Determining the Number of Operators based on Workload Analysis

by Eko Nursubiyantoro

Proceedings of International Conference on Engineering Optimization and Management in Industrial Applications (ICEOMIA 2022), Yogyakarta, Indonesia, October 29th, 2022

Determining the Number of Operators based on Workload Analysis

Wijayadi, F.G. [1*], Ristyowati, T. [1*], Nursubiyantoro, E.[1*]

[1] Department of Industrial Engineering, Faculty of Industrial Engineering, Universitas Pembangunan Nasional Veteran Yogyakarta, Yogyakarta, 55283, Indonesia

*Corresponding author: eko_nsby072@upnyk.ac.id

Abstract

PT. Perkakas Rekadaya Nusantara (PRN) is a company engaged in the production of automotive components, which has four mass production lines, namely steering axle, cylinder, inner tube, and bottom bracket. Cylinder production lines require periodic additional work due to fatigue, unlike mass production lines of steering axle, inner tube, and bottom bracket. Based on observations, operators are still found to be unemployed because the work is done alternately with other workers. The company does not yet have a basis for determining the optimal number of operators, so the company always fulfils the need to add operators to the cylinder production line. The Full-Time Equivalent (FTE) method is a method to determine the number of workers based on workload analysis on a cylinder production line, to propose the optimal number of operators. The optimal number of operators on the production line will provide a better workload for cylinder production line operators at each workstation, and can reduce costs incurred by the company. The results showed that there was an underload workload in the cylinder line production process, as well as the workload received by each operator.

Keywords: Workload, Full-Time Equivalent, Standard Time, Rating Factor

1. Introduction

Human resources are one of the most important factors in supporting the organization and operations of the company because the organization runs depending on the quality of human resources in it. In order to create good human resources, human resource management is needed in order to produce workers who are able to work effectively and efficiently so as to encourage the achievement of the goals or targets of the company. As one of the five main components in management, namely man, material, money, machine, method, human resources (man) needed by a company need to be considered properly and carefully by the company. The amount of labor that is not optimal will have an impact on production targets and costs incurred by the company.

PT Perkakas Rekadaya Nusantara (PRN) is one of the companies engaged in the production of large-scale automotive components. With a land area of about 50 hectares, 5 production buildings, and several supporting facilities, PT PRN has 426 workers to carry out activities. PT PRN has four mass production lines, namely steering shaft, cylinder, inner tube, and under bracket. The cylinder production line periodically requests additional workers due to fatigue unlike the steering shaft, inner tube, and under bracket mass production lines. This request for additional workers is always approved by the company because the company does not yet have a basis for determining the number of operators. The cylinder production line works in two shifts which are divided into day and night shifts. In the manufacturing process, cylinder production is divided into several work stations, namely the upsetter machine process, CNC lathe, punch hole machine, drill machine, and buffing machine. The cylinder production line has a total of 27 workers consisting of 6 permanent operators and 21 PKL operators. Each shift consists of 6 upsetter machine operators, 6 CNC lathe operators, 6 punch hole machine operators, drill machines, and buffing machines, and 9 inspection officers. After conducting field observations, there were several operators who were unemployed. The reason they were unemployed at that time was that the work was done alternately with their coworkers.

The alternation of work is commonly done by operators on the production line because by working alternately the production target of 3000 products per shift can be met. On the other hand, companies that do not have a basis for determining the optimal number of operators still maintain the current number of workers. To find out how many operators are optimal on the PT PRN cylinder production line, the Full Time Equivalent (FTE) method was chosen to determine the number of workers based on workload analysis.

1.1 Objectives

The purpose of this study is to determine the optimal number of operators on the cylinder production line based on workload analysis with the Full Time Equivalent (FTE) method.

2. Literature Review

Humans who lead a business so that the process of achieving goals can be achieved in accordance with the planned plan can be called managers (Suradinata, 1996). Human resource planning in organizations is the initial part that needs to be done to prepare competent human resources in accordance with the field they master to achieve high work efficiency and effectiveness (Novera, 2010). In addition, human resource planning is a neat and structured process of assessing the status of human resources to ensure quantity and quality with the right skills (Mondy & Noe, 1995).

