# CHAPTER I

# INTRODUCTION

## 1.1 Background of the Study

Cost reduction tools means managing of limited resource to produce high efficiency. It consists of those actions which are undertaken by manager to reduce cost. Nowadays every organization is facing the challenges of competition. Market is flooded by the products manufactured by different multinational companies. It is a challenging job to achieve success by producing product in low cost with standard quality. Success is not a matter of chance. It is not very hard, if organization use cost reduction tools. So, management of costs by using cost reduction tools is necessary in every business organization.

Cost reduction is different from cost control. Cost reduction, the achievement of real and permanent reduction in the unit cost of goods manufactured or services is rendered without impairing their suitability for the use intended or diminution in the quality of the product. Whereas, cost control is the regulation set up by executive action of costs of operating and undertaking. Cost control is achieved by setting targets of performance, collecting actual cost for each area of responsibility, comparing actual with targets and submitting prompt reports to top management showing deviations from targets. Cost reduction starts when control ends and cost reduction cost has no end. It is a continuous process. Cost control is the function of keeping cost within prescribed limits or establish standard, whereas, cost reduction challenges the standard. Again cost reduction is a corrective function; whereas cost controlling is a preventive function (Dangol, et al. 2066)

Most of the Nepalese manufacturing organizations were already shut down due to high cost involvement. Only qualitative goods cannot be sold due to high cost. So, reduction of cost is very much essential. Most of the Nepalese manufacturing organizations are facing such high cost problem. Main reason of shutting down of Nepalese manufacturing organization is not able to compete with the product of multinational company that produces product in high volume with mass customized product using design for manufacturability an concurrent engineering, lean production and other tools that reduces the cost. But, Nepalese manufacturing organization produces product using old outdated technology in a limited quantity involving high cost. In that condition, Nepalese product could not compete with the product of multinational company. Now this research work is going to explore the reason of failure of Nepalese organizations.

Reduction of cost may be defined as the achievement of real and permanent reduction in the unit cost of goods manufactured or services rendered without impairing their suitability for the use intended or diminution in the quality of the product. Cost reduction, should therefore not be confused with cost saving and cost reduction. Cost saving could be temporary affair and may be at the cost of quality. Cost reduction implies the retention of essential characteristics and quality of the product and thus it must be confined to permanent and genuine saving in the costs of manufacture, administration, distribution, and selling, brought about by elimination of wasteful and inessential element from the design of product and from the techniques and practices carried out in connection therewith.

The essential characteristics and techniques and quality of the products are retained through improved methods and techniques used and thereby a permanent reduction in the unit cost is achieved. The definition of cost reduction does not include reduction in expenditure arising from reduction or similar government action or the effect of price agreements.

## 1.2 Statement of the Problem

Frequent changes in government and their policies have gained less confidence and expectation of the private sector on the one hand and over capitalization bureaucratic system prone to corruption, long time consumption for decision making, political interference and excessive control have discouraged the private sector and hurt public sentiments or confidence on the other hand.

Hence, Nepal has been considered to be the country with limited level of investment climate. The main problem of Nepalese manufacturing organization is incurrence of high cost during the product production process. Due to this, many of the firms are being shut down. It is a very miserable condition for industry as well as nation also.

Most of the organizations think that they have to buy raw materials in very cost from their suppliers. The purchase manager only concerns with this topic. So, other managers show less responsibility towards cost minimization. This is why organizations have to face high cost problem. This is not only one's responsibility. There are so many cost centers in one manufacturing organization. In a cost center, manager alone has the authority to incur costs and is specifically evaluated on the basis of how they well costs are controlled. In many cost centers, revenues do not exist because the organization's unit does not engage in any revenue producing activity. For example the placement center in a university may be a cost center, since it does not charge for the use of its services, but it does incur costs.

All the cost centers involve cost and all the cost centers should be responsible for managing cost. So, management should known that using many cost reduction tools in all the cost centers other than direct bargaining for costs with the suppliers, can reduce cost of goods and services. Lack of well educated human resources and experienced management team are the problem in all Nepalese manufacturing organizations.

In the above context, the research work intends to explore the following questions:

- Do Nepalese manufacturing organizations apply cost reduction tools?
- Does the application of cost reduction tools have effect in the performance of the organization?
- What are the major practical difficulties in adopting the cost reduction tools?

## 1.3 Objectives of the Study

The main objective of the study is to identify and evaluate the application of cost reduction tools in Nepalese manufacturing organizations. The specific objectives are as follows:

- To examine the current state for application of cost reduction tools in Nepalese manufacturing organization.
- To evaluate the impacts of applying cost reduction tools on the performance of Nepalese manufacturing organizations.
- To examine the major practical difficulties in adopting the cost reduction tools

## 1.4 Limitations of Study

Due to resources, time and other factors every task must be limited within a certain area. Similarly, the study had to face the following limitations:

- The study has focused only the manufacturing organizations based in Butwal. It does not include the service sector organization and trading company as well as manufacturing organization located outside the Butwal.
- The research is mostly based upon primary data provided by the respondents. So, the reliability of the conclusion highly depends upon responses of respondents.
- The study is based on the application of selected cost reduction tools only.
- This study is based on the opinion survey conducted on 2012-2013.

## 1.5 Organization of the Study

The research has been categorized into following five main chapters as:

The first chapter is the introductory part of the research which deals with background of the study, statement of the problem, objective of the study and limitations of the study.

