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# A case study on the application of activity-based costing on the inductor component

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*Abstract*— **Traditional cost accounting (TCA) is no longer reflecting the current economic reality due to distorted information about the profitability of their orders, products and customers. A new costing method is required to overcome the shortcoming of TCA in the era of rapidly increasing product complexity and diversification. The aim of this work is to apply the method of activity-based costing (ABC) on the inductor component for better accuracy. The work begins by collecting data at electronic industry located at Pahang, Malaysia and the product selected is inductor component. ABC focuses on the costs inherent in the activity -based products to produce, distribute or support the products concerned. Through the method, the work successfully gathered the time spent by operator to complete the task given. The largest time spent is at workstation 1 with 92.12% while the smallest at workstation 2,7, 8 and 14 with 0.1727% respectively. The highest cost of capacity supplied is drum core winding with epoxy activity with MYR 5,869,250.40 and the amount of material used is assigned as the cost driver. As the demand quantity of the product is increase by 10%, the total cost of production is predicted to be MYR 6,365,159.18 while the product cost per unit is MYR 1.50.**

*Keywords*— Activity based costing, Inductor component, Traditional cost accounting, Cost driver rate

## I. INTRODUCTION

High manufacturing overhead cost means increasing transactions such as the exchange of materials and information between industry are the reason for the hidden factory [1]. Traditional cost accounting (TCA) practices is no longer able to allocate these costs to products accordingly [2] and accurate cost data are very important for decision making which has been seen as a source of competitive advantage [3]. An alternative cost accounting approach namely activity based costing (ABC) has been proposed by [4] to implement for intra-firm purposes at that moment [5]. However, the reduction of a company's own contribution to a product's value due to outsourcing resulted in more transactions at the inter-organizational level [6]. Furthermore, global competition has increased and puts pressure on firms and their supply chains [7]. On the other hand, costing systems provide information to decision makers about their product cost, product mix, process behavior and capital investment. Several costing methods are used in manufacturing industry such as ABC that allocates a cost for each product/operation/service based on activities required to process, which may provide insights into areas for improvement, using activities as a metric [8].

The purpose of this work is to apply the method of ABC on the magnetic inductor for better accuracy. The duration for each activity is collected through interview with the operators and the cost of resources are collected from the general ledger. Then, the cost per unit of product is compared with the current method being applied by the company to conclude the findings.

## II. LITERATURE REVIEW

ABC is a way to help companies effectively estimate the production cost [9]. The method used by companies for internal management and useful to create scenarios under simulation considering product-cost, production volume, and products diversification, providing subsidies for decisions toward profit increase. Since profits are the current main target for the company managers, economic drivers are considered when applying the ABC procedure [10]. The core idea of ABC is that the activity is the basic object and the total product consumption is the sum of all activities so that broadens the scope of cost and makes calculation more accurate [11]. This method measures the costs of related activities through all resources that are used to manufacture products. The method also traces these related costs into cost centers or departments [12], thereby improving the accuracy of product cost information [4]. To implement ABC, cost drivers been used in order to allocate the actual costs according to the involved activities. Factor that affect the cost of the activity would be the cost drivers. Besides, unit cost would be considered as an output of ABC for measurement. Generally, four simple steps were required to implement ABC. There are identify activities, allocate resource costs to activities, identify outputs and assign activity costs to outputs.

ABC had been widely used due to its several advantages. It provided accurate, timely and reliable information to managers

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in order to make decisions [13], helped to determine the process cost of contemporary production processes [14], provided a more accurate product cost than TCA [15], helped to doing cost estimation during complex processes exist [16], achieved a proper cost estimation tool to set up budget of a complex project [17], allowed to estimate production costs and environmental cost accurately [18], helped to estimates the product/service costs by assigning the cost to the activities involved in the creation process [19], provided actual cost information to support management to do decision making [20], provided detailed and accurate cost information often required in taking various managerial decisions [21], provided detailed information for planning and controlling which lead to reduce unnecessarily costs [22], provided actual cost information that make management easy to provide decision making [23], helped to understand how to allocate resources and funding for activities to each system through appropriate cost drivers [24], helped for effectively computing values of cost drivers as well as making accurate cost estimations [25], helped managers understand how to allocate resources for activities through appropriate cost drivers [26] and provided more detailed information on costs accurately calculate the manufacturing cost of our choice [27]. According to [28], the ABC approach has four advantages such as effective estimates of the overhead for a product, more precise understanding of cost drivers, accurate assignments of costs for products or production and the identification of non-value-added costs. [29] found that ABC supports decision makers in improving all company's inefficient activities, thus resulting in an efficiency improvement and profitability.

