Available online at: https://proceeding.researchsynergypress.com/index.php/rsfconferenceseries1
RSF Conference Series: Business, Management, and Social Sciences
e-ISSN 2807-5803/p-ISSN 2807-6699
Volume 2 Number 1 (2022): 166-175

Worker-Machine Relationship Based Strategy for Sustainable Management in A Machine Shop

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Abstract

Nowadays, establishing a sustainable management plan will help organizations use resources effectively and efficiently and help the business to have a competitive advantage in the long term. In a machine shop where the operation cost is high and resources are not effectively used, a worker-machine relationship-based strategy has been introduced. Many studies explored the use of different problem solving tools in different fields, however there is a lack of studies in the application of gang process chart, random and synchronous servicing especially in machine shop. Thus, the purpose of this study was to evaluate the job distribution during service operation, to determine which worker and machine will require reassignment to operate effectively, and lastly propose a sustainable management strategy to optimize the operation and reduce the operation cost. This study used a descriptive research design with an overt observational approach in a well-established machine shop in Oriental Mindoro, Philippines. A total of fifteen operators who were directly involved with the machines have been observed. The study discovered that Operators 1,2,3.4 and 5 are already operating on the ideal number of machines, Operator 6 will require one more additional machine, Operator 7,8 9 and 10 will require one less machine to operate on an ideal number and save operation cost.

Keywords: *work study, methods engineering, random servicing, synchronous servicing, sustainable management*

INTRODUCTION

Firms must carefully create and develop business strategies to obtain a long-term competitive advantage in today's complicated and dynamic business field. It's crucial to formulate as well as establish various approaches in the business industry (Chrigwin, C. 2016) since organizations without a plan are unable to use resources effectively and efficiently because of a lack of ability to conduct a strategic analysis that will allow making the best use of business financial and human resources (Durmaz, Y., & Düşün, Z. D. 2016). Sustainable management entails taking environmental concerns into account while making decisions and formulating strategies (Garner, 2021). Managing company sustainability benefits the environment and the local community in the long term. It's also becoming an indispensable goal for decision-making in global corporations (Bhinge, R. et al., 2015In addition, it has other advantages, such as enhanced employee morale, profitability, and recruitment. According to Merkus, S. et al. 2019, as a result of the implementation of the new strategy will help to reshape organizational operations to remain competitive.

Manufacturing businesses are under pressure to optimize their output to reduce costs and boost efficiency (Denkena et al., 2014). Optimization is critical in business (Dostal, P. 2013) as it reduces costs that can lead to higher profits and the success of the company and the most salient tools for

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achieving sustainability. Sadollah A. et al. pointed out that optimizing complex subjects that demand precise computing for solutions must consider much information, such as principles and notions for designing artificial computational processes. According to Kite-Pojell, J. (n.d.), machine tools and other materials exhibited in production are needed for a worker workforce to finish one job. All recorded sequenced elements through the complete procedure are required to obtain the relationship between the operator's working cycle and the machines' operating cycle (Freivalds, 2009, Meller and Gau, 1996; Phillips, 1997). In addition, with the help of the gang process chart, the idle time for both operator and the machine within the cycle will be known (Process Analysis). In this case, management distinguishes the whole process and job distribution of workers. Thus, management will be familiar with every operation and detail to polish in meeting sustainable management.

Machine shop in Calapan, Oriental Mindoro, the Calapan Oriental Machine & Engineering (COME), offers services including engine reconditioning specifically; crankshaft, engine block, cylinder head, and fabrication services of machine parts. Although it has been in existence for almost three decades, the problem persists. The owners are in trouble with the high operation cost and misallocation of resources. In this regard, evaluating and optimizing job distribution and reassignment of both machines and operators are necessary for assessing this machine shop. Therefore, the purpose of this study aims to examine the job distribution during each service operation. Moreover, determine which worker and machine will require reassignment to operate effectively, and lastly, propose a sustainable management strategy to optimize the business based on the result of the analysis.

