# Methodology for application of Maynard Operation Sequence Technique (MOST) for time-driven activity-based costing (TDABC)

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## Abstract

**Purpose** – The purpose of this paper is to present a procedure to implement time-driven activity-based costing (TDABC) using Maynard Operation Sequence Technique (MOST). In this paper three research questions are addressed: How can MOST be used to frame time equations? How can MOST be used for the improvement of productivity? How can TDABC cost information be used?

**Design/methodology/approach** – Case study research was performed at a manufacturing industry. Data have been collected for overhead distribution. The overhead cost was distributed on activity. Time equations are framed using MOST. Cost of activity is assigned to the product using time equations.

**Findings** – The proposed system simplifies the process of implementation of TDABC using MOST. This system not only determines the cost but also identifies the area where cost is consumed. It also identifies opportunity for productivity improvement.

**Research limitations/implications** – The case study was conducted in a manufacturing industry. The proposed methodology is suitable for manufacturing industry where standard work procedure is adapted.

**Practical implications** – The study explains the implementation of TDABC using MOST using a case study and results are meticulously discussed from a management point of view for appropriate decision making.

**Originality/value** – Besides the articles published so far dealing with the implementation of TDABC, no research was found on the implementation of TDABC using MOST.

**Keywords** Case studies, Manufacturing industry, Maynard Operation Sequence Technique (MOST), Time-driven activity-based costing (TDABC)

**Paper type** Case study

## 1. Introduction

Staying competitive in an uncertain business environment is a real challenge. This competitive environment and rapid change in technology force companies to find new manufacturing solutions. Therefore, it is important for companies to produce accurate and quick cost estimates, so that they can understand where the manufacturing process needs to be optimized.

Activity-based costing (ABC) has helped many manufacturing and service organizations in improving their competitiveness by enabling them for better decision making based on an improved understanding of their product cost behavior (Nachtmann and Al-Rifai, 2004). ABC is an advanced cost calculation technique that allocates resource costs to products based on resource consumption (Stouthuysen *et al.*, 2010; Suthummanon *et al.*, 2011). In ABC, overhead cost and indirect cost are first assigned to activities and then to products or services. Hence, ABC is more accurate than traditional cost accounting

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(Helberg *et al.*, 1994; Tangen, 2004). Therefore, managers have adapted ABC for a better picture of profitability. But implementing ABC can be fraught with problems (Öker and Adigüzel, 2010). To address these problems, time-driven activity-based costing (TDABC) was developed by Kaplan and Anderson (2004). TDABC requires only two parameters: first, the unit cost of supplying capacity and second, the time required to perform a transaction or an activity. The breakthrough of TDABC lies in the usage of time equations to estimate the time spent on each activity (Demeere *et al.*, 2009).

Maynard Operation Sequence Technique (MOST) is a predetermined motion time that is used primarily in industrial settings to get the standard time in which a worker should perform a task (Mishra *et al.*, 2014). MOST is more standardized method than conventional work measurement techniques such as time study (Go *et al.*, 2011) and is relatively easy to use, accurate and applicable to manual tasks which are not precisely defined (Kroll and Carver 1999). Therefore, it is employed to analyze each activity to determine associated standard time. The time equations are developed with the help of MOST.

The aim of this paper is to propose a procedure for implementation of TDABC using MOST. The concepts of TDABC system and MOST techniques are initially discussed. Then, a procedure to implement TDABC using MOST is presented. Based on this model an equation is developed. Afterward, a case study in small-scale furniture manufacturing industry is presented and results from MOST and TDABC analysis are discussed from a management point of view for appropriate decision making. Finally, the results from this approach are compared with TDABC using standard method and traditional costing system.

## 2. Literature review

A lot of research studies are carried out related to TDABC. Various approaches and case studies are presented in the literature. These are precisely reviewed in this section.

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

TDABC has been introduced as a simplification of the ABC model both in relation to the complexity and to the data requirements (Meddaoui and Bouami, 2013). TDABC works on the concept: Total cost = Cost rate×Time (Hennrikus *et al.*, 2012). That means, 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 activities (Chansaad *et al.*, 2012). Therefore, time is the most important factor for the distribution of cost on the products and services. Difficulties faced by different authors are given in Table I. This time estimation is expressed in a time equation, taking into account the different consumption rates for the same activity in a different context. This enables managers to capture the different amounts of time consumed by activity for different products and services. Demeere *et al.* (2009) and Stouthuysen *et al.* (2010) provided the following six-step procedure to implement TDABC:

(1) Identify the various activities.

(2) Estimate the total cost of each activity.

(3) Estimate the practical capacity of each resource group.

(4) Calculate the unit cost of each activity (cost driver rate of activity).

(5) Determine the time required each time the activity is performed.

(6) Multiply the unit cost of each activity by the time estimate for the event.

**Table I.**
Difficulties with time equation in TDABC

| Author | Difficulties in time estimation | Journal | Purpose of work |
|---|---|---|---|
| Gervais *et al.* (2010) | The accuracy of TDABC is doubtable if staff report their times and when it is not possible to observe them directly | *Journal of Applied Management Accounting Research* | Response to the criticism of ABC method, mainly regarding the cost and complexity of implementing and maintaining |
| Siguenza-Guzman *et al.* (2013) | Difficult to measure the time, the homogeneity and its maintenance | *Review of Business and Economic Literature* | Review of literature on TDABC to study its potential benefits and challenges |
| Kowsari (2013) | If time is measured by an inexperienced person, and if wrong time is considered for an activity then cost price allocated to activities will be unreliable | *European Online Journal of Natural and Social Sciences: Proceedings* | To study changes in models of TDABC |
| Öker and Adigüzel (2010) | Difficult to implement TDABC in manufacturing companies because the capacities are measured in terms of labor time, and sometimes it is difficult to measure capacity in terms of labor time | *Journal of Corporate Accounting & Finance* | Implementation of TDABC in a manufacturing company |
| Chiarini (2014) | Difficult to implement because of time equations | *International Journal of Productivity and Quality Management* | Case study inside a medium-sized manufacturing company to evaluate the pros and cons of implementing TDABC |
| Wouters and Stecher (2017) | Time equations are not always applicable to describe product variety | *International Journal of Production Economics* | Proposed TDABC based on actual machine times per business orders |
| Barros and Ferreira (2017) | TDABC requires two types of resources in production areas. Hence, it creates a need to split tasks and to create two equations for each process. Also, times are difficult to individualize for certain highly automated procedures | *Qualitative Research in Accounting & Management* | Presented TDABC model for production environments which is able to deal with the variability of the processes |
| Ganorkar *et al.* (2018) | Difficult to formulate time equations and to measure practical capacities | *Journal of Corporate Accounting & Finance* | Proposed TDABC model for small-scale manufacturing industries by eliminating time equations |

### *2.2 Maynard Operation Sequence Technique (MOST)*

MOST is developed to overcome the problems of the tediousness of work and handling huge amount of data as needed in the MTM for setting the standard time (Karim *et al.*, 2016). It was developed by H. B. Maynard and Company Inc. (Zandin, 1980; Luxhoj and Giacomelli 1990) since then, BasicMOST has been applied in many manufacturing, service and distribution industries as a most widely used system. The MOST system was expanded in 1980 to include MiniMOST and MaxiMOST (Zandin, 2002). BasicMOST is routinely used to analyze a wide range of manual activity in many industries. MiniMOST is used to analyze highly repetitive, short-cycle (less than 1/4 min), identically performed work that occurs more than 1,500 times per week (e.g. manual electronics fabrication). MaxiMOST is used for setting labor standards for long-cycle operations that have low unit production rates and long unit production times (e.g. ship building, rolling-stock fabrication, etc.). AdminMOST is a version of BasicMOST. It is used for analyzing office and administrative work.