On this issue, some examples can be found in scientific literature. ABC had been widely applied in many different areas like environment, engineering, healthcare etc. For environment, concept of ABC has been used to develop an optimal decision-making model for Taiwan's hybrid green power strategy [30]. The results were management able to make better decision making in order to get the maximum profits for green power planning. For engineering, a costing model for raw material handling section was developed based on concept of ABC in an Indian steel plant [21]. The results obtained from this model were all the activities are clearly defined and operate under efficiency resources. The steel plant allowed to minimize the manufacturing costs with an efficient resource planning. For healthcare, an ABC approach was used to develop a cost estimation model to identify cost information for an assisted reproductive technology treatment in Italy [31]. The results obtained from this model was the actual cost information of particular treatment has been clearly defined. Management also allowed to set up an efficient budget in order to maintenance the efficiency of particular treatment. Surprisingly, [32] applied ABC in the palm oil plantation while [33], [34] and [35] developed a distinctive pattern of crankshaft and identify the critical and non-critical parameter of crankshaft based on the Mahalanobis Taguchi System, then applied ABC as a method of estimation for the remanufacturing cost of crankshaft. On the other application, [36] applied the ABC as a method of cost estimation for the palm oil plantation and it makes the company's profitability more accurate. [37] compared the advantages of ABC and time driven activity-based costing by analysing the features and then [38] extended it towards the costing sustainment.

## III. Methodology

There are several workstations being involved to produce the inductor component as shown in Figure 1.

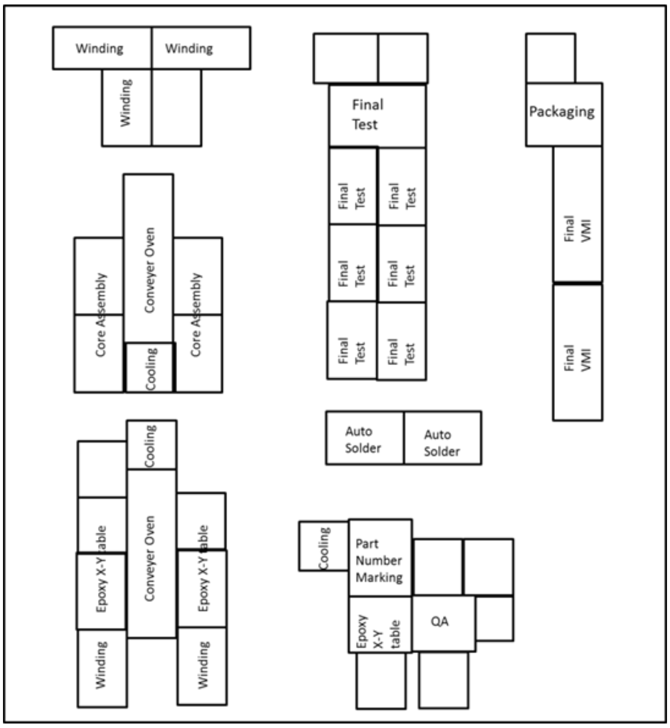


Figure 1. Workstations for inductor component

It starts with winding process whereby the equipment being used are winding machines, winding chuck, EFD machines, scissors and EFD needles. Then, the curing fixture with fitted with the units from workstation 1 shall be inserted into the curing oven for a minimum of 30 minutes at 140˚c to 160˚c. After that, the units will undergo cooling process and cooling fan about 15 to 20 minutes. The next workstation focussed on lead cutting and adjustment. The equipment needed is cutters, wire catch container, and flat nose pliers. It cut both lead outs approximately 5mm from the core and place the parts after cutting into vacuum tray. Next workstation focussed on assemble the drum core into the shield core. The equipment needed during this process are core assembly machine and travel bar. Then, the epoxy is applied into the drum core and next workstation focussed on epoxy inspection. Next workstation is the curing oven process to be heated in minimum 30 minutes and cooling process approximately 20 minutes. Subsequently, is a part number marking by using laser machine. The position of the travel bar must be right as directions and the

