Chapter
1

Productivity and Work Study

1.1. Introduction

A significant proportion of the Indian population is still struggling for its basic needs: food, shelter, clothes, security and health services. A nation can only raise the level of satisfaction with respect to these basic needs only if the return from resources is maximized or the productivity is improved. Then, the economy will grow and help provide a better quality of life. Productivity at an enterprise is assessed in terms of output of a production variable per unit of input. Fundamentally, it is used to measure the output of resources such as manpower, machinery, materials and money, in producing goods and services or commodities to produce income or profitability. There are ample examples of Japanese manufacturers increasing their productivity, after the Second World War when they faced the dilemma of vast shortage of material and human resources. The problem of Japanese manufacturers was entirely different from their Western counterparts. Later, in the mid-1940s, it was recognized by the president of Toyota Motor Company that American companies were outperforming them by a factor of ten. Therefore, in order to make a move towards rapid movement, Japanese leaders, such as Toyota, Shingo and Ohno devised a new process-oriented approach that is known as the 'Toyota Production System or Lean Manufacturing'. The main objective of this approach is to reduce wastes, which in Japanese terms is called 'Muda' and maximizing the activities that add value to the good or services in the customer's perspective. The term value can be attributed to anything in a product or service for which the customer is willing and ready to pay. The value addition in goods and services will increase the overall profitability of system, company or whole supply chain. According to the ***lean philosophy***, at an organizational level or throughout the supply chain there are three types of activities:

1. Non-necessary and non-value adding activities
2. Necessary but non-value adding activities
3. Necessary value adding activities

The first type of activities that constitutes majority (about 60 per cent) of all the activities, includes internal handling of material at the shop floor or packing and unpacking of semi-finished components and materials. The second category of activities is necessary but does not add value to the goods and services. These contribute about 35 per cent of the total supply chain activities; therefore labelled necessary, non-value adding activities. Example of such activity is cutting of a wire piece and mild steel rod on a machine into a standard size. These cut sizes will further be processed to change into usable goods such as shirt hangers and dumbbell rods, respectively. The third category is the necessary and

value-adding activities, which constitutes merely 5 per cent of the total activities in an organization. Example of such activity is bending the previously cut piece of wire and shaping it in the form of a shirt hanger; similarly, performing operations such as turning, knurling and facing on a lathe machine to make a dumbbell rod. Thus, the value adding activities contribute significantly towards increasing the productivity. Moreover optimizing the necessary but non-value adding activities and reducing to less numbers is also indicator of increased productivity.

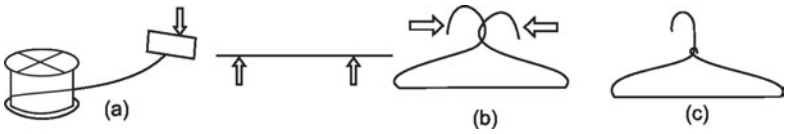

Fig. 1.1: (a) Cutting of wire in standard size, (b) Bending of wire into shape of hanger, (c) Final shape of hanger after paint/plastic coating.

In addition to the above example, there is a case of one small scale foundry unit, which produces a family of hydraulic valves. The manager of the firm was looking after all the operations starting from moulding, pouring, trimming, chipping/chiselling, grinding, etc. The manager observed that the productivity of the firm was lower due to bottleneck at a workstation where the worker was removing the extra metal from the parting line of the casting by using chisel and hammer tools. The manager was much concerned to increase the productivity of that particular workstation, so that the overall productivity could be improved. So, he started looking for better and efficient tools (than the chisel and hammer), so that the bottleneck can be removed. This is one good example of *non-necessary and non-value adding activity*. The manager hired a consultant and asked him for designing better tools or devise new method so that efficiency of the worker can be increased. The manager took the consultant to the live work place; and after that the consultant immediately said that there was no need to design any tools; in fact, there was hardly any need of this operation even. Being surprised the manager asked for the reason. The consultant explained that the actual problem was not due to the tools or efficiency of the workers, but somewhere else, i.e., due to the loose clamping of moulding boxes (cope and drag), the molten metal leaked out at the parting line between the upper and lower moulds. Therefore, before pouring the molten metal into the mould, there was a need to assure that the side clamps were tightly fastened, and if needed extra weight be used so that when the molten metal was poured, the upper half of the mould would not be lifted due to the pressure of the molten metal. Now, the activity like removing the extra metal at the parting line is unnecessary and non-value adding; however, clamping of the moulding boxes is necessary but non-value adding activity. Therefore, the higher productivity is the outcome of value adding activities. The work study is mainly focused upon eliminating the non-value adding activities and improving the efficiency of value adding activities. Nowadays, most of the supply chains or the value chains are focused upon eliminating the non-necessary and non-value adding activities, and optimizing value adding activities.

