INTERNATIONAL JOURNAL OF INDUSTRIAL MANAGEMENT (IJIM)
ISSN: 2289-9286 e-ISSN: 0127-564X
VOL. 06, ISSUE 01, 18 – 39
DOI: https://doi.org/10.15282/ijim.6.1.2020.5410

ORIGINAL ARTICLE

A Case Study on the Un-Used Capacity Assessment Using Time Driven Activity Based Costing for Magnetic Components

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ABSTRACT – The Electrical & Electronic (E&E) company is one of Malaysia's leading industries that has 24.5% in manufacturing sector production. With a continuous innovation of E&E company, the current costing being used is hardly to access the complete activities with variations required for each workstation to measure the un-used capacity in term of resources and cost. The objective of this work is to develop a new costing structure using time-driven activity-based costing (TDABC) at . This data collection was obtained at E&E company located at Kuantan, Pahang that focusing on magnetic component. The historical data was considered in 2018. TDABC is used to measure the un-used capacity by constructing the time equation and capacity cost rate. This work found three conditions of un-used capacity. Type I is pessimistic situation whereby according to winding toroid core, the un-used capacity of time and cost are -14820 hours and -MYR2.60 respectively. It means the system must sacrifice the time and cost more than actual apportionment. Type II is most likely situation whereby according to assembly process, the un-used capacity of time and cost are 7400 hours and MYR201575.45 respectively. It means the system minimize the time and cost which close to fully utilize from the actual apportionment. Type III is optimistic situation whereby according to alignment process, the un-used capacity of time and cost are 4120 hours and MYR289217.15 respectively. It means the system used small amount of cost and time from the actual apportionment.

ARTICLE HISTORY
Revised: 30-04-2020
Accepted: 06-05-2020

KEYWORDS
Time equation;
Capacity cost rate;
Unused capacity

INTRODUCTION

Activity based costing (ABC), which was proposed by Kaplan and Cooper at the beginning of the 1980s, resolves the cost-distortion and cost subsidization problems in the cost assessment of traditional cost accounting system. It assumes that the allocation basis for all relevant production costs is volume-based (i.e., quantity-relevant). (Hernandez-Matias et al., 2006) pointed out that the ABC costing model is one of the main methodologies and tools to analyze manufacturing system and support the decision-making process. ABC has two major stages. The first stage allocates the indirect costs to the activity centers and the second assigns the allocated costs of these centers to the cost objects, using the activity drivers. Lea and Fredendall (2002) compared traditional cost accounting system, ABC and theory of constraints and found that these management cost accounting systems differ significantly when they are used for cases with different production types, product types, degrees of automation and methods of allocating the manufacturing overhead cost. They also define 'production cost' in different ways.Traditional cost accounting system is only suitable for mass production, but is not adequate for the production of diversified products, because it can lead to an incorrect pricing decision, due to a distorted cost assessment,wherein the costs are not positively correlated to quantity. ABC improved this flaw in traditional cost accounting system, especially when there are diversified products and the manufacturing overhead is large because in practice, not all production costs are strictly quantity-relevant for example the cost to the material-sourcing department (Chang et al., 2014).

There are several works had been done in ABC. According to Gui et al. (2019), due to conflict between the carbon emission and cost of product variations, an improved genetic algorithm with a novel selection mechanism which used the correlation function is presented to optimize these parts in order to reduce both the carbon footprint and cost. Tsai and Jhong (2019) used a discontinuous piece wise linear function with full progressive tax rates for carbon emissions to improve the efficiency of operations by a variety of product mixes. In addition, unlike the typical metrics such as resource utilization and throughput used for simulations of processes to guide system improvements, the utilization of the cost

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aspect has been explicitly considered as it is directly related to practice (Calvi et al., 2019). Thus, Kaiser (2019) formulated the costing sustainment by describing the role factor models and ABC models play in offshore operating cost estimation. The inclusion of emergy drivers into the traditional ABC method could represent an innovative business approach in allocating a company's overheads to products since it supports a decision based on a reduced emergy demand and causing lower load on the natural environment by requesting a lower amount of energy and materials for the production processes (Neto et al., 2018). Work by Defourny and colleagues (2019) stated that traditional ABC also capable to accurately measure the treatment delivery activities represents 68.4% of the costs and treatment preparation is 31.6%. Phan et al. (2018) suggested that organizations should focus on analyzing the activities with environmental impacts, managing them via their cost drivers, and allocating the environmental activities costs to products and services. Allain and Laurin (2018) illustrated that cost systems characteristics required to meet regulatory needs are different from those required to support decision-making and because regulatory needs are usually prioritized, these needs are likely to prevail over those of decision-makers.

Finally on the formulation of costing sustainment, Yang (2018) proposed mixed integer linear programming to help green power suppliers to more accurately understand how to allocate resources to each green electric power system through appropriate cost drivers. Abu et al. (2017) estimated the cost of remanufactured crankshaft using ABC while (Kamil et al., 2018; Abu et al., 2018) developed a distinctive pattern of crankshaft and identify the critical and non-critical parameter of crankshaft based on the Mahalanobis Taguchi System, then applied the ABC as a method of estimation for the remanufacturing cost of crankshaft. Zheng and Abu (2019) applied the ABC as a method of cost estimation for the palm oil plantation and Zamrud et al. (2020) performed a comparative study for electronic component between ABC and time-driven activity-based costing.

Traditional standard cost systems were popular until the 1980s but became less useful because the direct labour content of products declined. The application of the traditional method based on a single basis, such as direct working hours, became less accurate and simply no longer reflected economic reality. As an improvement to ABC, TDABC in which cost allocation is based on total activities time, has been proposed. TDABC adopts a time driver from resource to the cost objects. Without relying on any human judgment, TDABC is an objective approach in that it skips the first stage of ABC that are time-costly and in particular, the estimation of activities' time proportions.

Time-driven activity-based costing (TDABC) is an accounting method which has gained popularity in business and is gaining increasing prominence as a tool for estimating health care delivery costs (Kaplan et al., 2014). TDABC allows health care providers to measure the costs of treating patients for a specific medical or surgical condition across a full longitudinal care cycle. It uses process mapping from industrial engineering and activity-based costing from accounting (Anzai et al., 2017). TDABC relies on estimates of capacity cost rates and utilization times to estimate the overall cost associated with a system or intervention (Oklu et al., 2015). Capacity cost rate is defined as the monetary cost of a resource per unit time (in dollars per hour), calculated by dividing the total cost of a resource by the approximate time the resource is utilized. This may be calculated for all resources employed in a system, including staff as wages plus benefit costs divided by hours worked, equipment as purchase cost divided by lifetime use and occupancy as rental costs divided by total annual productive occupancy time (Donovan et al., 2014). The TDABC model allows for accounting of multiple layers of cost, allowing for a more nuanced examination of cost contributors than existing estimates such as relative value units and charge-cost ratios. TDABC allows for both the identification of cost-driving steps in a process and the assessment of cost-reduction strategies. In addition, the calculations required for TDABC estimation are straightforward, requiring only estimates of time and capacity cost rate (Kaplan, 2014).

The application of TDABC has been validated through many research works. Due to the heavily investing in value-based health care, Keel and colleagues (2017) found that TDABC really help to efficiently cost processes and overcome the key challenge associated with current cost-accounting methods. In case of cost variation in the health care, Haas and Kaplan (2017) found that TDABC still provided accurate estimation in care cycle cost. Afonso and Santana (2016) presented a cost model using TDABC associated with multiple time equations and discussed the profitability at different cost objects. Yu et al. (2016) found that TDABC resulted in precise cost and identified inefficiencies in health care. Zaini and Abu (2019) explored the research gap of TDABC among published works that can be used as guideline in applying TDABC system in palm oil plantation. (Zamrud et al., 2020; Kamil et al., 2020; Safeiee et al., 2020) analyzed the manufacturing cost of electronic components incurred on production in electric and electronic industry using TDABC. Kamil et al. (2020) extended her work by proposing of Mahalanobis-Taguchi System and TDABC in electric and electronic industry to evaluate the significant parameters and develop time equation and capacity cost rate respectively. Finally, Zamrud et al. (2020) also extended her work by performing a comparative study for electronic component between ABC and TDBAC.

The purpose of this work is to assess the un-used capacity with respect to the cost and time using TDABC at E&E company on the magnetic components.

METHODOLOGY

The manufacturing process as shown in Figure 1 is started from auto stripping, cutting and soldering. This process need to cut the leadout with the length 200 mm. For soldering process, it needs soldering pot temperature within 340°C - 360°C with titanium solder pot. Then, winding toroid core process need winding machine, core, and 2 pieces of leadout wire. It started when the core is clamped on the winding machine. The first leadout wire is winding to the right core while second leadout wire is winding to the left right core. The winding must complete of 5 turns for both directions. Then, the wound core with the header with the position of part number must be in front during this process. Use the holder to prevent the leadout from affecting of epoxy and put an epoxy at leadouts between core and header. The units were arranged into curing jug and after that transfer into curing oven. Cool the component under a cooling fan and insert the component into chopper base to cut the leadout and transfer to conveyor for marking process that used laser marking. Pass of fail quality a unit of magnetic component are depend on visual mechanical inspection requirement that checking by a winding gap gauge, leadout pitch and length gauge, and magnifying glass. The aim of final test to check the inductance frequency in provided limits. Lastly, packaging the component into ship cartons after pass with quality check by previous process.

