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Work System Design in the Wallet Production Process Using the Full Time Equivalent (FTE) and Cardiovascular Load (CVL) Method

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ABSTRACT

UKM Gudang Dompet is a company that produces wallets. The number of orders will affect employee performance because the number of targets achieved will increase the workload for employees, causing fatigue. To prevent excessive fatigue felt by workers in the production division at the Dompet Warehouse, it is necessary to measure workload. The Full Time Equivalent (FTE) method measures working time, which is based on working time, measuring the time needed to complete a particular task and then converting it into an FTE index value. The cardiovascular load (CVL) method measures physical workload based on a comparison between pulses. Working pulse with a maximum pulse. This research showed that worker fatigue occurred in the packing section, indicated by a CVL value of more than 30%, so FTE calculations were carried out to determine energy consumption. Based on energy consumption calculations, the results obtained are an additional rest time of 32.85 minutes in the packing section.

Keywords: *workloads; full-time equivalent; CVL; work system design.*

Introduction

Humans are a source of labour that has a large and significant influence in carrying out the production process, especially in manual activities. To maximise employee productivity and performance, several factors can influence two aspects: physical condition and the workload received by workers. UKM Gudang Dompet is a company that produces wallets. In running this business, 25 craftsmen employees have expertise in producing various products, most importantly wallets. SME Wallet Gudang does not specialise in making wallets from imitation materials, so they are also relatively cheap in terms of price. Within a month, UKM Gudang wallet can produce 500-1000 wallets for both men and women. Excluding other production results, this depends on the product's size and the difficulty in making it, even though the product type is a wallet with a different subscription model.

The average production from August to December is 750 wallets. In November, the production target was 600, but the production that could be achieved was 480 wallets. In December, the production target was 750, but the production that could be achieved was 600 wallets. One of the influencing factors is employee performance. In the Wallet Warehouse UKM, older people are vulnerable to work fatigue due to decreased muscle strength. To prevent excessive fatigue among workers in the production section at the Wallet Warehouse, it is necessary to measure workload. One method that can be used to measure workload is the full-time equivalent. The full-time equivalent method is useful for analyzing or reducing employee workload during certain hours. After that, the Full Time Equivalent (FTE) method measures working time, which is based on working time, measuring the time required to complete a task and then converting it into an FTE index value[1]. The cardiovascular load (CVL) method measures physical workload, which is measured based on comparing the working pulse rate with the maximum pulse rate [2]–[6]. Research conducted by [7] measured the workload level of one goods wholesaler using the full-time equivalent and workload analysis method. Based on full-time equivalent workload measurements and workload analysis used to obtain results. After determining the amount of work associated with one year, operator 1's receipt printer received an FTE index of 0.68, which means underutilization. means overload, i.e. too much work of the three order receiving operators, got an FTE index of 2.34, meaning the overload category of the four ordering operators got an FTE index of 2.13, meaning the overload category and the cashier had an FTE index of 0.19, meaning underload, namely. Less workload. In research conducted by [8], the results of CVL workers' pulse rate measurements = 38.14%, normal resting energy expenditure = 5.5 kcal/minute, and an additional 16 minutes of rest time were obtained, for a total of 76 minutes at 10.00 -10.16 WIB. Increased productivity in measuring and cutting wood for ship parts resulted in 16 ship parts, thus increasing work productivity by two ship parts. 34 means overload categories; of the four ordering operators, they get an FTE index of 2.13, meaning the overload category, and the cashier has an FTE index of 0.19, meaning underload, namely. Less workload. In research conducted by [9], [10], the results of CVL workers' pulse rate measurements = 38.14%, normal resting energy expenditure = 5.5 kcal/minute, and an additional 16 minutes of rest time were obtained, for a total of 76 minutes at 10.00 -10.16 WIB. Increased productivity in measuring and cutting wood for ship parts resulted in 16 ship parts, thus increasing work productivity by two ship parts. 34 means overload categories. Of the four ordering operators, they get an FTE index of 2.13, meaning the overload category and the cashier has an FTE index of 0.19, meaning underload. Less workload. In research conducted by[9], the results of CVL workers' pulse rate measurements = 38.14%, normal resting energy expenditure = 5.5 kcal/minute, and an additional 16 minutes of rest time were obtained, for a total of 76 minutes at 10.00 -10.16 WIB. Increased productivity in measuring and cutting wood for ship parts resulted in 16 ship parts, thus increasing work productivity by two ship parts. In research conducted by [9], the results of CVL workers' pulse rate measurements = 38.14%, normal resting energy expenditure = 5.5 kcal/minute, and an additional 16 minutes of rest time were obtained for a total of 76 minutes at 10.00 - 10.16 WIB. Increased productivity in measuring and cutting wood for ship parts resulted in 16 ship parts, thus increasing work productivity by two ship parts. In research conducted by [7]–[9], [11], [12], the results of CVL workers' pulse rate measurements = 38.14%, normal resting energy expenditure = 5.5 kcal/minute, and an additional 16 minutes of rest time were obtained for a total of 76 minutes at 10.00 - 10.16 WIB. Increased productivity in measuring and cutting wood for ship parts resulted in 16 ship parts, thus increasing work productivity by two ship parts.