One of the most important reasons for the decline of an enterprise or a supply chain is low productivity. Failure to achieve the targeted level of productivity leads to the higher cost per unit, hence higher prices and low competitiveness in the market. In the current scenario of a competitive world, many companies are striving to maintain the competeveness in the market. The productivity improvement at the local level cannot solely increase the productivity and profitability of a supply chain. Thus, it is very important to device a competitive strategy that enables not only an individual stage (enterprise) but also the whole supply chain to improve the productivity and profitability.

1.2. Definition of Productivity

Productivity is simply defined as 'the ratio of output to a given input', and represented as follows:

$$\text{Productivity} = \frac{\text{output}}{\text{input}}$$

This definition can be applied to an enterprise, a sector of economic activity or the economy as a whole. The term '**productivity**' is useful to assess or measure the extent to which a certain output can be extracted from a given input. While this appears simple enough in cases where both the output and the input are tangible and can be easily measured, productivity can be more difficult to estimate once intangibles are introduced. Let us elaborate further the meaning of the term productivity with an example as follows:

A handcrafter working eight hours a day produces 800 crafts a month using a traditional old method and can sell each craft for \$2.0; hence, his monitory output value is \$1600/month.

- Let us assume that as a result of a change in the method of work he was able to produce 1000 crafts in a month instead of 800 with the same equipment and hours of work. His productivity calculated in terms of number of crafts produced will then have increased by 25 per cent.
- Now, let us assume that due to 25 per cent surplus production, as a result he was unable to sell all 1000 crafts and had to lower his price from \$2.0 per piece to \$1.80 per piece. If he wants to assess his productivity gain, the crafter may be more interested in using monetary terms rather than using the number of crafts produced. He could then disagree that the value of his output used to be $800 \times 2 = \$1600$ per month and is now $1000 \times 1.80 = \$1800$/ month while his input has not changed. Hence his productivity gain is calculated as follows:

$$\text{Productivity} = \frac{\$(1800 - 1600)}{\$1600} \times 100 = 12.5\%.$$

From this example that is deliberately kept simple, one can make two observations. In the first case, productivity was used to measure increase in output expressed in numbers of crafts produced, although in monetary terms it gives different values in each case. In other words, it can be interpreted that depending upon the interest of an individual in measuring productivity, the nature of the output and input will vary accordingly. Secondly, in this example while actual production increases from 800 to 1000 crafts, productivity in monetary terms does not show the same improvement. This means that we have to differentiate between increased production and increased productivity, which in this example is measured in terms of monetary gains.

Let us continue with our example and assume that the crafter decided to replace his old manual method by an improved technique (machine). This requires an additional cost to him as an investment of \$12,000 which he reckons should be amortized or repaid over ten years. In other words, the cost of this investment will be \$1200 per year for ten years, or \$100 a month. He also would need some supplies and maintenance, which would cost him \$100 a month more than what he would have paid for the wood. Let us also assume that his production remained constant at 1000 crafts a month. Measured in monetary terms, the value of his output is:

$$\text{Production} = 1000 \times 1.80 = \$1800/\text{month}$$

From $1800, $100 will be deducted for capital investment and another $100 for maintenance, which makes a total of $200. Therefore his monetary gain is:

$$\text{Gain} = \$1800 - \$200 = \$1600.$$

In this case, his productivity expressed in monetary gain has not yet improved, while originally he was producing only 800 crafts, he sold them for $2 each, thus arriving at the same monetary digits.

However, the crafter may wish to argue that due to the new technique quality of his crafts has improved, that he will have less rejection level and that the users' satisfaction will increase over time, so that he may be able to increase his price again. Furthermore, his own sense of satisfaction at work has improved, as it has become much easier to operate with the new machine/method. Here, the definition of the output has been enlarged to encompass quality and a relatively intangible factor, that of consumer satisfaction. Similarly, the input now encompasses another intangible factor such as ease in making crafts or satisfaction at the workplace. Thus productivity gains become more difficult to measure accurately because of these intangible factors and because of the time lag that needs to be estimated until or unless satisfaction of end users will permit an increase in prices of the crafts produced with the new technique.