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round button is on the right side and then closes the laser machine door. Termination and trimming process is conducted at next workstation. After that, the drum core will be dipped on solder which call auto dip soldering process. The pot temperature for the solder is 385˚C ∓ 5˚C. Then, next workstation focussed on the ultrasonic cleaning and cooling process. Ultrasonic cleaning process is the process of cleaning the unit after the soldering process before sending it to the final workstation which is VMI.

After identifying the activities involved in the production, the proper cost drivers of each activity should be identified as shown in Figure 2.

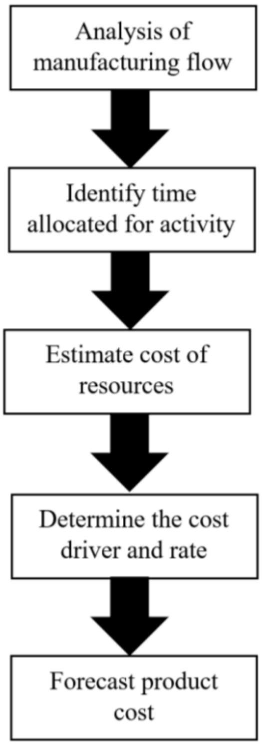


Figure 2. Flowchart of ABC

Cost driver is the root cause that effect the expense of a production operation. Management would allow to determine the real causes to perform an activity. Third step is allocating resources cost to each activity. Firstly, the resources cost used to operate each activity has to be measure. A unit of work done within the organization are the activities that done within the organization. Next, the amount of overhead cost required by those activities has to be forecast and allocated in percentage. In fact, the resources costs are already recorded in the existing accounting system like the salaries, supplies and utilities. Overhead cost apportioned into different activities. Besides, overhead cost would be apportioned based on percentage for categories such as consumables, salaries, materials cost and other costs. The cost information obtained is more accurate when the larger the number of categories. Estimating the cost per unit of activity driver would be the fourth step. The purpose of an activity driver is as a cost drive to estimate the required cost of an activity. The activity cost or the cost consumed by the cost object should be proportional to the activity driver. For example, the direct labor cost will drive the cost of activity labor cost. The more employees required, the more the direct labor cost. A process or product that required two employees to work will be allocated twice as much in direct labor cost. The list of the activities performed in the business and total activity cost would be the outcome. The cost obtained is more accurate when the larger the number of activity driver of activity cost. However, there is only one or two activity drivers be considering in order to reduce the complexity of the costing. The last step is preparing a list of activities for each of the product. Any product for which the management wants a separate cost measure is a cost object. Total yearly expenses would be obtained after annual quantity if cost driver consumed multiply with the cost per unit of activity driver. The outcome is a total expense for each product, which includes a list of activities and costs of the product. Therefore, the accurate profitability will be obtained. As a result, actual cost information and proper cost drivers will be obtained using this ABC method. Therefore, accurate profitability will be calculated and it's moving the production from moving based to activity based.

## IV. RESULT AND DISCUSSION

The time spent for each activity is recorded from each workstation as shown in Table 1. It has been collected through interview with particular operators and engineers who are directly involve with the production of inductor component. The highest time allocated is at workstation 1 which is winding process with 92.124% because the total resources is very high. Then, it followed by workstation 15 and 16 with 1.18% respectively.