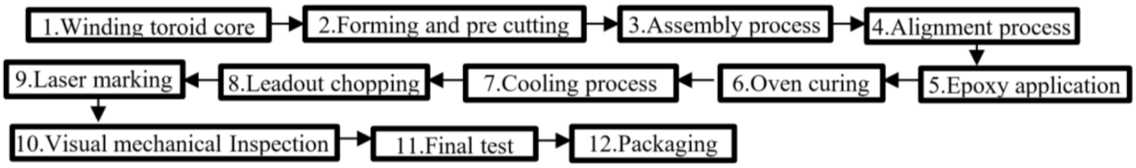

Figure 1. Manufacturing process of magnetic component.

There are 4 important elements of TDABC with specifically twelve steps to produce the new costing structure as shown in Figure 2. The flow is divided into process mapping, time equation development, capacity cost rate establishment and forecast analysis.

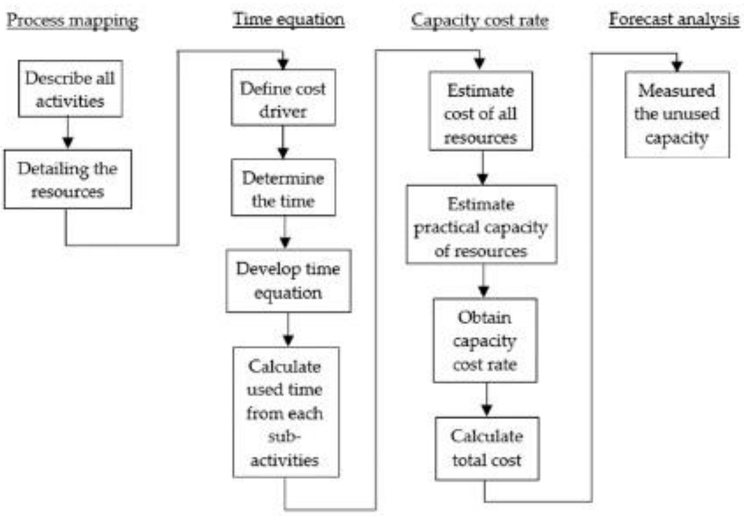

Figure 2. Flowchart of TDABC implementation.

According to Erhun et al (2018), TDABC has seven steps which are select the product, develop process map for each workstation, determine the time estimation for each process, estimate the cost resources supplied, calculate the total product cost, and the last step is optimize the capacity planning. The first step is selecting the product that to apply TDABC concept. This selection must be based on the condition of activities that contribute to the production process because of the different style and condition of different company and organization. Therefore, measuring the unused capacity in term of resources and time are very important to increase the profit margin in all the company. This is because the company is lack of knowledge about the TDABC system that up-to-date to apply in industry especially in electronic industry. The second step is developing the process map for each workstation. The process map is very important and systematic for all each workstation to avoid the problem such as delay process or any mistaken that cause by the workers in industry. This is because these problems will cause unsmooth of the process in each workstation to produce the product. The third step is to determine the time estimation for each process to produce the product. This is because the time estimation is different from sharing a same process with a same component. In fact, time is very closely related to the cost. Therefore, timing is a big issue in production industry because if one time is delay of process it will affect and delay all the activities in a production in a certain time. Besides, timing also can make the company forecast to the future for the product. Next step is to estimate the product cost resources supplied. Logically, all the industries in Malaysia or other countries have their own regular supplier. So, it is very important in production process must be on track with on time to avoid delay in production department. Consequently, time equation also will be used to calculate and estimate the cost based on the product cost resources supplied. Estimation the capacity of each resources and calculate the capacity cost rate is the next step of TDABC system. Equation (1) shows a calculation of capacity cost rate which is the main calculation in TDABC system that will provide good ability in a business operation. In order to get the smooth process, the capacity of each resources must be check regularly. The capacity cost rate also can increase the expectation of market demand in worldwide business for industry.

$$\text{Capacity cost rate} = \frac{\text{Cost of capacity supplied}}{\text{Practical capacity of resources supplied}} \tag{1}$$

Sixth step is calculating the total product cost. In business, although the cost is cheap, the quality is good. So, the quality is not based on the cost which the large amount the cost, the better quality sometimes cannot be acceptable. In a conclusion, the company will know the profit and the rate of product on the market. Finally, optimization the capacity planning is the last step of TDABC system. This estimated capacity is required by each activity center that determined by quantifying the frequency of the activity in month. This step can show the total production costs is used for the products in a month.

RESULTS

If the resources sharing the same activity, costs can be allocated directly to that activity while different activity, the cost-driver has to be used to allocate the cost. There are four types of resources such as labor, maintenance, material, and consumable. Table 1 shows cost of all resources at winding toroid core. At winding toroid core, this workstation requires two employees in each sub-activity at a cost of MYR26,400 for a year, giving a total MYR79,200. Core incurs material cost at MYR336,000 for a year in each sub-activity, giving a total MYR1.01 million. This means the total resources cost is MYR1.09 million.

Table 1. Labor, maintenance, material, and consumable costs at winding toroid core.

Workstation	Sub-activities	Labor cost (MYR)	Maintenance cost (MYR)	Material cost (MYR)	Consumable cost (MYR)	Cost of all resources supplied (MYR)
Winding toroid core	1.Tranfer the core to the winding gap	26,400	nil	336,000	nil	362,400
	2.Put a wire at the right core for winding	26,400	nil	336,000	nil	362,400
	3.Put a wire at the left core for winding	26,400	nil	336,000	nil	362,400
	Total	79,200	nil	1,008,000	nil	1,087,200

Table 2 summarizes all the resources cost at forming and pre-cutting. This step requires one employees at a cost MYR13,200 per year. Since one employees handles two sub-activities, including transfer wound core to the forming machine, and push the button, so the total labor cost at MYR26,400. The material cost of wound core at MYR4.27 million for both sub-activity giving a total MYR852,200. This gives a total cost for this activity of MYR8.55 million.

Table 2. Labor, maintenance, material, and consumable cost at forming and pre-cutting.

Workstation	Sub-activities	Labor cost (MYR)	Maintenance cost (MYR)	Material cost (MYR)	Consumable cost (MYR)	Cost of all resources supplied (MYR)
Forming and pre-cutting	1.Tranfer wound core to the forming machine	13,200	nil	4266,000	nil	4273,200
	2.Push button	13,200	nil	4266,000	nil	4273,200
	Total	26,400	nil	852,200	nil	8,546,400

The detail resources cost of labor, maintenance, material, and consumable at assembly process as shown in Table 3. This stage involves four employees in each sub-activity that giving a total of MYR105,600. The header incurs at MYR132,000 for both sub-activities. The total cost of this activity is MYR369,600.

Table 3. Labor, maintenance, material, and consumable cost at assembly process.

Workstation	Sub-activities	Labor cost (MYR)	Maintenance cost (MYR)	Material cost (MYR)	Consumable cost (MYR)	Cost of all resources supplied (MYR)
Assembly process	1.Insert the wound core onto the header	52,800	nil	132,000	nil	184,800
	2.Put a wire at the right core for winding	52,800	nil	132,000	nil	184,800
	Total	105,600	nil	264,000	nil	369,600

Table 4 shows the all resources cost of labor, maintenance, material, and consumable at alignment process. The labor cost for the one employee for one sub-activity used during this stage is MYR13,200. With the additional use of header at MYR264,000. As a result, the total cost for this activity is MYR290,400 per year.

Table 4. Labor, maintenance, material, and consumable cost at allignment process.

Workstation	Sub-activities	Labor cost (MYR)	Maintenance cost (MYR)	Material cost (MYR)	Consumable cost (MYR)	Cost of all resources supplied (MYR)
Alignment process	1.Put the unit onto the base leadout and Coil Adjuster	13,200	nil	132,000	nil	145,200
	2.Give a straighten to the leadout	13,200	nil	132,000	nil	145,200
	Total	26,400	nil	264,000	nil	290,400

Table 5 summarizes all the resources cost at epoxy application. This workstation requires four employees at a cost of MYR52,800 for both sub-activities which giving a total of MYR105,600. Epoxy indicates consumable cost at a cost of MYR2.11 million per year. Therefore, the total cost for this stage is MYR2.16 million.

Table 5. Labor, maintenance, material, and consumable cost at epoxy application.

Workstation	Sub-activities	Labor cost (MYR)	Maintenance cost (MYR)	Material cost (MYR)	Consumable cost (MYR)	Cost of all resources supplied (MYR)
Epoxy application	1.Insert the unit into the holder	52,800	nil	nil	nil	52,800
	2.Put the epoxy at the 4 leadout within core and header	52,800	nil	nil	2,112,000	2,164,800
	Total	105,600	nil	nil	2,112,000	2,217,600

As shown in Table 6, the detail resources cost of labor, maintenance, material, and consumable at oven curing. This workstation requires one employees for each sub-activity that sharing labor cost at MYR13,200. The burn fuse incurs maintenance cost MYR3.00. As a result, the total cost for this stage is MYR26,406.

Table 6. Labor, maintenance, material, and consumable cost at oven curing.

Workstation	Sub-activities	Labor cost (MYR)	Maintenance cost (MYR)	Material cost (MYR)	Consumable cost (MYR)	Cost of all resources supplied (MYR)
Oven curing	1.Tranfer the core to the winding machine	13,200	3.00	nil	nil	13,203
	2.Transfer the curing jug into the curing oven	13,200	3.00	nil	nil	13,203
	Total	26,400	6.00	nil	nil	26,406

The detail of resources cost of labor, maintenance, material, and consumable at cooling process as shown in Table 7. This work only involves labor cost which requires one employees for both sub-activities. This means the total cost is MYR26,400 per year.

Table 7. Labor, maintenance, material, and consumable cost at cooling process.