This simple example helps us to understand that there are many interrelated factors affecting the productivity of an organization. Many people have been misled into thinking of productivity exclusively as the productivity of labour, mainly because labour productivity usually forms the basis for published statistics on the subject. At the same time, it is very significant to mention that, in a society or a country, improving productivity or extracting the best possible output from available resources does not mean exploitation of labour, but controlling of all the available resources to stimulate a higher rate of growth that can be used for public betterment, a higher standard of living and an improved quality of life. The detailed productivity issues are beyond the scope of this book, but emphasis is given on work study as it applies to every individual organization.

1.3. Productivity of the Individual Organization

Productivity of an organization may vary as it may be affected by a number of external as well as internal factors. The internal factors are within the control of managers of an enterprise and these basically include the number of limitations within the operations of an organization. The external factors are beyond the control of any employer. These factors comprise availability of raw materials and skilled labour, taxation and tariffs posed by the government, infrastructure in hand, capital availability and interest rates, etc.

1.3.1. The output and input factors in an organization

In a typical enterprise the output is normally described in terms of products/services provided. Therefore, products are articulated in digits and valued based upon the compliance to predetermined quality standards. Whereas in a service firm like a public or private transport company or may be a travel agency, the output is expressed in terms of the services rendered. Therefore, for a transport company, this could be expressed in terms of the number of passengers or tons of load/km carried. However, for a travel agency it could be an average value of tickets per customer. Hence, in order

to achieve the best level of productivity, manufacturing and service enterprises should focus upon consumers' or users' satisfaction, such as number of complaints or rejects.

The enterprise also arranges certain resources or inputs which are used to produce the desired output. These are mainly classified as follows:

1. **Land and buildings:** Land and buildings are constructed or hired in a suitable location.
2. **Materials:** Arrangement of materials that can be converted into saleable products. These include raw materials, semi-finished components and complementary materials that are required for manufacturing and packing of finished products.
3. **Energy:** Energy is one of the vital resources, hence arranged and managed in its various forms such as electricity, solar power and fuel like gas, oil, coal, etc.
4. **Machinery and equipment:** These are required for the various operations of the enterprise. It also includes transport and handling, heating or air conditioning, office equipment, computer terminals, etc.
5. **Manpower:** This includes the arrangement of experienced and trained manpower (male and female) for planning, controlling and carrying out the various process activities, procurement of materials and selling of finished products, maintaining the accounts and other maintenance work.

Over and above, it includes funding and procurement of land, machines, tools, supplies, etc.

1.4. The Role and Responsibility of the Management of an Organization

The management of an organization is accountable for considering that the enterprise resources cited above are combined in the best possible way to achieve the highest productivity. The planning, organizing, directing and controlling these resources and balancing one resource against another are the tasks of the management. If the management fails to do so in an effective manner, the enterprise will fail in the end. In such a case, the five resources become uncoordinated just like the efforts of five horses without a driver and the enterprise a driverless coach that moves forward incoherently, gets held up for lack of material, lack of equipment, because machines or equipments are badly chosen and even more badly maintained, or because energy sources are inadequate or employees unwilling to contribute their best. Figure 1.2 illustrates this management function.

In its quest for higher productivity, an efficiency-minded management acts to influence either one or both of the two factors, the output (i.e., products and services) or the input (i.e., the five resources at its disposal). Thus the management should aim to produce a larger quantity with better quality or higher value products or services with the same input, or it may achieve a better result by changing the nature of the input such as investing in advanced technology, information systems and computers or by using an alternative source of raw material or energy. However, it is very uncommon that one manager or a small team of top managers can by themselves attend to the normal running of an enterprise and at the same time devote enough thinking and energy to the various issues raised in way of improving the productivity. More frequently, they will rely on specialists to assist them in this task, and among them is the work study practitioner. In the subsequent part of the chapter, we shall see how work study and productivity are related.