LITERATURE REVIEW

Sustainable Management Strategy

According to the World Commission on Environment and Development's report, humankind faces economic, social, and environmental risks. Human beings must continue to grow and meet their current demands, but this should not come at the expense of the next generation's well-being. The ideals of fairness, sustainability, and commonality are applicable to achieve this (Costanza, R. 1995). Sustainability is a complex concept (Aragon-Correa, a. Jo. Et al. 2017), and Pantelic et al. pointed out that researchers must be specific when utilizing the idea of sustainability to minimize confusion. The general measure of company performance, on the other hand, can be separated into three dimensions: financial, business, and organizational performance (Venkatraman, N. et al. 1986). Nevertheless, pursuing sustainability is crucial for a society's environmental circumstances and welfare as well as from a company standpoint, legal requirements and stakeholder pressures demand more significant social and natural responsibility (Winkler, H. 2010). Stakeholders such as employees have to maximize their beneficial benefits while reducing the negative ones. Many companies have spent on social responsibility and social welfare to improve their performance to social challenges. Moreover, many firms recognize the need for their social and environmental management performance. The corporation follows a corporate strategy that considers social, environmental, and economic factors (Polychronopoulos, D. et al., 2021). Workers' performance usually depends on whether a business' successfully achieved financial goals resulting entire company failing to move towards effective implementation of sustainability (Ali, M. R. 2020). Thus, companies should design a sustainability plan to enhance the organizational structure and merge the strategies to become more sustainability-oriented (Kennedy, S., Whiteman, G., & van den Ende, J. 2017). It will become sustainable is when leaders can devise methods to boost market share, talent, and stakeholder benefits while lowering operational costs and job dissatisfaction (Banker et al., 2014), and a company emerges to be sustainable if it continues to exist in the face of market risks and internal change.

Application of Worker-Machine Relationship

The worker and machine process chart allows analysts to observe the exact time relationship between the operator's working cycle and the machines' operating cycle (Freivalds, 2009, Meller and Gau, 1996; Phillips, 1997). With these engineering methods, the worker-machine relationship utilized synchronous and random servicing. Synchronous servicing refers to more than one machine to an operator where both machine and worker perform during the whole cycle. On the other hand, random servicing pertains to a situation when it is unknown when a facility needs or how long service takes. Concerning the methods engineering used in optimizing operation, the scientific process relies heavily on accurate record-keeping (Steneck, N. H., 2004). Thus, the gang process charts as recording and analysis tools were vital to evaluate individuals' operation processes. Both of these recording tools contain details of each component of an operation, including the distance traveled, delays, and idle time are exposed.

METHODOLOGY

Research design/ paradigm

This study used a descriptive research design of an observational method with an overt observational approach. All the operators were aware of the observation conducted by the researchers.

Study site

The research was conducted in one of the well-established machine shops in Calapan, Oriental Mindoro, the Calapan Oriental Machine & Engineering (COME), from March 29, 2021, to April 8, 2021.

Participants

A total of 15 workers from the machine shop were observed. The participants were directly involved in the service operations, such as reconditioning of; the crankshaft, engine block, cylinder head, fabrication services of machine parts, calibration of the injection pump, and the general process of automotive services.

Data gathering

The researcher gathered at Calapan Oriental Machine & Engineering (COME). The overt observational method was used in recording the flow of the process, distance traveled, worker's performance, and machine operation. In recording the duration and name of events in a flow process, the researcher utilized the software Workstudy+6. After the acquired data from observation, the researcher conducted short interviews with every worker regarding their wage.

Data interpretation

The gathered data will become input to recording-analysis tools, quantitative tools, and worker-machine relationships. The output will be in the form of charts and figures then the researcher will interpret the data by describing the contents and explaining the circumstances highlighted in the chart or figure.

FINDINGS AND DISCUSSION

Job distribution

The gathered data will become input to recording-analysis tools, quantitative tools, and worker-machine relationships. The output will be in the foIn assessing the job distribution of 15 workers of Calapan Oriental Machine & Engineering, figure 1 displays the gang process chart, and figure 2 supplies the performed task of each worker on a period of 8 hours. The total idle time for the present method is 29.73 hours.

In the proposed method, considering the total size of workers as a single team, the overall idle time will remain the same, with the workload of loaded workers distributed to most minor loaded workers. Workers 3, 4, 6, 7, 8, 10, and 15 were fixed operators of machines, worker 11 was definite in performing valve seat setting and assembling of the cylinder head, and workers 12 & 14 were record keepers and drivers that carried out their task apart from the main operation. Only the remaining worker 1, 2, 5, 9, and 13 can perform dynamically and possibly assigned with other operation tasks, among these groups of workers, only workers 2 and 13 were the least loaded.rm of charts and figures then the researcher will interpret the data by describing the contents and explaining the circumstances highlighted in the chart or figure.