Workload is a set or several activities that must be completed within a certain period of time by the organizational unit or person in charge. Workload is production capacity multiplied by time and labor demand is workload divided by the average monthly labor contribution. In a company, a person's workload is determined by the company according to the company's work standards and according to the type of work in each department (Novera, 2010). Workload analysis is the process of determining the number of person-hours used or required to complete a particular job within a certain period of time. In other words, workload analysis aims to determine how many people are suitable and how much responsibility or workload is appropriate for the job (Liu et al. 2016).

3. Methods

3.1 Data uniformity and adequacy

This test is used with the aim of knowing whether the data or samples taken are sufficient or not. The more data or samples of time studied, the closer the data processed will be to the actual conditions. In addition to testing the number of samples, a data uniformity test is also carried out to determine whether there is extreme data or not. To determine the amount of data needed, the formula in Eq.(1) is used (Nugroho, 2008).

$$N' = \left[\frac{\frac{k}{s}\sqrt{N\sum xi^2 - (\sum xi)^2}}{\sum xi}\right]^2 \quad (1)$$

N ': Number of observations that should have been made
N : Number of observations made
K : Confidence level (95%; k=2)
S : The level of accuracy (5%)
X : Observation data

Meanwhile, to determine the upper and lower limits on data uniformity, Eq.(2) and Eq.(3) are used.

$$UCL = \bar{x} + k.\,\delta \quad (2)$$

$$LCL = \bar{x}\text{-k}.\ \delta \quad (3)$$

δ : Standard deviation
$\bar{x}$: Data average
K : Confidence level (95%; k=2)

3.2 Standard time

Standard time is the time required under normal conditions by a worker to complete the work carried out in the best work system (Sutalaksana, 2006). In general, standard time can be interpreted as the time required by a worker who has an average level of ability to complete a job. This includes the time allowance given by taking into account the situation and conditions of the work to be completed. The allowance given is determined using a performance rating scale as a comparison between the operator's actual performance and normal performance conditions (Tanner, 1990). Classical Westinghouse Method (CWM) is one of the systems used to assess tempo. With this method, worker performance can be calculated based on skill, environmental conditions, effort, and consistency value. The Performance Rating Scale is expressed as a percentage (%) or decimal. Standard time is calculated using Eq.(4) and Eq.(5) (Sutalaksana, 2006).

$$\text{Normal Time} = \text{Working Time} + \text{Performance Rating} \quad (4)$$

$$\text{Standard Time} = \text{Normal Time} + \text{Allowance} \quad (5)$$

3.3 Workload assessment

Full Time Equivalent (FTE) is a time-based workload analysis method. The method measures the length of time to complete a job and then converts it into an FTE index value. The workload calculation method uses the Full Time Equivalent method, where the time used to complete various tasks is compared with the effective working time available. FTE aims to change working hours by converting working hours into the number of people needed to complete a particular job (Gallagher & Rapoza, 2010). Basically, FTE is the number of people needed to perform all activities of a particular process within a certain period of time (Zimmerman, 2002). The meaning of FTE value is divided into 3 types, namely overload, normal and underload (Adianto, 2014). Based on the workload analysis criteria of the total FTE index value released by the National Personnel Agency in 2010, values above 1.28 are considered overloaded, between 1 and 1.28 are considered normal workload and if the FTE index value is between 0 and 0.99 it is considered underload or under working. Workload assessment is done with Eq.(6) and Eq.(7) (Karo & Adianto, 2014).

$$\text{Total Hours} = \frac{\text{Frequency x process time x working days current years}}{60} \quad (6)$$

$$\text{FTE} = \frac{\text{Total Hours}}{\text{Effectife hours/year}} \quad (7)$$

3.4 Manpower planning

At this stage, the optimal labor requirement is calculated for a certain position with the task approach per job assignment obtained from the calculation of the number of task completion times for one year divided by the number of working hours effective for one year. This approach is the result of FTE calculations to measure workload.