The second chapter is related with review of related literature which consists of theoretical as well as empirical review.

The third chapter deals with research methodology which shows the guideline of the research contains research design, population and samples, sources of data, data collection techniques and data analysis tools.

The fourth chapter is the main chapter of the study which is related with data presentation and analysis. In this chapter collected data and information have been properly analyzed with the help of various tools and techniques mentioned in chapter three.

The fifth chapter conducted with summary, conclusion and recommendations for further improvement have been mentioned in chapter five.

At the end of the chapters bibliography and appendices have been incorporated.

# CHAPTER II

# REVIEW OF LITERATURE

In this chapter the researcher has presented the conceptual framework of cost reduction tools and techniques in selected Nepalese manufacturing organizations. In this connection, the researcher has reviewed various literatures in the form of books written by various prominent authors, published newspapers, journals, browsing materials from the concerned websites and encyclopedia, previous dissemination in the relevant subject matters etc.

## 2.1 Conceptual Review

### 2.1.1 Cost Concept

The cost is the Amount which is expenses for production of goods and services or used in operation. When we take any goods or service, we have to pay some amount for that. Organization has to bear various types of costs like variable cost, fixed cost or semi variable cost. Variable cost can be controlled. So, it is also called controllable cost. Since fixed cost can not be controlled it is known as uncontrollable cost. For the operation of Business, cost is required but it should be controlled to earn profit. Different organization should bear different types of costs. For the cost volume profit Analysis, production and operation cost should be segregated in- to variable cost and fixed cost. So every organization should segregate their various types of cost into fixed and variable (Dahal, 2004).

In dictionary we find that cost is price paid to acquire, produce, accomplish or maintain anything volume in mass or quantity of something or amount. In business, retail and accounting, a cost is the value of money that has been used up to produce something and hence, is not available for use anymore. In economics, a cost is an alternative that is given up as a result of a decision. In business, the cost may be one of the acquisitions, in which case the amount of money expended to acquire it is counted as cost. In this case, money is the input that is gone in order to acquire the things. This acquisition cost may be the sum of the cost of production as incurred by the original producer and further cost of transaction as incurred by the acquirer over and above the price paid to the producer (Paudel, 2005)

### 2.1.2 Cost Classification

Classification is the process of grouping cost according to their common characteristics. It is a systematic placement of like items together according to their common characteristics (Dangol, 2005).

Costs are often further described based on their timing or their applicability.

**1. Accounting vs opportunity cost:**

In accounting, costs are the monetary value of expenditure for supplies, services, labor, products, equipment and other items purchased for use by a business or other accounting entity. It is the amount denoted on invoices as the price and recorded in bookkeeping records as an expenses or asset cost basis.

Opportunity cost, also referred to as economic cost is the value of the best alternative that was not chosen in order to pursue the current endeavor- i.e. what could have been accomplished with the resources expend in the undertaking. It represents opportunities forgone. In theoretical economics, cost used without qualification often means opportunity cost (Dangol, 2005)

**2. Private cost, external cost, social and psychic cost:**

Private costs are the costs that the buyer of a good or service pays the seller. This can be described as the cost internal to the firm's production function.

External costs (also called externalities) are the costs that people other than buyers are forced to pay as a result of transaction. The bearer of the such cost can be either particular individual or society at large. Note that external costs are often both non-monetary and problematic to quantify comparison with monetary values. They include things like pollution, things that society will likely have to pay for in some ways or at sometime in the future, but that are not included in transaction prices (Dangol, 2005).

Social cost are the sum of private cost and external costs. For example, the manufacturing cost of car (i.e. the cost of buying inputs, land tax rates for the car plant, overhead cost of running the plant and labour cost) reflects the private cost for the manufacturer (in some ways, normal profit can also be seen as a cost of production, see e.g. Ison and Wall,2007, p 181). The polluted waters or polluted air also created as part of the process of producing the car is an external cost borne by those who are affected by the pollution. Because the manufacturer does not pay for the external cost (the cost of emitting undesirable waste into the commons) and to be external to the market pricing mechanism. The air pollution from driving the car is also an externality produced by the car user in the process of using his good. The driver does not compensate for the environmental damage caused by using the car (Dangol, 2005).

**3. Cost overrun:**

A cost overrun, also known as a cost increase or budget overrun, is an unexpected cost incurred in excess of a budgeted amount due to an under-estimation of the actual cost during budgeting. Cost overrun should be distinguished from cost escalation which is used to express an anticipated growth in a budgeted cost due to factors such as inflation.

When developing a business plan for a new or existing company, product or project, planners typically make cost estimates in order to assess whether revenue benefits will cover costs. This is done in both business and government. Costs are often underestimated resulting in cost overrun during implementation. Main causes of cost underestimation and overrun are optimism bias and strategic misrepresentation (Dangol, 2005).

**4. Manufacturing vs. non-manufacturing cost:**

Manufacturing cost are those costs that are directly involved in manufacturing of product. Example of manufacturing cost includes raw material and charges released to workers and other direct and indirect cost which are involved within the factory. Manufacturing cost is divided into three broad categories.

I. **Direct material cost:**

Direct material cost is the cost of direct materials which can be easily identified with the unit of production. For example the cost of glass is a direct material cost in light bulb manufacturing. The manufacture of products or goods requires material as the prime element. In general, these materials are divided into two categories. These categories are direct materials and indirect materials. Direct materials are also called productive materials, raw material, raw stock etc.