MOST 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. A general move consists of three phases get, put and return with sequence model of "ABGABPA" as shown in Figure 1. 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

| Sr. No | Activity | Phases of Sequence Model | | | | |
|---|---|---|---|---|---|---|
| 1 | General Move | Get | Put | | | Return |
| | | ABG | ABP | | | A |
| 2 | Controlled Move | Get | Move Or Actuate | | | Return |
| | | ABG | MXI | | | A |
| 3 | Tool Use | Get Tool Or Object | Put Tool OR Object In Place | Tool Action | Put Tool Or Object Aside | Return Operation |
| | | ABG | ABP | * | ABP | A |

A – Action Distance
B – Body Motion
G – Gain Control
P – Placement
M – Move Control
X – Process Time
I – Alignment
(*) is filled with below tool useparameter:
F – Fasten
L – Loosen
S – Surface Treatment

**Source:** Zandin (2002)

**Figure 1.** Sequence models comprising the Basic MOST system

starting lever, turning a steering wheel and engaging a starting switch. Control move also consists of three phases: get, move and return with sequence model of "ABGMXIA." The tool use sequence covers the use of common hand tools. Cutting, gauging, fastening and writing with tools are all covered by this sequence. Tool use has five sequence models as get tool, put tool, tool action, put tool and return operation.

The MOST has advantages that only one or two observations are needed to measure the work and the rating factor is inbuilt (Thakre *et al.*, 2009). For the implementation of the MOST, five-step procedure used to develop the normal time (Rabie, 2000; Puvanasvaran *et al.*, 2013) is as follows:

- Step 1: observe and document the methods of operation.
- Step 2: break down the sub-operation into logical activities.
- Step 3: select the appropriate sequence model for each activity.
- Step 4: select the appropriate "indices values" for the parameters of the models, including their repetitions.
- Step 5: synthesis the normal time of the operation.

## 3. The proposed procedure for implementation of TDABC using MOST

Literature indicates that formulating time equation is the most difficult activity (Chiarini, 2014). Time equations are framed to estimate the time of activity in a different context. Formulation of time equation requires standard time for each context. There are two approaches to obtain the time. Firth approach is based on the presence of a real observation environment whereas the second approach determines planned times via calculated analytical methods, i.e. predetermine motion time system (PMTS) (Seifermann *et al.*, 2014). Time estimation by real observation requires around ten to over hundreds of observations depending on duration and frequency of occurrence, in order to get a reliable sample (Puvanasvaran *et al.*, 2013). Furthermore, they require additional time to break down the method into steps, to conduct performance rating and to relate method descriptions to times, whereas PMTS defines the time needed for the performance of various operations by derivation from preset standards of time for various motions and not by direct observation and measurement (Razmi and Shakhs-Niyaee, 2008). The examples of PMTS are MTM-1 to MTM-3, work factor, MOST and MODAPTS. MOST utilizes larger blocks of fundamental motions than MTM-1 and even MTM-2 using only 16 time fragments for describing manual works. As a result, analysts can establish standards at least five times faster than with MTM-1 without compromising accuracy (Salvendy, 2001; Razmi and Shakhs-Niyaee, 2008). Also, MOST uses clearly defined and easily understood rules, and eliminates the subjective aspects. Hence, MOST is used for time estimation.

Considering all the difficulties in implementation of TDABC using the standard procedure, a new method is developed by authors. In this method, TDABC is implemented using MOST. This procedure consists of input and output. This procedure also produces the output, which is useful for the management. Similarly, this procedure requires input such as the practical capacity of activities, cost of resources and their consumption, etc. The following assumptions were considered while developing this procedure:

- standard work procedure is adopted;
- work procedures are clearly defined; and
- one employee is handling many activities.

Based on these assumptions the procedure presented in Figure 2 is adapted. This procedure requires estimations at overheads, consumables, activities and product level as shown in Figure 2 by different colors. In this process, the cost of overhead and consumable is assigned to the activity. Then, the cost of the activity is assigned to the product. The stepwise procedure for TDABC using MOST is summarized in Figure 2 and elaborated below.

Step 1: in order to implement this approach, the list of products produced by the company needs to be prepared. This list can be obtained from the sale register of the company.

Step 2: once the products are identified, the complete process of manufacturing each product should be divided into a set of activities. A flowchart of the process is a commonly used tool for identifying these main activities.

Step 3: an activity required to carry out the production can vary from product to product. Therefore, the time is measured using MOST analysis for each activity of each product.

Step 4: the practical capacity of activity is calculated as the sum of the product of MOST time of an activity consumed by the product and quantity of a product manufactured.

Step 5: thereafter, the list of overheads of each activity should be prepared. The cost of each overhead is obtained from the balance sheet of the company.

Step 6: once the overheads and their costs are determined, cost driver for each overhead is identified and practical capacity of overhead is measured. Practical capacity of the overhead is the quantity of overheads consumed by an activity.

Step 7: afterward, cost driver rate of the overhead is calculated by dividing the total cost of each overhead by the practical capacity of the overhead.

Step 8: similar to overheads, the list of consumables for each activity should be prepared. The cost of each consumable can be obtained from the balance sheet of the company.

Step 9: practical capacity of consumable is the total quantity of consumable used in the industry. Practical capacity is determined for each identified consumable.


**Figure 2.**
Costing process

Step 10: cost driver rate of the consumable is obtained by dividing the cost of consumable by the practical capacity of the consumable.

Step 11: subsequently, the cost of an activity will be determined. Cost of activity is obtained by allocating the overhead cost and consumable cost on the activity. The cost of activity due to overhead is calculated by taking the sum of the product of cost driver rate of overhead and the practical capacity of overhead consumed by the activity. Similarly, the cost of activity due to consumable is the sum of the product of cost driver rate of consumable and practical capacity of consumable used (consumed) by the activity. The total cost of the activity is the sum of activity due to overhead and consumable.

Step 12: after that, the cost driver rate of activity will be determined by dividing the cost of activity by practical capacity of a respective activity.

Step 13: then, practical capacity of activity consumed by each product is determined. As TDABC uses time as its primary cost driver, the capacity of activity consumed by product is measured in terms of time. Its value is obtained from the time equation.

Step 14: furthermore, the cost of activity consumed by the product is calculated as the sum of multiplication of cost driver rate of each activity by the practical capacity of activity consumed by the product.

Step 15: finally, the cost of the product is the sum of the total cost of each activity consumed by a product, direct expenses and the total cost of overhead consumed by product.

## 4. Case study and formulation of costing equation

For actual implementation, a company was selected that was already using TDABC.

*4.1 About company*

The implementation of this procedure is carried out in a small-scale furniture manufacturing industry located in central India. The company is established in 1983 and is backed by strong technical support typically in design and manufacturing. This industry is mainly engaged in manufacturing hospital furniture and home furniture using sophisticated machines. The specialized hospital products are manufactured such as fowler bed, two-section bed, ward bed, ICU bed, bed-side lockers, instrument cabinet, trolleys, stretcher, stands and stools, wheel chair and many more items. The industry supplies these products to various hospitals in India. The annual turnover of the company is $0.7m. The company receives an order from distributors or customers and then estimates its cost. The company used to estimate the cost by traditional costing system. In traditional costing system, indirect costs are allocated to product cost based on single or a few volume-based cost drivers. However, in recent time, it was observed that estimated and quoted was much lower in some incidences resulting in a loss to the company and in some cases, higher estimation resulted in losing the order. Therefore, it was essential for the company to estimate the cost accurately.