4. Data Collection

Respondents in this study were 3 men in each production process with the time data used was 15 working time data per person. The allowance given by PT PRN is 20% with an effective working time of 6.4 hours per shift with a production target of 3000 products in one shift for 336 work days. In addition to the allowance given by the company, this study uses a rating factor for each work element of each operator as a normalization of the work time performed. The salary received by PKL operators is IDR 300,000 per month and IDR 900,000 for regular operators.

5. Results and Discussion

The results of the calculation of adequacy and uniformity of data can be explained that the data collected is enough with the value of N '<N for all elements of the activity. Meanwhile, uniformity calculation data can also be concluded that all the data entered in the control limits, so that the data collected is already eligible to be counted workload.

5.1 Numerical Results

Table 1 shows the results of the workload assessment received by operators on each work element in the work process to carry out the work, while, Table 2 shows the optimization of the number of operators based on the workload received by each operator.

Table 1. Workload assessment

Work Elements	Std time	Wrk days /year	Frequency/ shift	Total hours	Eff. Hours /shift	Eff. Hours /year	Workload		
Upsetter									
1. Heats the cylinder head									
Picking up materials	0,023	336	3000	394,441	6,4	2150,4	0,183	1,111	
Attach materials to the machine	0,027	336	3000	461,729	6,4	2150,4	0,215		
Operating the machine	0,011	336	3000	193,163	6,4	2150,4	0,090		
Waiting	0,080	336	3000	1340,640	6,4	2150,4	0,623		
2. Forming a hexagon hole									
Taking the heated material	0,031	336	3000	514,017	6,4	2150,4	0,239	0,484	2,193
Installing the material	0,016	336	3000	264,932	6,4	2150,4	0,123		
Operating the machine	0,016	336	3000	261,333	6,4	2150,4	0,122		
3. Inspection									
Take the material from the machine	0,024	336	3000	400,222	6,4	2150,4	0,186	0,598	
Measuring length	0,014	336	3000	233,484	6,4	2150,4	0,109		
Measuring the hexagon hole	0,023	336	3000	383,149	6,4	2150,4	0,178		
Laying out the material	0,016	336	3000	269,099	6,4	2150,4	0,125		
CNC Lathe									6,580
1. Machining									

Work Elements	Std time	Wrk days /year	Frequency/ shift	Total hours	Eff. Hours /shift	Eff. Hours /year	Workload		
Picking up materials	0,023	336	3000	389,155	6,4	2150,4	0,181		
Installing materials	0,122	336	3000	2056,404	6,4	2150,4	0,956	2,208	
Operating the machine	0,009	336	3000	151,962	6,4	2150,4	0,071		
Waiting	0,128	336	3000	2150,019	6,4	2150,4	1,000		
2. Inspection									
Taking material out of the machine	0,024	336	3000	402,603	6,4	2150,4	0,187		
Cleaning residue	0,107	336	3000	1793,033	6,4	2150,4	0,834		
Measuring length	0,046	336	3000	773,677	6,4	2150,4	0,360	4,373	
Checking thread	0,169	336	3000	2841,288	6,4	2150,4	1,321		
Measuring diameter	0,180	336	3000	3024,620	6,4	2150,4	1,407		
Laying the material	0,034	336	3000	567,541	6,4	2150,4	0,264		
Punch Hole Machine									
Picking up materials	0,026	336	3000	443,968	6,4	2150,4	0,206		
Installing materials	0,011	336	3000	192,642	6,4	2150,4	0,090	0,459	
Operating the machine	0,007	336	3000	124,273	6,4	2150,4	0,058		
Putting materials away	0,013	336	3000	226,613	6,4	2150,4	0,105		
Picking up materials									
Drill Machine	0,017	336	3000	282,912	6,4	2150,4	0,132		
Picking up materials	0,029	336	3000	484,325	6,4	2150,4	0,225	1,038	2,243
Installing materials	0,070	336	3000	1182,904	6,4	2150,4	0,550		
Operating the machine	0,006	336	3000	104,841	6,4	2150,4	0,049		
Removing materials	0,010	336	3000	176,139	6,4	2150,4	0,082		
Putting materials away									
Buffing Machine	0,010	336	3000	171,061	6,4	2150,4	0,080	0,746	
Picking up materials	0,008	336	3000	126,342	6,4	2150,4	0,059		
Installing materials	0,067	336	3000	1123,161	6,4	2150,4	0,522		