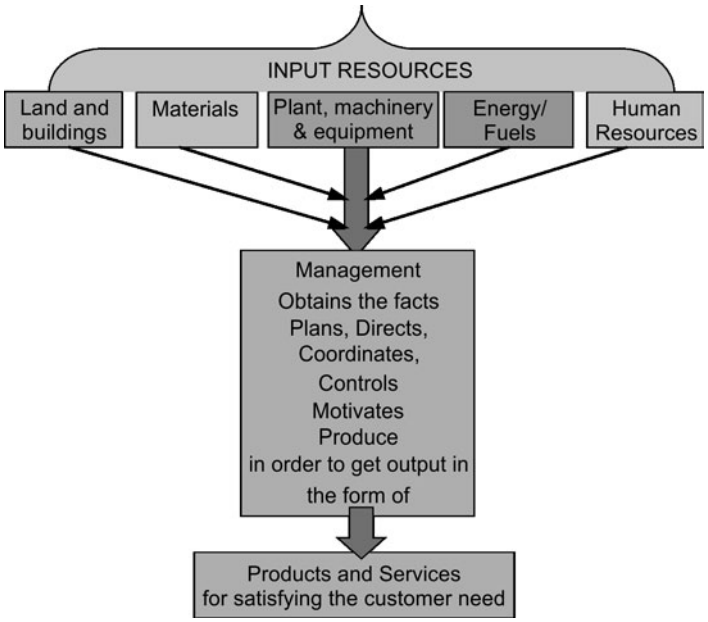

Fig. 1.2: Role and responsibility of management in coordinating the resources of an enterprise.

1.5. Work Study and Productivity

In the previous sections, we pointed out that management regularly calls specialists to help it in improving the productivity. One of the most powerful tools they can use is work study. *Work study is defined as the systematic examination of the existing methods of carrying on activities so as to improve for the effective use of resources and to set up standards of performance for the activities being carried out.*

Work study is mainly focused at investigating the way an activity is being carried out, simplifying or modifying the method of operation to reduce unnecessary non-value adding activities in terms of rework, wastage, and finally fixing the standard time for an activity. Therefore, the relationship between productivity and work study is noticeable. This fact could be understood by a simple example; that if the work–study engineers merely rearrange the sequence or simplify the method of operation with no additional expenses and lower down the time of an activity by 20 per cent, then productivity automatically increases by an equivalent value, i.e., 20 per cent. In order to understand, how work study performs to slash down the time and reduce costs of a certain activity, it is essential to analyze the different constituents of time, i.e., how the total time of a certain job is made up.

The time taken by a worker or a machine to carry out an operation or to produce a given quantity of a certain product is enhanced by the three main constituents as illustrated in Figure 1.3. Ideally, there is a basic work content of the product or operation. The basic *work content* is defined as the amount of work 'contained in' a given product or a process measured in '*work-hours*' or '*machine-hours*'.

A *work-hour* is defined as is the labour of one person for one hour, whereas a *machine-hour* is the running of a machine or part of plant for one hour.

Therefore, the basic work content is the time taken to manufacture the product or to perform the operation in ideal conditions i.e., when everything is perfect be it the design of product or service is perfect, the process or method of operation, and when there is no loss of working time from any other reason during the period of the operation for reasons apart from permissible rest pauses. In other terms, the basic work content is also defined as the irreducible minimum time theoretically required for producing one unit of output.

This is clearly an ideal situation, which is not practical, even though it might sometimes be approached, particularly in line manufacturing or process industries. Generally, actual operation time is relatively very high due to the excess work content.