Workstation	Sub-activities	Labor cost (MYR)	Maintenance cost (MYR)	Material cost (MYR)	Consumable cost (MYR)	Cost of all resources supplied (MYR)
Cooling process	1.Tranfer the curing jug from curing oven	13,200	nil	nil	nil	13,200
	2.Cool the unit by cooling fan	13,200	nil	nil	nil	13,200
	Total	26,400	nil	nil	nil	26,400

Table 8 summarizes the resources cost of labor, maintenance, material, and consumable at leadout chopping. In this work, it involves labor cost which requires one employees for both sub-activities. This mean the total cost is MYR26,400 per year.

Table 8. Labor, maintenance, material, and consumable cost at leadout chopping.

Workstation	Sub-activities	Labor cost (MYR)	Maintenance cost (MYR)	Material cost (MYR)	Consumable cost (MYR)	Cost of all resources supplied (MYR)
Leadout chopping	1.Insert the unit into the chopper base	13,200	nil	nil	nil	13,200
	2.Remove the unit from the chopper base	13,200	nil	nil	nil	13,200
	Total	26,400	nil	nil	nil	26,400

Table 9 shows the resources cost of labor, maintenance, material, and consumable at laser marking. This work only involves labor cost which requires one employees for both sub-activities. This means the total cost is MYR26,400 per year.

Table 9. Labor, maintenance, material, and consumable cost at laser marking.

Workstation	Sub-activities	Labor cost (MYR)	Maintenance cost (MYR)	Material cost (MYR)	Consumable cost (MYR)	Cost of all resources supplied (MYR)
Laser marking	1.Tranfer the unit to the conveyor for laser marking	13,200	nil	nil	nil	13,200
	2.Label the unit by laser marking	13,200	nil	nil	nil	13,200
	Total	26,400	nil	nil	nil	26,400

Table 10 shows all the resources cost of labor, maintenance, material, and consumable at visual mechanical inspection (VMI). This workstation requires five employees for all sub-activity. One employee handle inspection winding gap at labor cost of MYR13,200, another one employee handles inspection leadout pitch and length at labor cost of MYR13,200 while three employees handles checking the component by magnifying glass at labor cost of MYR39,600 that giving total of MYR66,000.

Table 10. Labor, maintenance, material, and consumable cost at visual mechanical inspection.

Workstation	Sub-activities	Labor cost (MYR)	Maintenance cost (MYR)	Material cost (MYR)	Consumable cost (MYR)	Cost of all resources supplied (MYR)
Visual Mechanical Inspection (VMI)	1.Inspect the winding gap by using gauge	13,200	nil	nil	nil	13,200

	2.Inspect leadout pitch and length by using gauge	13,200	nil	nil	nil	13,200
	3.Check the unit by using magnifying glass based on VMI requirement	nil	nil	852,200	nil	8,520,000
	Total	26,400	nil	852,200	nil	8,546,400

The detail of resources cost of labor, maintenance, material, and consumable at final test as shown in Table 11. This work only involves labor cost which requires one employees for both sub-activities. This means the total cost is MYR26,400 per year.

Table 11. Labor, maintenance, material, and consumable cost at final test.

Workstation	Sub-activities	Labor cost (MYR)	Maintenance cost (MYR)	Material cost (MYR)	Consumable cost (MYR)	Cost of all resources supplied (MYR)
Final test	1.Tranfer the unit onto conveyor	13,200	nil	nil	nil	13,200
	2.Arrange the component into vacuum tray	13,200	nil	nil	nil	13,200
	Total	26,400	nil	nil	nil	26,400

Table 12 summarizes the resources cost of labor, maintenance, material, and consumable at packaging. This workstation involves one employees for each sub-activity at a cost of MYR13,200. Material cost incurs partition assembly at cost of MYR2,428.80, corr. Paper at cost of MYR3,024, ship cartons at cost of MYR4,377.60, layer pad at cost of MYR7,660.80 for put the vacuum tray into ship carton while for label ship carton and with the blank label and tape incurs blank label at cost of MYR259.20 and tape at cost of MYR576. So, the total cost is MYR71,443.20 per year.

Table 12. Labor, maintenance, material, and consumable cost at packaging.

Workstation	Sub-activities	Labor cost (MYR)	Maintenance cost (MYR)	Material cost (MYR)	Consumable cost (MYR)	Cost of all resources supplied (MYR)
Packaging	1.Put the vacuum tray into ship carton	13,200	nil	44,208	nil	4273,200
	2.Label the ship carton with the blank label and tape	13,200	nil	835.20	nil	4273,200
	Total	26,400	nil	45,043.20	nil	71,443.20

Based on all the workstation to produce magnetic component, the highest resources cost spent to produce magnetic component at forming and pre-cutting workstation. The lowest resources cost spent at cooling process, leadout chopping, laser marking, and final test workstation. The E&E company's working hours are Monday to Saturday, 7.30 a.m. to 5.30 p.m. within 2 shift. An employee works of eight hours 35 minutes a day, for 20 days for a month and 240 days for a year. Deduction for breaks is 0.75 hours (45 minutes). So, an employee has acceptable practical capacity of 171.67 hours (10300.20 minutes) each per month and 2060 hours (123600 minutes) each per year. Table 13 gives a summary of the capacity cost rate of each sub-activity to produce magnetic component.

Table 13. Capacity cost rate of each sub-activity to produce magnetic component.

Workstation	Sub-Activities	Cost of all resources supplied (MYR/year)	Practical capacity (min/year)	Capacity cost rate (MYR/min)
1.Winding toroid core	1.Transfer the core to the winding machine	362,400	123,600	2.93

	2.Put a wire at the right core for winding	362,400	123,600	2.93
	3.Put a wire at the left core for winding	362,400	123,600	2.93
	Total	1,087,200	370,800	
2.Forming and pre-cutting	1.Transfer wound core to the forming machine	4273,200	123,600	34.57
	2.Push the button	4273,200	123,600	34.57
	Total	8,546,400	247,200	
3.Assembly process	1.Insert the wound core onto the header	184,800	494,400	0.37
	2.Straighten the leadout	184,800	494,400	0.37
	Total	369,600	988,800	
4.Alignment	1.Put the unit onto the Base Leadout and Coil Adjuster	145,200	123,600	1.17
	2.Straighten the leadout	145,200	123,600	1.17
	Total	290,400	247,200	
5.Epoxy application	1.Insert the unit into the holder	52,800	494,400	0.11
	2.Put the epoxy at the 4 leadout within core and header	2,164,800	494,400	4.38
	Total	2,217,600	988,800	
6.Oven curing	1.Transfer the curing jug from curing oven	13,203	123,600	0.11
	2.Cool the unit by cooling fan	13,203	123,600	0.11
	Total	26,406	247,200	
7.Cooling process	1.Transfer the curing jug from curing oven	13,200	123,600	0.11
	2.Cool the unit by cooling fan	13,200	123,600	0.11
	Total	26,400	247,200	
8.Leadout chopping	1.Insert the unit into the chopper base	13,200	123,600	0.11
	2.Remove the unit from the chopper base	13,200	123,600	0.11
	Total	26,406	247,200	
9.Laser marking	1.Transfer the unit to the conveyor for laser marking	13,744	123,600	0.11
	2.Label the unit by laser marking	13,744	123,600	0.11
	Total	27,488	247,200	
10.Visual Mechanical Inspection	1.Inspect the winding gap by using gauge	13,200	123,600	0.11
	2.Inspect leadout pitch and length by using gauge	13,200	123,600	0.11
	3.Checking the unit by using magnifying glass based on visual inspection requirement	39,600	370,800	0.12
	Total	66,000	618,000	
11.Final test	1.Transfer the unit onto conveyor	13,200	123,600	0.11
	2.Arrange the component into vacuum tray	13,200	123,600	0.11
	Total	26,400	247,200	
12.Packaging	1.Put the vacuum tray into ship carton	57,408	123,600	0.46
	2.Label the ship carton with the blank label and tape	14,035.20	123,600	0.11
	Total	71443.20	247,200	

As an example, for sub-activity transfer the wound core to the forming machine, the capacity cost rate is MYR4.27 million/123,600 minute (MYR4.27 million/2060 hours) or 34.57 MYR per minute (2074.20 MYR per hour). Determination of time equation for each activity is needed to calculate the estimated production time. Time estimation for each activity is different although sharing same manufacturing process. Consequently, to determine time equation for each activity, the principles of Motion and Time Study Principles can be used as a reference to get accurate time equation. Time equation of sub-activity in each workstation are developed by taking time taken multiplied by the relevant cost driver. Table 14 gives a summary of development of time equation for each sub-activity of each workstation in production.

Table 14. Time equation for sub-activity of each workstation.