**II. Direct labor cost:**

Direct labor cost is a part of wage bill or payroll that can be specifically and consistently assigned to or associated with the manufacture of a product, or a particular work order or provision of a service also. We can say also it is the cost of work done by those workers who actually make the product on the product line.

**III. Manufacturing overhead cost:**

Manufacturing overhead costs are all manufacturing cost that are related to the cost of object but can not be traced to that cost object in an economically feasible way. Example include supplies, indirect material such as lubricant, indirect manufacturing labor such as plant maintenance and cleaning labor, plant rent, plant insurance, property taxes on the plant, plant depreciation and the compensation of plant managers. Manufacturing overhead includes other costs in manufacturing that are neither direct material costs nor direct labor costs. It might also be referred as the factory burden or production overhead. Its value is essential for determining the cost of products to be manufactured.

Non-manufacturing costs are those costs that are not directly incurred to manufacture a product. Examples of such cost are salary of sales personnel and advertising expenses. Generally non-manufacturing costs are further classified into two categories.

**IV. Selling and distribution costs:**

Selling is offering to exchange something of value for something else. The something of value being offered may be tangible or intangible. The something else, usually money is most often seen by the seller as being of equal or greater value than that being offered for sale. Another person or organization expressing an interest in acquiring the offered thing of value is referred to as a potential buyer or prospective customer. Buying and selling are understood to be two sides of the same coin or transaction. Both seller and buyer engage in a process of negotiation to consummate the sales. It is implied that the selling process will proceed fairly and ethically so that the parties end up nearly equally rewarded. The stages of selling and buying involve getting acquainted, assessing each party's need for the others item of value and determining if the values to be exchanged are equivalent or nearly so, or in buyers terms "worth the price"

Selling cost is the cost of seeking to create and stimulating demand and of securing orders. Distribution cost is the cost of sequences of operations which begins with making the packed product available for dispatch and ends with making the reconditioned returned empty package for reuse, it includes advertising, samples warehousing cost, upkeep and running cost of delivery van (Dangol,2005).

**V. Administrative costs:**

This is general administration cost and includes all expenditures incurred in formulating the policy directing the organization and controlling the operation of and undertaking which is not directly related to production, selling, distribution and research and development functions. It includes account office expenses, audit fees, bank charges, legal expenses, office rent, postage, telephone charge, directors remuneration etc (Dangol, 2005).

**1) Biological cost:**

In biology, the biological cost or metabolic price is a measure of the increased energy metabolism that is required to achieve a function. Drug resistance in microbiology, for instance has a very high metabolic price, especially for antibiotic resistance (Dangol, 2005).

**2) Marginal cost:**

In economics and finance, marginal cost is the change in total cost that arises when the quantity produced changes by one unit. That is, it is the cost of producing one more unit of a good. If the good being produced is infinitely divisible, so the size of a marginal cost will change with the change in volume, as a non-linear and non proportional cost function includes the following:

- Variable terms dependent to volume,
- Constant terms independent to volume and occurring with the respective lot size,
- Jump fix cost increase or decrease dependent to steps of volume increase.

If the cost function is differentiable, the marginal cost is the cost of the next unit produced referring to the basic volume.

MC= dtc/dq

If the cost function is not differentiable, the marginal cost can be expressed as follows:

MC=ΔTC/ΔQ

A number of other factors can affect marginal cost and its applicability to real world problems. Some of these may be considered as market failures. These may include information asymmetric, the presence of negative or positive externalities, transaction costs, price discrimination and others ((Dangol, 2005).

**3) Historical cost:**

In accounting, historical cost is the original value of an economic item. Historical cost is based on the stable measuring unit assumption. In some circumstances, assets and liabilities may be shown at their historical cost as if there had been no change in value since the date of acquisition. The balance sheet value of the item may therefore differ from the true value.

While historical cost is criticized for its inaccuracy, it remains in use in most accounting systems, various corrections to historical cost are used, many of which require the use of management judgment and may be difficult to implement or verify. The trend in most accounting standard is a move to make accurate reflection of the fair or market value, although the historical cost principle remains in use, particularly for assets of little importance.

Under the historical cost basis of accounting, assets and liabilities are recorded of their values when first acquired. They are not then generally restated for changes in values (Dangol, 2005).

**4) Sunk costs:**

In economics and business decision-making, sunk costs are retrospective costs that are already been incurred and cannot be recovered. Sunk costs are sometimes contrasted with prospective costs, which are future costs that may be incurred or changed if an action is taken. Both retrospective and prospective cost may be either fixed or variable.

In traditional microeconomic theory, only prospective costs are relevant to an investment decision. Traditional economics proposes that an economic actor not let sunk costs influence one's decision, because doing so would not be rationally assessing a decision exclusive in its own merits. The decision maker may make rational decisions according to their own incentives, these incentives may dictate different decisions than would be dictated by efficiency or profitability, and this is considered an incentive problem and distinct from a sunk cost problem.

Evidence from behavioral economics suggests this theory fails to predict real-world behavior. Sunk costs greatly affect actor's decisions, because many humans are loss-averse and thus normally act irrationally when making economic decisions (Dangol, 2005).

**5) Fixed costs:**

In economics, fixed costs are business expenses that are not dependent on the level of goods or services produced by business. They tend to be time-related such as salaries or rents being paid per month and are often referred to as overhead costs. This is in contrast to variable costs, which are volume related. In management accounting, fixed costs are defined as expenses that do not change as a function of the activity of a business within the relevant period. For example, a retailer must pay rent and utility bills irrespective of sales.