TABEL I
TIME SPENT FOR ALL WORKSTATIONS

| Workstation | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time allocated (%) | 92.1 | 0.17 | 0.89 | 1.15 | 0.23 | 0.37 | 0.17 | 0.17 | 0.35 | 0.43 | 0.12 | 0.86 | 0.35 | 0.17 | 1.18 | 1.18 |

Table 2 shows all the annual costs incurred for each workstation. There are 3 workers to handle the winding machines and the cost of materials come from drum core and winding. Maintenance is not recorded because it depends on the current condition of the machine. Usually the cost is really minor. The convention oven needs only one person to handle at one time. The labour cost is RM 13,200 per year and there is no material and consumable required in this process. There are four workers to cut and adjust the lead using the cutter and long nose pliers after cooling process. The material that added in this process is wound drum core. Similarly, there is no maintenance is required in this process. Assemble drum core to shield core in workstation 5 is required two workers. The equipment being used is travel bar and core assembly machine. The preventive

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maintenance occurs in 4 to 5 months. After drum core and shield core has been assemble, epoxy must be applied. Epoxy act as glue to attach both part which are drum core and shield core. There is consumable cost for epoxy and needs one person only to handle the x-y table machine. Similarly, the maintenance cost is really minor and can be neglected. In the epoxy inspection by using isopropyl alcohol and cotton bud, it needs preventive maintenance on the CCTV equipment and there is no cost recorded for the maintenance. Part number marking takes approximately 20 seconds to perform the work by one worker. In order to trim the lead-out by using manual cutter, two workers are needed in the process and preventive maintenance is necessary to change if blunt is occurred. One worker is needed to dip soldering the component. Consumable cost consists of the flux and lead free solder. Ultra-sonic cleaning takes approximately 3 minutes and it needs only one worker to handle the process. The consumable cost comes from the isopropyl alcohol and there is no maintenance needed. In VMI workstation, five workers are required to inspect the unit component using mantis scope and inspection tools. There is no maintenance cost recorded but preventive maintenance will be covered. In order to check the co-planarity by using co-planarity fixture and CCTV, two workers are required and preventive maintenance occurs at least once in 6 months. Inductance test has only preventive maintenance once in 6 months. It has no cost for material and consumable in this workstation. During tape and reel process, there are varieties of material used because finally, the component will be wrapped. Only one person is handled the machine. Furthermore, there is no maintenance cost recorded but preventive maintenance will be covered once in six months. Finally, the packaging process is managed by one person and the costs included are labour and material. Maintenance and consumable has no cost allocation because both are not necessary to complete the process.

TABEL 2
LABOR, MAINTENANCE, MATERIAL AND CONSUMABLE COST IN WORKSTATION

| Workstation | Labor | Maintenance | Material | Consumable | Cost all resources supplied |
|---|---|---|---|---|---|
| Drum core winding with epoxy | 33,000 | Nil | 5,832,614.40 | 3,636 | 5,869,250.40 |
| Convection oven & Cooling Process | 11,000 | Nil | Nil | Nil | 11,000 |
| Lead cutting & lead adjustment | 44,000 | Nil | 12,749.40 | Nil | 56,749.40 |
| Assemble drum core to shield core | 22,000 | Nil | 51,507.58 | Nil | 73,507.58 |
| Epoxy Application | 11,000 | Nil | Nil | 3,636 | 14,636 |
| Epoxy inspection | 22,000 | Nil | Nil | 1,581.60 | 23,581.60 |
| IR Reflow & Cooling Process | 11,000 | Nil | Nil | Nil | 11,000 |
| Part Number Marking | 11,000 | Nil | Nil | Nil | 11,000 |
| Termination & Trimming | 22,000 | Nil | Nil | Nil | 22,000 |
| Auto-dip Soldering | 11,000 | 8,197.60 | Nil | 8,197.60 | 27,395.20 |
| Ultra-sonic cleaning & Cooling process | 11,000 | Nil | Nil | 1,581.6 | 12,581.60 |
| Final VMI | 55,000 | Nil | Nil | Nil | 55,000 |
| Co-planarity check | 22,000 | Nil | Nil | Nil | 22,000 |
| Inductance test | 11,000 | Nil | Nil | Nil | 11,000 |
| Tape & Reel | 11,000 | Nil | 64,172.26 | Nil | 75,172.26 |
| Packaging | 11,000 | Nil | 64,172.26 | Nil | 75,172.26 |