Workstation	Time Equation	Time Equation
1.Winding toroid core	1.Transfer the core to the winding machine	$1.05X_1$
	2.Put a wire at the right core for winding	$0.02X_2$
	3.Put a wire at the left core or winding	$0.04X_3$
2.Forming and pre-cutting	1.Transfer wound core to the forming machine	$0.03X_4$
	2.Push button	$0.07X_5$
3.Assembly process	1.Insert the wound core onto the header	$0.02X_6$
	2.Put a wire at the right core for winding	$0.03X_7$
4.Allignment process	1.Put the unit onto the Base Leadout and Coil Adjuster	$0.87X_8$
	2.Straighten the leadout	$0.67X_9$
5.Epoxy application	1.Insert the unit into the holder	$1.15X_{10}$
	2.Put the epoxy at the 4 leadout within core and header	$0.13X_{11}$
6.Oven curing	1.Transfer the core to the winding machine	$0.28X_{12}$
	2.Transfer the curing jug into the curing oven	$0.03X_{13}$
7.Cooling process	1.Transfer the curing jug from curing oven	$0.65X_{14}$
	2.Cool the unit by cooling fan	$5X_{15}$
8.Leadout chopping	1.Insert the unit into the chopper base	$0.99X_{16}$
	2.Remove the unit from the chopper base	$0.8X_{17}$
9.Laser marking	1.Transfer the unit to the conveyor for laser marking	$0.84X_{18}$
	2.Label the unit by laser marking	$0.84X_{19}$
10.Visual Mechanical Inspection	1.Inspect the winding gap by using gauge	$1.44X_{20}$
	2.Inspect leadout pitch and length by using gauge	$0.57X_{21}$
	3.Checking the unit by using magnifying glass based on visual inspection requirement	$0.11X_{22}$
11.Final test	1.Transfer the unit onto conveyor	$0.23X_{23}$
	2.Arrange the component into vacuum tray	$1.34X_{24}$
12.Packaging	1.Put the vacuum tray into ship carton	$1.34X_{25}$
	2.Label the ship carton with the blank label and tape	$1.54X_{26}$

Table 15 gives a summary of the time equation in each workstation. As an example, the time equation of alignment process can be stated as $0.87X_8+0.67X_9$. The value of 0.87 and 0.67 are indicate the time recorded at workstation while X_8 and X_9 are belongs the value of cost driver in a year.

Table 15. Time equation for each workstation

Workstation	Time Equation
1.Winding toroid core	$1.05X_1+0.02X_2+0.04X_3$
2.Forming and pre-cutting	$0.03X_4+0.07X_5$
3.Assembly process	$0.02X_6+0.03X_7$
4.Allignment process	$0.87X_8+0.67X_9$
5.Epoxy application	$1.15X_{10}+0.13X_{11}$
6.Oven curing	$0.28X_{12}+0.03X_{13}$
7.Cooling process	$0.65X_{14}+5X_{15}$
8.Leadout chopping	$0.28X_{16}+0.03X_{17}$
9.Laser marking	$0.84X_{18}+0.84X_{19}$
10.Visual Mechanical Inspection	$1.44X_{20}+0.57X_{21}+0.11X_{22}$
11.Final test	$0.23X_{23}+1.34X_{24}$
12.Packaging	$1.34X_{25}+1.54X_{26}$

Determination of estimated capacity required of each activity is quantified based on the frequency of the activity in a year. The total time spent on the activity can be calculated by multiplying the amount of a given activity by the time spent. Table 16 shows the volume of cost driver in each sub-activity for a year.

Table 16. Volume of cost driver for each workstation

Workstation	Variable	Sub-Activities	Driver	Quantity/year
1.Winding toroid core	X_1	1.Transfer the core to the winding machine	Number of core (pieces/year)	1200000
	X_2	2.Put a wire at the right core for winding	Number of winding machine operating (frequency/year)	2
	X_3	3.Put a wire at the left core for winding	Number of winding machine operating (pieces/year)	2
2.Forming and pre-cutting	X_4	1.Transfer wound core to the forming machine	Number of forming machine operating (frequency/year)	1
	X_5	2.Push button	Number of button operating (frequency/year)	1
3.Assembly process	X_6	1.Insert the wound core onto the header	Number of wound core (pieces/year)	1200000
	X_7	2.Straighten the leadout	Frequency to straight the leadout (times/year)	4
4.Allignment process	X_8	1.Put the unit onto the Base Leadout and Coil Adjuster	Number of base leadout and coil adjuster operating (frequency/year)	1
	X_9	2.Straighten the leadout	Frequency to straight the leadout (times/year)	4
5.Epoxy application	X_{10}	1.Insert the unit into the holder	Number of holder (pieces/year)	4
	X_{11}	2.Put the epoxy at the 4 leadout within core and header	Quantity of epoxy (grams/year)	9600000
6.Oven curing	X_{12}	1.Transfer the core to the winding machine	Number of curing jug (frequency/year)	6
	X_{13}	2.Transfer the curing jug into the curing oven	Number of curing ovens operating (unit/year)	2
7.Cooling process	X_{14}	1.Transfer the curing jug from curing oven	Number of curing oven operating (frequency/year)	2
	X_{15}	2.Cool the unit by cooling fan	Number of cooling fan operating (frequency/year)	2
8.Leadout chopping	X_{16}	1.Insert the unit into the chopper base	Number of component insert into the chopper base (pieces/year)	1200000
	X_{17}	2.Remove the unit from the chopper base	Number of component remove from chopper base (pieces/year)	1200000
9.Laser marking	X_{18}	1.Transfer the unit to the conveyor for laser marking	Number of component transfer to the conveyor (pieces/year)	1200000
	X_{19}	2.Label the unit by laser marking	Number of laser marking operating (frequency/year)	1
10.Visual Mechanical Inspection	X_{20}	1.Inspect the winding gap by using gauge	Number of boundary jig gauge (unit/year)	2
	X_{21}	2.Inspect leadout pitch and length by using gauge	Number of leadout and pitch jig gauge (unit/year)	2
	X_{22}	3.Checking the unit by using magnifying glass based on visual inspection requirement	Number of units pass with VMI Requirement (pieces/year)	1200000
11.Final test	X_{23}	1.Transfer the unit onto conveyor	Number of unit to transfer onto conveyor (pieces/year)	1200000
	X_{24}	2.Arrange the component into vacuum tray	Number of vacuum tray (pieces/year)	1152000
12.Packaging	X_{25}	1.Put the vacuum tray into ship carton	Number of ship carton(pieces/year)	11520

	X_{26}	2.Label the ship carton with the blank label and tape	Number of labelling at the ship carton (frequency/year)	2880

As an example, the actual time spent for winding toroid core per year was developed by substituting the relevant volume cost driver from Table 16 as shown below.

The actual time spent for winding toroid core =

(1.05×1200000)+(0.02×2)+(0.04×0.02) = 1260000.12 minutes

The total time for the transfer the core to the winding machine in a year can be represented by X_1 equals 1200000 in 1.05X_1. It means, 1.05x1200000=1260000 minutes (21000 hours). The total production cost of this sub-activity comes out MYR3.69 million per year by multiplying total time of sub-activity with capacity cost rate. The total production cost and elapsed time to produce magnetic component is illustrated in Table 17.

Table 17. Elapsed time and total production costs to produce magnetic component

Workstation	Sub-Activities	Used time (min)	Capacity cost rate (MYR/min)	Total cost (MYR/year)
1.Winding toroid core	1.Transfer the core to the winding machine	1260000	2.93	3,691,800
	2.Put a wire at the right core for winding	0.04	2.93	0.12
	3.Put a wire at the left core for winding	0.08	2.93	0.23
	Total	1,260,000.12		3,691,800.35
2.Forming and pre-cutting	1.Transfer wound core to the forming machine	0.03	34.57	1.04
	2.Push the button	0.07	34.57	2.42
	Total	0.01		3.46
3.Assembly process	1.Insert the wound core onto the header	444000	0.37	164,280
	2.Straighten the leadout	1.48	0.37	0.55
	Total	444,001.48		164280.55
4.Alignment	1.Put the unit onto the Base Leadout and Coil Adjuster	1.17	1.17	1.37
	2.Straighten the leadout	4.68	1.17	5.48
	Total	5.85		6.85
5.Epoxy application	1.Insert the unit into the holder	0.44	0.11	0.05
	2.Put the epoxy at the 4 leadout within core and header	42,048,000	4.38	184,170,240
	Total	42,048,000.44		184,170,240.05
6.Oven curing	1.Transfer the curing jug from curing oven	0.66	0.11	0.07
	2.Cool the unit by cooling fan	0.22	0.11	0.02
	Total	0.88		0.09
7.Cooling process	1.Transfer the curing jug from curing oven	0.22	0.11	0.02
	2.Cool the unit by cooling fan	0.22	0.11	0.02
	Total	0.44		0.04
8.Leadout chopping	1.Insert the unit into the chopper base	13,200	0.11	1452
	2.Remove the unit from the chopper base	13,200	0.11	1452
	Total	26,4000		2904
9.Laser marking	1.Transfer the unit to the conveyor for laser marking	13,200	0.11	1452
	2.Label the unit by laser marking	0.11	0.11	0.22
	Total	13200.11		1452.22
10.Visual Mechanical Inspection	1.Inspect the winding gap by using gauge	0.22	0.11	0.02
	2.Inspect leadout pitch and length by using gauge	0.22	0.11	0.02

	3.Checking the unit by using magnifying glass based on visual inspection requirement	13,200	0.11	1452
	Total	13,200.44		1452.04
11.Final test	1.Transfer the unit onto conveyor	13,200	0.11	1452
	2.Arrange the component into vacuum tray	126,720	0.11	13939.20
	Total	139,920		15391.20
12.Packaging	1.Put the vacuum tray into ship carton	5299.20	0.46	2,437.63
	2.Label the ship carton with the blank label and tape	316.80	0.11	34.85
	Total	5616.00		2508.48

The total production cost to produce magnetic component is MYR1.88 billion per year. Below is time equation of whole workstation to complete one-unit magnetic component as presented in equation (2).

$$T_{Magnetic\quad component} = 1.05X_1 + 0.02X_2 + 0.04X_3 + 0.03X_4 + 0.07X_5 + 0.02X_6 + 0.03X_7 + 0.87X_8 + 0.67X_9 + 1.15X_{10} + 0.13X_{11} + 0.28X_{12} + 0.03X_{13} + 0.65X_{14} + 5X_{15} + 0.99X_{16} + 0.8X_{17} + 0.84X_{18} + 0.84X_{19} + 1.44X_{20} + 0.57X_{21} + 0.11X_{22} + 0.23X_{23} + 1.34X_{24} + 1.34X_{25} + 1.54X_{26} \quad (2)$$

The capacity utilization is analysed to reduce the production cost. From Table 18, this analysis is able to identify un-used capacity in term of waste time and cost for each workstation.

