# COST AND PRODUCTIVITY ANALYSIS OF THE MANUFACTURING INDUSTRY USING TDABC & MOST

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## ABSTRACT

Costing is important for manufacturing industries. Large methods of costing have evolved over time. Recently, the time-driven activity-based costing (TDABC) system has gained importance and application. This article describes the procedure that allows companies to implement TDABC using the Maynard operation sequence technique (MOST) for improving productivity and profitability. Two parameters are required for TDABC: (1) the unit cost of supplying capacity, and (2) the time required to perform a transaction or an activity. MOST is employed to estimate the time required for each activity. Based on this, time equations are formulated and the practical capacity of activities is determined. The procedure is explained with the help of a case study from a manufacturing industry. The results of the case study are discussed from the perspective of the overall company and also at the product level. This approach provides the capacity analysis and the cost analysis together with its hierarchical decomposition. This paper also discusses the different information obtained from TDABC, and its usefulness for managers and decision-makers.

## OPSOMMING

Kosteberaming is belangrik vir die vervaardigingindustrie. Verskeie kosteberamingmetodes is met die verloop van tyd ontwikkel. Tydgedrewe aktiwiteitsgebaseerde kosteberaming (TDABC) het onlangs aan die lig gekom en word in hierdie artikel bespreek, spesifiek met die klem op die prosedure om TDABC te implementeer deur middel van die Maynard operasie sekwensiële tegniek (MOST) om sodoende produktiwiteit en winsgewendheid te verbeter. Twee parameters word vir TDABC benodig, naamlik (1) die eenheidskoste van voorsieningskapasiteit en (2) die tyd benodig om ’n transaksie of aktiwiteit te verrig. MOST word ingespan om die tyd vir elke aktiwiteit te skat. Op grond hiervan word tydvergelykings opgestel en die praktiese kapasiteit van aktiwiteite bepaal. Die prosedure word toegelig met die hulp van ’n gevallestudie vanuit die vervaardigingindustrie. Die gevallestudie resultate is bespreek vanuit die algehele maatskappy se perspektief asook op produkvlak. Hierdie benadering verskaf die kapasiteit en die koste analise saam met die hiërargiese samestelling. Die artikel bespreek ook die informasie wat vanuit die TDABC verkry word en die nut daarvan vir bestuurders en besluitnemers.

## 1 INTRODUCTION

Today’s business environment has become very uncertain. Staying competitive in this world is a real challenge. The rapid change in technology and a competitive environment force companies to find new solutions. Adapting to the best solution requires accurate and fast cost estimates.

Like other companies, the case company was also struggling with increasing manufacturing costs and a competitive environment. The company was struggling with the following questions:

- Which activities are mostly responsible for the productivity of the company?
- Which activities mostly affect the profitability of the company?
- Which overheads/resources are responsible for the higher cost of activity?
- Which activities are most responsible for the productivity of the product?
- How much activity time can be reduced to increase the productivity?
- Which activities most affect the profitability of the product?
- Which overheads/resources are responsible for the higher cost of the product?

To answer these questions, time-driven activity-based costing (TDABC) using the *Maynard operation sequence technique* (MOST) approach is adopted. TDABC is an advanced cost calculation technique that evolved from activity based costing (ABC). TDABC allocates resource costs to products, and helps many manufacturing and services organisations to improve their competitiveness by enabling them to make better decisions based on an improved understanding of their product cost behaviour. TDABC requires only two parameters: the unit cost of supplying capacity, and the time required to perform a transaction or an activity. The breakthrough of TDABC lies in the use of time equations to estimate the time spent on each activity [1].

*MOST* — a predetermined motion time system that is used primarily in industrial settings to get the standard time within which a worker should perform a task [***2***]. Itis used to formulate the time equations. MOST is a standardised method [***3***] that is relatively easy to use; it is accurate, and applicable to manual tasks that are not precisely defined [4]. It is thus employed to analyse each activity to determine its associated standard time.

The aim of this paper is to present the implementation of TDABC using MOST. The concepts of the TDABC system and the MOST technique are discussed first. Then a procedure to implement TDABC is presented. Afterwards, a case study in the furniture manufacturing industry is presented, and results from the MOST and TDABC analysis are discussed from the point of view of management taking appropriate decisions. The results are discussed at company and product level analysis.

## 2 LITERATURE REVIEW

Costing is important for every industry. Many costing systems have been developed over the years. TDABC has gained in importance and application in the last decade. Time is one of the most important parameters in TDABC. MOST is a technique to measure the standard time of activities. In the paragraphs that follow, the TDABC and MOST techniques are described.

### 2.1 Time-driven activity-based costing (TDABC)

TDABC has been introduced as a simplification of the ABC model, in relation to both complexity and data requirements and their maintenance [5]. TDABC is a complicated name for a simple concept: Total cost = Cost rate x time [6]. That means that, instead of defining product costs through multiple cost drivers, TDABC uses a resource capacity, which in this case is 'time', to measure the demand on any given activity [7]. Time is thus the most important factor for the distribution of the cost of products and services.

The difficulties faced by different authors are shown in Table 1. This time estimation is expressed in a time equation, taking into account the different consumption rates for the same activity in different contexts. This enables managers to capture the different amounts of time taken up by an activity for different products and services.

