal, for example, the diameter is not uniform and the results are not smooth and even. On average, it takes 3-4 minutes to produce one broom handle with a length of 120 cm and a diameter of 2.1. In addition, the worker works with tables of varying heights, so the movements performed are not natural, which will result in muscle injury and fatigue. To solve this problem, it is necessary to develop a wood lathe machine with an adjustable rotation speed and worker anthropometry/size body to improve worker comfort and productivity (Bridger, 2008).

A lathe is a commonly used machine tool for manufacturing components that rotates a workpiece around an axis of rotation to perform operations like cutting, sanding, knurling, drilling, deformation, facing, and turning. Turning in principle is to make a round object with a certain diameter by cutting. Therefore, several steps must be followed before operating a lathe. For this reason, the design of a lathe for the process of making broom handles must be customized based on the task for it to function properly, produce optimal products, and not endanger workers. Potential hazards in the workplace should be reduced or eliminated (Kroemer & Grandjean 2009). The objectives of this study are (1) Designing a model of a wood lathe with the addition of speed control and following the anthropometry of workers, and (2) increasing work productivity from the use of a wood lathe with the addition of speed control and following worker anthropometry (Charles & Nixon, 2019; Jung & Jung, 2001).

2 Materials and Methods

This study used an experiment with treatment by subject design method (Pocock, 2013). Subjects received two treatments, first using the traditional method (first period) and using the proposed method (second period). The traditional way of making broom handles still uses simple tools such as chisels to cut wood and grinders to turn wood. This process takes a long time, 4-5 minutes per piece, and the work position is still rough and pushing the wood, the diameter is not uniform, and the surface is still rough. The process of working on a new method (Period 2) using a designed lathe.

Santosa, I. G. (2022). Developing a wood lathe machine with speed control and workers' anthropometry to increase the productivity of broom industry. International Research Journal of Engineering, IT & Scientific Research, 8(4), 144-151. https://doi.org/10.21744/irjeis.v8n4.2156

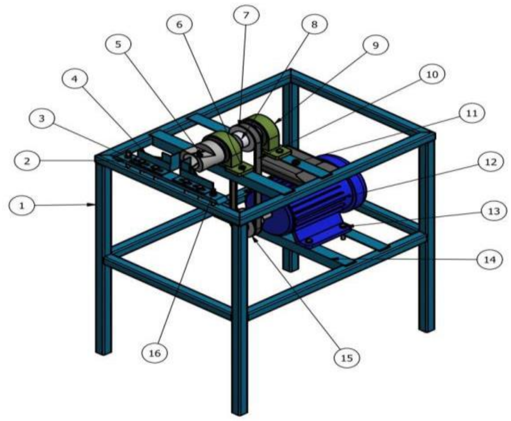

Figure 1. The design of the lathe machine for the production of the wooden broom handle

1. Frame
2. Tool rest for the wood
3. Bolts and nuts of the tool rest
4. Locking handle for the Wood
5. Blade
6. Pillow block bolt
7. Pully
8. Connecting shaft
9. Pillow block
10. Belt
11. Pillow block mount
12. Electric motor
13. Electric motor bolts and nuts
14. Electric motor mount
15. Pully electric motor
16. Long thread

This study was volunteered by ten workers as the sample subject. The workload was calculated based on the worker's pulse measured using a pulse meter, skeletal muscle complaints observed from the Nordic Body Map questionnaire, and worker productivity calculated based on the number of brooms handles produced per hour by the workload. The results were analyzed using the t-pair test at the error rate (alpha) = 5%.

3 Results and Discussions

The anthropometric description of the worker is as follows:

Table 1
Subject anthropometry data

Unit	Min	Max	Mean	SD	Percentile		
					5	50	95
Standing height	163,21	178,02	169,17	5,21	164,21	166,32	177,92
Standing elbow height	96,11	117,51	106,84	5,50	97,10	117,65	116,30
Hand length	17,60	19,01	18,01	1,41	17,70	19,30	17,90
Hand grip diameter	3,46	4,20	3,94	0,39	3,45	3,95	4,18
Fore reach distance	69,51	75,31	72,46	2,46	69,70	75,45	74,90

SD: standard deviation

Based on the anthropometric data in Table 1 above, the dimensions of the lathe machine frame design are as follows:

1) The seat height is adjusted to the worker's elbow height, which is 106.9 cm
2) The maximum dimension of the lathe machine table according to the fore reach of the worker's hand is 72.5 cm
3) The width of the table is adjusted to the size of the lathe machine, in this case, the work table can be made 50 cm.