*4.2 Case study*

At the beginning of the project, the initial assessment of working industry was carried out. It was found that the company prepared balance sheet annually and maintained the record of cost estimation of products at the beginning of work order and actual cost incurred at the end of the order completion. The industry was managed by the proprietor who was supported by four supervisors and a finance account officer. Initial screening of the records helped to decide the period for collection of data as one year. In the following pages the calculation of TDABC using MOST as per procedure outlined above is presented.

*4.2.1 Identify various products manufactured in the industry*. During the analysis period of one year, the company manufactured 332 products. The total quantity of products manufactured during this period was 9,484. This information is collected from the database of the warehouse.

*4.2.2 Identify activities involved in each product*. A process flowchart is used to identify the main activities. In the flowchart of the process, activities are represented by each box and flow of the system is represented by arrows. Then flowchart of each product is prepared. After that homogeneous processes are grouped to identify needed activities for TDABC. In this study, total 52 activities were identified such as welding, assembly, material handling, packing, treatment, pressing, cutting, etc.

*4.2.3 Determine the time required for each activity for each product using MOST*. Time consumed by an activity is different for different products. For example, buffing is an activity. But the time required for buffing process is different for different products depending upon the different parameters. Therefore, time equations are framed for each activity. For time equation of an activity, each activity is divided into sub-activity based on each variant. The time required for each activity and for its every variant is determined using MOST analysis. Kaplan and Anderson (2007), Siguenza-Guzman *et al.* (2013), Chiarini (2014), Everaert *et al.* (2008) and de Arbulo *et al.* (2012) gave a general time equation for an activity as a function of potential factors differentiating this activity, which is expressed as follows:

$$T_A = \beta_0 + \beta_{A1} X_{A1} + \cdots + \beta_{An} X_{An}, \quad (1)$$

where $T_A$ is the time needed to perform an activity $a$; $\beta_0$ the standard time for performing the basic activity a from the MOST analysis; $\beta_{A1}$ the estimated time for the incremental activity $i$ from MOST analysis ($i = 1, 2, \ldots, n$); $X_{A1}$ the quantity of incremental activity $i$ ($i = 1, 2, \ldots, n$); and $A$ is the activity symbol.

Time equations are suitable for standard activities like drilling, punching and notching. The standard activities are having the standard operating procedure (SOP). But there is no SOP for non-standard activities like repairing or rework. Hence, it is difficult to construct a time equation for non-standard activities. MOST analysis is carried out to determine the time required for an activity. For MOST analysis, each activity is divided into sub-activities. Then, each sub-activity is further divided into elements. These elements are arranged in a sequence model. For example, buffing activity is divided into sub-activities such as fixed activities, applying chemical activity and buffing process on the machine. Each division of activity is based on the variation that is affecting the time of the activity. Then "fixed activity," sub-activity of buffing activity, is divided into elements such as start the m/c, get the material, cleaning of material, put the material aside and stop the m/c (see Table III). After that, for each element, a sequence model is applied. For the element "start buffing m/c," application of sequence model is shown in Table II. This sub-activity is an example of the controlled move. Therefore, sequence model "ABGMXIA" is applied. For each parameter, the index value is accomplished by observing or visualizing the operator's action and selecting appropriate index from the data card given by Zandin (2002). Time taken by each sub-activity in TMU is calculated by using the equation = 10×total index value, where TMU is time measurement unit (1 TMU = 0.0006 min). Time equations of some activities are as shown in Table IV. Microsoft Excel® software package was used for the calculation (see Figure 3) (Tables II–IV).

| Element | Phase of sequence model | Parameter (refer Figure 1) | Phase of element | Index value |
|---|---|---|---|---|
| Start buffing m/c | Get | A1 | Reach to switch | 1 |
| | | B0 | No body movement | 0 |
| | | G0 | Grasp the switch | 0 |
| | Actuate | M1 | Press the switch | 1 |
| | | X1 | Process time | 1 |
| | | I0 | No alignment | 0 |
| | Return | A0 | No return | 0 |
| Total | | | | 3 |
| TMU | | | | 3 × 10 = 30 |
| Time (1 TMU = 0.0006 min) | | | | 0.018 min |

**Table II.** Application of sequence model to an activity

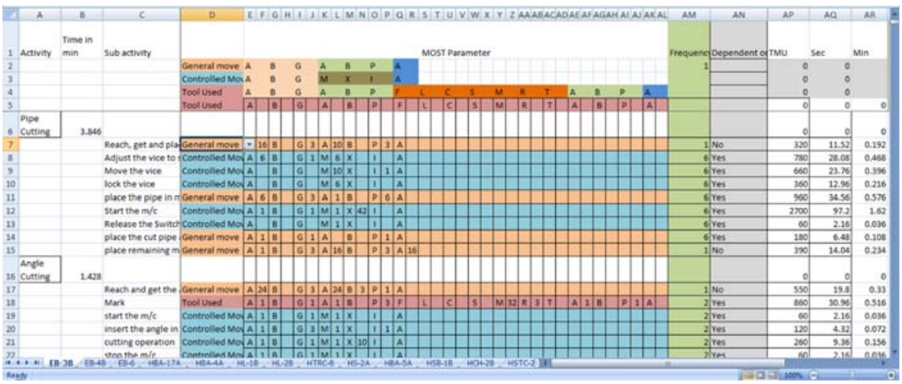

**Figure 3.** Screenshot of Microsoft Excel for MOST analysis

Table III.
MOST analysis of buffing activity

| Sub-activities | Element | Sequence model | TMU | Time in min | Total |
|---|---|---|---|---|---|
| Fixed activity | Start the buffing m/c (refer Table II) | A1B0G0M1X1I0A0 | 30 | 0.018 | 0.282 |
| | Get the material | A3B0G1A3B0P6A0 | 130 | 0.078 | |
| | Cleaning of material | A1B0G1A1B0P6S10A1B0P1A0 | 210 | 0.126 | |
| | Put the material aside | A0B0G0A6B0P1A0 | 70 | 0.042 | |
| | Stop the buffing m/c | A1B0G0M1X1I0A0 | 30 | 0.018 | |
| Applying chemical activity | Get and place the soap | A1B0G1A1B0P3A0 | 60 | 0.036 | 0.084 |
| | Use the soap | A0B0G0M0X6I0A0 | 60 | 0.036 | |
| | Put the soap back | A0B0G0A1B0P1A0 | 20 | 0.012 | |
| Buffing process on the machine | Buffing | A0B0G0M0X620I0A0 | 6,200 | 3.72 | 3.72 |