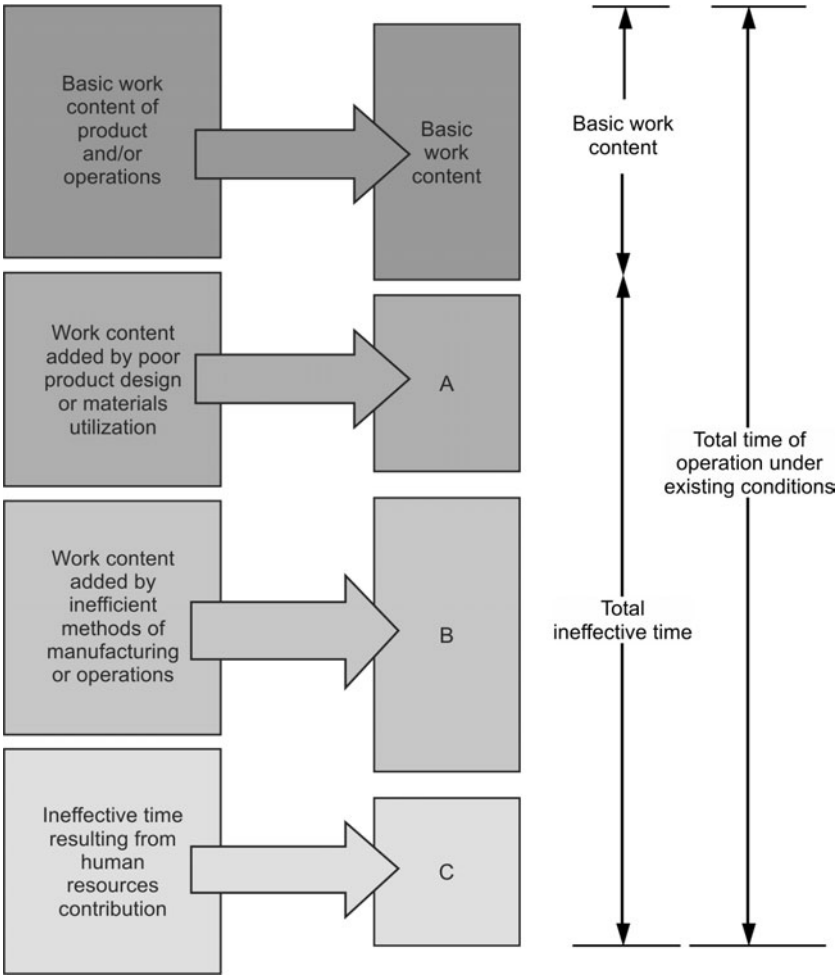

Fig. 1.3: Constituents of operation time.

1.5.1. Work content enhancement

The **work content** is enhanced on shop floor due to different causes; these can be classified broadly into three areas as follows:

A. Design specifications of products and improper utilization of materials
B. Methods of operation or way of doing the operation
C. Human resources or manpower

A. *Work content enhanced due to poor design specification and improper utilization of materials*

There are several ways in which unnecessary time and waste (resulting in higher cost of the product) can be attributed to poor design of the product or its parts, or to incorrect quality control; these are described as follows:

A-1. *Poor design or frequent changes in the design*

This is the situation when the design of a product may require a number of poor quality (non-standard) parts that lead to a long time of assembly. Too many varieties of products and lack of standardization of products/components may demand for the production in small batches, which results in loss of time, as the operator alters from one batch to another.

A-2. *Wastage of materials*

This refers to a situation when the design of the components of a product may demand material removal of too much amount to get them to their final shape. In addition to the wastage of material, this also increases the work content of the job. Hence, the cutting operation specifically need a vigilant examination to watch whether the resulting waste can be minimized or at least reused. For example, a small scale industry is manufacturing dumbbell for health gymnasiums: the bad design of the component (dumbbell rod) requires 5 mm reduction of radius i.e., extra metal to be removed from the work piece (Figure 1.4). Thus the design demands more turning cuts with an appropriate depth of cut. However, if the design is changed and the provision is made for fitting a thick washer with press fitting or joining process, there will be a reduction in wastage of material as well as time.

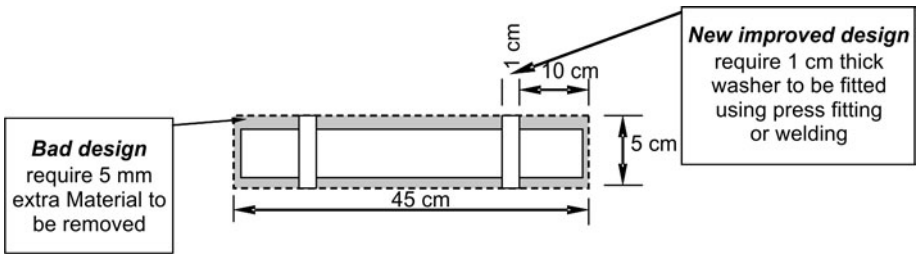

Fig. 1.4: Wastage of material due to bad design of product.

A-3. *Inaccurate quality standards*

The excessively high or low quality standards can result in increased work content. Nowadays in the competitive environment, firms like engineering and automobile industry are moving towards six-sigma standards and thus more emphasis is being given upon high quality of components with tight tolerances, which require extra machining and consequently leading to wastage of materials. On the other hand, e.g., in small scale industry, setting too loose tolerances may result in a large proportion

of rejection. Therefore, deciding on the appropriate quality standard and the method of quality control is one of the significant efficiency deliberations.