Table 18. Analysis of capacity utilization of magnetic component.

Workstation	Sub-Activities	Practical capacity (min/year)	Used time (min)	Un-used capacity (min)	Capacity cost rate (MYR/min)	Un-used manufacturing cost (MYR)
1.Winding toroid core	1.Transfer the core to the winding machine	123,600	1260000	-1,136,400	2.93	-3,329,652
	2.Put a wire at the right core for winding	123,600	0.04	123,599.96	2.93	362,147.88
	3.Put a wire at the left core for winding	123,600	0.08	123,599.92	2.93	362,147.77
	Total	370,800	1,260,000.12	-889,200.12		-2,605,356.35
2.Forming and pre-cutting	1.Transfer wound core to the forming machine	123,600	0.03	123,599.97	34.57	4,272,850.96
	2.Push the button	123,600	0.07	123,599.93	34.57	4,272,849.58
	Total	247,200	0.01	247,199.90		8,545,700.54
3.Assembly Process	1.Insert the wound core onto the header	494,400	444000	50,400	0.37	18,648
	2.Straighten the leadout	494,400	1.48	494,398.52	0.37	182,927.452
	Total	988,800	444,001.48	544,798.52		201,575.45
4.Alignment	1.Put the unit onto the Base Leadout and Coil Adjuster	123,600	1.17	123,598.83	1.17	144,610.63
	2.Straighten the leadout	123,600	4.68	123,595.32	1.17	144,606.52
	Total	247,200	5.85	247,194.15		289,217.15
5.Epoxy application	1.Insert the unit into the holder	494,400	0.44	494,399.56	0.11	54,383.95
	2.Put the epoxy at the 4 leadout within core and header	494,400	42,048,000	-41,555,600	4.38	-182,013,528
	Total	988,800	42,048,000.44	-41,059,200.44		-181,959,144.10

6.Oven curing	1.Transfer the curing jug from curing oven	123,600	0.66	123,599.34	0.11	13,595.93
	2.Cool the unit by cooling fan	123,600	0.22	123,599.78	0.11	13,595.98
	Total	247,200	0.88	247,199.12		25,191.91
7.Cooling process	1.Transfer the curing jug from curing oven	123,600	0.22	123,599.78	0.11	133,595.98
	2.Cool the unit by cooling fan	123,600	0.22	123,599.78	0.11	133,595.98
	Total	247,200	0.44	247,199.56		27,191.95
8.Leadout chopping	1.Insert the unit into the chopper base	123,600	13,200	110,400	0.11	12,144
	2.Remove the unit from the chopper base	123,600	13,200	110,400	0.11	12,144
	Total	247,200	26,4000	220,800		24,288
9.Laser marking	1.Transfer the unit to the conveyor for laser marking	123,600	13,200	110,400	0.11	12,144
	2.Label the unit by laser marking	123,600	0.11	123599.89	0.11	13,595.99
	Total	247,200	13200.11	233,999.89		25,739.99
10.Visual Mechanical Inspection	1.Inspect the winding gap by using gauge	123,600	0.22	123,599.78	0.11	133,595.98
	2.Inspect leadout pitch and length by using gauge	123,600	0.22	123,599.78	0.11	133,595.98
	3.Checking the unit by using magnifying glass based on visual inspection Requirement	370,800	13,200	357,600	0.11	39,336
	Total	618,000	13,200.44	604,799.56		306,527.96
11.Final test	1.Transfer the unit onto conveyor	123,600	13,200	110,400	0.11	12,144
	2.Arrange the component into vacuum tray	123,600	126,720	-3,120	0.11	-343.20
	Total	247,200	139,920	107,280		11,800.80
12.Packagin g	1.Put the vacuum tray into ship carton	123,600	5299.20	118,300.80	0.46	54,418.37
	2.Label the ship carton with the blank label and tape	123,600	316.80	123,283.20	0.11	13,561.15
	Total	247,200	5616.00	241,584		67,979.52
	Total	4,944,000	44,187,945.77	-39,006,345.86		-175,038,987.20

DISCUSSION

Based on the analysis above, the value of un-used capacity (minute) and loss manufacturing cost (MYR) have two sign either the value comes out positive sign or negative sign. The positive value of an un-used capacity means the sub-activity has un-used capacity while negative value means no an un-used capacity that means the worker need more time to produce the component at the sub-activity. Besides, for loss manufacturing cost, the positive value means the sub-activity has waste cost while the negative value means the sub-activity has more money to cover the resources cost. As an example, for workstation 1, winding toroid core, for loss manufacturing cost, the sub-activity 2 incurs a lot of waste, at MYR362,147.88, followed by sub-activity 3 at MYR362,147.77, and sub-activity 1 at –MYR3.33 million of waste. This work found the sub-activity 2 and 3 for this workstation are spent more at labor cost. For an un-used capacity, the sub-activity 2 shows an un-used capacity 2060 hours (123,599.96 minutes), followed by sub-activity 3 shows 2060 hours (123,599.92 minutes). These both sub-activities need to revise the time for the worker to produce a component. For sub-activity 1, -18940 hours (-1,136,400 minutes), the production need to spend more time for the worker to produce the component. By having the analysis, the loss manufacturing cost and un-used capacity can identify in each workstation. This will lead the resource waste can be reduced and time efficiency will be more accurate to manufacture the component. Figure 3 illustrates graph the used and un-used capacity of time (minute) and cost (MYR) at winding toroid core. The orange graph indicates the used capacity of time and cost while blue graph indicates the un-used capacity of time and cost. Based on the analysis of time, the graph shows the used capacity, 21000 hours (1260000.12 minute) and un-used capacity, -14820 hours (-889200.12 minute). The negative value of un-used capacity at this workstation means the time is over utilized in each sub-activity. In suggestion, in order to get the accurate time, the capacity of time in each sub-activity of this workstation must be re-record and re-calculate. For the used capacity or the total cost, the analysis shows MYR3.69 million and un-used loss manufacturing cost, -MYR2.61 million. The negative value of un-used loss manufacturing cost means the cost is not enough to manufacture the product in this workstation. So, the production must be re-calculate the manufacturing cost of each sub-activity either to reduce the manufacturing cost at certain sub-activity or increase more manufacturing cost at this workstation.

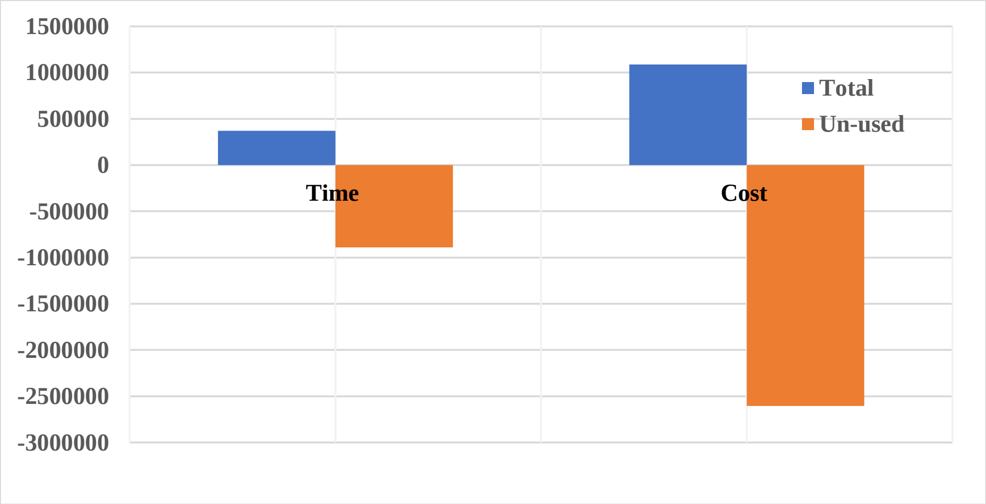

Figure 3. Capacity of time(minute) and cost (MYR) at winding toroid core.

Figure 4 shows the used and un-used capacity of time (minute) and cost (MYR) at forming and pre-cutting. The orange graph indicates the used capacity of time and cost while blue graph indicates the un-used capacity of time and cost. Based on the analysis of time, the graph shows the used capacity, 0.01 minute and un-used capacity, 4120 hours (247199.90 minute). The positive value of un-used capacity means the workstation has excessive time. In suggestion, in order to get the accurate time, the un-used capacity of time must reduce in terms of the efficiency of worker to finish the activity in this workstation. For the used capacity or the total cost, the analysis shows MYR3.46 and un-used loss manufacturing cost, MYR8.55 million. The positive value of un-used loss manufacturing cost means the cost has balance. In suggestion, the excessive money can use at another workstation with negative value of un-used loss manufacturing cost.