Fixed costs are not permanently fixed; they will change overtime, but are fixed in relation to the quantity of production for the relevant period. For example, a company may have unexpected and unpredictable expenses unrelated to production and warehouse costs and the like are fixed only over the time period of the lease. By definition, there are not fixed cost in the long run. Investment in facilities, equipment and basic organization that can not be significantly reduced in a short period of time are referred to as committed fixed costs. Discretionary fixed costs usually arise from annual decisions by management to spend on costlier fixed cost items. Examples of discretionary costs are advertising, machine maintenance and research and development expenditures. In business planning and management accounting, usage of the terms fixed costs, variable costs and others will often differ from usage in economics, and may depend on the intended use. Some cost accounting practices such as activity based costing will allocate fixed costs to business activities, in effect of treating them as variable costs. This can simplify decision making, but can be confusing and controversial (Dangol, 2005).

**6) Variable costs:**

Variable costs are expenses that change in proportion to the activity of a business. Variable cost is the sum of marginal costs over all units produced. It can also be considered normal costs. Fixed costs and variable costs make up two components of total cost. Direct costs, however, are cost that can easily be associated with a particular cost object. However, not all variable costs are direct costs. For example, variable manufacturing overhead costs are variable costs that are indirect costs, not direct costs. Variable costs are sometimes called unit level costs as they vary with the number of units produced. Direct material and direct labor are often referred to as prime costs (Dangol, 2005).

**7) Transaction costs:**

In economics and related disciplines, a transaction cost is a cost incurred in making an economic. For example, most people, when buying or selling a stock must pay a commission to their broker, that commission is a transaction cost of doing the stock deal. Consider buying a banana from a store, to purchase the banana, your costs will be not only the price of the banana itself, but also the energy and effort it requires to find out which of the various banana products you prefer, where to get them and at what price, the cost of traveling from your house to the store and back, the time waiting in line, and the effort of the paying itself, the costs above and beyond the cost of the banana are the transaction costs. When rationally evaluating a potential transaction, it is important to consider transaction costs. When rationally evaluating a potential transaction, it is important to consider transaction costs that might prove significant (Dangol, 2005).

**8) Social cost:**

Social cost, in economics, is generally defined in opposition to private cost. In economics, theorist model individual decision often assumes that individuals consider only the costs they themselves bear when making decisions, not the costs that may be borne by others. If there is a negative externality, then social costs will be greater than private costs. Environmental pollution is an example of social costs that is seldom borne completely by the polluter thereby creating a negative externality. If there is a positive externality, then one will have higher social benefit than private benefits. For example, when a supplier of educational services indirectly benefits the society as a whole but only receives education, the benefits to society of an educated populace is a positive externality. In either case, economists refer to this as marker failure because resources will be allocated inefficiently. In the case of negative externalities, private agents will engage in too little (Dangol, 2005).

### 2.1.3 Cost Reduction

Cost reduction may be defined as an attempt to bring cost down. Cost reduction implies real and permanent reduction in the unit cost of goods manufactured or services rendered without impairing their product suitability for the use intended. The goal of cost reduction is achieved in two ways: i) by reducing the cost per unit and b) by increasing productivity. The steps for cost reduction include elimination of waste, improving operation, increasing productivity search for cheaper materials, improved standards of quality finding other means to reduce costs (Lal, 1996).

Cost reduction programs are directed towards specific efforts to reduce costs by improving methods, work arrangements and products. It is an achievement of real and permanent reduction in the unit cost of goods produced or services rendered without impairing their quality or functional suitability. Thus, the term cost reduction denotes real or genuine savings in production, administration, selling and distribution costs brought about by the elimination of wasteful and inessential elements from the design of the product and from the techniques and practices carried out in connection therewith. The necessity for cost reduction arises when profit margin has to be increased without an increase in the sales turnover i.e. for the same volume of sales, the cost of sales should be reduced (Ojha and Gautam, 2008).

### 2.1.4 Cost Control

Cost control, in a narrower sense, may be thought of as to attain cost goals within a particular operational unit. In a broad sense, cost control includes cost reduction. To automate a procedure by replacing, human resources is an example of cost reduction program without reducing the utility. To exercise control so that desired benefits could be obtained from the given level of expenses. It can be defined as the guidance and regulation by executive action of the costs of operating an undertaking, particularly where such action is guided by cost accounting.

In cost control, the first step is to set up target to be achieved i.e. the goal or objective to be attained. The cost control system guides the organization to reach that goal. For this purpose, budgets or standards are used. These budgets or standards provide the yardstick against which actual cost and performances may be compared. If at any stage, it is noticed that the expenses are showing a trend away from the goal, resulting thereby in a variation from the target, the cost control systems help to regulate this trend and to eliminate the variations. This guidance and regulation is by executive action, i.e. through an action taken by the executive who is responsible for the incurring of the expenditure. It should be clearly understood that a cost accountant by him does not control the expenses. He merely assists in the control of expenses since expenditure can be controlled only by the person who incurs the expenditure. Thus, cost control is the guidance and regulation through an executive action and this executive is exercised in respect of all the expenses incurred in operating an undertaking (Ojha & Gautam, 2008).