Table IV.
Time equations for activities

| Activity | Abbreviation for activity | Time equation ($T_A=\beta_0+\beta_{A1}X_{A1}+\cdots+\beta_{An}X_{An}$) | Variable description |
|---|---|---|---|
| Buffing (refer Table III) | B | $0.282+0.084X_{B1}+3.72X_{B2}$ | $X_{B1}$ = number of times chemical is applied<br>$X_{B2}$ = buffing length per feet |
| Coating | C | $0.456+1.442X_{C1}+0.354X_{C2}$ | $X_{C1}$ = number of times the booth is cleaned<br>$X_{C2}$ = surface area per square feet |
| Drilling | D | $0.198+1.008X_{D1}+0.072X_{D2}$ | $X_{D1}$ = number of drills on a work piece<br>$X_{D2}$ = number of times work piece moved |
| Grinding | G | $0.792+1.326X_{G1}$ | $X_{G1}$ = number grinding points |
| Notching | N | $0.1014+0.108X_{N1}+0.567X_{N2}$ | $X_{N1}$ = set parameter in machine<br>$X_{N2}$ = number of operations |
| Pipe bending | PB | $0.39+0.234X_{PB1}+3.192X_{PB2}$ | $X_{PB1}$ = number of change of dies<br>$X_{PB2}$ = number of bends |
| Pipe cutting | PC | $0.426+0.57X_{PC1}$ | $X_{PC1}$ = number of cuts |
| Flat or angle cutting | FAC | $0.666+1.26X_{FAC1}$ | $X_{FAC1}$ = number of cutes |
| Shearing | S | $0.018+0.39X_{S1}+0.624X_{S2}$ | $X_{S1}$ = number of cuts on a sheet<br>$X_{S2}$ = number of sheets used |
| Sheet pressing | SP | $0.33+2.076X_{SP1}+0.162X_{SP2}$ | $X_{SP1}$ = number of bends<br>$X_{SP2}$ = number of alignment of sheet |
| Sheet punching | SPU | $0.108+3.126X_{SPU1}+3.29X_{SPU2}$ | $X_{SPU1}$ = number of die change<br>$X_{SPU2}$ = number of punches |
| Welding | W | $0.245+3.456X_{W1}+0.15X_{W2}+0.21X_{W3}$ | $X_{W1}$ = number of jig used<br>$X_{W2}$ = number of parts placed in jig<br>$X_{W3}$ = per inch welding length |

The normal times obtained from the time equation for all activities are transformed into standard times by considering an allowance factor. As per ILO (Kanawaty, 1992), allowances for personal requirements and basic fatigue were determined. Sample calculation for buffing activity is shown in Table V. The point value is accomplished by observing or measuring the condition and selecting an appropriate point from the data card given by Kanawaty (1992). Then these points are converted into a percentage using standard charts given by Kanawaty (1992). Similarly, allowances are calculated for other activities.

*4.2.4 Calculate the practical capacity of each activity*. Practical capacity of an activity is calculated as the sum of the product of the MOST time of an activity consumed by the product and quantity of a product manufactured. It is represented using the following equation. MOST time of an activity consumed by the product is determined from time equations (see Table IV):

$$PC_A=\sum_{i=1}^{n} T_A \times Q_A, \tag{2}$$

| Type of strain | Points |
|---|---|
| *Physical strains* | |
| Average force (lb) | 10 |
| Posture | 4 |
| Vibration | 1 |
| Short cycle | 0 |
| Restrictive clothing | 0 |
| *Mental strains* | |
| Concentration/anxiety | 0 |
| Monotony | 0 |
| Eye strain | 0 |
| Noise | 2 |
| *Working conditions* | |
| Temperature/humidity | 6 |
| Ventilation | 1 |
| Fumes | 0 |
| Dust | 0 |
| Dirt | 0 |
| Wet | 0 |
| Total points | 24 |
| Relaxation allowance, including tea breaks (%) | 14 |

**Table V.** Calculation of allowances for pipe cutting activity

where $PC_A$ is the practical capacity of an activity; $Q_A$ the quantity of products manufactured; $T_A$ time required to perform an activity for a product (activity-driven factor); and $n$ the number of type of product.

The actual implementation of the matrix shown in Table VII is used for determining the practical capacity of activities. Suppose, the company is manufacturing only three products EB-3B, EB-6 and HBA-17A, then the practical capacity of pipe cutting activity will be 143.55 min. Similarly, for all 332 products, practical capacity of pipe cutting activity is found to be 13,796.2 min (Tables VI and VII).

*4.2.5 Identify various overheads and their cost.* After determining the activities, the overheads of each activity are determined. For each activity, the overheads like building maintenance, depreciation, sludge disposal, etc., are identified. Then the cost of each overhead is taken from the balance sheet of the company.

*4.2.6 Estimate practical capacity of overheads.* Once the overheads and their costs are determined then cost driver for each overhead is identified and capacity of overhead is measured. Cost driver is a unit of quantity of overheads consumed by an activity. For example, cost driver for building maintenance is the floor area of the building. Therefore, practical capacity of the building material is the total floor area available. Similarly, for all other overheads practical capacity supplied is determined. For different overhead, cost driver along with the practical capacity is shown in Table VIII.

*4.2.7 Calculate cost driver rate of overhead.* 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 the following equation. For example, cost driver rate of the building maintenance is 0.91047928 Rs/ft$^2$. It is obtained by dividing amount spent on building maintenance by the total floor area. Cost driver rate of some other overheads is shown in Table IX:

$$CDR_O = \frac{CO_O}{PC_O}, \tag{3}$$

**Table VI.**
Time consumed of activity by product

| Product | Pipe cutting: Time equation (0.426 +0.57$X_{PC1}$) (refer Table IV) ($A$) | Allowance (refer Table V) ($B$) | Time required to perform activity for a product (practical capacity of activity consumed by the product) ($PCA_P$) = $A$×$B$ | Shearing: Time equation (0.018 +0.39$X_{S1}$+0.624$X_{S2}$) (refer Table IV) | Allowance (refer Table V) ($B$) | Time required to perform activity for a product (practical capacity of activity consumed by the product) ($PCA_P$) = $A$×$B$ | Welding: (0.245 +3.456$X_{W1}$+0.15$X_{W2}$+0.21$X_{W3}$) (refer Table IV) | Allowance (refer Table V) ($B$) | Time required to perform activity for a product (practical capacity of activity consumed by the product) ($PCA_P$) = $A$×$B$ |
|---|---|---|---|---|---|---|---|---|---|
| EB-3B | 0.426+0.57×6 = 3.846 min | 0.14 | 4.384 | 0.018+0.39×10 +0.642×1 = 4.56 min | 0.16 | 5.289 | 0.245+3.456×1 +0.15×14 +0.21×32 = 12.521 | 0.17 | 14.64 |
| EB-6 | 0.426+0.57×6 = 3.846 min | 0.14 | 4.384 | 0.018+0.39×13 +0.624×1 = 5.73 min | 0.16 | 6.647 | 0.245+3.456×2 +0.15×28 +0.21×59 = 23.747 | 0.17 | 27.784 |
| HBA-17A | 0.426 +0.57×10 = 6.126 | 0.14 | 6.984 | 0 min (shearing activity not used in manufacturing of this product) | 0.16 | 0 | 0.245+3.456×1 +0.15×17 +0.21×18 = 10.031 | 0.17 | 11.736 |

**Table VII.** Practical capacity calculation for activities

| List products manufactured in industry | Quantity of products manufactured in analysis period ($C$) | Pipe cutting activity: Time required by activity (refer Table VI) ($PCA_P$) | Pipe cutting activity: $D = PCA_P \times C$ | Shearing activity: Time required by activity (refer Table VI) ($PCA_P$) | Shearing activity: $D = PCA_P \times C$ | Welding activity: Time required by activity (refer Table VI) ($PCA_P$) | Welding activity: $D = PCA_P \times C$ |
|---|---|---|---|---|---|---|---|
| EB-3B | 15 | 4.384 | 65.76 | 5.289 | 79.33 | 14.64 | 219.6 |
| EB-6 | 5 | 4.384 | 21.92 | 6.647 | 33.23 | 27.784 | 139.8 |
| HBA-17A | 8 | 6.984 | 55.87 | 0 | 0 | 11.736 | 93.88 |
| Practical capacity of activity for three products | | $\sum D = 143.55$ | | $\sum D = 112.56$ | | $\sum D = 453.28$ | |
| Practical capacity of activity for all products ($PC_A$) (min) | | 13,796.2 | | 61,558.2 | | 209,530 | |

where $CDR_O$ is the cost driver rate of overhead; $CO_O$ the cost of overhead; and $PC_O$ the practical capacity of overhead.