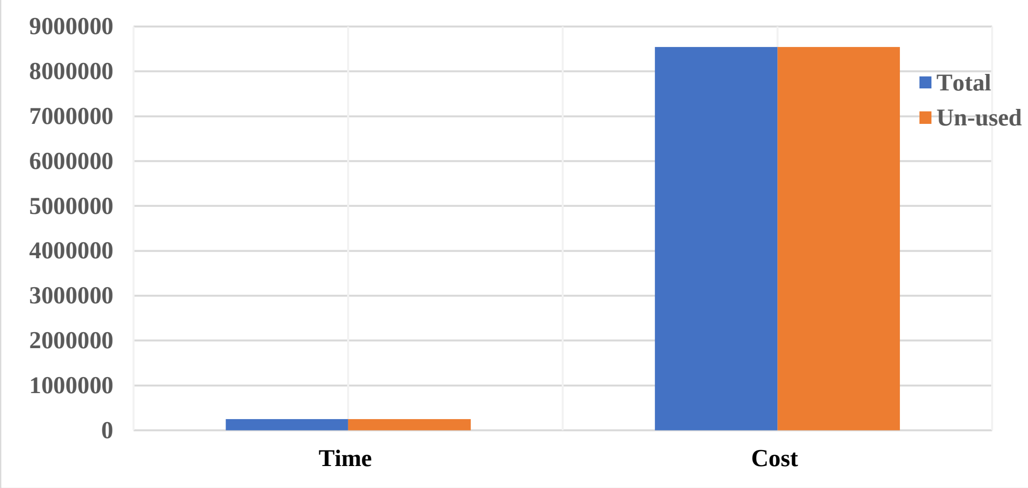

Figure 4. Capacity of time (minute) and cost (MYR) at forming and pre-cutting.

Figure 5 gives a summary of the used and un-used capacity of time (minute) and cost (MYR) at assembly process. The orange graph indicates the used capacity of time and cost while blue graph indicates the un-used capacity of time and cost. Based on the analysis of time, the graph shows the used capacity, 7400 hours (444001.48 minute) and un-used capacity, 9079.98 hours (544798.52 minute). The positive value of un-used capacity means the workstation has excessive time. In suggestion, in order to get the accurate time, the un-used capacity of time must reduce in terms of the efficiency of worker to finish the activity in this workstation. For the used capacity or the total cost, the analysis shows MYR164,280.55 and un-used loss manufacturing cost, MYR201,575.45. The positive value of un-used loss manufacturing cost means the cost has balance. In suggestion, the excessive money can use at another workstation with negative value of un-used loss manufacturing cost.

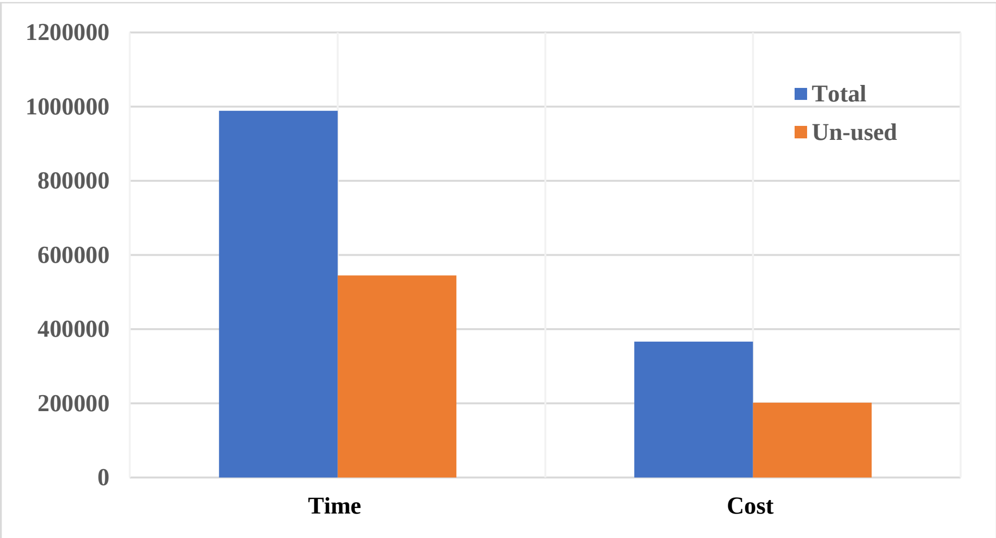

Figure 5. Capacity of time (minute) and cost (MYR) at assembly process.

Figure 6 shows the used and un-used capacity of time (minute) and cost (MYR) at alignment process. The orange graph indicates the used capacity of time and cost while blue graph indicates the un-used capacity of time and cost. Based on the analysis of time, the graph shows the used capacity, 5.85 minute and un-used capacity, 4119.90 hours (247194.15 minute). The positive value of un-used capacity means the workstation has excessive time. In suggestion, in order to get the accurate time, the un-used capacity of time must reduce in terms of the efficiency of worker to finish the activity in this workstation. For the used capacity or the total cost, the analysis shows MYR6.85 and un-used loss manufacturing cost, MYR289,217.15. The positive value of un-used loss manufacturing cost means the cost has balance. In suggestion, the excessive money can use at another workstation with negative value of un-used loss manufacturing cost.

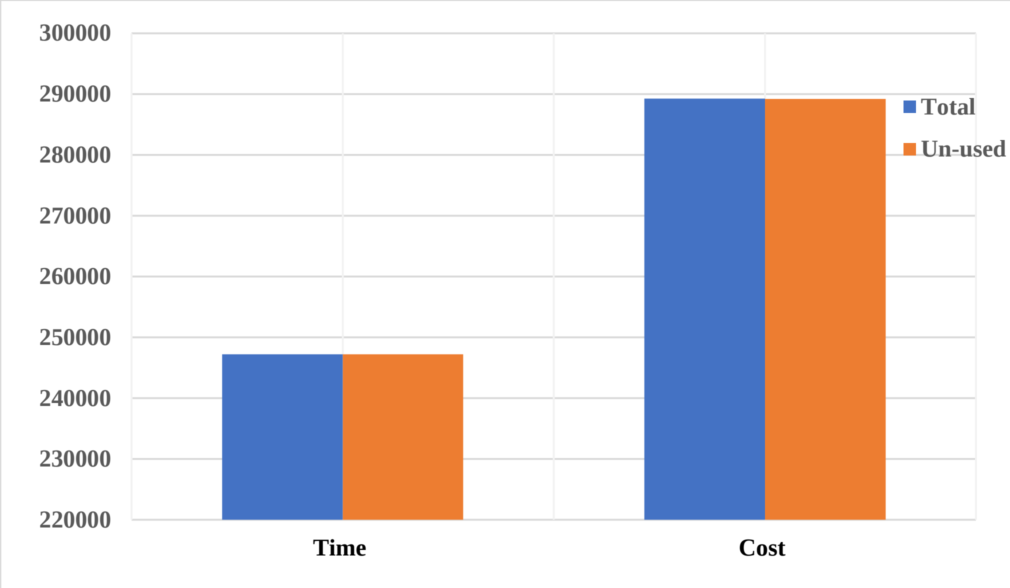

Figure 6. Capacity of time (minute) and cost (MYR) at alignment process.

Figure 7 shows the used and un-used capacity of time (minute) and cost (MYR) at epoxy application The orange graph indicates the used capacity of time and cost while blue graph indicates the un-used capacity of time and costing. Based on the analysis of time, the graph shows the used capacity, 700800.01 hours (42048000.44 minute) and un-used capacity, 684320.01 hours (-41059200.44 minute). The negative value of un-used capacity at this workstation means the time is over utilized in each sub-activity. In suggestion, in order to get the accurate time, the capacity of time in each sub-activity of this workstation must be re-record and re-calculate. For the used capacity or the total cost, the analysis shows MYR184.17 million and un-used loss manufacturing cost, -MYR181.96 million. The negative value of un-used loss manufacturing cost means the cost is not enough to manufacture the product in this workstation. So, the production must be re-calculate the manufacturing cost of each sub-activity either to reduce the manufacturing cost at certain sub-activity or increase more manufacturing cost at this workstation.

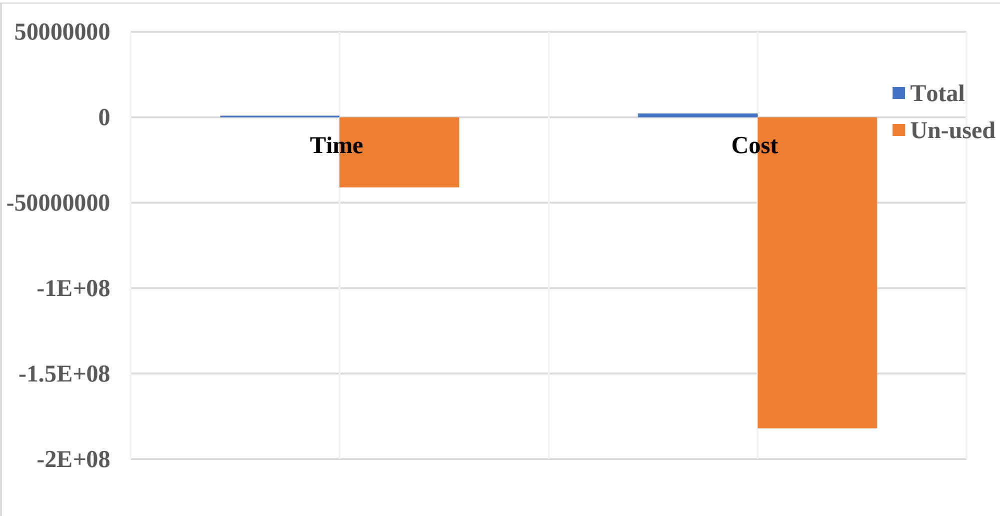

Figure 7. Capacity of time (minute) and cost (MYR) at epoxy application.

Figure 8 shows the used and un-used capacity of time (minute) and cost (MYR) at oven curing. The orange graph indicates the used capacity of time and cost while blue graph indicates the un-used capacity of time and cost. Based on the analysis of time, the graph shows the used capacity, 0.88 minute and un-used capacity, 4119.99 hours (247199.12 minute). The positive value of un-used capacity means the workstation has excessive time. In suggestion, in order to get the accurate time, the un-used capacity of time must reduce in terms of the efficiency of worker to finish the activity in this workstation. For the used capacity or the total cost, the analysis shows MYR0.99 and un-used loss manufacturing cost, MYR25,191.91. The positive value of un-used loss manufacturing cost means the cost has balance. In suggestion, the excessive money can use at another workstation with negative value of un-used loss manufacturing cost.