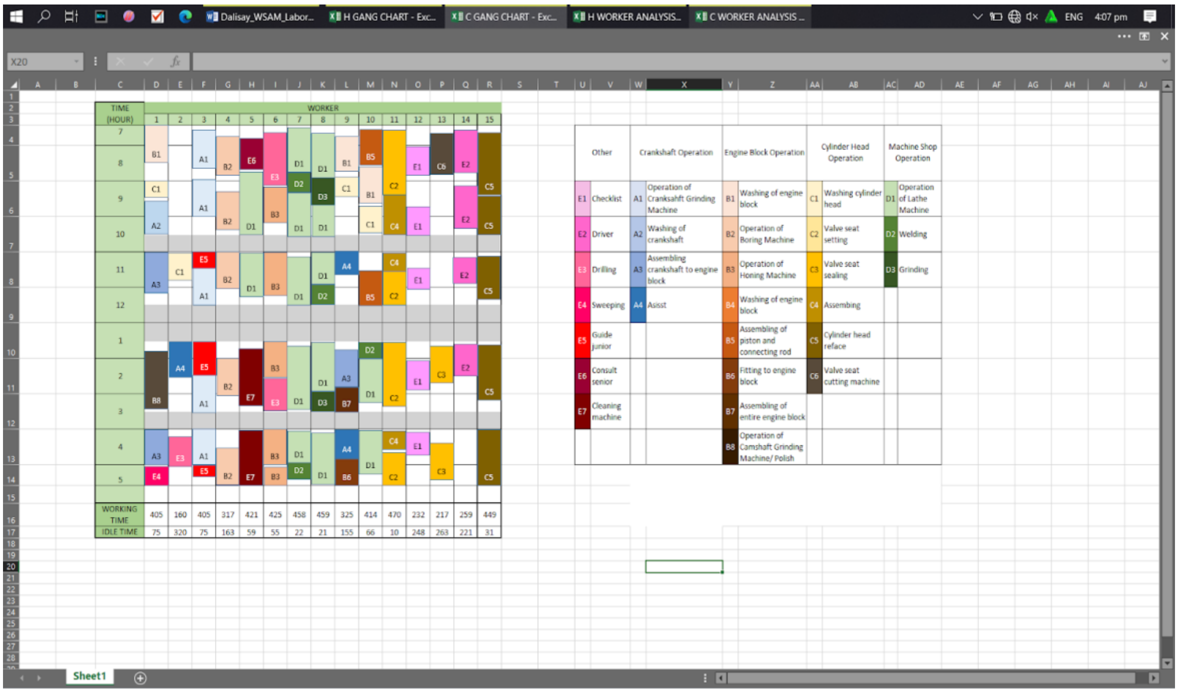

Figure 1: Gang process chart for 8 hour periods.

In the proposed distribution, worker two will have the task of drilling plates of worker six to reduce its idle time from 5.33 hours to 0.58 hours and allow worker 6 to perform additional operation of honing machine. Moreover, worker 13 will assist worker 11 by assembling the parts of the cylinder head to reduce its idle time from 4.38 hours to 2.46 hours.

Workers operating on the ideal number of machines

Operators 1 and 2 were few to have an ideal number of machines among the ten operators. Both worked on a crankshaft grinding machine, camshaft grinding machine, and arc force electric welding machine with different expected costs. Operator 2 currently with a greater total expected cost of Php498.69/unit with Php17.09/unit differences on the combined predicted cost of Operator 2.

Table 1. Traditional set-up with ideal number of machines

Operators	Machines	Total Expected Cost (Php/unit)	
1	1 unit of Crankshaft Grinding Machine AMC K1500-M 1 unit of Camshaft Grinding Machine REPCO RT-7 1 unit of Arc Force Electric Welding Machine	n3=498.69	n4=4609.57
2	1 unit of Crankshaft Grinding Machine AMC K1500-M 1 unit of Camshaft Grinding Machine REPCO RT-7 1 unit of Arc Force Electric Welding Machine	n3=481.6	n4=593.21
3	1 unit of Arc Force Electric Welding Machine 1 units of Master Heavy Duty Lathe Machine I 120h	n2=298.85	n3=350.1
4	1 unit of Arc Force Electric Welding Machine 1 units of Master Heavy Duty Lathe Machine I 120h	n2=269.59	n3=312.95
5	1 unit of Arc Force Electric Welding Machine 1 units of Lathe Machine C6150	n2=320.98	n3=393.57

Operators 4 and 5 also operated on the ideal number of machines, the arc force electric welding machine and lathe machine. Operator 5 currently has the highest total expected cost of Php320.98/unit, followed by Operator 3 of Php298.85/unit and Operator 4 of Php269.59/unit.