FTE will measure the workload received by wallet production employees. Then, from the FTE measurement results, alternative improvements were made. Additional rest time reduces worker fatigue in wallet production operations. So that employee performance in wallet production remains optimal without being affected by the number of targets. To achieve the expected results, research was carried out with the title "Work System Design in the Wallet Production Process Using the Full Time Equivalent (FTE) and Cardiovascular Load (CVL) Method"[13]–[15].

Research methods

This research was carried out using qualitative and quantitative methods. The qualitative method collects data by observing the work systems and methods implemented by UKM Gudang Dompet. For quantitative methods, namely, combining the Full-Time Equivalent (FTE) and Cardiovascular Load (CVL) methods[16]–[20].

Work system design

Work system design is a field of technical science and principles for achieving good work system planning. One of the main tasks of a work system design is to define the work steps of the expected process from input to output [2].

Working Time Measurement

Measuring working time is an effort to determine the amount of time workers need to complete a job. The measurement results obtain a time standard for completing a series of work as a standard for completing the work of all employees with similar work [21], [22].

Working time measurement determines the standard time required to complete certain work. Measuring working time can be done directly or indirectly. Direct measurement means that the observer carries out measurements and records that the operator needs to do their work directly at the operator's workplace. In contrast, indirect measurement means that the observer does not directly observe the work the operator does because it is conditional[23]–[25].

Work fatigue

Work fatigue is related to reduced work performance, skills and boredom. Work fatigue is a problem that often affects workers. Fatigue can seriously affect workers' health and reduce productivity [5].

Work fatigue describes the body's reaction to the activities carried out and stress during work. When the body is active for 8 hours of work, it will feel tired. When tired, the body experiences symptoms such as frequent yawning, thirst, drowsiness, and difficulty concentrating. There are three signs of work fatigue: decreased activity, decreased work motivation, and physical fatigue [6].

Full Time Equivalent (FTE)

Full Time Equivalent (FTE) measures working time based on working time, measuring the time required to complete a task and then converting it into an FTE index value. The FTE index is divided into three categories: Underload (lost load) has an index value of 0-0.99, normal (adequate load) has an index value between 1-1.28, and overload has an index value above 1.28 . The formula for measuring the full-time equivalent value is:

$$\text{FTE} = \text{Total Time}/\text{Effective Working Time} \quad (1)$$

Full-time equivalent (FTE) is a method for analysing workloads. FTE measurement determines how much time employees need to complete work. The advantage of the FTE method is that it can increase company productivity .

$$\text{TE } (\text{Total Activity Time} + \text{Allowance})/\text{Total Available Time} \quad (2)$$

Where Total Activity Time, Allowance and Total Available Time can be calculated using the following equation:

$$\text{Total Activity Tim} = \text{Primary Working Time} + \text{Supporting Working Time} + \text{Incidental Work Timel} \quad (3)$$

$$\text{Allowance} = \text{Allowance} \times \text{Number of Days a Year} \times \text{Working Hours a Day} \quad (4)$$

$$\text{Total Available Time} = \text{The Number of Days in a Years} \times \text{Working Hours a Day} \quad (5)$$

Cardiovascular Load (%CVL)