B. *Work content added as a result of inefficient methods of operation (B)*

Work content may also be added due to a poor method of carrying out the operations, resulting in unnecessary movements of persons or materials, which result in ineffective time and higher cost. Similarly, such ineffective time can be due to inappropriate methods, material handling, poor maintenance of machinery or equipment resulting in frequent breakdowns, or poor inventory control causing delays because of an absence of products or parts or may be the higher costs as a result of overstocking. Work content increased due to inefficient methods of operations can be mainly attributed to the following six factors:

B-1. *Poor layout design and utilization of space*

Where there is use of space for any operation, there is an investment. Therefore it is very important to ensure proper utilization of space for realizing the reduction in operational cost. This is necessary particularly when a firm is increasing and it requires an increased working area. In addition, a proper layout design of the work place area will also reduce the waste movement, time and effort.

B-2. *Inadequate materials handling*

In a manufacturing firm throughout a production process, materials are always moved from one place to another in the form of raw material, semi-finished components and finished products. The unnecessary movement and handling of materials can be avoided by using the most appropriate handling equipment and can save time and effort.

B-3. *Quick changeover from one product to another*

The proper planning and control of production operations can ensure that one production batch or order immediately follows another so that idle time of machinery, equipment or labour is eliminated or at least minimized. Nowadays, single minute exchange of dies (SMED) is one of the most popular concepts being followed by many enterprisers like hand tool manufacturers, which enables them to reduce the change over time for shift from one component to another.

B-4. *Ineffective method of work*

In an enterprise, there may be a well planned sequence of operations but some or many of them may be done in an awkward way; resulting in unproductive time. Through an examination of operations being carried out and by developing an improved method, the unproductive time can be reduced.

B-5. *Poor planning of inventory*

In each of the operation going on in a firm, raw material is usually ordered and stocked ahead of time. However, in between the various stage of the production operation, semi-finished components and various parts are temporarily stocked as work-in-progress (WIP) material till further processing. All of these inventories correspond to a tied-up investment. This can be minimized by using proper

inventory control systems like MRP (materials requirement planning) and at the same time it will ensure that operators do not run shortage of the necessary material.

B-6. *Frequent breakdown of machines and equipment*

Any enterprise running with poor maintenance policy and practices often faces the occurence of machinery and equipment breakdown and consequently due to waiting for repairs there exists an idle time. This can be corrected by establishing a preventive maintenance system. Moreover augmented maintenance campaigns can also be very fruitful to ensure the smooth running of machines and equipment.

C. *Work content resulting mainly from the contribution of human resources (C)*

Workers in an enterprise can influence the time of operations voluntarily or involuntarily as follows:

C- 1. *Absenteeism and lateness*

In case the administration of a company falls short in providing a safe and satisfactory work conditions, it is quite possible that the workers might respond by absenteeism, lateness or may intentionally work at a slow pace. For example, in a small scale casting industry, the hot humid and dusty environment is inevitable, which may cause health deterioration and hence lead to absenteeism and lateness.

C-2. *Poor workmanship*

Due to the lack of proper training of the workers, the company may experience the poor workmanship, which results in rejections and rework. Losses may also occur in the form of material wastage by such untrained workers.

C-3. *Accidents and occupational hazards*

When a firm fails to provide a safe and healthy work place, the chances of accidents or occupational illnesses increase, which finally affect the morale of and increase absenteeism among employees.

The impacts of all the above mentioned factors (A to C) are shown in Figure 1.5. If these factors can be eliminated, which is an ideal situation and can never happen in real life (as shown in Figure 1.6), there will be minimum input of time and cost for the production of a given output and maximum productivity can be achieved. It is very important to note that the work study specialist has to keep all these factors in his/her mind while examining an operation and to develop an improved method.

1.6. Interrelationship of the Various Methods Used to Reduce Ineffective Time

None of the methods discussed above can be implemented in isolation, since each factor has an effect and is affected by others. It is not possible to plan programmes of work without standards provided by time study. Simultaneously, production planning will become easier if an effective employees' policy and a well-applied incentive schemes are implemented to support and motivate the workers to perform consistently. Standardization of products or parts will reduce the efforts for inventory control as less variety of materials need to be bought and held in stock.