### 2.2 Maynard operation sequence technique (MOST)

The advantages of MOST are that only one or two observations are needed to measure the work, and the rating factor is inbuilt [13]. MOST was developed by H.B. Maynard & Company Inc. [14,15]; since then, BasicMOST has been applied in many manufacturing, service, and distribution industries as the most widely used system.

**Table 1: Difficulties in implementation of TDABC**

| Author | Difficulties in time estimation |
|---|---|
| Gervais *et al*. [*8*] | Accuracy of TDABC is doubtful if staff report their times and when it is not possible to observe them directly |
| Siguenza Guzman *et al*. ***[9]*** | Difficult to measure the time, the homogeneity, and its maintenance |
| Kowsari [10] | If time is measured by an inexperienced person, and if the wrong time is recorded for an activity, then the cost price allocated to activities will be unreliable |
| Öker & Adigüzel [11] | Difficult to implement TDABC in manufacturing companies because the capacities are measured in terms of labour time, and sometimes it is difficult to measure capacity in terms of labour time |
| Chiarini [12]] | Difficult to implement because of time equations |

BasicMOST identifies three basic sequence models: general move, controlled move, and tool use. The general move sequence is defined as the spatial free movement of an object through the air. The controlled move sequence describes the movement of an object when it either remains in contact with a surface, or remains attached to another object during the movement. It covers manual operations such as cranking, pulling a starting lever, turning a steering wheel, and engaging a starting switch. The tool-use sequence covers the use of common hand tools. Cutting, gauging, fastening, and writing with tools are all covered by this sequence.

## 3 PROCEDURE FOR IMPLEMENTATION OF TDABC USING MOST

Considering the difficulties in implementing TDABC, the procedure for implementing TDABC using MOST is developed. Every procedure consists of input and output. Similarly, this procedure also gives the output, which is useful to management as discussed in the results. Similarly, this procedure requires input. But there are some constraints while giving input. While developing this procedure, the following constraints were considered:

- Standard work procedure is adopted.
- Work procedures are clearly defined.
- One employee handles many activities.

Based on these assumptions, a proposed procedure consists of 12 steps, summarised in Figure 1.

In order to implement this approach, the list of products or services provided by the company is prepared. This list of data can be obtained for the sales department or storage department of the company. Thereafter the complete process should be divided into a set of activities. A flowchart of the process is a commonly used tool for identifying these main activities. An activity required to carry out the production can vary from product to product. The time is then measured using MOST analysis for each activity. Then the time equations are framed, based on the variation in the activities. These time equations are used to estimate the time of the activity for different products (practical capacity consumed by the product).

Often the practical capacity of activity is estimated as a percentage — say, 80 or 85 per cent — of theoretical capacity. This system is more suitable for assembly lines or a continuous system. In the case of job production, it can be calculated as the sum of the product of the time of an activity consumed by the product, and the quantity of a product manufactured.