Increasing heart rate plays a very important role in increasing cardiac output between rest and maximum work. Therefore, workload classification is based on the increase in heart rate during work compared to the maximum heart rate due to cardiovascular load (cardiovascular load = % CVL) calculated using the following formula :

$$\%CVL = \frac{100\ x\ (work\ pulse - resting\ pulse)}{maximum\ pulse\ rate - resting\ pulse} \quad (6)$$

Where:
Man : Maximum pulse rate = 220 – age
Woman : Maximum pulse rate = 200 – age
The results of the %CVL calculation are then compared with the following classification:

Table 1. Cardiovascular Load Classification (%CVL)

%CVL	Handling
X ≤ 30%	No fatigue occurs
30% ≤ X ≤ 60%	Repair required
60% ≤ X ≤ 80%	Work in a short time
80% ≤ X ≤ 100%	Immediate Action Required
X > 60%	No activities are allowed

The flow diagram for this research is shown in Figure 1:

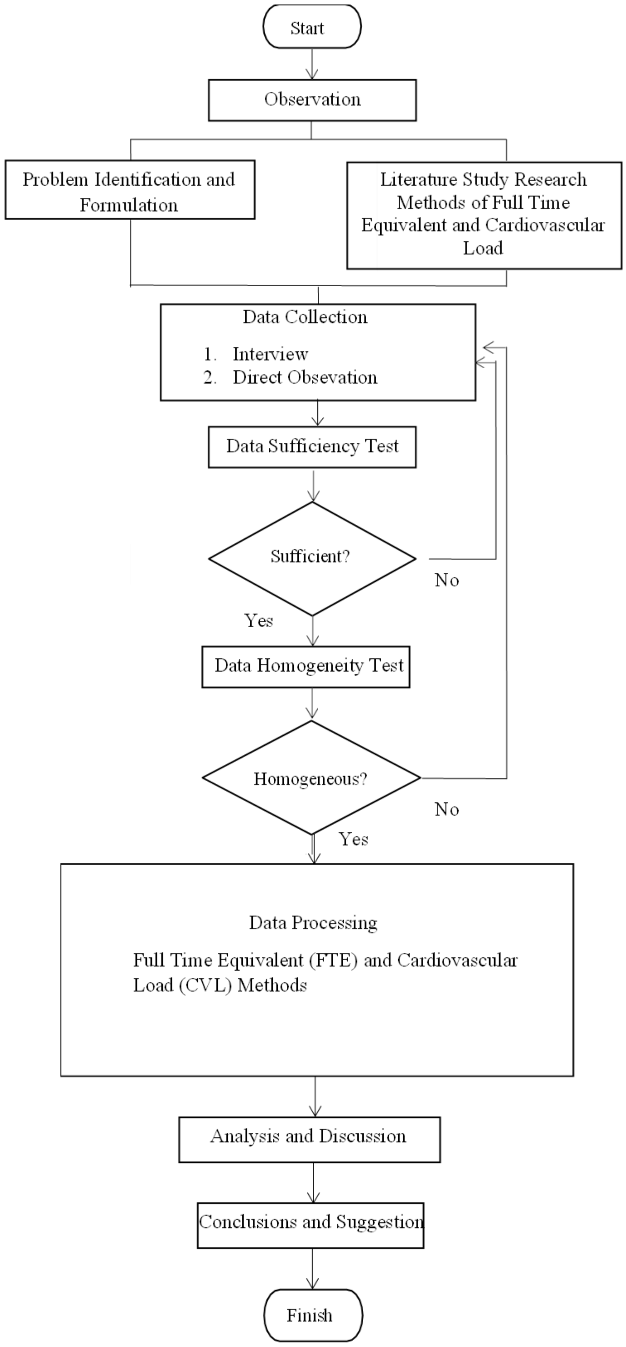

Figure 1. Research flow diagram

Results and Discussion

The results of data collection are then processed using the Full-Time method and the CVL method

Data Sufficiency Test

The data adequacy test determines whether the data collected is sufficient. If the value of N' > N, the data collected is considered insufficient, so data collection must be carried out again . In this study, the data adequacy test used a confidence level of 95% with a degree of accuracy of 0.05, so the constant value k = 2 was obtained. The results of the adequacy test calculations are shown in Table 2.