Workers requiring addition or deduction of machine/s

Only Operator 6 requires one more machine to operate on the ideal number and reduce the current total expected cost of Php10.22/unit. Further, increased machinery will only increase the total anticipated cost of at least Php45.7/unit. Operators 7, 8. 9, and 10 were the workers who would require one less machine to operate on an ideal number and reduce each of their total expected costs.

Table 2. Synchronous servicing on traditional set-up

Operators	Machines	Total Expected Cost (Php/unit)	
6	1 unit of Cylinder Boring Machine AC170 1 unit of Cylinder Block Boring & Milling Machine CM-1200V 1 unit of Line Boring Machine	n4=346.48	n5=336.26

	1 unit of Arc Force Electric Welding Machine		
7	1 unit of Honing Machine (Stationary) 1 unit of CBN Milling Machine M3000 1 unit of Arc Force Electric Welding Machine 1 unit of Master Heavy Duty Lathe Machine I 120h	n2=157.93	n3=150.66
8	1 unit of Surface Grinding Machine 1 unit of CBN Milling Machine M3000 1 unit of Arc Force Electric Welding Machine	n1=184.36	n2=175.77
9	1 unit of Valve Seat Cutting Machine 1 unit of Arc Force Electric Welding Machine	n1=174	n2=185.01
10	1 unit of Tig Welding Machine 1 unit of Arc Force Electric Welding Machine 1 unit of Master Heavy Duty Lathe Machine I 120h	n2=240.84	n3=234.55

Operator 7 will only require three machines from four machines to reduce the total expected cost to Php150.66/unit. In comparison, Operator 8 will require only two machineries to minimize the total expected cost to Php175.77/unit. Operator 9 will only need to operate on one machine to reduce the overall anticipated cost of Php11.01/unit. Operator 10 will work on two pieces of machinery to minimize the total expected cost of Php 30.71/unit.

Set of machines requiring addition or deduction of workers

Among the machine-worker relationship, only the set of machines being operated by Operator 6 was viable for the possibility of an increase in workers. However, based on the random servicing with 0.05 percent of machine downtime, none of the addition in workers will produce any difference in total expected cost due to the application of the synchronous servicing result in the requirement of additional machines.

Table 3. Random servicing on traditional set-up

Operators	Machines	Total Expected Cost (Php/unit)
6	1 unit of Cylinder Boring Machine AC170 1 unit of Cylinder Block Boring & Milling Machine CM-1200V 1 unit of Line Boring Machine	One Operators = 2314.22 Two Operators = 2314.22
5 3 9 10 7	Lathe Machine C6150 Master Heavy Duty Lathe Machine I 120h Master Heavy Duty Lathe Machine I 120h Master Heavy Duty Lathe Machine I 120h Master Heavy Duty Lathe Machine I 120h	Two Operators = 7919.64 Three Operators = 7919.64 Four Operators = 7919.64

Only the set of lathe machines was viable for the possibility of worker reduction. However, as the result of random servicing, none of the decreases in the worker will cause any changes since 0.27 percent of expected downtime was too negligible due to their regular machine maintenance of each operator.

Reassignment of worker and machine

Synchronous servicing reduces or balances the idle time between machine and worker services by producing an ideal number of machinery based on the cycle duration of the operation. The suitable number has the lowest total expected cost regarding the operator's rate and machine cost per hour between the two options.

Table 6 shows the proposed machines with their total and expected cost. Operator 6 was currently operating on four pieces of machinery with a total anticipated cost of Php346.48/unit and a suggestive expected savings of Php10.22/unit if there will be one more machinery increase. Among the 16 machines, the addition of a surface grinding machine qualified the ideal number and further decreased the expected cost of Php24.83/unit.