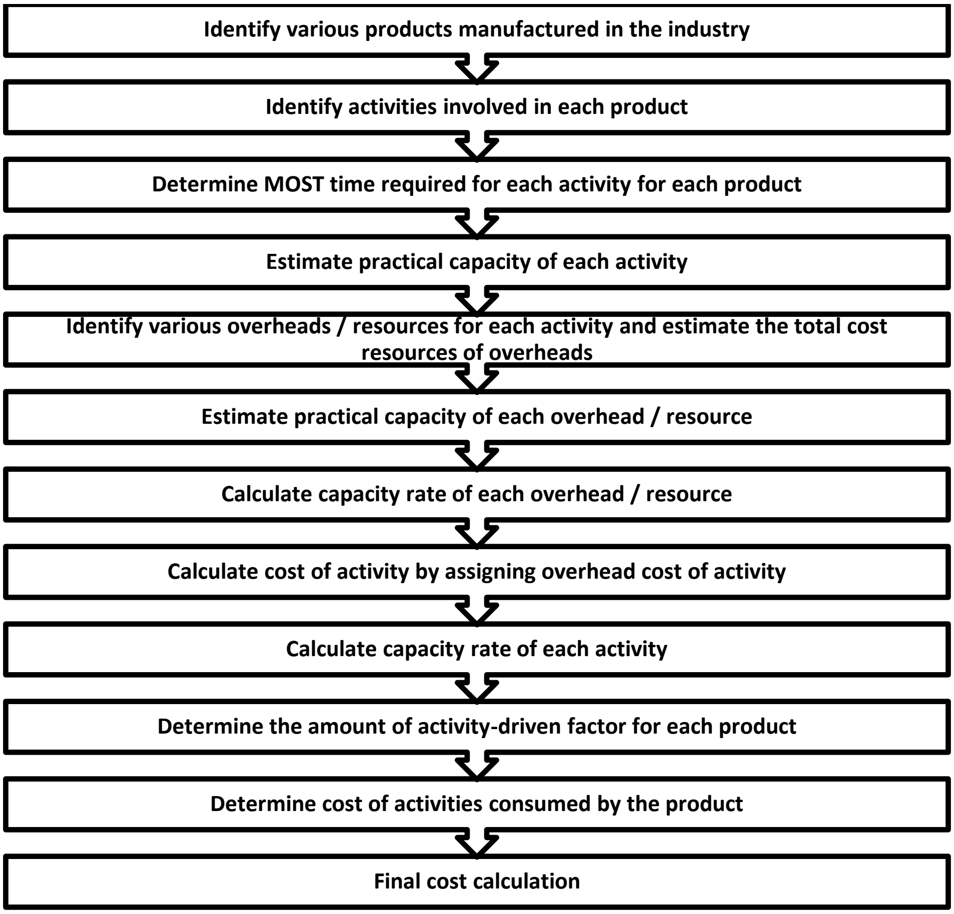


**Figure 1: Costing process**

Thereafter the list of overheads of each activity should be prepared. The cost of each overhead can be obtained from the trial balance of the company. Then the cost and the cost driver for each overhead are identified. The cost driver rate of the overhead is calculated by dividing the total cost of each overhead by the practical capacity of the overhead.

Next, the activity cost is obtained by allocating the cost of the overhead on the activity. It can be calculated by taking the sum of the product of the cost driver rate of the overhead and the practical capacity supplied by the overhead to an activity. After that, the cost driver rate of the activity will be determined by dividing the cost of the activity by the practical capacity of each respective activity.

Finally, the cost of the product is determined. It is the sum of the cost of the activity consumed by the product, the raw material cost, and the cost of other overheads, such as marketing, advertisements, etc. The cost of the activity consumed by the product is the sum of the multiplication of the cost driver rate of each activity by the practical capacity of the activity consumed by the product.

## 4 CASE STUDY

At the beginning of the project, the analysis period is determined, and the data is collected from this analysis period. Generally, the trial balance of company is prepared annually. Therefore, a period of one year is considered for analysis.

### 4.1 Identify various products manufactured in the industry

In this step, a list of products and the quantity of products manufactured over the analysis period is prepared. The list of manufactured products is obtained from the database of the store and from the sales statements.

### 4.2 Identify activities involved in each product

A process flow chart is used to identify the main activities. In the flow chart of the process, activities are represented by each box, and the flow of the system is represented by arrows. The flow chart of each product is then prepared. After that, homogeneous processes are grouped to identify needed activities for TDABC. In this study, 50 activities were identified, such as welding, assembly, material handling, packing, treatment, pressing, cutting, etc.

### 4.3 Determine MOST time required for each activity for each product

The time consumed by an activity is different for different products. For example, buffing is an activity; but the time required for the buffing process is different for different products, depending upon the different parameters. Therefore, time equations are framed for each activity. For the time equation of an activity, each activity is divided into sub-activities based on each variant. The time required for each activity and for each variant is determined using MOST analysis. The time equation for a given activity is a function of *n* potential factors differentiating this activity. It is expressed as:

$$\boldsymbol{T = \beta_0 + \beta_1 X_1 + \cdots + \beta_n X_n} \tag{1}$$

where

T— the time needed to perform an activity,
$\beta_0$— standard time for performing the basic activity from MOST analysis,
$\beta_1$— the estimated time for the incremental activity i from MOST analysis, (i=1,2,….,n)
$X_1$— the quantity of incremental activity i, (i= 1,2,….,n)

Time equations are suitable for standard activities such as drilling, punching, and notching. But it is difficult to construct a time equation for non-standard activities such as repairing or rework. The MOST analysis is carried out to determine the time required for an activity. For the MOST analysis, each activity is divided into sub-activities. Each sub-activity is further divided into elements. These elements are arranged in a sequence model. The sequence models are given in Figure 2. Indexing each parameter of a sequence model is accomplished by observing or visualising the operator's action during each phase of the sub-activity, and selecting the appropriate index from the data card given by Zandin [16]. The time taken by each sub-activity is calculated by using the equation = 10 × index × TMU, where TMU is the time measurement unit, which equals 1/100000 h = 0.036 sec. For example, 'buffing activity' is divided into three sub–categories: fixed activities, chemical applying activities, and the buffing process on the machine. Then, for each sub–activity, standard time is determined using MOST by dividing the sub-activity into elements. For example, for fixed activities the elements are: Start the m/c; Get the material; Clean the material; Put the material aside; and Stop the m/c. So the time required for the fixed activities, chemical applying activities, and the buffing process is 0.282, 0.084, and 3.72 minutes respectively. Therefore the time equation for the buffing activity is expressed as:

*Time required for buffing activity = 0.282 + 0.084 (number of times chemical is applied) + 3.72 (buffing length per feet)* (2)

<table>
<tr><th>Sr. no.</th><th>Activity</th><th>Phases of sequence model</th><th>Sub-activity / parameter</th></tr>
<tr><td>1</td><td>General move</td><td><table><tr><th>Get</th><th>Put</th><th>Return</th></tr><tr><td>ABG</td><td>ABP</td><td>A</td></tr></table></td><td>A- Action distance<br>B- Body motion<br>G- Gain control<br>P – Placement</td></tr>
<tr><td>2</td><td>Controlled move</td><td><table><tr><th>Get</th><th>Move or actuate</th><th>Return</th></tr><tr><td>ABG</td><td>MXI</td><td>A</td></tr></table></td><td>A- Action distance<br>B- Body motion<br>G- Gain control<br>M - Move control<br>X - Process time<br>I - Alignment</td></tr>
<tr><td>3</td><td>Tool use</td><td><table><tr><th>Get tool or object</th><th>Put tool or object in place</th><th>Tool action</th><th>Put tool or object aside</th><th>Return operation</th></tr><tr><td>ABG</td><td>ABP</td><td>*</td><td>ABP</td><td>A</td></tr></table></td><td>A- Action distance<br>B- Body motion<br>G- Gain control<br>P - Placement<br>Blank space (*) is filled with the tool use parameter below:<br>F: Fasten<br>L: Loosen<br>S: Surface treatment<br>M: Measure<br>R: Record<br>T: Think</td></tr>
</table>