Table 2. Data adequacy test results

Activity	∑xi	∑(xi)2	∑(xi2)	N	N'	Adequacy
Cutting	154.93	24003.3	2400,628	10	0.446	Enough
Tailoring	277.49	77000.7	7715.73	10	1,804	Enough
Pasting	152.85	23363.12	2338,389	10	1,193	Enough
Finishing	151.08	22825.17	2283,146	10	0.664	Enough
Packing	141.46	20010,93	2002,26	10	0.966	Enough

Data Uniformity Test

The data uniformity test is useful for determining whether the data taken is uniform and for identifying extreme data. Extreme data is too large or too small compared to the average value of the data taken. The results of the data uniformity test for each activity process can be seen in Figure 2, Figure 3, Figure 4, Figure 5, and Figure 6.

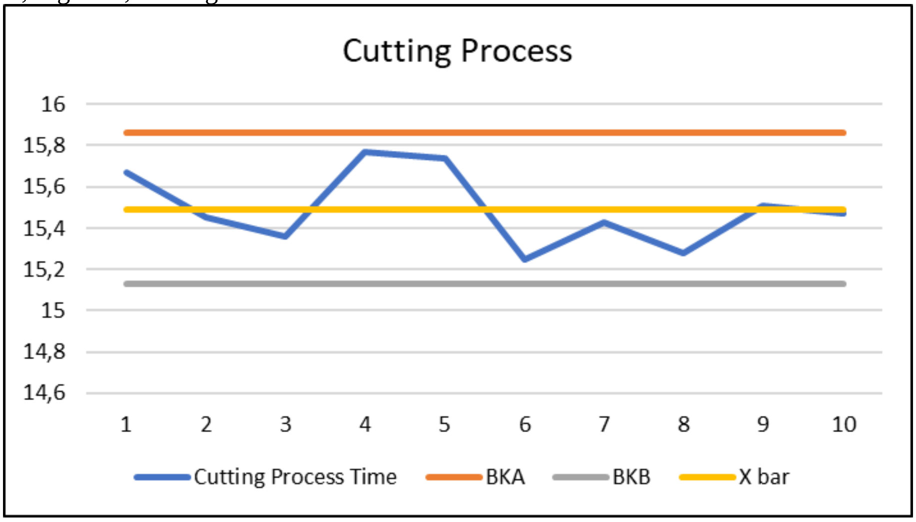

Figure 2. Cutting data uniformity test graph

The calculation graph in Figure 2 shows no extreme data in the cutting process.

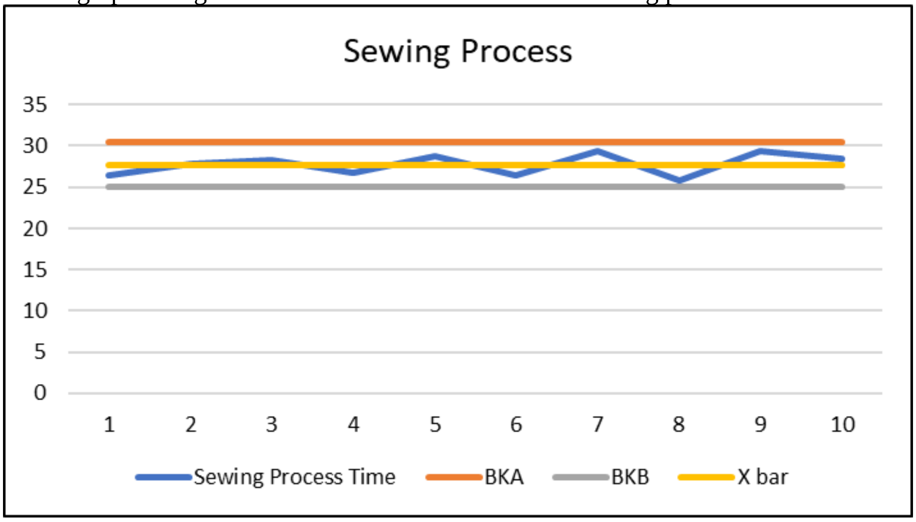

Figure 3. Sewing data uniformity test graph

The calculation graph in Figure 3 shows no extreme data in the sewing process.