Table 4. Application of synchronous servicing on proposed set-up

Operators	Machines	Total Expected Cost (Php/unit)	
6	1 unit of Cylinder Boring Machine AC170 1 unit of Cylinder Block Boring & Milling Machine CM-1200V 1 unit of Line Boring Machine 1 unit of Arc Force Electric Welding Machine 1 unit of Surface Grinding Machine	n4=331.20	n5=321.65
7	1 unit of Honing Machine (Stationary) 1 unit of CBN Milling Machine M3000 1 unit of Arc Force Electric Welding Machine 1 unit of Master Heavy Duty Lathe Machine I 120h	n2=166.64	n3=167.63
8	1 unit of Surface Grinding Machine 1 unit of CBN Milling Machine M3000 1 unit of Arc Force Electric Welding Machine	n1=214.46	n2=247.95
9	1 unit of Valve Seat Cutting Machine 1 unit of Arc Force Electric Welding Machine	n1=303.03	n2=303.28
10	1 unit of Tig Welding Machine 1 unit of Arc Force Electric Welding Machine 1 unit of Master Heavy Duty Lathe Machine I 120h	n2=202.47	n3=260.05

In the case of Operator 7, the ideal number of machines from four is three than two with a savings of Php24.83/unit, while Operator 8 has the suitable number of two pieces of machinery to save Php8.59/unit. One machine reduction from the set of Operator 9 will save an amount of Php11.01/unit, and another machine from Operator 10 to save a cost of Php29.71/unit.

However, on the utilization of reduced numbers of the machine, the new expected cost exceeds the initial anticipated cost. The only viable machinery to be removed from Operator 6 was a CBN milling machine M3000 to yield the ideal number of three pieces of machinery. Nonetheless, the new expected cost would exceed the initial expected cost of Php29.71/unit. While surface grinding machine of Operator 8 was removed from the set and gained by Operator 6, resulting in an increase of Php72.18/unit in the new expected cost. In the case of Operator 9 reassignment, the valve seat cutting machine can be optional since the electric welding machine is a shared operation. However, the new expected cost still exceeds the initial anticipated cost of Php129.03/unit. For Operator 10, the lathe machine is the most viable machinery that is removable as stated in random servicing, but there will still be an increase of Php55.21/unit in the new expected cost.

CONCLUSION AND FURTHER RESEARCH

The job distribution reveals that the total idle time in COME will remain the same as the entire workforce operates as a single team due to the shared tasks of some workers in the proposed method with the workload of loaded workers distributed to most minor loaded workers.

Application of worker-machine relationship reveals that five workers: Operators 1, 2, 3, 4, and 5, are currently operating on the ideal number of machines and suggest that their set of machinery be excluded from any alteration for the meantime unless the company encounters significant changes that may cause an occurrence of idleness or fluctuation on the total expected cost of each unit production.

Only Operator 6 will require one more machine to his set of machinery to have an ideal number and reduce idle performance in both machine and worker. Four workers will lose one machinery to operate on an appropriate number: Operator 7, 8, 9, and 10 will only gain three machines to save in production.

None of the machines will require additional operators. The result of random servicing was due to the outcome of synchronous servicing; thus, an increase in the number of workers is inconsiderable as the number of machines is a deficit. Subtraction of workers was optional in the case of operators of lathe machines since the percentage of expected machine downtime was too small to be significant. The worker's job description, not only as an operator but also mechanic, was the primary reason for a minute percentage of machine downtime.

Depending on the price of the company's services, the manager or supervisor may implement the changes resulting from the application of synchronous and random servicing since the yielded total expected cost of each set of machines is not consistently decreasing. The actual reduction of one machinery from Operator 7, 8, 9, and 10 only exceeded the initial total expected cost. Wherein the reduction of surface grinding machine from the Operator 8 was used as gain in Operator 6. The increase in total expected cost may reduce the company's expenses if this will eliminate present idleness between the machine and its operator and boost the overall production rate of its services.

The result of this study will serve as a basis for developing the ideal method for the company that will optimize the productivity between the machine and the operator and reduce production costs. Further studies with regards to the methods engineering will focus on the significant effects upon the installation of the proposed set-up in machine-operator distribution with the objectives of assessing the reduction of idle time and determining the impact of decrease and increase of service/production cost per unit with regards to the prices of services to the overall company's production rate and operating expenses.

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