TABEL III
COST DRIVERS ASSIGNED FOR INDUCTOR COMPONENT IN EACH WORKSTATION

| Workstation | Cost Driver | Assigned Cost (RM) | Cost Driver Quantity | Cost Driver Rate |
|---|---|---|---|---|
| 1. Winding | Amount of material (pcs) | 5,869,250.40 | 849,960 | 6.91 |
| 2. Curing & cooling | Reflow curing machine (frequency) | 11,000 | 1,000,000 | 0.011 |
| 3. Cutting & Adjustment | Amount of material (pcs) | 56,749.40 | 424,980 | 0.45 |
| 4. Assemble process | Amount of material (pcs) | 73,507.58 | 849,960 | 0.086 |
| 5. Epoxy applications | Consumable usage (ℓ) | 14,636 | 10,000 | 1.46 |
| 6. Epoxy inspections | Consumable usage (ℓ) | 23,581.60 | 10,000 | 2.36 |
| 7. Curing & cooling | Reflow curing machine (frequency) | 11,000 | 1,000,000 | 0.011 |
| 8. Marking | Laser machine (frequency) | 11,000 | 1,960,000 | 0.005 |
| 9. Trimming | Labor time (Quantity) | 22,000 | 6,866.40 | 3.2 |
| 10. Soldering | Amount of consumable usage (g/ℓ) | 27,395.20 | 64,200 | 0.43 |
| 11. Cleaning solder & cooling | Ultra-sonic machine (frequency) | 12,581.60 | 1,800,000 | 0.007 |
| 12. VMI | Labor time (hour) | 55,000 | 17,166 | 3.2 |
| 13. Co-planarity check | Labor time (hour) | 22,000 | 6866.4 | 3.2 |
| 14. Inductance test | Test machine (frequency) | 11,000 | 1,000,000 | 0.011 |

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| 15. Tape & reel | Tape and reel machine (frequency) | 75,172.26 | 980,000 | 0.077 |
| 16. Packaging | Product items (quantity) | 75,172.26 | 18,156 | 4.14 |
| Total | | 6,371,046.2 | | 25.56 |

TABEL IV
COST DRIVER RATE AND CAPACITY FORECAST IN 2018

| Activity | Activity cost driver | Cost driver rate (RM) | Cost driver quantity | Total cost (RM) |
|---|---|---|---|---|
| 1. Winding | Amount of material and consumable usage (g) | 6.91 | 849,960 | 5,873,223.60 |
| 2. Curing & cooling | Labor time (quantity) | 0.011 | 1,000,000 | 11,000 |
| 3. Cutting & Adjustment | Amount of material & labor time | 0.45 | 424,980 | 56,545.17 |
| 4. Assemble process | Amount of material & labor time | 0.086 | 849,960 | 73,096.56 |
| 5. Epoxy applications | Consumable usage & labor time | 1.46 | 10,000 | 14,647.19 |
| 6. Epoxy inspections | Labor time (quantity) | 2.36 | 10,000 | 23,598.25 |
| 7. Curing & cooling | Labor time (quantity) | 0.011 | 1,000,000 | 10,999.97 |
| 8. Marking | Laser machine & labor time (frequency & quantity) | 0.005 | 1,960,000 | 10,001.72 |
| 9. Trimming | Labor time (quantity) | 3.2 | 6,866.40 | 21,999.95 |
| 10. Soldering | Amount of consumable usage (g) | 0.43 | 64,200 | 27,395.28 |
| 11. Cleaning solder & cooling | Ultra-sonic machine (frequency) | 0.007 | 1,800,000 | 12,600 |
| 12. VMI | Labor time (quantity) | 3.2 | 17,166 | 54,999.86 |
| 13. Co-planarity check | Labor time (quantity) | 3.2 | 6866.4 | 21,999.95 |
| 14. Inductance test | Machine time | 0.011 | 1,000,000 | 11,000 |
| 15. Tape & reel | Amount of material | 0.077 | 980,000 | 71,025.84 |
| 16. Packaging | Product items (quantity) | 4.14 | 18,156 | 71,025.84 |
| Total (RM) | | | | 6,365,159.18 |
| Unit (RM) | | | | 1.50 |

This work also compares the costing being applied by the company as shown in Table 5. It covers the product cycle time for each workstation, total cycle time, grand total and 20% of allowance cost of maintenance, operators' short break and unproductive process time. The total cycle time of all activities in each workstation is 3.24 hours. Then, the grand total of cycle time with allowance is 3.888 hours.