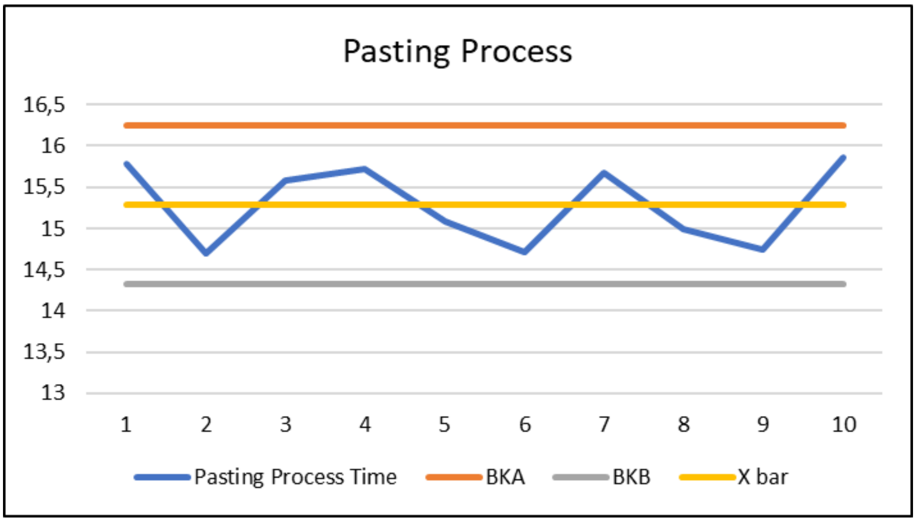

Figure 4. Pasting data uniformity test graph

From the calculation graph in Figure 4, it shows that there is no extreme data in the pasting process.

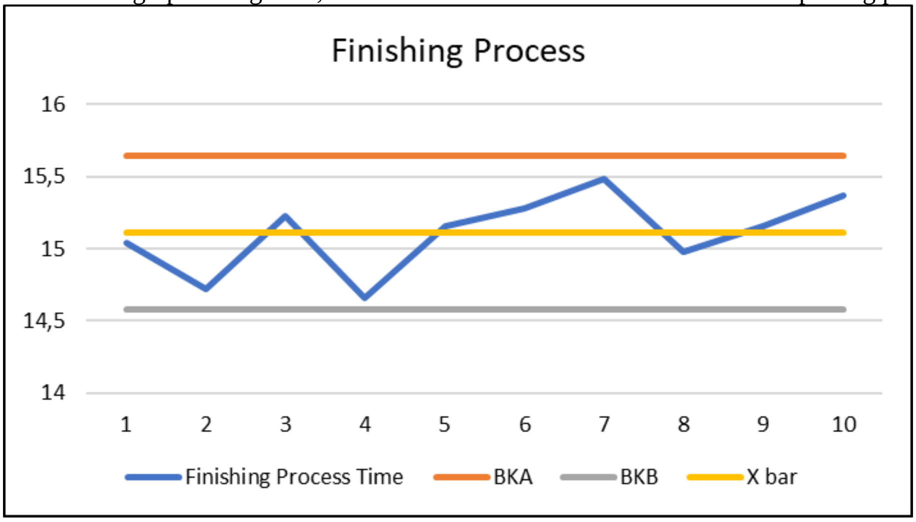

Figure 5. Finishing Data Uniformity Test Chart

The calculation graph in Figure 5 shows no extreme data in the finishing process.