**Figure 2: Sequence models comprising the BasicMOST system**

### 4.4 Estimate practical capacity of each activity

The practical capacity of an activity is the total time for which the activity occurred in the analysis period. It is calculated as the sum of the product of time of an activity consumed by the product, and the quantity of a product manufactured. It is represented using equation 3.

$$PC_A = \sum_{i=1}^{n} \mathrm{T_A} \times \mathrm{Q_A} \tag{3}$$

$PC_A$ = Practical capacity of an activity
$Q_A$ = Quantity of products manufactured
$T_A$ = Time required to perform the activity for a product (practical capacity of activity consumed by the product)
N = number of type of product

To determine the practical capacity of the buffing activity, the time required for the buffing activity for each product ($T_A$) is estimated using equation 2. Then, using equation 3, the practical capacity is calculated. The practical capacity of buffing is found to be 30 970 min. The practical capacity of other activities is determined in the same way. For treatment activity, the practical capacity is found to be 137 380 min.

### 4.5 Identify various overheads / resources for each activity, and estimate the total cost resources of the overheads

After determining the activities, the overheads of each activity are determined. For each activity, the overheads (such as building rent, building maintenance, power consumption, machine maintenance cost, chemical consumables, etc.) are identified. The cost of each overhead is then taken from the trial balance.

## 4.6 Estimate the practical capacity of each overhead / resource

Once the overhead and its cost is determined, the practical capacity of each overhead is measured. The measuring unit for the practical capacity of the overhead is based in the consumption of the overhead.. For example, the practical capacity of building maintenance is measured in the floor area of the building. Therefore, the practical capacity of the building material is 13 691.69 feet$^2$ floor area.

## 4.7 Calculate the cost driver rate of each overhead / resource

The cost driver rate of the overhead is calculated by dividing the total cost of each overhead by the practical capacity of the overhead. It is represented by equation 4. For example, the cost driver rate of building maintenance is 0.910479276, obtained by dividing the amount spent on building maintenance by the total floor area.

$$CR_O = \frac{CO_O}{PC_O} \tag{4}$$

$CR_O$ = cost driver rate of overhead
$CO_O$ = cost of overhead
$PC_O$ = practical capacity of overhead

## 4.8 Calculate cost of activity by assigning overhead cost on activity

The cost of the activity is calculated by assigning the cost of the overhead on the activity based on its consumption. Mathematically, it is calculated by taking the sum of the product of the cost driver rate of the overhead, and the practical capacity of the overhead consumed by an activity. The cost of activity is represented by equation 5.

$$C_A = \sum_{j=1}^{j} \mathrm{CR_O} \times \mathrm{OC_A} \tag{5}$$

$C_A$ = cost of activity
$OC_A$ = overhead capacity consumed by activity
j = number of overheads

In this step, the overheads are allocated to different activities, and the cost of each activity is determined. For the implementation, the list of overheads / resources consumed by each activity is prepared. For example, for the treatment activity, the list of overheads consists of building maintenance, depreciation, insurance of assets, building tax, electricity, etc. The cost driver rate of these overheads is obtained from equation 4, and the practical capacity of these overheads consumed by the activity is measured. For example, the practical capacity of a building maintenance overhead consumed by a welding activity is 800 feet$^2$ — the area occupied by the treatment activity. Then the cost of the building maintenance consumed by the treatment activity is Rs. 728.384, which is the product of 0.91048 Rs./feet$^2$ (cost driver rate of overhead $CR_O$) and 800 feet$^2$ (practical capacity of building maintenance overhead consumed by treatment activity). The sum of the cost of all overheads consumed by the treatment activity is the cost of the treatment activity, which is found to be Rs. 9 737.229.

## 4.9 Calculate the cost driver rate of each activity

The cost driver rate of an activity is determined by dividing the cost of the activity by the practical capacity of that activity. It is represented by equation 6.

$$CR_A = \frac{C_A}{PC_A} \tag{6}$$

$CR_A$ = cost driver rate of activity
$PC_A$ = practical capacity of activity

For example, the cost driver rate of treatment activity is the division of the cost of treatment activity (obtained from equation 5) Rs. 9 737.22875 and the practical capacity of the treatment activity (obtained from equation 3) 137 380 min. So the cost driver rate of treatment activity is 0.07088 Rs./min. The cost driver rate for the activities, such as re-treatment, is considered the same as that of the treatment activity, because treatment and re-treatment is the same activity.

Re-treatment is separated from treatment so that rework caused by poor quality can be determined, and so that this cost of rework can be considered in the costing.