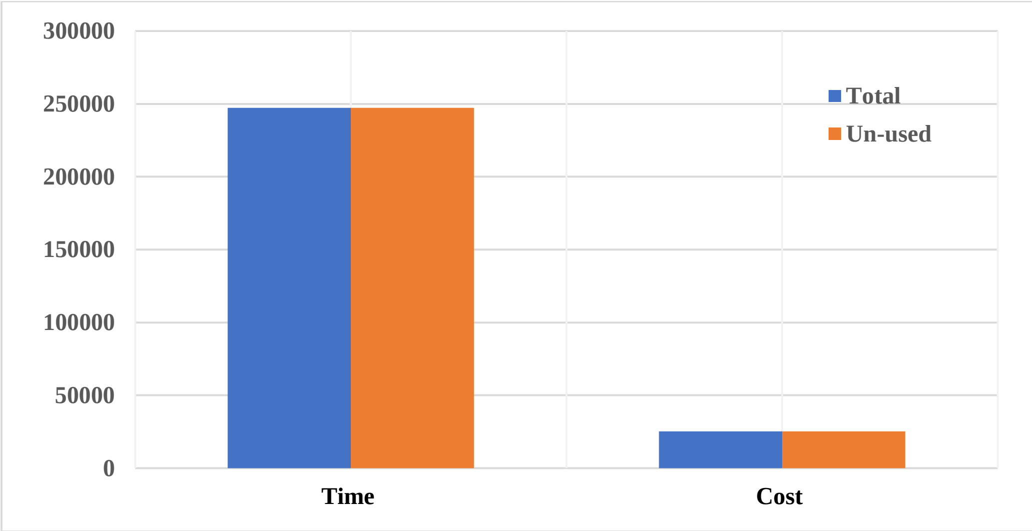

Figure 8. Capacity of time (minute) and cost (MYR) at oven curing

Figure 9 shows the used and un-used capacity of time (minute) and cost (MYR) at cooling process. The orange graph indicates the used capacity of time and cost while blue graph indicates the un-used capacity of time and cost. Based on the analysis of time, the graph shows the used capacity, 0.44 minute and un-used capacity, 4120 hours (247199.56 minute). The positive value of un-used capacity means the workstation has excessive time. In suggestion, in order to get the accurate time, the un-used capacity of time must reduce in terms of the efficiency of worker to finish the activity in this workstation. For the used capacity or the total cost, the analysis shows MYR0.04 and un-used loss manufacturing cost, MYR27,191.95. The positive value of un-used loss manufacturing cost means the cost has balance. In suggestion, the excessive money can use at another workstation with negative value of un-used loss manufacturing cost.

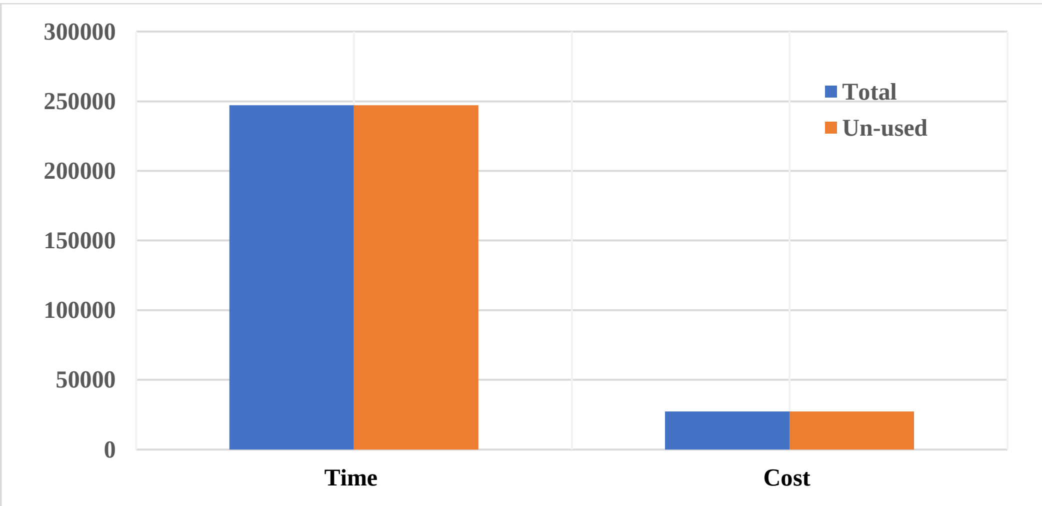

Figure 9. Capacity of time (minute) and cost (MYR) at cooling process.

Figure 10 shows the used and un-used capacity of time (minute) and cost (MYR) at leadout chopping. The orange graph indicates the used capacity of time and cost while blue graph indicates the un-used capacity of time and cost. Based on the analysis of time, the graph shows the used capacity, 4400 hours (264000 minute) and un-used capacity, 3680 hours (220800 minute). The positive value of un-used capacity means the workstation has excessive time. In suggestion, in order to get the accurate time, the un-used capacity of time must reduce in terms of the efficiency of worker to finish the activity in this workstation. For the used capacity or the total cost, the analysis shows MYR2,904 and un-used loss manufacturing cost, MYR24,288. The positive value of un-used loss manufacturing cost means the cost has balance. In suggestion, the excessive money can use at another workstation with negative value of un-used loss manufacturing cost.

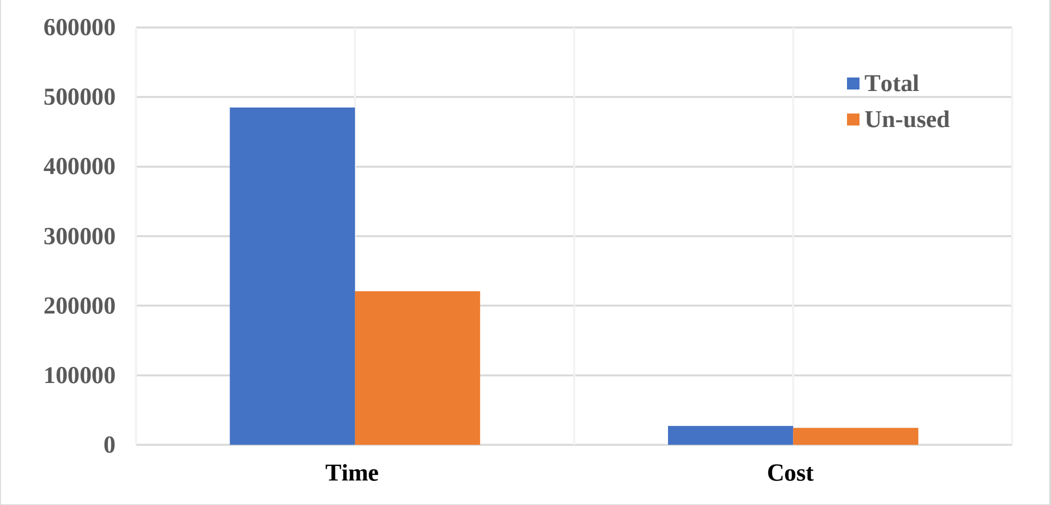

Figure 10. Capacity of time (minute) and cost (MYR) at leadout chopping.

Figure 11 shows the used and un-used capacity of time (minute) and cost (MYR) at laser marking. The orange graph indicates the used capacity of time and cost while blue graph indicates the un-used capacity of time and cost. Based on the analysis of time, the graph shows the used capacity, 220 hours (13200.11 minute) and un-used capacity, 3900 hours (233999.89 minute). The positive value of un-used capacity means the workstation has excessive time. In suggestion, in order to get the accurate time, the un-used capacity of time must reduce in terms of the efficiency of worker to finish the activity in this workstation. For the used capacity or the total cost, the analysis shows MYR1,452.22 and un-used loss manufacturing cost, MYR25,739.99. The positive value of un-used loss manufacturing cost means the cost has balance. In suggestion, the excessive money can use at another workstation with negative value of un-used loss manufacturing cost.

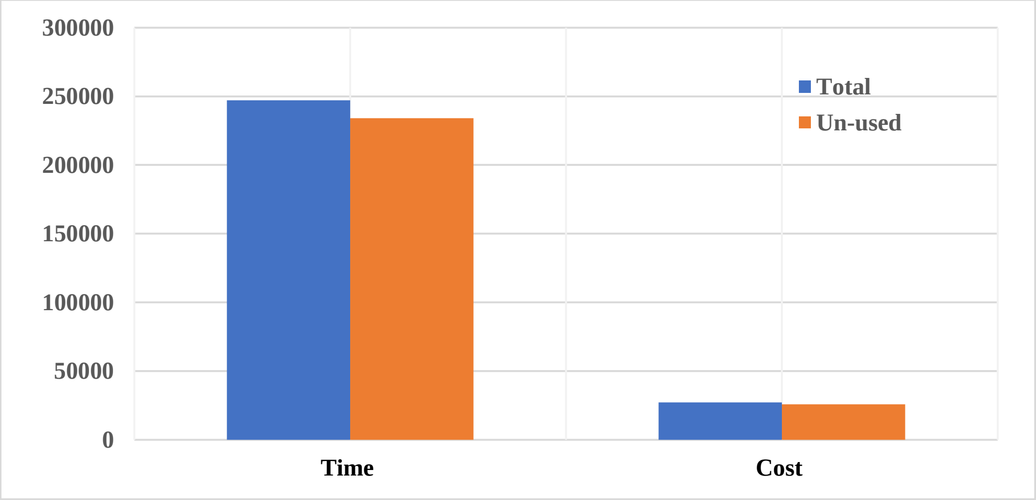

Figure 11. Capacity of time (minute) and cost (MYR) at laser marking.