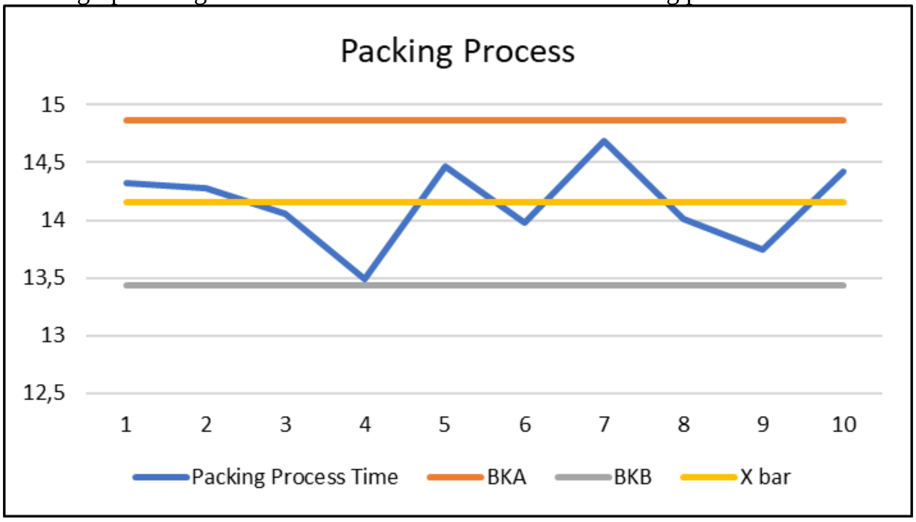

Figure 6. Packing Data Uniformity Test Chart

The calculation graph in Figure 6 shows no extreme data in the packing process.

FTE Measurement Results

Table 3. Workload measurement using the FTE method

No	Name of activity	Intensity	Frequency	Normal time	Total hours/year	Effective hours/year	FTEs
1	Cutting	Daily	100	17.66	140.31	1602	0.09
2	Sew	Daily	100	31.63	251.31	1602	0.16
3	Pasting	Daily	100	17.42	138.43	1602	0.09
4	Finishing	Daily	100	17.22	136.83	1602	0.09
5	Packing	Daily	100	16,13	128.12	1602	0.08
				Average			0.10

Table 3 shows the details of the workload per production process, namely for the cutting process at 0.09, sewing at 0.16, sticking at 0.09, and packing at 0.08. From these details, it can be identified that the workload received by workers is 0.10, which means the workload is underloaded or normal because it is below the full-time equivalent of 1.28.

Workers receive a workload of 0.10, which means that when working on 1 unit of wallet, each operator receives a normal workload (underload), so there is no need to improve by reducing the workload.

CVL Measurement Results

Table 4. Cardiovascular Strain Measurement (%CVL)

Name of activity	Operator	Working pulse (per minute)	Resting pulse (per minute)	Maximum heart rate (per minute)	%CVL
Cutting	1	108	82	180	26.53
Sew	2	97	92	187	5.26
Pasting	3	99	87	179	13.04
Finishing	4	110	96	199	13.59
Packing	5	106	85	150	32,31

Based on the results of cardiovascular strain calculations shown in Table 4, shows that workers in packing activities need to improve their need for rest time, which can be seen in Table 5 below:

Table 5. Data on improving the need for rest time

Name of activity	Operator	Working pulse (per minute)	Resting pulse (per minute)	Maximum heart rate (per minute)
Packing	5	106	85	150

In the improvement data table above, it is necessary to calculate the quadratic regression equation to change the pulse rate to form energy and then determine energy consumption to increase rest time using the following formula:

$$E = 1{,}80411 - 0{,}0229083\, X + 4{,}71733\ x\ 10^{-4} X^2 \quad (7)$$

$$K = Et - Ei \quad (8)$$

With this formula, calculations can be made as follows:

Known: X = 106 (working pulse)

$ET = 1{,}80411 - 0{,}0229083\ (105) + 4{,}71733\ x\ 10^{-4} (105)^2$

Et = 4.68 kcal/minute

Known: X = 85 (resting heart rate)

$Ei = 1{,}80411 - 0{,}0229083\ (85) + 4{,}71733\ x\ 10^{-4} (85)^2$

Ei = 3.27 kcal/minute

From the calculation of energy from work and rest, the following is the calculation of energy consumption:

K = 4.68 – 3.27 = 1.41 kcal/minute

After calculating energy consumption, the next step is to determine the need for rest time using the following formula and calculations:

$$R = T\frac{(W-S)}{W-1{,}5} \quad (9)$$

$R = 480\frac{(4{,}68-4)}{4{,}68-1{,}5}$

R = 102.19 minutes

Based on the calculation of workers' rest time requirements in the packing section, the results were 102.19 minutes/working day. Therefore, rest time, initially only 60 minutes/per working day, needs to be given an additional rest time of 42.19 minutes/per working day so that workers do not easily feel tired.