4) The diameter of the wood on the handle of the broom made by a lathe is adjusted to the diameter of the handle of most anthropometric hands in Indonesia. In this case, the diameter of the worker's hand is between 3.5 - 4.2 cm.


Figure 2. Traditional method (P0)


Figure 3 Proposed method (P1)

The common lathe machine that is designed following the worker's anthropometry changes works posture, including standing bent over to standing naturally, reducing workload and skeletal muscle complaints. The compatibility of work tools with the anthropometry of the worker will reduce workload (Kroemer & Grandjean 2009; Yusuf 2014).

3.1 Worker workload

The workload can be measured objectively and subjectively. The workload is inferred objectively based on the employee's work pulse, and the workload is evaluated subjectively based on skeletal muscle complaints and general fatigue (Adiputra, 2002).

Working Pulse

The working pulse of a worker is measured both at rest (resting pulse) and while working (work pulse). The normality test of the data was carried out using the Shapiro-Wilk test. The results of the test revealed that the resting and working pulse rates in both treatments (first and second period) were normally distributed ($p>0.05$). The t-pair test was used to analyze this worker's workload as measured by his pulse rate (Waongenngarm et al., 2018; Escorpizo, 2008). The analysis results shows in Table 2 below.

Table 2
Analysis of worker pulse

Variable	1st Period		2nd Period		t	p
	Mean	SD	Mean	SD		
Resting Pulse (beats/minute)	69,19	2,39	70,42	2,91	0,814	0,264
Working Pulse (beats/minute)	121,17	2,59	102,18	3,01	8,431	0,000

Table 2 shows that the resting pulse rate was not significantly different between periods ($p>0.05$). This demonstrates that the initial conditions of the worker's resting pulse at P0 and P1 are the same. While the working pulse differed significantly between the first and second periods ($p<0.05$). According to the average, the working pulse has dropped from 121.17 beats per minute to 102.18 beats per minute, a 15.7% drop. Based on the category of workload, the

ISSN: 2454-2261

crafters are in the medium workload (Kroemer & Grandjean, 2009). Ergonomics interventions are effective for reducing work pulse or worker workload (Manuaba 2005; Santosa & Yusuf 2017).

Skeletal Muscle Complaints

Skeletal muscle complaints were measured using a Nordic Body Map questionnaire. The comparability test for skeletal muscle complaints was performed using the paired t-test to compare the average skeletal muscle complaints in the first and second periods before work, and it was discovered that the data on skeletal muscle complaints in both the first and second periods were normally distributed based on the normality test of the data. The analysis results are shown in table 3 below.

Table 3
Analysis of skeletal muscle complaints

Variable	1st Period		2nd Period		t	p
	Mean	SD	Mean	SD		
Pre-muscle complaints	38,71	3,26	39,82	3,15	1,761	0,168
Post-muscle complaints	78,64	4,21	57,21	2,49	9,211	0,001

According to Table 3, there is no difference in the initial condition (pre-muscle complaints) in subjects with skeletal muscle complaints, but there is a significant difference ($p<0.05$) in the final condition (post) between the first and second periods. Between those periods, there was a decrease in skeletal muscle complaints from 78.64 to 57.21, or a 27,3 % decline, and a decrease in fatigue by 27.3%. These fewer musculoskeletal complaints occurred due to the lathe machine being anthropometrically compatible with the worker, resulting in the change of unnatural work attitudes becoming natural work postures. According to Bridger (2008); Kroemer & Grandjean (2009); and Suarbawa et al. (2018), work postures that contradict the body's natural attitude will result in fatigue and musculoskeletal complaints, necessitating a more natural work attitude regulation. The results of this study are consistent with Manuaba's assertion that ergonomic intervention is required to reduce fatigue, and muscle complaints, and increase employee productivity (Manuaba, 2006). These renovations are simple and inexpensive, requiring only the addition of speed control and the adjustment of the lathe table to the worker's anthropometry. The cost of intervention is low, especially since planning is required to improve workers' work posture, reduce subjective complaints, and reduce workload (Sutjana, 2008). Adjusting tools with anthropometry have been shown in various ergonomic intervention studies to reduce workload (Dianat et al. 2015; Irwanti et al. 2018) and skeletal muscle complaints (Kamat et al. 2017; Sudiajeng et al., 2012).

3.2 Work Productivity

The work productivity is determined by dividing the number of broom handles produced by the workload and working time. The results of the workers' productivity analysis are shown in Table 3 below.