### 4.10 Determine the practical capacity of activity consumed by each product

The practical capacity of the activity consumed by the product is generally measured in terms of time. It is the time consumed by an activity in manufacturing a product. The time required for each activity of a product is determined using time equations (refer to equations 1 and 2). The value of other cost drivers, such as welding length and surface area, is obtained from the product details.

### 4.11 Determine cost of activities consumed by the product

The total cost of each activity consumed by a product is calculated as the sum of the product of the cost driver rate of the activity and the practical capacity of the activity consumed by the product.

$$C_P = \sum_{\mathrm{m}=1}^{\mathrm{m}} \mathrm{CR_A} \times \mathrm{AC_P} \tag{7}$$

$C_P$ = Total cost of activity consumed by the product
$AC_P$ = Activity consumed by the product
m = number of activities

The cost of the activity consumed by the product is calculated by multiplying the practical capacity of the activity consumed by the product, with the corresponding cost driver rate of the activity. For example, the practical capacity (time) consumed by 'EB-6B' for the grinding activity is 4.59778 minutes, and the cost driver rate is 1.500498. Therefore the total cost of the treatment activity consumed by the product is 6.898962, which is a multiplication of 4.59778 by 1.500498. The sum of the cost of all activities consumed by the product is Rs. 146.4962.

### 4.12 Final cost calculation

The final cost of the product is the sum of the total cost of each activity consumed by a product, and the direct expenses (see equation 8).

$$Product\ cost = Total\ cost\ of\ activity\ consumed\ by\ a\ product\ (C_p) + direct\ expences \tag{8}$$

The direct expenses include the cost of material, cost of direct labour, etc. So the cost of the product is the sum of the cost of the activity consumed by the product, plus the direct expenses, which is found to be Rs. 5 682.617.

## 5 RESULTS AND DISCUSSION

In the proposed procedure, MOST is used in the implementation of TDABC. The adaptation of this approach therefore offers the benefit of both techniques. The TDABC and MOST analysis provides useful information to management. This information is obtained at company level and product level. How this information is useful to management is explained in the paragraphs that follow.

### 5.1 Company level analysis

In the proposed methodology, the practical capacity of the activities is measured in terms of labour time. This data is obtained from equation 3. The practical capacity of various activities is plotted on a pareto chart, as shown in Figure 3. This identifies welding, assembly, coating, and treating as the major activities in the company. In order to improve productivity, these activities should be focused on first. The welding activity has the highest practical capacity. But MOST analysis indicates that welding consumes 38.03 per cent more time than the time obtained from MOST. This extra time is due to non-value-adding activities.

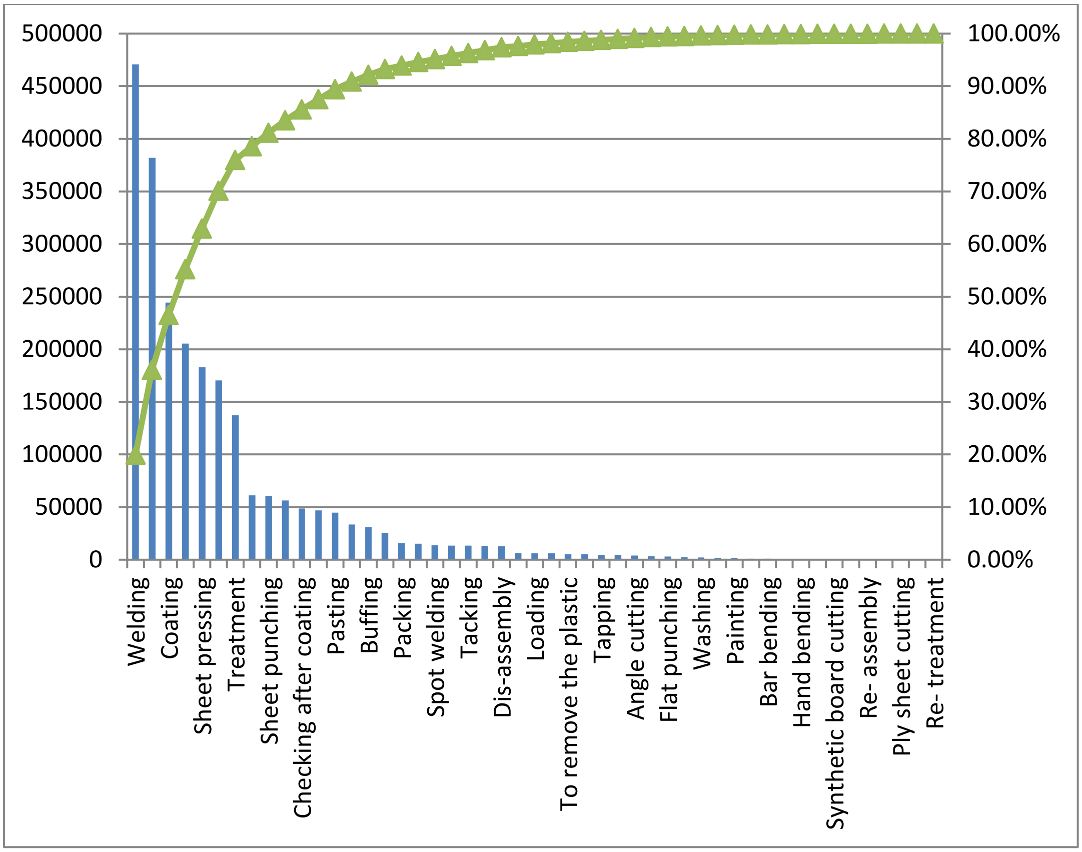


**Figure 3: Practical capacity of activities for a company**

The cost of an activity is obtained by assigning the overhead / resource cost based on its consumption. This data is obtained from equation 5. A pareto chart, shown in Figure 4 is prepared for the cost of activities. It indicates that sheet punching, shearing, coating, and hand cleaning consume 80 per cent of the total cost of resources. To increase the profitability of the industries, these activities must be focused.