### 2.1.5 Cost Management

In management accounting, cost management establishes budget and actual cost of operations, process, departments or product and the analysis of variances, profitability or social use of funds. Managers use cost accounting to support decision making to cut a company's cost and improve profitability. As a form of management accounting, cost accounting need not follow standards such as GAAP, because its primary use is for internal managers, rather than outside users, and what to compute is instead decided pragmatically (Ojha & Gautam, 2008).

Cost management focuses on cost reduction and continuous improvement and change rather than cost containment. Traditional cost control systems tend to be based on the preservation of the status quo and the ways of performing existing activities are not reviewed. The emphasis is on cost containment rather than cost reduction. Indeed, the term cost reduction could be used instead of cost management but the former is an emotive term. Therefore, cost management is preferred. Whereas traditional cost control systems are routinely applied on a continuous basis, cost management tends to be applied on an adhoc basis when an opportunity for cost reduction is identified. Also many of the approaches that are incorporated with the area of cost management do not necessarily involve the use of accounting techniques. In contrasts, cost control relies heavily on accounting techniques (Drury, 2004).

Cost management consists of those actions that are taken by managers to reduce cost, some of which are prioritized on the basis of information extracted from the accounting system. Other action, however, are undertaken without the use of accounting information. They involve process involvements, where opportunity has been identified to perform process more effectively and efficiently and which have obvious cost reduction outcomes. It is important that organizations are aware of all approaches that can be used to reduce costs even if these methods do not really based on accounting information. Organizations should also note that although cost management seeks to reduce costs it should not be at expenses of customer satisfaction. Ideally, the aim is to take actions that will both reduce cost and enhance customer satisfaction (Drury, 2004).

### 2.1.6 Cost Reduction Tools

Manager commonly use the following tools to implement the firms broad strategy and to facilitate the achievement of success on critical success factors, that are lean production, design for manufacturability and concurrent engineering, build-to-order, mass customization, part standardization, total quality management, benchmarking, total quality management, continuous improvement technique (kaizen), Kanban system, activity based costing, reengineering, theory of constraints mass customization, target costing, life cycle costing, balance scorecard etc.

**1. Design for manufacturability and concurrent engineering**:

Design for manufacturability is the process of proactively designing products to optimize all the manufacturing functions such as fabrication, assembly, test, procurement shipping, delivery, service and repair, and to assure the best cost quality, reliability, regulatory, compliance, safety, time to market and customer satisfaction.

Concurrent engineering is the practice of concurrently developing products and their manufacturing process. If existing processes are to be utilized, then the product must be design for the processes. If new processes are to be utilized, then the product and the process must be developed concurrently.

Design for manufacturability and concurrent engineering are proven design methodologies that work for any size company. Early consideration of manufacturing issues shortens product development time, minimizes development cost, and ensures a smooth transaction into production for quick time to market. Quality can be designed in with optional part selection and proper integration of parts, for minimum interaction problems. By considering the cumulative effect of part quality on product quality, designers are encouraged to carefully specify part quality.

Design for manufacturability can reduce costs, since product can be quickly assembled from fewer parts. Thus products are easier to build and assemble in less time, with better quality. Parts are designed for ease of fabrication and commonality with other designs. DFM encourages standardization of parts, maximum use of purchased parts, modular design and standard design features. Designs will save time and money by not having to reinvent the wheel. The result is a broader product line that is responsible to customer needs.

Companies that have applied DFM realized substantial benefits. Costs and time to market are often cut in half significant improvement in quality, reliability, serviceability, product line breadth, delivery, customer acceptance and in general, competitive posture.

In order to design for manufacturability, everyone in product development team needs to: 1) understand how products are manufactured through experience in manufacturing, training, rules, guidelines or multi-functional design teams with manufacturing participation, 2) specifically, design for the processes to be used to build the product you are designing. If the products will be built by standard processes, design teams must understand them and design for them, if the processes are new, then design teams must concurrently design the new processes as they design the product.

Before DFM, the motto was “I designed it you build it”. Design engineers worked alone or only in the company of other design engineers in “The engineering department”. Designs were then thrown over the wall leaving manufacturing people with the dilemma of either objecting or struggling to lunch a product that was not designed for manufacturability. Often this delayed both the product launch and time to ramp up to full production, which is the only meaningful measure of time-to-market.

One way that manufacturability can be assured by developing products in multi-functional teams with early and active participation from manufacturing, marketing even customers, finance industrial designers, quality, services, purchasing, vendors, compliance specialists, lawyers and factory workers. The team works together to not only design for functionality, but also to optimize cost, delivery, reliability, case of assembly, testability, ease of service, shipping, human factors, styling, safety, customization, and various regulatory and environmental compliance.

By the time a product has been designed, only at cost of 8% of the total product budget has been spent. By that time, the design has determined 80% of the cost of product. A key conclusion from this article of Dr Anderson’s “design for manufacturability and concurrent engineering" is that the concept/architecture phase alone determines 60% of the cost. This starts with creative concepts, ideas that hold the biggest potential of all cost reduction ideas. Product architecture determines team composition, technology, part combinations, and off the shelf parts. Further, this phase determines strategies for manufacturing, supply chain, vendors, quality, reliability, service variety, configuration, customization, and derivative products. These decisions determine cost throughout the life of the product. Concept/architecture activities have the highest impact of all cost reduction strategies (Ojha & Gautam, 2008).