Table 4
Analysis of work productivity

Description	1st Period			2nd Period			t	p*
	Mean	SD	p	Mean	SD	p		
Work productivity (production/hr bpm)	0,110	0,01	0,320	0,261	0,02	0,217	0,876	0,001

p = Significance for normality; p* = Significance for comparability

According to Table 4, the p-value of data normality (p) in the groups using the traditional tool (first period) and using the proposed tool (second period) is statistically insignificant ($p>0.05$), indicating that the two data are normally distributed. As a result, the t-pair test can be used to analyse the work productivity difference between the first and second periods (Sathish et al., 2020). The analysis results show that there is a significant difference between work productivity in the first and second periods (p*<0.05). According to the average work productivity in the first period (using traditional tools) and second period (using proposed tools based on anthropometry and speed control), there was a 137.2% increase in average work productivity from 0.110 to 0.320. According to the findings of this study, using the wood lathe machine with speed control and anthropometry compatibility can increase the work productivity of the worker (Uchino et al., 2014; Varonen & Mattila, 2000). Based on other studies, the design of ergonomically oriented tools, such as adjusting tools based on anthropometry and work system settings, will be able to increase workers' production results and work productivity (Dianat et al. 2015; Kasper 2014; Santosa et al. 2021; Wibolo and Antara 2018). As a result, to effectively produces broom handles, it is recommended that worker use the proposed lathe machine to increase their work productivity.

4 Conclusion

The following conclusions can be drawn from the research's findings and discussion.

1) The lathe machine designed for the production of wooden broom handles has dimensions based on worker anthropometry, namely a table height of 106.9 cm, a table length of 72.5 cm, and a table width of 50 cm.
2) Using the wood lathe machine with speed control and following the worker's anthropometry can help the worker reduce their workload.
3) Using the wood lathe machine with speed control and following the worker's anthropometry can help to reduce the skeletal muscle complaints of the worker.
4) Using the wood lathe machine with speed control and following worker anthropometry can increase the work productivity of the worker.

Conflict of interest statement
The author declared that he has no competing interests.

Statement of authorship
The author has a responsibility for the conception and design of the study. The author has approved the final article.

Acknowledgements
I am grateful to two anonymous reviewers for their valuable comments on the earlier version of this paper.

References

Adiputra, N. (2002). Pulse Rate and Its Use in Ergonomics. *Indones. J. Ergon*, *3*(1), 1-6.

Bridger, R. (2008). *Introduction to ergonomics*. Crc Press.

Charles, R. L., & Nixon, J. (2019). Measuring mental workload using physiological measures: A systematic review. *Applied ergonomics*, *74*, 221-232. https://doi.org/10.1016/j.apergo.2018.08.028

Dianat, I., Nedaei, M., & Nezami, M. A. M. (2015). The effects of tool handle shape on hand performance, usability and discomfort using masons' trowels. *International Journal of Industrial Ergonomics*, *45*, 13-20. https://doi.org/10.1016/j.ergon.2014.10.006

DiDomenico, A., & Nussbaum, M. A. (2011). Effects of different physical workload parameters on mental workload and performance. *International Journal of Industrial Ergonomics*, *41*(3), 255-260. https://doi.org/10.1016/j.ergon.2011.01.008

Escorpizo, R. (2008). Understanding work productivity and its application to work-related musculoskeletal disorders. *International Journal of Industrial Ergonomics*, *38*(3-4), 291-297. https://doi.org/10.1016/j.ergon.2007.10.018

Irwanti, N. D., Yusuf, M., Anggreni, N. Y., & Widiastuty, L. S. (2018). Workload Analysis Of Front Office Staff At Water Mark Hotel And Spa Jimbaran-Bali. *Editorial Board*, *7*(8), 63.

Jung, H. S., & Jung, H. S. (2001). Establishment of overall workload assessment technique for various tasks and workplaces. *International Journal of Industrial Ergonomics*, *28*(6), 341-353. https://doi.org/10.1016/S0169-8141(01)00040-3

Kamat, S. R., Zula, N. M., Rayme, N. S., Shamsuddin, S., & Husain, K. (2017). The ergonomics body posture on repetitive and heavy lifting activities of workers in aerospace manufacturing warehouse. In *IOP Conference Series: Materials Science and Engineering* (Vol. 210, No. 1, p. 012079). IOP Publishing.

Kasper, E. Per L. .. (2014). Design of Systems for Productivity and Well Being. *Journal of Applied Ergonomics 45*(1):26–32.