*4.2.8 Identify various consumables and their cost*. Consumables are the goods used by the activity. For example, consumables of welding activity are electrode (mig wire), $CO_2$. Similarly, for each activity consumables are identified. The cost of consumable is from the balance sheet of the company.

*4.2.9 Estimate practical capacity of consumable*. The practical capacity of consumable is measured in terms of used unit. For example, $CO_2$ is purchased in kg. But, its usage on the shop floor is measured in terms of flow rate, i.e. $m^3$. So, the purchase unit is kg and used unit is $m^3/h$. Hence, the practical capacity of $CO^2$ is measured in $m^3$. Similarly, the capacity of other consumables is measured. Practical capacity of another consumable is shown in Table X.

*4.2.10 Calculate cost driver rate of consumables*. A consumable is used in multiple activities. For example, consumable gas (LPG) is used in various activities like gas cutting, gas welding, treatment, etc. Therefore, cost driver rate of consumable is determined to allocate the cost of consumable to the activities. The cost driver rate of each consumable is obtained by dividing the total cost of consumable by the practical capacity of the consumable. It is represented by the following equation. For example, the cost of $CO_2$ is

**Table VIII.** Measurement of the capacity of overhead

| Overhead | Cost driver | How to measure | Practical capacity of overhead ($PC_O$) |
|---|---|---|---|
| Building maintenance | Area ($ft^2$) | Total area floor area | 13,691.69 |
| Depreciation | Cost of the machine (Rs) | Sum of the cost of all machines | 108,178 |
| Sludge disposal | Coating surface area ($inch^2$) | Total surface area coated in a year | 151,825 |
| Insurance of assets | Cost of the machine (Rs) | Sum of the cost of all machines | 108,178 |
| Tax building | Area ($ft^2$) | Total area floor area | 13,691.69 |
| Electricity | Power (kW-h) | Sum of power consumed by each activity | 370.433 |

**Table IX.** Cost driver rate of overhead

| Overhead | Cost of overhead in Rs ($CO_O$) | Practical capacity of overhead (refer Table VIII) ($PC_O$) | Cost driver rate of overhead ($CDR_O = CO_O/PC_O$) |
|---|---|---|---|
| Building maintenance | 12,466 | 13,691.69 $ft^2$ | 0.91047928 Rs/$ft^2$ |
| Depreciation | 242,292 | Rs 10,817,895 | Rs 0.02239733 |
| Insurance of assets | 8,684 | Rs 10,817,895 | Rs 0.00080274 |
| Sludge disposal | 8,631 | 1,518,257.214 $inch^2$ | 0.00568481 Rs/$inch^2$ |
| Tax building | 11,363 | 13,691.69 $ft^2$ | 0.82991946 Rs/$ft^2$ |
| Electricity | 92,140 | 370,433 kW-h | 0.24873594 Rs/kW-h |

**Table X.** Measurement of practical capacity of consumable

| Consumables | Cost driver | Practical capacity of consumable ($PC_C$) | Used unit |
|---|---|---|---|
| Water | Volume of water | 1,003 | $m^3$ |
| Chemical | Weight of chemical | 900 | kg |
| Gas (LPG) | Weight of gas | 3,439 | kg |
| $CO_2$ | Volume of $CO_2$ | 3,600 | $m^3$ |
| Oxygen | Volume of $O_2$ | 870 | $m^3$ |
| Mig wire | Weight of mig wire | 540 | kg |
| Powder | Weight of powder | 1,250 | kg |
| Tool cost | Cost of tools | 513,858 | Rs |

Rs 24,114 and practical capacity is 3,600 $m^3$ then, the cost driver rate of the $CO_2$ is 6.698333333 Rs/$m^3$. Similarly, cost driver rate of another consumable is calculated as shown in Table XI:

$$CDR_C = \frac{CO_C}{PC_C}, \tag{4}$$

where $CDR_C$ is the cost driver rate of consumable; $CO_C$ the cost of consumable; and $PC_C$ the practical capacity of consumable.

*4.2.11 Calculate the cost of the activity*. The cost of the activity is sum of the cost of overhead and the cost of consumable. Cost of overhead is the sum of the product of cost driver rate of overhead and the practical capacity of overhead consumed by the activity. Cost of consumable is a sum of the product of cost driver rate of consumable and the practical capacity of consumable used (consumed) by the activity. The cost of the activity is represented by using the following equation:

$$C_A = \text{Cost of overhead consumed by the activity}$$
$$+\text{Cost of consumable consumed by the activity}$$

$$C_A = \sum_{j=1}^{j} CR_O \times PCO_A + \sum_{k=1}^{k} CR_C \times PCC_A, \tag{5}$$

where $C_A$ is the cost of activity; $PCO_A$ the practical capacity of overhead consumed by the activity; $PCC_A$ the practical capacity of consumable used (consumed) by the activity; $j$ the number of overheads; and $k$ the number of consumables.

In this step, the overhead and consumable costs are allocated to various activities and cost of each activity is determined. For the implementation, list of overheads and consumables used by each activity is prepared along with their cost driver. For example, welding activity uses various overheads and consumables such as building maintenance, depreciation, insurance of assets, building tax, $CO_2$, mig wire, electricity, etc. The cost driver for $CO_2$ and mig wire is welding length, whereas the cost driver for building maintenance, depreciation, insurance of assets and building tax is time. Hence, the cost of welding activity is calculated separately for both the cost driver, i.e. for time and welding length. Sample calculation for the cost of welding for both cost drivers is shown in Table XII. The cost of welding activity for a time as cost driver is Rs 3,059.91 and welding length as cost driver is Rs 14,592.79.

| Resources | Cost of consumable in Rs ($CO_C$) | Practical capacity of consumable (refer Table X) ($PC_C$) | Cost driver rate of consumable ($CDR_C = CO_C/PC_C$) |
|---|---|---|---|
| Water | 12,281 | 1,003 $m^3$ | 12.2442672 Rs/$m^3$ |
| Chemical | 146,290 | 900 kg | 162.5444444 Rs/kg |
| Gas (LPG) | 265,710 | 3,439 kg | 77.26373946 Rs/kg |
| Co2 | 24,114 | 3,600 $m^3$ | 6.698333333 Rs/$m^3$ |
| Oxygen | 6,060 | 870 $m^3$ | 6.965517241 Rs/$m^3$ |
| Mig wire | 10,246 | 97 kg | 105.6288659 Rs/kg |
| Powder | 188,504 | 1,250 kg | 150.8032 Rs/kg |