**2. On demand lean production:**

Lean production accelerates production while eliminating many types of waste such as setup, excess inventory, unnecessary handling, waiting, low equipment utilization, defects, and rework. Lean production is lean because it provides a way to do more and more with less and less human efforts, less equipment, less time and less space- while coming closer and closer to providing customers with what exactly they want (Ojha & Gautam, 2008).

Lean manufacturing, lean enterprise, or lean production, often simply lean is a production practice that considers the expenditure of resources for any goal other than the creation of value for the customer to be wasteful, and thus a target for elimination. Working from the perspective of the customer who consumes a product or service, value is defined as any action or process that a consumer would be willing to pay for.

Essentially, lean is centered on preserving value with less work. Lean manufacturing is a management philosophy derived from the Toyota production system (TPS). TPS is renowned for its focus on reduction of the original Toyota seven wastes to improve overall customer value, but there are varying perspectives on how this is best achieved. The steady growth of Toyota, from a small company to the world's largest automaker, has focused attention on how it has achieved this.

Lean manufacturing is a variation on the theme of efficiency based on optimizing flow, it is a present day instance of the recurring theme in human history towards increasing efficiency, decreasing waste and using empirical methods to decide what matters, rather than uncritically accepting pre-existing ideas. Lean manufacturing is often seen as a more refined version of earlier efficiency efforts, building upon the work of earlier leaders such as Taylor, or Ford, and learning from their mistakes (Ojha & Gautam, 2008).

Lean production is a prerequisite for build-to-order and mass customization. The key prerequisites of lean production are product line rationalization and standardization, which simplify both the supply chain and manufacturing operations. This will make implementation easier and faster and ensure the success of lean production as well as build-to-order and mass customization. The ability to build mass-customized and standard products on demand is the pay-off for lean production. There are two types of lean production replacement and spontaneous build-to-order. In replacement lean production, parts are common enough to be already built and available to be pulled into assembly from Kanban bins. If not, then parts are made by spontaneous build-to-order with common parts made available through Kanban and the non common parts built on demand from standard raw materials by CNC machine tools or manually from on line instructions (Ojha & Gautam, 2008).

**A. Set up and batch elimination:**

If successive products are to be unique and different there can not be any significant setup delays to get parts change dies and fixtures, download programs, find instructions or any kind of manual measurement, adjusting settings or positioning of parts or fixtures. For a plant to mass customize or spontaneously build-to-order, all product setup must be eliminated, not just the low-hanging or reduce setup "as much as you can". Definition of eliminating of setup means that setup is reduced to the point where it is still feasible to operate efficiently in a batch size of one mode.
Setup and batch elimination steps include:

- Distribute parts at all points of use,
- Eliminate setup,
- Make a setup changes as quickly as possible,
- Consolidate inflexible parts,
- Uses of CNC machine tools that are very versatile tools eliminate setup since programs can be changed quickly and electronically. However physical setup must be eliminated.
- Maximize the amount of dimensional variation done with CNC machine tool.

- Standardize raw work pieces and fixing to eliminate setup,
- Quick and automatic program change,
- Standard cutting tools within tools capability,
- Automatic material feed and eject,
- For unusual and low-volume parts using a CNC machine to "hog out" parts may lower total cost if it avoids a) stocking a high variety of low volume parts or b) complications and delays in the supply chain for low volume costing or molding.
- Manual processing setup: all the above setup elimination strategies apply to manual processing. But a setup applies uniquely to manual assembly is finding and understanding instruction on monitor that instantly and clearly show what is to be done at that area to any product being worked on.
- For parts with unavoidable setup, consolidate parts and arrange Kanban re-supply (Ojha & Gautam, 2008).

**B. The lean supply chain:**

The typical response when suppliers are asked to deliver parts just-in-time to their customers pull signal is to keep building the parts in large batches, try to stock enough in their finished goods inventory, and meter them out "just in time". However, this is not really just in time and it is certainly not conductive to spontaneous build-to-order (BTO). Parts available would depend on the assembler's forecasts, which are becoming increasingly less accurate, and the supplier's inventory which is costly to carry, especially as obsolescence risks increase. There are four basic techniques that contribute to a spontaneous supply chain.

- **Kanban re-supply:**

Parts that qualify for kanban re-supply and the related technique of min/max and bread-truck, can be made in batches as long as the response time and bin size is adequate. Even though parts are made in batches, this still qualifies for a spontaneous supply technique because the batch is made upon the pull signal that the current bin has emptied. Of course, the parts manufacturers may have to implement setup reduction to make small batch production economical. Thus, kanban re-supply avoids the hazards of forecasting the cost and delays of purchasing and the cost and risk of inventory. The re-supply is automatic once the pull signal gets to the supplier.

- **Spontaneous build-to-order of parts:**

For the parts that do not qualify for kanban, suppliers themselves would need to implement spontaneous BTO, so that they could actually build on demand to their customer's pull signals. This is the only way to supply mass customized parts on demand, which may be needed for mass customized products. Spontaneous BTO of parts may require: 1) the development of vendor-partner relationship for suppliers to establish the ability to build parts in any quantity on demand, and 2) versatile information system to process and distribute the necessary information.

- **In-house part fabrication:**

In order for spontaneous BTO to work, all parts and materials must be available on demand. If there are any key parts are not suitable for kanban and no supplier can build them to your pull signal, then you might have to bring those operations in house. Companies that have outsourced certain operation in the interest of focusing on functional "core competencies" may have to re-evaluate their strategies. Unfortunately, most outsourcing is a batch operation which does not lend itself to spontaneous BTO.