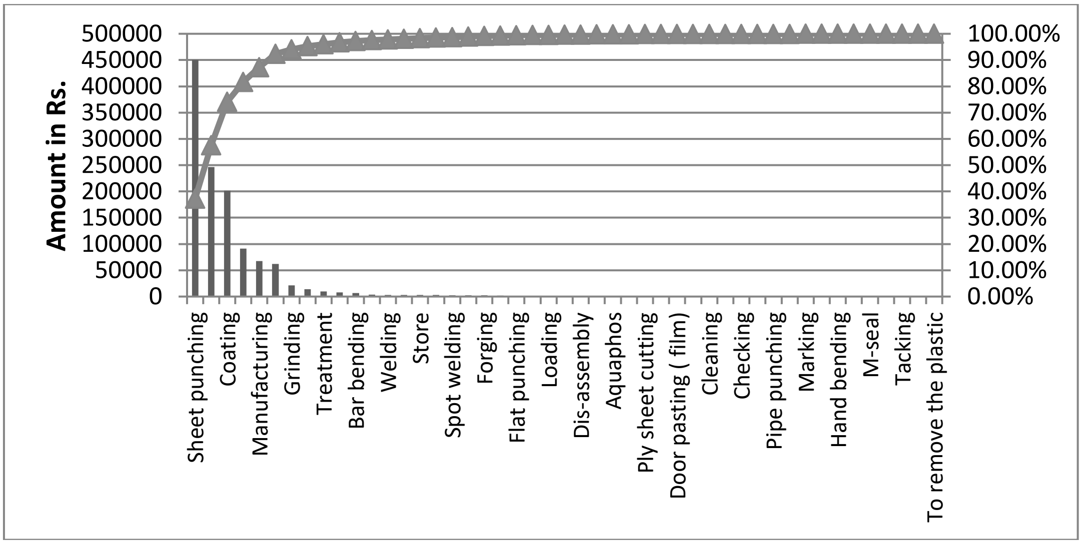


**Figure 4: Cost of activities**

TDABC not only identifies the important activities that influence the performance of the company; it also provides the detailed decomposition of the cost of each activity and the factors responsible for it. Figure 4 identifies sheet punching as one of the most cost-consuming activities. Figure 5 indicates the detailed cost decomposition of the sheet punching activity. It shows that a high tool cost is responsible for the high cost of the activity. As the company manufactures more than 300 products, and a different type of tool is used for each type of punching, the cost of tooling is high.

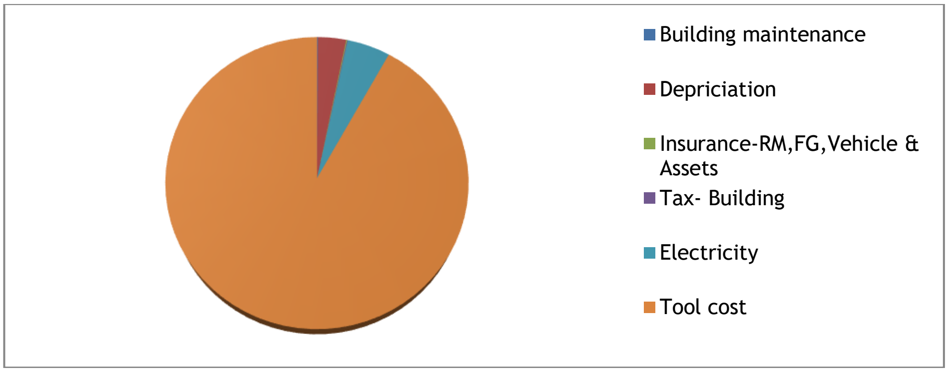


**Figure 5: Cost decomposition of sheet punching activity (see online for colour version)**

From Figure 3 it is concluded that the partial productivity of labour can be increased by reducing the manufacturing time of the welding, assembly, coating, and treating activities. Figure 4 infers that partial productivity of capital can be increased by reducing the expenses of the sheet punching, shearing, coating, and hand cleaning activities.

### 5.2 Product-level analysis

An analysis of product EB-6B is presented in this section. Figure 6 shows the pareto chart of the time taken by activities in manufacturing EB-6B. This data is obtained from the time equations of the activities (refer to equations 1 and 2). Figure 6 shows that assembly, coating, welding, and treatment take 80 per cent of the manufacturing time. As assembly is a manual activity, it takes a long time in manufacturing. Assembly consists of various operations, such as riveting, drilling, fastening, hammering, labelling, aligning, etc. The contribution of each operation in the assembly activity is shown in Figure 7.