Figure 12 shows the used and un-used capacity of time (minute) and cost (MYR) at visual mechanical inspection. The orange graph indicates the used capacity of time and cost while blue graph indicates the un-used capacity of time and costing. Based on the analysis of time, the graph shows the used capacity, 220.01 hours (13200.44 minute) and un-used capacity, 10080 hours (604799.56 minute). The positive value of un-used capacity means the workstation has excessive time. In suggestion, in order to get the accurate time, the un-used capacity of time must reduce in terms of the efficiency of worker to finish the activity in this workstation. For the used capacity or the total cost, the analysis shows MYR1,452.04 and un-used loss manufacturing cost, MYR306,527.96. The positive value of un-used loss manufacturing cost means the cost has balance. In suggestion, the excessive money can use at another workstation with negative value of un-used loss manufacturing cost.

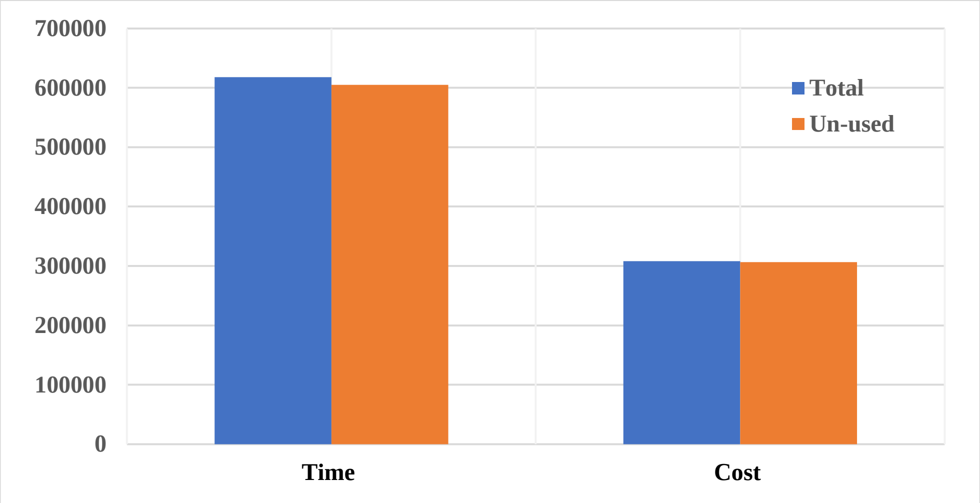

Figure 12. Capacity of time (minute) and cost (MYR) at visual mechanical inspection.

Figure 13 shows the used and un-used capacity of time (minute) and cost (MYR) at final test. The orange graph indicates the used capacity of time and cost while blue graph indicates the un-used capacity of time and cost. Based on the analysis of time, the graph shows the used capacity, 2332 hours (139920 minute) and un-used capacity, 1788 hours (107280 minute). The positive value of un-used capacity means the workstation has excessive time. In suggestion, in order to get the accurate time, the un-used capacity of time must reduce in terms of the efficiency of worker to finish the activity in this workstation. For the used capacity or the total cost, the analysis shows MYR15,391.20 and un-used loss manufacturing cost, MYR11,800.80. The positive value of un-used loss manufacturing cost means the cost has balance. In suggestion, the excessive money can use at another workstation with negative value of un-used loss manufacturing cost.

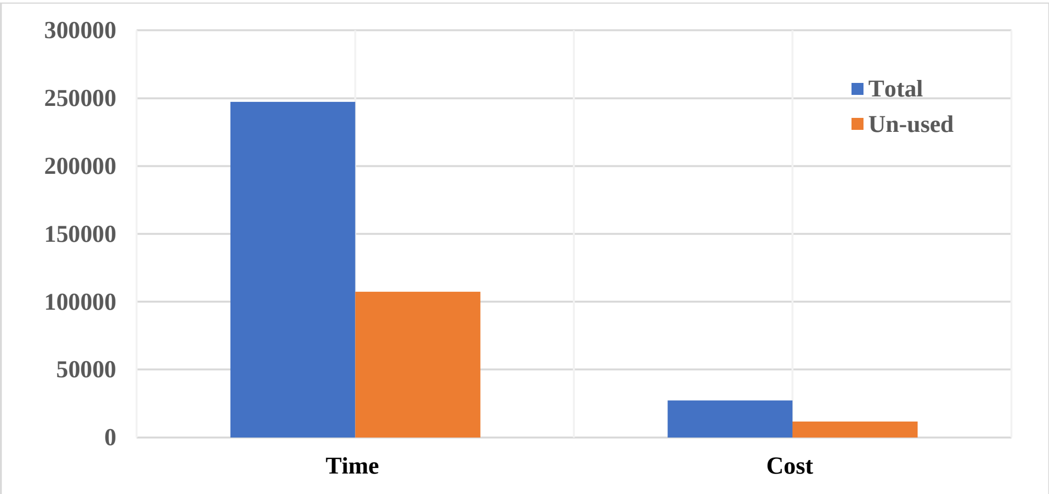

Figure 13. Capacity of time (minute) and cost (MYR) at final test.

Figure 14 shows the used and un-used capacity of time (minute) and cost (MYR) at packaging. The orange graph indicates the used capacity of time and cost while blue graph indicates the un-used capacity of time and cost. Based on the analysis of time, the graph shows the used capacity, 93.6 hours (5616 minute) and un-used capacity, 4026.4 hours (241584 minute). The positive value of un-used capacity means the workstation has excessive time. In suggestion, in order to get the accurate time, the un-used capacity of time must reduce in terms of the efficiency of worker to finish the activity in this workstation. For the used capacity or the total cost, the analysis shows MYR2,472.48 and un-used loss manufacturing cost, MYR67,979.52. The positive value of un-used loss manufacturing cost means the cost has balance. In suggestion, the excessive money can use at another workstation with negative value of un-used loss manufacturing cost.

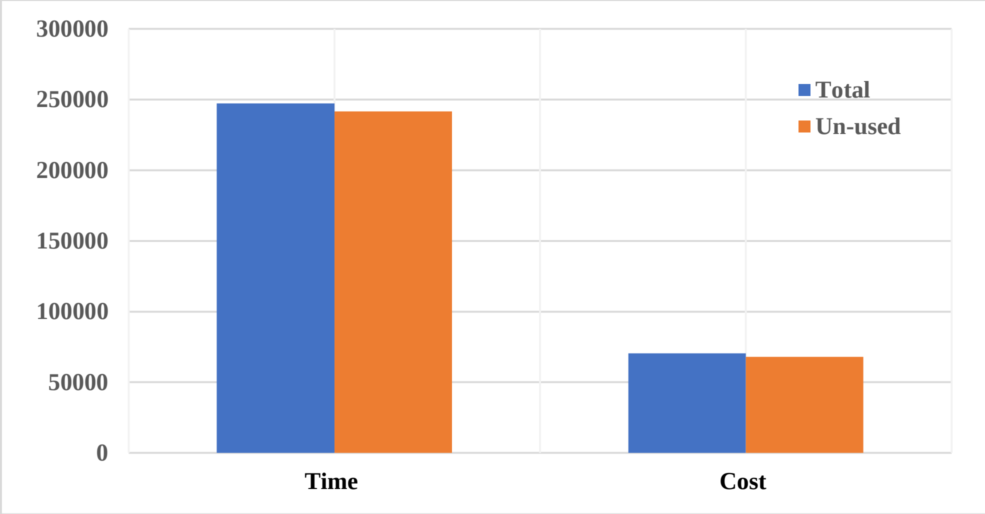

Figure 14. Capacity of time (minute) and costing (MYR) at packaging.

TDABC effectively measures the time efficiency, accurately identifies the idle capacity and separately lists the used and un-used capacity. From the analysis, the loss of manufacturing cost and un-used capacity could be identified at each workstation. Thus, resource waste can be reduced and time efficiency to produce the component could be better achieved.

There are some recommendations listed for future study. This work is done at an electrical and electronic industry in a manufacturing environment. The originality of this research gap regarding the TDABC method its related information is accurate as the different industries may have different systems in order to evaluate and improve the product quality. Therefore, to gain more knowledge on how TDABC method could work at other sectors, it is recommended to implement this method in different fields. The capacity utilization of TDABC analysis shows the used and un-used capacities of time and cost for all workstations that is implemented in magnetic component production. It is recommended to apply at product-based service sector in order to gain better accuracy in a particular system. This research contributes towards the understanding of TDABC method application which related in terms of data and quality of the product, efficiency, accuracy, and overall performance of the industry. In future, this validation is recommended to be applied at other industries to increase the data accuracy in production line.

CONCLUSION

This work successfully developed the time equation through the process mapping for the magnetic components in the E&E company. All sub-activities are revealed to explain that the cost are directly proportional to them. Thus, the time equation constructed as shown in equation (2). The un-used capacity with respect to the time and cost are 736,465.76 hours (44,187,945.77 minutes) and -MYR175.04 million respectively. Therefore, the manager has a clear view to reduce production costs based on the analysis of capacity utilization in order to increase working capacity and decrease waste costs.

ACKNOWLEDGEMENT

The authors would like to thank to the Universiti Malaysia Pahang and Universiti Teknologi Malaysia for financial assistance under Collaborative Research Grant project No. RDU192312.

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