Kroemer, K. H. E. & E. Grandjean. (2009). Fitting The Task To The Human, Fifth Editione A Textbook Of Occupational Ergonomics. London: CRC Press.

Manuaba, A. (2005). Accelerating OHS-Ergonomics Program By Integrating'Built-In" Within The Industry's Economic Development Scheme Is A Must-With Special Attention To Small And Medium Enteprises (SMEs). In *Proceedings the 21st Annual Conference of The Asia Pasific Occupational Safety & Health Organization, Bali* (pp. 5-8).

Manuaba, A. (2006). Total approach is a must for small and medium enterprises to attain sustainable working conditions and environment, with special reference to Bali, Indonesia. *Industrial health*, *44*(1), 22-26.

Miyake, S. (2001). Multivariate workload evaluation combining physiological and subjective measures. *International journal of psychophysiology*, *40*(3), 233-238. https://doi.org/10.1016/S0167-8760(00)00191-4

Mulawarman, A. A. N. B. (2022). Design of prada paint dulang craft drying machine to improve product quality and work productivity of dulang fiber crafters in Bangli regency. *International Research Journal of Engineering, IT & Scientific Research*, *8*(1), 27-35. https://doi.org/10.21744/irjeis.v8n1.2046

Pocock, S. J. (2013). *Clinical trials: a practical approach*. John Wiley & Sons.

Santosa, I. G., & Yusuf, M. (2017). The application of a dryer solar energy hybrid to decrease workload and increase dodol production in Bali. *International Research Journal of Engineering, IT and Scientific Research*, *3*(6), 99-106.

Santosa, I. G., Yusuf, M., Gunung, I. N., & Rimpung, I. K. (2021). Application of Forging Hammer to Increases Productivity of Balinesse Blacksmith. In *International Conference on Innovation in Science and Technology (ICIST 2020)* (pp. 195-199). Atlantis Press.

Sathish, T., Sabarirajan, N., Chandramohan, D., & Karthick, S. (2020). A novel technique to design and production of coil spring in centre lathe. *Materials Today: Proceedings*, *33*, 2521-2523. https://doi.org/10.1016/j.matpr.2019.12.015

Suarbawa, I. K. G. J., Arsawan, M., Yusuf, M., & Santiana, I. A. (2018). Improvement of environment and work posture through ergonomic approach to increase productivity of balinese kepeng coin workers in Kamasan village Klungkung Bali. In *Journal of Physics: Conference Series* (Vol. 953, No. 1, p. 012105). IOP Publishing.

Sudiajeng, L., Adiputra, N., & Leibbrandt, R. (2012). Ergonomics work stations decreases the health impairment and saves electrical energy at the woodworking workshop in Bali, Indonesia. *Journal of Human Ergology*, *41*(1_2), 41-54.

Sutjana, D. P. (2008). Application of Ergonomics at the Bali Sanur Bungalows Hotel. *Indones. J. Biomed. Sci*, *2*(1), 1-11.

Uchino, M., Uchino, Y., Dogru, M., Kawashima, M., Yokoi, N., Komuro, A., ... & Tsubota, K. (2014). Dry eye disease and work productivity loss in visual display users: the Osaka study. *American journal of ophthalmology*, *157*(2), 294-300. https://doi.org/10.1016/j.ajo.2013.10.014

Varonen, U., & Mattila, M. (2000). The safety climate and its relationship to safety practices, safety of the work environment and occupational accidents in eight wood-processing companies. *Accident Analysis & Prevention*, *32*(6), 761-769. https://doi.org/10.1016/S0001-4575(99)00129-3

Waongenngarm, P., Areerak, K., & Janwantanakul, P. (2018). The effects of breaks on low back pain, discomfort, and work productivity in office workers: A systematic review of randomized and non-randomized controlled trials. *Applied ergonomics*, *68*, 230-239. https://doi.org/10.1016/j.apergo.2017.12.003

Wibolo, A., & Antara, I. N. L. (2018). Designing Plastic Cupes Ring Cutting Machine To Increase Productivity. *Logic: Jurnal Rancang Bangun dan Teknologi*, *18*(2), 56-63.

Yusuf, M. (2014). Design of Jewel Stone Sharpener to Increase Jewel Worker Work Productivity in Bali.

Yusuf, M., Adiputra, N., Sutjana, I. D. P., & Tirtayasa, K. (2016). The improvement of work posture using rapid upper limb assessment: analysis to decrease subjective disorders of strawberry farmers in Bali. *International Research Journal of Engineering, IT & Scientific Research*, *2*(9), 1-8.