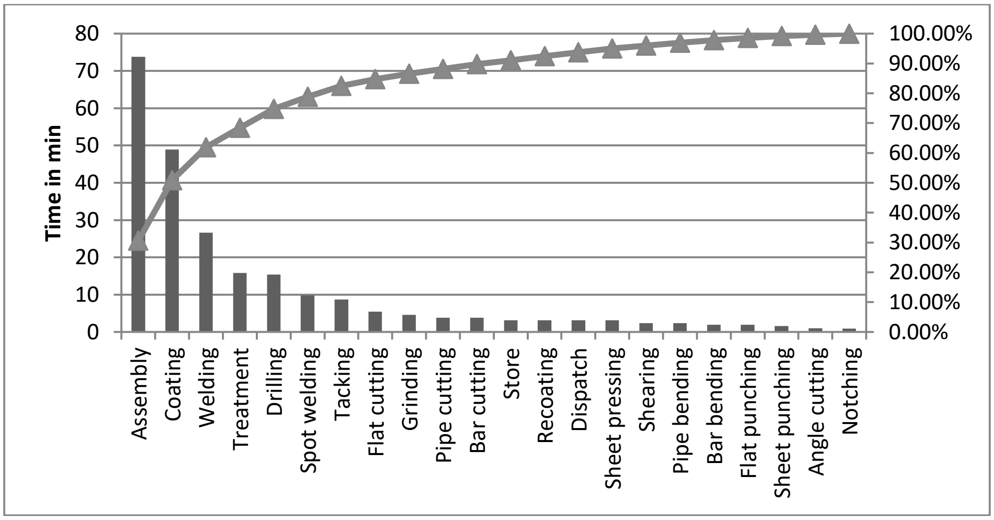


**Figure 6: Time taken by activities for product EB-6B**

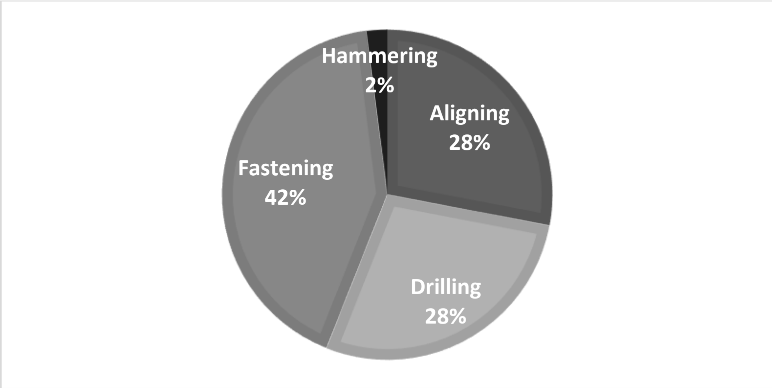


**Figure 7: Time contribution of each operation in the assembly activity**

The MOST analysis of each activity indicates that the actual time consumed by an activity is much higher than the time estimated by MOST. Figure 8 shows the time compression of activities for product EB-6B. This indicates the scope for improvement in the production time.

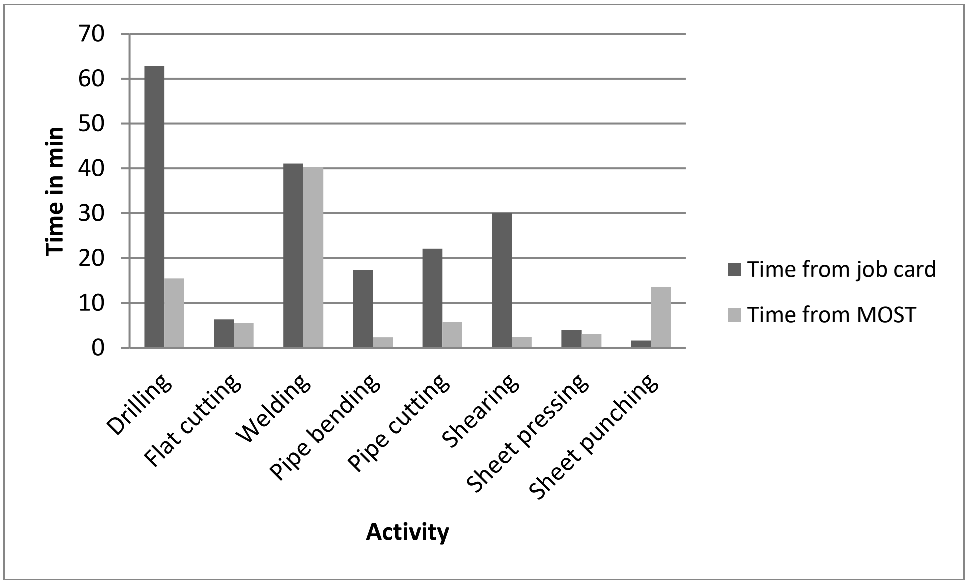


**Figure 8: Comparison of actual time with MOST time for product EB-6B**

The cost consumed by the activities for product EB-6B is obtained from equation 7, and is shown in Figure 9. It indicates that coating, pipe cutting, bar bending, sheet punching, and shearing are responsible for 80 per cent of the total cost. The coating activity time and surface area are two other cost drivers. Therefore the total cost of the coating activity from both the drivers is Rs. 46.507, and contributes 31.84 per cent of all the activities. TDABC provides the hierarchical decomposition of the cost. Figure 10 shows the contribution of overheads /consumables in the coating activity. The cost of powder and gas is responsible for 91.82 per cent of the cost of the coating activity. These need to be reduced to reduce the cost of this coating activity.