Work Elements	Std time	Wrk days /year	Frequency/ shift	Total hours	Eff. Hours /shift	Eff. Hours /year		Workload
Operating the machine	0,005	336	3000	89,973	6,4	2150,4	0,042	
Removing materials	0,006	336	3000	93,259	6,4	2150,4	0,043	
Inspection								
Picking up materials	0,043	336	500	120,710	6,4	2150,4	0,056	
Visual inspection	0,058	336	500	163,136	6,4	2150,4	0,076	
Drill hole inspection	0,366	336	500	1024,897	6,4	2150,4	0,477	
Hole lip inspection	0,231	336	500	645,742	6,4	2150,4	0,300	3,434
Cylinder length inspection	0,240	336	500	673,385	6,4	2150,4	0,313	
Brush	0,135	336	300	226,189	6,4	2150,4	0,105	
Thread check	0,670	336	450	1688,219	6,4	2150,4	0,785	
Hexagon hole check	0,022	336	3000	363,005	6,4	2150,4	0,169	
Perpendicularity check	0,148	336	3000	2479,543	6,4	2150,4	1,153	

Table 2. Optimizing the number of operators

Work Process	WL	Current Number of Operator	WL/ operator	Description	Optimal Number of Operator	WL/ operator	Description
Upsetter	2,19	6	0,3655	Underload	2	1,0965	Normal
CNC Lathe	6,58	6	1,096	Normal	6	1,096	Normal
Punch Hole Machine							
Drill Machine	2,24	6	0,3738	Underload	2	1,1215	Normal
Buffing Machine							
Inspection	3,4	9	0,381	Underload	3	1,144	Normal

5.2 Graphical Results

Figure 1 and Figure 2 show the difference in operator workload before WLA and after WLA. With the reduction of workers, it can be seen that the workload received is above the underload limit and below the overload limit or in the normal area.