**Table XI.** Cost driver rate of consumables

**Table XII.** Calculation for the cost of the activity

| Overheads/ consumable | Cost driver rate of overhead (refer Table IX) ($CR_O$) and consumable (refer Table XI) ($CR_C$) | Pipe cutting: Practical capacity of overhead consumed by the activity ($PCO_A$) and practical capacity of consumable used the activity ($PCC_A$) | Pipe cutting: $CR_O \times PCO_A$ or $CR_C \times PCC_A$ | Welding (time): Practical capacity of overhead consumed by the activity ($PCO_A$) and practical capacity of consumable used the activity ($PCC_A$) | Welding (time): $CR_O \times PCO_A$ or $CR_C \times PCC_A$ $G = E \times F$ (Rs) | Welding (welding length): Practical capacity of overhead consumed by the activity ($PCO_A$) and practical capacity of consumable used the activity ($PCC_A$) | Welding (welding length): $CR_O \times PCO_A$ or $CR_C \times PCC_A$ $G = E \times F$ (Rs) |
|---|---|---|---|---|---|---|---|
| | ($E$) | ($F$) | $G = E \times F$ (Rs) | ($F$) | | ($F$) | |
| Building maintenance | 0.91047928 Rs/ft$^2$ | 400 ft$^2$ | 364.191712 | 500 ft$^2$ | 455.24 | 0 | 0 |
| Depreciation | Rs 0.02239733 | Rs 213,750 | 4,787.42929 | Rs 55,000 | 1,231.85 | 0 | 0 |
| Insurance of assets | Rs 0.00080274 | Rs 213,750 | 171.585675 | Rs 55,000 | 44.1507 | 0 | 0 |
| Tax building | 0.82991946 Rs/ft$^2$ | 400 ft$^2$ | 331.967784 | 500 ft$^2$ | 414.96 | 0 | 0 |
| Tool cost | Rs 1 | Rs 55,364 | 55,364 | 0 | 0 | 0 | 0 |
| Electricity | 0.24873594 Rs/kW-h | 3,007.2 kW-h | 747.998719 | 3,673.4 kW-h | 913.707 | 0 | 0 |
| Mig wire | 105.6288659 Rs/kg | 0 | 0 | 0 | 0 | 97 kg | 10,246 |
| $CO_2$ | 6.698333333 Rs/m$^3$ | 0 | 0 | 0 | 0 | 648.936 m$^3$ | 4,346.791 |
| Cost of activity ($C_A = \sum_{j=1}^{j} CR_O \times PCO_A + \sum_{k=1}^{k} CR_C \times PCC_A$) | | | Rs 61.767.18 | | Rs 305,9.91 | | Rs 14,592.79 |

*4.2.12 Calculate the cost driver rate of activities*. The cost driver rate of activity is determined by dividing the cost of activity by practical capacity of a respective activity. It is represented by the following equation:

$$CDR_A = \frac{C_A}{PC_A}, \tag{6}$$

where $CDR_A$ is the cost driver rate of activity and $PC_A$ the practical capacity of activity.

The cost driver rate for some of the activities is shown in Table XIII. For example, cost driver rate of welding (time) activity is the division of cost of welding activity Rs 3,059.91 and practical capacity of welding activity 209,530 min. So, the cost driver rate of treatment activity is 0.0146 Rs/min. Cost driver of the welding (welding length) activity is a length of total welding over an analysis period. Therefore, the practical capacity of this activity is 4,776,350 inches and cost driver rate is 0.003055 Rs/inch.

The cost driver rate for the activities like re-treatment is considered the same that of the treatment activity, because treatment and re-treatment are the same activity. Re-treatment is separated from treatment so that rework caused by poor quality can be determined, and to consider this cost of rework in the costing.

*4.2.13 Determine the practical capacity of activity consumed by the product*. In TDABC time is used as a cost driver. Therefore, the practical capacity of activity consumed by the product is measured in terms of time. Its value is obtained from the time equation (see Table VI). But, the welding activity has two cost drivers, i.e. time and welding length. Therefore, practical capacity of the welding (welding length) activity is the total welding length of the product and practical capacity of the welding (time) activity is time.

*4.2.14 Determine the cost of activities consumed by the product*. The total cost of each activity consumed by a product is calculated as the sum of multiplication of cost driver rate of each activity by the practical capacity of activity consumed by the product:

$$C_P = \sum_{m=1}^{m} CDR_A \times PCA_P, \tag{7}$$

**Table XIII.** Cost driver rate of activities

| Activity | Cost driver | Cost of activity in Rs (refer Table XII) ($C_A$) | Practical capacity of activity consumed by the product ($PCA_P$) | Cost driver rate an activity ($CDR_A = C_A/PCA_P$) |
|---|---|---|---|---|
| Buffing | Time | 2,358.99 | 9,934.46 min | 0.23745 Rs/min |
| Coating | Time | 201,644 | 196,647 min | 1.02541 Rs/min |
| Drilling | Time | 13,831.7 | 35,696.1 min | 0.38749 Rs/min |
| Grinding | Time | 21,280.2 | 16,451.2 min | 1.29353 Rs/min |
| Notching | Time | 8,156.42 | 17,362.1 min | 0.46978 Rs/min |
| Pipe bending | Time | 104.424 | 4,484.67 min | 0.02328 Rs/min |
| Pipe cutting | Time | 61,767.18 | 13,796.2 min | 4.4771 Rs/min |
| Shearing | Time | 246,139 | 61,558.2 min | 3.99847 Rs/min |
| Sheet pressing | Time | 1,803.65 | 144,881 min | 0.01245 Rs/min |
| Sheet punching | Time | 450,244 | 70,229.3 min | 6.41105 Rs/min |
| Welding (time) | Time | 3,059.91 | 209,530 min | 0.0146 Rs/min |
| Angle cutting | Time | 3,486.54 | 2,498.3 min | 1.39556 Rs/min |
| Bar bending | Time | 6,768.46 | 868.19 min | 7.79605 Rs/min |
| Treatment | Time | 9,737.23 | 151,118 min | 0.06443 Rs/min |
| Treatment (surface area) | Surface area | 252,763.66 | 2,015,593.575 $inch^2$ | 0.125404 $Rs/inch^2$ |
| Coating (surface area) | Surface area | 188,504 | 2,015,593.575 $inch^2$ | 0.093523 $Rs/inch^2$ |
| Welding (welding length) | Welding length | 14,592.79 | 4,776,350 inch | 0.003055 Rs/inch |

where $C_P$ is the total cost of activity consumed by the product; $PCA_P$ the practical capacity of activity consumed by the product; and $m$ the number of activities.

Cost for each activity is calculated by multiplying cost driver rate of activity with a practical capacity of activity consumed by the product. For example, the practical capacity consumed (i.e. time consumed) by "EB-6" for grinding activity is 5.3343 min and cost driver rate is 1.29353 Rs/min. Therefore, the total cost of grinding activity consumed by product is Rs 6.898952 which is the multiplication of 5.3343 min and 1.29353 Rs/min. The total cost of activity consumed by the product is Rs 164.7524, which is the sum of the cost of activities consumed by the product. It is shown in Table XIV.

*4.2.15 Final cost calculation.* The final cost of the product is the sum of the cost of each activity consumed by a product, direct expenses and the total cost of overhead consumed by the product (see the following equation):

$$\text{Product cost} = \text{Total cost of each activity consumed by a product} + \text{direct expences}. \tag{8}$$

Cost of product is the sum of the cost of each activity consumed by the product, direct labor cost, direct material cost and the overhead cost consumed by the product. So, in this case study, the total cost of the product is Rs 5,700.682. Product cost calculation of EB-6 is shown in Table XV.