Conclusion

Processing workload data calculated using the full-time equivalent method showed that producing 1 wallet unit took 114.36 minutes. The average workload value for each department was 0.10. In the cardiovascular load method, the calculation results for determining the need for rest time are obtained with a description of the results of working pulse energy consumption of 4.68 kcal/minute and resting pulse energy consumption of 3.27 kcal/minute, with the result of a reduction in energy consumption of 1.41 kcal. /Minute. Based on the energy consumption results obtained, rest time requirements were calculated, resulting in an additional rest time of 42.19 minutes/working day for older packing department employees.

The proposed work system improvements are based on activities with relatively old workers, namely making improvements related to work regulation policies by providing additional rest time outside of normal rest hours to workers in several production parts so that workers can stretch their bodies so that injuries or fatigue do not occur.

References

[1] M. A.Muzakiki, A. W.Rizqi, andE. D.Priyana, “Analisis Beban Kerja Fisiologis Pada Karyawan Bongkar Muat Bahan Bangunan Dengan Metode CVL Dan Konsumsi Kalori,” *J. Tek. Ind. J. Has. Penelit. dan Karya Ilm. dalam Bid. Tek. Ind.*, vol. 9, no. 2, pp. 447–453, 2023.

[2] A. R.Putri andA.Bakhtiar, “Analisis Beban Kerja Fisiologis Dan Psikologis Pada Tenaga Kerja Bongkar Muat Bahan Peledak Menggunakan Metode Cardiovaskular Load (Cvl) Dan National Aeronautics And Space Administration–Task Load Index (NASA-TLX)(Studi Kasus PT Semen Padang),” *Ind. Eng. Online J.*, vol. 12, no. 2, 2023.

[3] M.Dias, “Cardiovascular load assessment in the workplace: A systematic review,” *International Journal of Industrial Ergonomics*, vol. 96. 2023. doi: 10.1016/j.ergon.2023.103476.

[4] N. T.Putri, “Ergonomics Evaluation of Manual Material Handling Activities in the Section of Feeding Laying Hens at Poultry Farm,” *IOP Conference Series: Materials Science and Engineering*, vol. 1003, no. 1. 2020. doi: 10.1088/1757-899X/1003/1/012074.

[5] N.Panjaitan, “Calculation of Physiological Load and Energy Consumption of Warehouse Operators in Manufacturing Companies,” *IOP Conference Series: Materials Science and Engineering*, vol. 851, no. 1. 2020. doi: 10.1088/1757-899X/851/1/012004.

[6] W.Kusmasari, “Measurement of Physical and Mental Workload in Onlline Ojek Drivers: A Case Study in Serang City,” *Int. J. Disabil. Sport. Heal. Sci.*, vol. 7, no. 3, pp. 655–662, 2024, doi: 10.33438/ijdshs.1409225.

[7] B.Bakhtiar, S.Syarifuddin, andM. P.Putri, “Pengukuran beban kerja dengan metode full time equivalent dan penentuan jumlah tenaga kerja efektif menggunakan workload analysis,” *J. Ind. Eng. Oper. Manag.*, vol. 4, no. 1, 2021.

[8] N.Hudaningsih, “Analisis Kebutuhan Karyawan Dengan Menggunakan Metode Full Time Equivalent (FTE) Pada Departemen Produksi PT. Borsya Cipta Communica,” *J. Tambora*, vol. 3, no. 2, pp. 98–106, 2019.

[9] A.Hakiim, W.Suhendar, andD. A.Sari, “Analisis beban kerja fisik dan mental menggunakan CVL dan NASA-TLX pada divisi produksi PT X,” *Barometer*, vol. 3, no. 2, pp. 142–146, 2018.

[10] S.Siswanto, E. M.Widodo, andR.Rusdjijati, “Perancangan Alat Pengupas Salak dengan Pendekatan Ergonomi Engineering,” *Borobudur Eng. Rev.*, vol. 1, no. 1, pp. 25–38, 2021.

[11] S. R. S.Family, “Faktor Penyebab Terjadinya Kelelahan Kerja Pada Pekerja Pt. Dungo Reksa Di Minas,” *J. Pengabdi. Kesehat. Komunitas (Journal Community Heal. Serv.*, vol. 1, no. 1, pp. 32–37, 2021.