TABEL V
CYCLE TIME FOR EACH WORKSTATION

| Workstation | Process | Cycle time (Hour) |
|---|---|---|
| 1 | Winding | 0.0014 |
| 2 | Curing & cooling | 1.00 |
| 3 | Cutting & Adjustment | 0.0015 |
| 4 | Assemble process | 0.00083 |
| 5 | Epoxy applications | 0.0089 |
| 6 | Epoxy inspections | 0.051 |
| 7 | Curing & cooling | 1.00 |
| 8 | Marking | 0.0056 |
| 9 | Trimming | 0.0016 |
| 10 | Soldering | 0.011 |
| 11 | Cleaning solder & cooling | 0.05 |
| 12 | VMI | 0.0125 |
| 13 | Co-planarity check | 0.0014 |
| 14 | Inductance test | 0.0013 |
| 15 | Tape & reel | 0.25 |
| 16 | Packaging | 0.83 |
| Total | | 3.24 |
| 20% Allowance | | 0.648 |
| Grand total | | 3.888 |

Subsequently, the grant total is bringing forward to Table 6. Material handling unit (MHU) is the accumulation of cycle time of all workstations which is 3.888 hours. Bill of material (BOM) is the accumulation of cost of material used in every activity for the process which is US$ 1.6895. Then, labor and overhead (LOH) is obtained by multiplying the MHU and LOH rate to get 15.52. Finally, the total cost is obtained by summing the LOH and BOM to get US$ 106,910.52.

TABEL VI
COSTING STRUCTURE OF INDUCTOR COMPONENT

| Product Number | Year | MHU | Basic BOM | LOH US$4.00 | Total Cost US$ | Margin % |
|---|---|---|---|---|---|---|
| xxxx | 2018 | 3.888 | 1.5018 | 15.52 | 106,910.52 | 35% |

This work compares the methodology of proposed ABC from Table 1 until Table 4 and costing being applied by the company from Table 5 until Table 6. The cost driver in Table 3 indicates that ABC emphasizes time spent for each activity to conclude the final cost of product. The analysis under ABC method has been revealed and applications of initiatives for cost reduction by using ABC method can be concluded that this is one of the best methods for cost reduction. Cost allocation in ABC is very important to predict the cost planning and justify for pricing and reimbursement. According to Table 2, winding process has cost allocation of RM 33,000 per year for labor, RM 5,832,614.40 for material and RM 3,636 for consumable. This proves that ABC is properly allocated the cost according to the operation. ABC also classified as subjective during the determination of time estimation. It proved by referring the time allocation as shown in Table 1 at workstation 1 of winding process with its cost driver rate is RM 25.56. Basically, the information of time and cost driver are identified through the interview process with operators and engineers. With respect to the maintenance, normally it comes through the recorded documents. Obviously, the important of cost driver is to highlight the major factor to the particular activity which

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eventually reflect to the final cost of product. ABC considered only one cost driver per activity as shown in Table 3. ABC is classified as informative method in the cost management and effective strategy in the cost reduction. Total cost of resources supplied will be taken into cost driver analysis to determine the cost driver rate and eventually to perform forecast analysis. Therefore, ABC is a great method to describe the relationship between resources of activity and cost object. In other word, ABC is capable to estimate the cost of resources in the operation to the product cost. Capacity forecast also related to the time spent, cost of capacity and cost driver. Through the analysis, the forecast capacity is RM 6,365,159.18 with RM 1.50 cost per unit product. This is really important as the cost strategies for the company to reduce the complications in future.

## V. Conclusion

This work was successfully gathered the time spent by operator to complete the task given. The largest time spent is at workstation 1 with 92.12% while the smallest at workstation 2,7, 8 and 14 with 0.1727% respectively. The highest cost of capacity supplied is drum core winding with epoxy activity with MYR 5,869,250.40 and the amount of material used is assigned as the cost driver. As the demand quantity of the product is increase by 10%, the total cost of production is predicted to be MYR 6,365,159.18 while the product cost per unit is MYR 1.50.

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