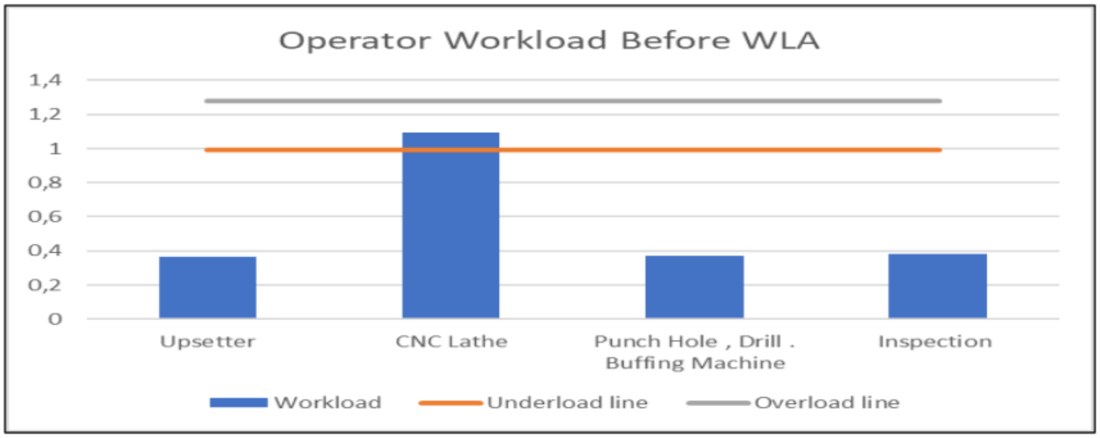

Figure 1. Operator workload before WLA

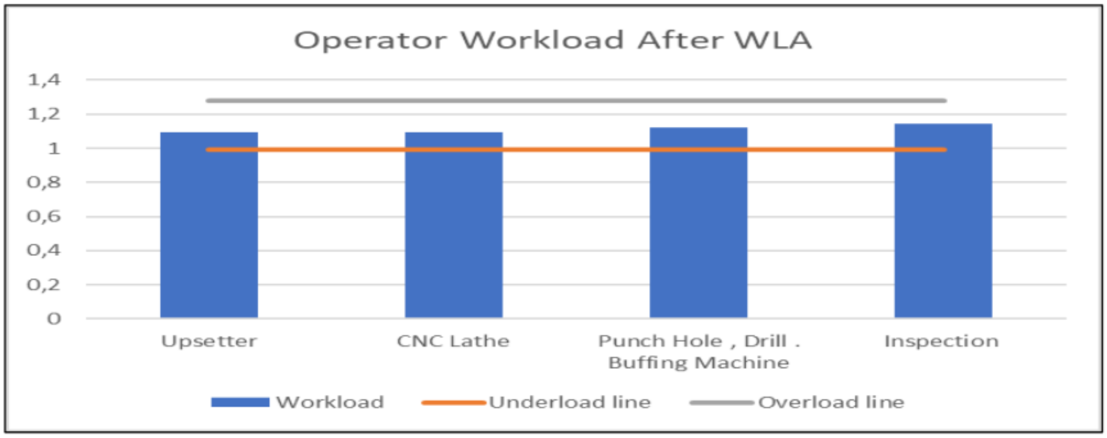

Figure 2. Operator workload after WLA

5.3 Proposed Improvements

The research that has been done has not discussed the level of understanding or ability of operators in detail because the assumption used in this study is that the operators who work are graduates or vocational students with the same understanding. For this reason, the suggestion that can be given for further research is to add an operator ability test, especially for production lines with various backgrounds of workers. In addition, this research has not involved quality control to ensure the percentage of material that can be processed in each shift. Suggestions for these shortcomings are to ensure the adequacy of the amount or percentage of material that can be used for processing.

6. Conclusion

Based on the analysis of the results of the research that has been carried out, it is concluded that the change in the number of workers from 27 operators (6 regular operators and 21 street vendors) to 13 operators (6 regular operators and 7 street vendors). The overall reduction in the number of workers is 51.851% of the number of workers per shift or 66.667% of PKL operators. This reduction can be implemented in the next PKL recruitment process by reducing the need for PKL workers to 7 people. This implementation will make the company save Rp8,400,000.

References

Adianto, E & Karo, G. (2014). *Pengukuran Produktivitas Karyawan dengan Metode Full Time Equivalent (FTE) PT. Astra International Tbk Divisi Astra Motor Penempatan Jakarta Honda Center.* Journal of Industrial Engineering and Management Systems 7(1).

Gallagher, E., & Rapoza, D. (2010). Issues and Solutions in Accurately Measuring Clinical Full-Time Equivalents. *The Journal of Pediatrics. 157(5), 696-698 e2.*

Nugroho (2008). Keperawatan Gerontik. Jakarta: Buku Kedokteran EGC.

Liu, Y et al. (2016). Robotic and Computer-Integrated Manufacturing Workload-Based Multi-Task Scheduling in Cloud Manufacturing. *Robotic and Computer Integrated Manufacturing. Oktober 2015), 0-1.*

Mondy, R.W., Noe, R.M. (1995). *Human Resources Management. 4th Edition. Boston: Allyn and Boaccom.*

Novera. (2010). Analisis Beban Kerja dan Kebutuhan Karyawan Bagian Administrasi Akademik dan Kemahasiswaan (Studi Kasus Unit Tata Usaha Departemen pada Institusi Pertanian Bogor). *Jurnal Jurusan Teknik Industri, Fakultas Teknologi Industri, Institusi Bogor.*

Suradinata, Ermaya. (1996). *Manajemen Sumber Daya Manusia. Bandung: Ramadhan.*

Sutalaksana et al. (2006). *Teknik Perancangan Sistem Kerja. Bandung: ITB.*

Tanner. J. P. (1990). *Manufacturing Engineering -An introduction to the basic function, 2nd edition. Florida: CRC Press.*

Determining the Number of Operators based on Workload Analysis

ORIGINALITY REPORT

2%	2%	2%	0%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

MATCH ALL SOURCES (ONLY SELECTED SOURCE PRINTED)

2%

★ www.ieomsociety.org

Internet Source

Exclude quotes	On	Exclude matches	< 2%
Exclude bibliography	On		