[12] M.Juliana, A.Camelia, andA.Rahmiwati, “Analisis faktor risiko kelelahan kerja pada karyawan bagian produksi PT. Arwana anugrah keramik, tbk,” *J. Ilmu Kesehat. Masy.*, vol. 9, no. 1, pp. 53–63, 2018.

[13] Nayla Kamilia Fithri, Putri Handayani, andGisely Vionalita, “Faktor-faktor yang berhubungan

dengan jumlah mikroorganisme udara dalam ruang kelas lantai 8 Universitas Esa Unggul," *digilib.esaunggul.ac.id*, vol. 13, 2016, Accessed: Feb.09, 2023. [Online]. Available: https://digilib.esaunggul.ac.id/public/UEU-Article-8445-Nayla Kamilia Fithri.pdf

[14] A. Y.Pradana andF.Pulansari, "Analisis pengukuran waktu kerja dengan stopwatch time study untuk meningkatkan target produksi di PT. XYZ," *JUMINTEN*, vol. 2, no. 1, pp. 13–24, 2021.

[15] M.Rahayu andS.Juhara, "Pengukuran Waktu Baku Perakitan Pena Dengan Menggunakan Waktu Jam Henti Saat Praktikum Analisa Perancangan Kerja," *J. Pendidik. dan Apl. Ind.*, vol. 7, no. 2, pp. 93–97, 2020.

[16] E. A.Setiawan andM.Mubariz, "Penerapan Metode Full Time Equivalent (FTE) Dalam Menentukan Keseimbangan Beban Kerja Pada Distributor Pompa Air," *J. Teknol. dan Manaj. Ind. Terap.*, vol. 3, no. I, pp. 40–46, 2024.

[17] D. W.Setyawan, T. S. F.Himmah, andL.Kholifah, "Optimalisasi Manajemen Beban Kerja di Assessment Center Menggunakan Metode Full Time Equivalent (FTE)," *J. Teknol. dan Manaj. Ind. Terap.*, vol. 3, no. I, pp. 11–19, 2024.

[18] I.Hartanto, "Sustainable Measurement of Mental and Physical Workloads of Transjakarta Bus Drivers," *IOP Conference Series: Earth and Environmental Science*, vol. 1324, no. 1. 2024. doi: 10.1088/1755-1315/1324/1/012025.

[19] R.Widiastuti, "Implementation of the cardiovascular load and rating scale mental effort to reduce the bakery worker's workload," *AIP Conference Proceedings*, vol. 2590. 2023. doi: 10.1063/5.0106674.

[20] A.Amri, "Work system design using macroergonomic analysis and design approach to increase productivity," *AIP Conference Proceedings*, vol. 2484. 2023. doi: 10.1063/5.0138960.

[21] D.Diniaty andI.Ariska, "Penentuan jumlah tenaga kerja berdasarkan waktu standar dengan metode work sampling di stasiun repair overhoul gearbox (studi kasus: Pt. Imeco inter sarana)," *J. Tek. Ind.*, vol. 3, no. 1, 2017.

[22] P. E.Sekarningsih andA. F.Hadining, "Analisis Pengukuran Kerja Dalam Menentukan Waktu Baku Pada Operator Mesin Broaching Dengan Metode Pengukuran Waktu Jam Henti (Studi Kasus: PT XYZ)," *J. Tek. Ind. J. Has. Penelit. dan Karya Ilm. dalam Bid. Tek. Ind.*, vol. 8, no. 2, pp. 175–184, 2022.

[23] C. K.Correll, "2015 American College of Rheumatology Workforce Study and Demand Projections of Pediatric Rheumatology Workforce, 2015–2030," *Arthritis Care Res.*, vol. 74, no. 3, pp. 340–348, 2022, doi: 10.1002/acr.24497.

[24] A. D.Shields, "Maintaining access to maternal fetal medicine care by telemedicine during a global pandemic," *J. Telemed. Telecare*, vol. 28, no. 8, pp. 583–594, 2022, doi: 10.1177/1357633X20957468.

[25] S. C.Kulhawy-Wibe, "Results From the 2020 Canadian Rheumatology Association's Workforce and Wellness Survey," *J. Rheumatol.*, vol. 49, no. 6, pp. 635–643, 2022, doi: 10.3899/jrheum.210990.