| Product | Activity | Cost driver | Practical capacity of activity consumed by the product (refer Table VI) ($PCA_P$) | Cost driver rate of an activity (refer Table XIII) ($CDR_A$) | Cost of activity consumed by the product in Rs ($H = PCA_P \times CDR_A$) |
|---|---|---|---|---|---|
| EB-6 | Coating | Time | 41.6053 min | 1.02541 Rs/min | 42.66249 |
| | Drilling | Time | 17.5925 min | 0.38749 Rs/min | 6.816918 |
| | Grinding | Time | 5.33343 min | 1.29353 Rs/min | 6.898952 |
| | Notching | Time | 1.035 min | 0.46978 Rs/min | 0.486222 |
| | Pipe bending | Time | 2.64096 min | 0.02328 Rs/min | 0.061482 |
| | Pipe cutting | Time | 4.26906 min | 4.4771 Rs/min | 19.11301 |
| | Bar cutting | Time | 4.384 min | 0.09643 Rs/min | 0.422749 |
| | Flat cutting | Time | 6.2721 min | 0.02117 Rs/min | 0.13278 |
| | Dispatch | Time | 3.47368 min | 0.21309 Rs/min | 0.740206 |
| | Angle cutting | Time | 1.1454 min | 1.39556 Rs/min | 1.598474 |
| | Shearing | Time | 6.647 min | 3.99847 Rs/min | 26.57783 |
| | Sheet pressing | Time | 3.61224 min | 0.01245 Rs/min | 0.044972 |
| | Sheet punching | Time | 1.83158 min | 6.41105 Rs/min | 11.74235 |
| | Welding (time) | Time | 27.784 min | 0.0146 Rs/min | 0.405646 |
| | Welding (welding length) | Welding length | 406 inch | 0.003055 Rs/inch | 1.24033 |
| | Recoating | Time | 2.68421 min | 1.02541 Rs/min | 2.752416 |
| | Flat punching | Time | 2.1942 min | 1.34976 Rs/min | 2.961643 |
| | Assembly | Time | 195.91579 min | 0.0031 Rs/min | 0.607339 |
| | Bar bending | Time | 2.19744 min | 7.79605 Rs/min | 17.13135 |
| | Spot welding | Time | 10.7712 min | 0.16844 Rs/min | 1.814301 |
| | Store | Time | 3.47368 min | 1.44101 Rs/min | 5.005608 |
| | Tacking | Time | 9.9 min | 0.00619 Rs/min | 0.061281 |
| | Treatment | Time | 17.3684 min | 0.06443 Rs/min | 1.119046 |
| | Treatment (surface area) | Surface area | 65.56965 inch$^2$ | 0.125404 Rs/inch$^2$ | 8.222696 |
| | Coating (surface area) | Surface area | 65.56965 inch$^2$ | 0.093523 Rs/inch$^2$ | 6.13227 |
| | Total cost of activity consumed by the product ($C_P$) | | | | Rs 164.7524 |

**Table XIV.** Total cost of activity consumed by the product

## 5. Result and discussion

TDABC, as the name implies, uses the time to drive resource costs directly to objects such as transactions, orders, products, services and customers. This time is obtained through the time equations. Literature indicates that, in TDABC, time equations are formulated by using direct observation, taking the average time per transaction and interviewing or surveying employees (Kaplan and Anderson, 2007). This approach of TDABC is called as TDABC using standard method.

In the proposed procedure, TDABC is implemented using MOST, which is used for generating time equations. The use of MOST eliminates complicated work of interviewing or surveying for generating time equation and simplifies the work of an industrial engineer. This approach is called TDABC using MOST.

In small-scale industry, it is difficult to measure the practical capacity, as many times, in small-scale industries, a dedicated employee and machine is not available for an activity. An employee performs various activities on various machines. Also, the occurrence of the activity is dependent not only on the availability of machine but also an employee. Furthermore, depending on the product order, some of the activities occur once a while, many times, an activity is performed by a number of employees, also, it is performed by an individual, and there may be a time when the activity will not be performed at all. The proposed approach simplifies the difficulty in measurement of practical capacity by using time equations (refer Table VII).

The approach adopted in this paper for the first time combines TDABC and MOST for the benefit of small-scale industries.

### *5.1 The utility of the output from TDABC using the MOST approach*

*5.1.1 Productivity improvement.* It is observed that, for the majority of the activities, the time required to perform the activities according to MOST analysis is much less than the actual time. Figure 4 shows this comparison between the time obtained from the job card

| Product | Parameters | Amount in Indian rupee |
|---|---|---|
| EB-6 | The total cost of activity consumed by the product | 164.7524 |
| | Direct labor cost | 1,150.65 |
| | Direct material | 4,192.04 |
| | Other overheads (marketing, admin, etc.) | 193.42 |
| The total cost of the product in Indian rupee | | 5,700.682 |

**Table XV.** Total cost of product

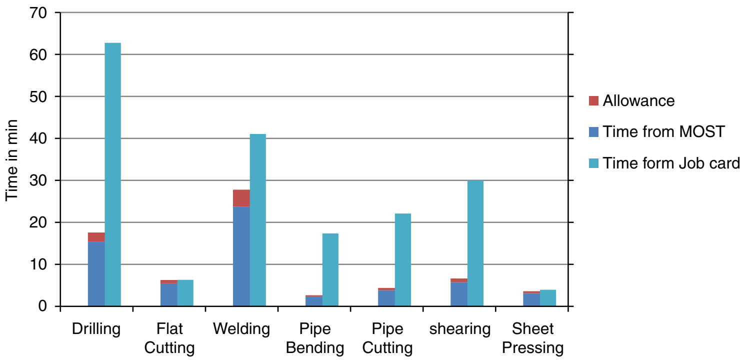


**Figure 4.** Comparison of actual time with MOST time for product EB-6B

and the MOST for the product EB-6B. In this case, the time required for the activities such as drilling, welding, pipe bending, pipe cutting and shearing can be reduced by modifying existing work methods, jigs and fixtures and value stream mapping of the process. For example, the company has prepared the process chat to reduce the time required for shearing activity. Initially, each parameters identified from MOST were critically examined to eliminate or reduce the non-value-adding activities associated with that parameter. In this case, it is observed that the operator was moving a long distance to place the material in the storage rack. This was reduced by placing the storage rack nearer to the machine. So, this small change in workplace layout has reduced the time of activity by 13.9 percent. This reduction in activity time has also reduced the cost of labor. In this way, the productivity of activity is increased and ultimately the productivity of product as well as industry is increased. Similarly, the productivity of other activities is improved.

In this costing system, the practical capacity of activities is measured in terms of labor time, which is obtained from MOST analysis from Table VII. This practical capacity of various activities is plotted on Pareto chart as shown in Figure 5. This identifies welding, assembly, coating and treating as the major time-consuming activities in the company. These activities should be focused first in order to improve the productivity.

The company used the data and analysis in above ways. Based on this work methods are modified, suitable hand tools and devices are incorporated into the workstations and jigs and fixtures designed and introduced. It has led to a conducive and ergonomic work environment and operators performed the tasks rapidly with lower physical fatigue. So, TDABC with MOST for activity analysis resulted in throughout enhancement.

*5.1.2 Profitability analysis*. TDABC helps companies to properly allocate indirect overhead costs on products and produces the meaningful profitability analysis. When this TDABC is implemented in the company, the product cost of traditional costing system and TDABC using standard method is compared with TDABC using MOST. This comparison is shown in Figure 6 and it can be inferred that the cost estimation by traditional costing method is more by 11.27 percent as compared to TDABC using MOST. This difference affects the competitiveness and profitability of the company.

Distribution of overhead cost on different products by TDABC using MOST is shown in Figure 7. This bar chart helps to identify more cost-affecting activities. This information is useful in identifying an area for improvement in order to reduce cost. The contribution of activity cost for product EB-6B is shown in Table XVI. It indicates that coating activity contributes to 25.89 percent of the total overhead cost. Therefore, this activity should be analyzed for reducing the cost to improve the profitability.

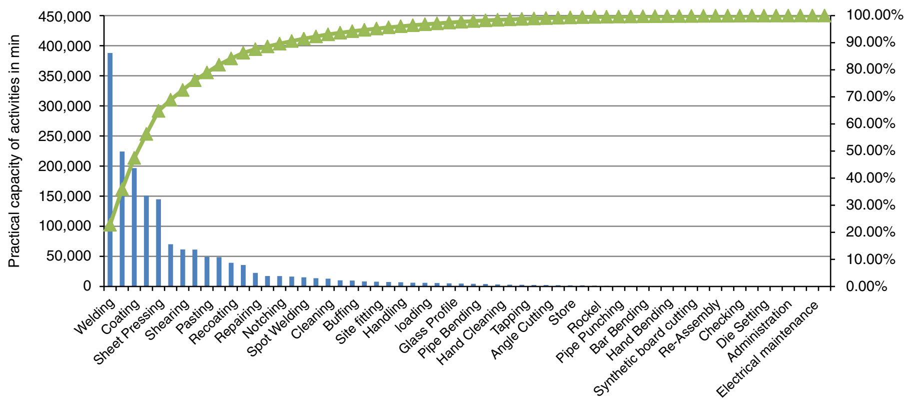


**Figure 5.**
Practical capacity in terms of labor time from MOST

Comparison of cost of activity from TDABC using MOST with TDABC using the standard method for product EB-6 is given in Figure 7. The results obtained from both the approaches are similar. The percentage variation in the cost of the activity varies from 0 to 15 percent. This validates the results of TDABC using MOST.