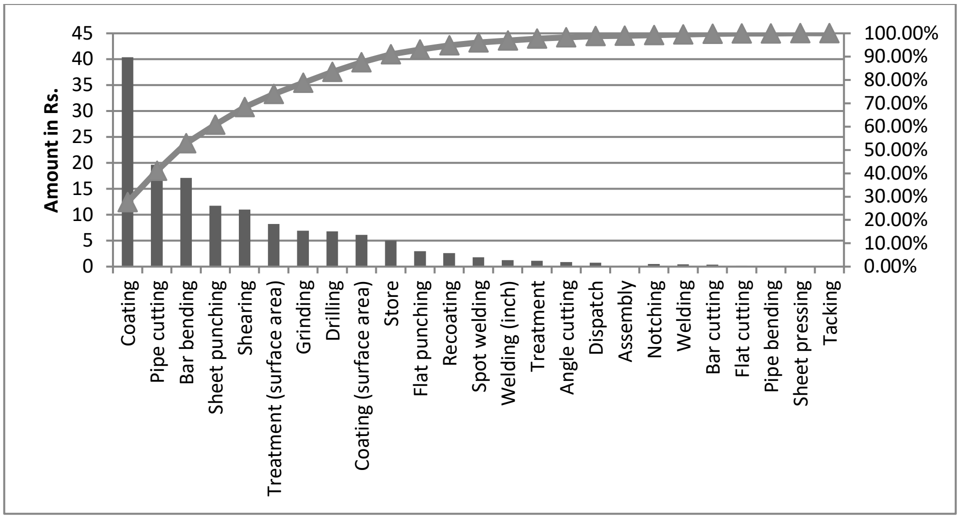


**Figure 9: Cost consumed by activities for product EB-6B**

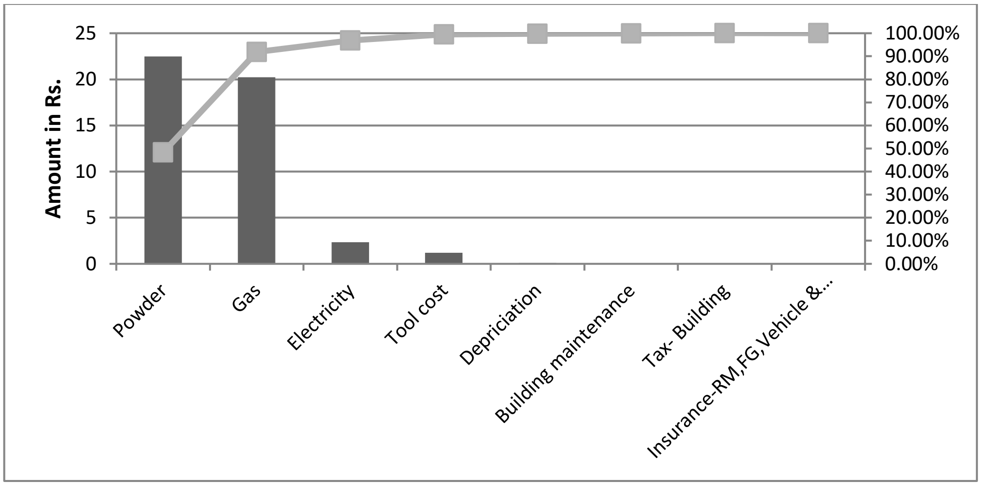


**Figure 10: Cost of overheads contributing to the coating activity of product EB-6B**

## 6 CONCLUSION

This paper presents a case study for implementing TDABC using MOST to improve productivity and profitability. The procedure is explained with the help of a case study in a manufacturing industry. The proposed procedure is more suitable for fast implementation and for validating an existing costing system. This is because it requires neither a great investment in sophisticated data collection systems, nor serious organisational restructuring.

This approach not only identifies the cost and the time consuming processes; it also indentifies the opportunities to increase productivity and profitability. The results indicate that the cost of the product reduces with a reduction in manufacturing time. It is also observed that the time required from the MOST analysis is less than the actual time required. This analysis thus identifies areas for improvement. The TDABC analysis identifies the bottleneck to reducing the cost and increasing productivity. It provides the analysis for individual products and plants, and hence has the advantages of both systems — i.e. of TDABC and MOST.

The implementation of TDABC using MOST requires detailed analysis, engineering calculations, and information about the manufacturing process. The drawback is thus that it requires skilled manpower for the analysis and implementation of this model.

The application of TDABC using MOST in a manufacturing environment to improve productivity and profitability has led to the enrichment of the literature, because:

- the results of TDABC have provided the information for strategic decision-making;
- it provides the practical capacity to analyse the activities;
- the results of the study provide the cost analysis and its hierarchical decomposition; and
- it provides the procedure to identify the factors affecting productivity and profitability.

As a future step, a software package based on this procedure can be developed that would benefit MOST and TDABC analysis.

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