If the new core competency is to be spontaneous BTO or mass customization, then the manufacturer will need a complete supply chain that can build products and all their parts on-demand.

- **Strategic stockpiles:**

Strategic stocks may be necessary until one of the above three strategies can be applied. As far as overall inventory strategy is concerned, this could be considered temporarily moving one step backwards after moving twenty steps forwards. Hopefully these parts are standardized and consolidated so that there would be few to stock and each would have a good chance of being used one way or another (Anderson, David, www.google.com).

**C. Flow manufacturing and one-piece-flow:**

If setup can be eliminated or reduced enough to eliminate the need to manufacture in batches then parts, subassemblies, and products can flow one piece at a time. One piece flow may be essential when building to order a wide variety of standard or mass customized products. It also eliminates much of the waste of batch or queue manufacturing, waiting, interruptions, overproduction, extra handling, recurring defects, and other non value-added activities.

- **One piece flow:**

One piece flow has a distinct advantage for assuring quality at the source. First, flow manufacturing eliminates the possibility that recurring defects may be built into several batches before being caught at a downstream inspection step. Second, peoples working in flow manufacturing look for any visible deviation as each part is handed to its customer. Further, if the part does not fit or work in the next operation, the feedback will be immediate leading to quick rectification of the problem. In flow manufacturing, parts may be manually handed to the next station, which may be very close, thus eliminating the need for mechanized conveyance or forklifts, whose aisles may occupy as much space as the production line.

- **U-shaped lines:**

One piece lines are usually sequential, sometimes breaking into parallel routes when needed to balance the line. Rather than laying out “lines” in a literal straight line, it may be advantageous to create a U-shaped line which bends the line into the “U” shape.

- **Machine maintenance:**

In sequential one-piece flow, when one production machine breaks down, the whole line will go down. Therefore, proactive equipment is important to prevent unexpected production interruptions. A good TPM program should assure this. Inventory buffers may give an allusion of protection but may still require special measures to recover. Equipment maintenance can be more responsive and less costly with standardization of all replaceable parts, belts, motors, fuses, controllers etc.

- **Line balancing:**

Ideally, to achieve optimal machine tool and work station utilization, one-piece flow lines should be balanced so that the time to do the required tasks at each station, called the task time, is fairly constant.

- **Cellular manufacture:**

Flexible operations work best with dedicated cells or lines for every product family. Cells can be permanently configured so that within a product family all setup has been eliminated. This strategy work best with many simpler dedicated machines instead of a single “mega machine”, unless the mega machine can handle a very large family enough to justify its expense. In some cases older or obsolete machines may be used to provide complete set of machines for the cell, this was one of the solutions covered “Eli Goldraft’s The Goal”. Remember that speed or capacity may be as important as flexibility. Total cost analysis must be used taking into account all related overhead costs in addition to the usual material and processing cost. In some cases, cells may be installed even if the cell alone cannot be justified by traditional analysis but if the cell completes a valuable plant capability like build to order. The guiding strategy for cell design is flexibility and setup elimination (Ojha & Gautam, 2008).

### D. Results of setup elimination and batch size of one flow:

Eliminating setup itself can:

- Decrease throughput time to approach the labor standard
- Elimination setup delays on expensive equipment and thus improve machine tool utilization,
- Save setup labor costs,
- Eliminate inspection time and scrap costs verifying the first parts made after setup,

In addition, batch size of one flexibility can:

- Allow build to order and mass customization,
- Allow dock-to-stock part delivery, thus eliminating inventory cost and delays of incoming inspection and logging in parts.
- Eliminate the penalties of kitting.

In addition, one piece flow can:

- Improve quality with rapid feedback to catch and rectify quality problems fast. Large batches of parts can all be made with the same defect so that many parts will have to be scrapped or reworked,
- Eliminate forklift including the labor, equipment and floor space for the aisles,
- Foster psychological, improve job satisfaction, relieve boredom and encourage continuous improvement.

In addition, eliminating WIP inventory can:

- Eliminate WIP inventory carrying cost = 25% of value of inventory per year,

- Cut floor space needs in half. This is especially important in times of growth, but floor space savings should always be assigned a value to encourage more efficient utilization of space (www.google.com).

### E. Cost reduction potential for lean production:

Former MIT researcher James p. Womack and Daniel T. Jones, authors of the definitive book on the subject “lean thinking”, summarize the corporate benefits of lean production as follows:

Based on years of benchmarking and observations in organizations around the globe, we have developed the following simple rules of thumb: converting a classic batch and queue production system to continuous flow with effective pull by the customer will:

- Double labor productivity all the way through the system (for direct, managerial and technical workers, from raw materials to delivered product),
- Cut production throughput times by 90 percent,
- Reduce inventories in the system by 90 percent,
- Cut in half errors reaching the customer and scrap within the production process,
- Cut in half job related injuries,
- Cut in half time to market for new products,
- Offer a wider variety of products, within product families, at very modest additional cost,
- Reduce capital investments required to very modest, even negative, levels if facilities and equipment can be freed up or sold.

Firms having completed the radical realignment can typically double productivity again through incremental improvements within two to three years and halve again inventories, errors and lead times during this period (Ojha & Gautam, 2008).

## 3. Build to order:

Build to order is the capability to quickly build standard or mass-customized products upon the receipts of spontaneous orders without forecast of inventory or purchasing delays. These products may be shipped directly to individual customers to stores or dealers or as a response to assemblers "pull signals".