### *5.2 Benefits to management for appropriate decision making*

Apart from the above analysis, TDABC provides the useful information for decision making:

- Time equations are useful for predicting the time of the activity. This information is useful in production planning and scheduling.
- MOST analysis helps in identifying non-value-adding activities. The difference in time due to non-value-added activity is shown in Figure 4. This helps in improving the productivity.
- It provides the information about the capacity utilization of each activity. Figure 5 shows the practical capacity of each activity. This information is useful for the decision making about investment for improving productivity and future expansion.

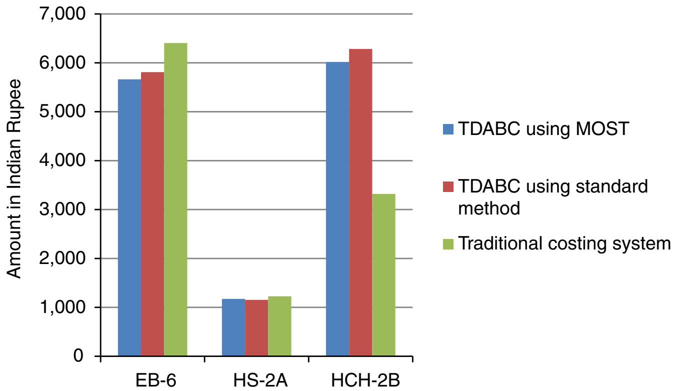


**Figure 6.** Comparison of cost obtained by traditional costing system, TDABC using standard method and TDABC using MOST

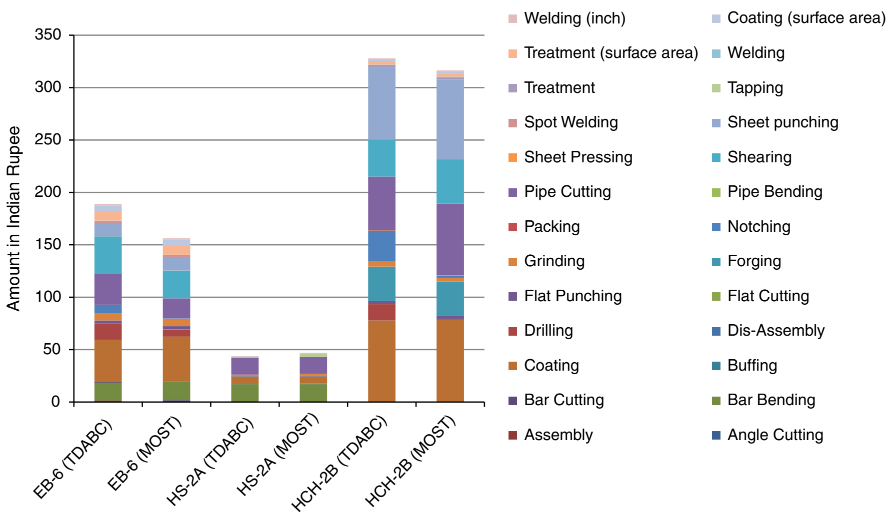


**Figure 7.** Distribution of cost of each activity on different products

Table XVI.
Percentage contribution of activity in total cost of activity for product EB-6

| Sr. No. | Activity | Cost of activity consumed by product EB-6 | Percentage |
|---|---|---|---|
| 1. | Coating | 41.6053 | 42.66 |
| 2. | Shearing | 6.647 | 26.58 |
| 3. | Pipe cutting | 4.26906 | 19.11 |
| 4. | Bar bending | 2.19744 | 17.13 |
| 5. | Sheet punching | 1.83158 | 11.74 |
| 6. | Treatment (surface area) | 65.56965 | 8.22 |
| 7. | Grinding | 5.33343 | 6.90 |
| 8. | Drilling | 17.5925 | 6.82 |
| 9. | Coating (surface area) | 65.56965 | 6.13 |
| 10. | Store | 3.47368 | 5.01 |
| 11. | Flat punching | 2.1942 | 2.96 |
| 12. | Recoating | 2.68421 | 2.75 |
| 13. | Spot welding | 10.7712 | 1.81 |
| 14. | Angle cutting | 1.1454 | 1.60 |
| 15. | Welding (welding length) | 406 | 1.24 |
| 16. | Treatment | 17.3684 | 1.12 |
| 17. | Dispatch | 3.47368 | 0.74 |
| 18. | Assembly | 195.91579 | 0.61 |
| 19. | Notching | 1.035 | 0.49 |
| 20. | Bar cutting | 4.384 | 0.42 |
| 21. | Welding (time) | 27.784 | 0.41 |
| 22. | Flat cutting | 6.2721 | 0.13 |
| 23. | Pipe bending | 2.64096 | 0.06 |
| 24. | Tacking | 9.9 | 0.06 |
| 25. | Sheet pressing | 3.61224 | 0.04 |

- TDABC gives the decomposition of cost consumed by each activity (see Figure 7). This helps in comparing the cost of two or more activities and selecting the most appropriate activity.
- TDABC also identifies the higher cost contributing activities in product cost. These activities are the opportunities for reduction of the cost.
- TDABC provides the cost driver rate for each activity (i.e. unit cost of activity) (see Table XIII) and time equations (see Table IV) and estimates the time of each activity. Using this, the cost of the new product can be easily estimated.
- Also, the effect of cost due to small modification in activity can be easily estimated using time equations and cost driver rate of activity.
- TDABC identifies the overheads and consumables responsible for high cost of the activity (see Table XII). The cost of activity can be reduced by reducing the cost of these overheads.
- TDABC provides the profitability analysis of the product (see Figure 6 and Table XVI). This identifies the higher profit-making products as well as loss making or less profit-making products.

## 6. Conclusion

The implementation of TDABC involves investment in time and money. A cost system based on TDABC using standard method requires organizational changes, employee acceptance, investment in software and hardware, equipment for data collection and surveying. Although TDABC using standard method has been successfully used in many large companies, using the MOST for implementation of TDABC costing system, the risk of implementation can be reduced significantly, because TDABC using MOST does not require a high investment in sophisticated data collection systems as well as organizational restructuring. Hence, TDABC using MOST is more suitable for quick implementation and validation of existing costing system.

As literature indicates, formulating time equations and estimating the practical capacity of activities are one of the most difficult parts of the implementation. The proposed TDABC using MOST system reduces the efforts in designing time equation. The new way of estimating practical capacity using MOST makes implementation easier. Also, MOST provides a detailed analysis of the activities. Therefore, it is easier to update the time equations.

Application of TDABC using MOST in a manufacturing environment, for the first time, has led to the enrichment of literature as follows:

- it has given a pathway to implement TDABC using MOST;
- developed a procedure for fast implementation in TDABC;
- overcomes the difficulties of time equation in implementing TDABC;
- it can be applied in a small-scale organization; and
- data analysis of TDABC using MOST can be used for productivity improvement.

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

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