Similarly, your suppliers may need to use build to order to respond to your pull signals, which is a key element of flow manufacturing, and yet, if suppliers cannot actually build parts on-demand, then they will be tempted to meter them out from inventory, in essence, transferring your parts inventory to their finished goods inventory ((Ojha & Gautam, 2008).

### A. Build to order strategy:

The basic strategies for implementing build-to-order are supply chain simplification, concurrent design of versatile products and flexible processes, the mass customization of variety and the development of a spontaneous supply chain. Build-to-order can actually build products on demand at less cost than mass produced batches, if cost computed as total cost. Therefore, total cost measurements should also be part of this process (Ojha & Gautam, 2008).

### B. Supply chain simplification:

The simplification steps for supply chain management are standardization, automatic resupply techniques and rationalization of the product line to eliminate or outsource the unusual low volume products that contribute to part variety way out of proportion to their profit generation ability. The goal of supply chain simplification is to drastically reduce the variety of parts and raw materials to the point where these materials can be procured spontaneously by automatic and pull-based resupply techniques. Reducing the part and material variety will also shrink the vendor base, further simplifying the supply chain.

- **Part variety reduction**:

Drastic reduction in existing part variety are possible through product line rationalization which eliminates or outsources products and product variations that are problem prone, do not fit into a BTO/ e-commerce environment, have low sales, have excessive overhead demands, are not really appreciated by customer, have limited future potential or may really be losing money. Eliminating old technology products can eliminate whole categories of part and suppliers. Not only is rationalization an important prerequisite for spontaneous BTO, as a standalone program, it can have the immediate benefits of raising profits and freeing valuable resources to implement e-commerce and spontaneous BTO programs.

Part variety can also be reduced by designing new products around standard parts, using an effective zero-based standardization approach developed by the author. One of these techniques is to eliminate separate categories of parts for various tolerances and strengths.

- **Raw material variety reduction**:

Too many types of raw material can thwart spontaneity and make the manufacturer have to choose between stocking of all types or ordering them and waiting for delivery. The solution is to aggressively standardize incoming raw materials which are then cut into various shapes by programmable CNC equipment, such as laser cutters and screw machines. The ultimate scenario for spontaneous BTO is to reduce the number of raw material types within each category to one, in which case "ordering" material is as simple as matching the tonnage into the tonnage out, so a steady flow of materials can be negotiated. Such purchasing leverage and other material overhead savings would compensate for any cut-off waste and for some products getting "better" material than you need. As raw material variety is reduced, it becomes more feasible to use automatic resupply techniques, like Kanban, Min/Max or Breaktruck.

- **Automatic resupply:**

If the above steps are successful in reducing part and material variety, then much, maybe all, of the procurement can be automatic based on demand, without the need of MRP or purchase orders through Kanban, Min/Max, and Breadtruck supply.

Kanban is a versatile technique that enables automatic resupply of parts that can be made in batches or have not-quite spontaneous delivery times.

A related concept is the Min/Max technique, often used for raw material like sheet metal, where material consumed until the stack reaches the 'Min" level, usually marked on the rack or wall. This triggers a reorder of the material to bring it up the "Max" level.

The easiest and lowest hanging fruit in material logistics is the breaktruck delivery system for small, inexpensive parts like fasteners. Instead of counting on forecasts to trigger an MRP system to generate purchase orders, all the “jelly bean” parts can be available in bins at all the points of use. A local supplier is contracted to simply keep the bins full and bill the company monthly for what has been used, much like the way bread is resupplied by the bread truck in a small market ((Ojha & Gautam, 2008).

**C. Seasonal products:**

Although lean/flow production works best for level demand, spontaneous build-to-order techniques can accommodate seasonal demands better than stock piling finished goods inventory with all the associated inventory cost and risk of building products that may not sell. The first effort would be to try to level demand with off-season incentives based on actual difficulties in total cost. For the remaining seasonal variations, seasonal products can be manufactured on-demand with a minimum of part inventory and risk with industry specific strategies that include the following:

- Developing industry specific supply chain and operational strategies,
- Reducing labor content and maximizing plant output with design for manufacturability,
- Reducing part and material variety with standardization,
- Leveling part production by standardizing on parts and modules that can be used on out of phase seasonal products, such as the same engines, power train elements, electrical systems for both snow removal with lawn mowing products even if manufactured in different plants or for different companies.
- Optimizing fabrication flexibility and output with CNC machine tools,
- Developing selective part stocking strategies based on variety, cost, size and demand uncertainty (Ojha & Gautam, 2008).

**D. Concurrent engineering of versatile products and flexible production:**

Existing products designs may not be suitable for spontaneous BTO or mass customization. There may be too many different products and thus, too many different parts to distribute at all the points of use. Even within any group of products, there may be a needless and crippling proliferation of parts and materials. The specified parts may be hard to get quickly. The products and processes may have too many setups designed in quality may not be designed into the products/processes which results in disruptions when failures loop back for correction. The product/process design may not make optimal use of CNC as most CNC equipment is used in a batch mode, not flexibly.

To be successful at designing products for spontaneous BTO, product development teams must proactively plan product portfolios for compatibility with spontaneous BTO operations, design product in synergetic product platforms, design around aggressively standardized parts and raw materials, make sure specified parts are quickly available, consolidate inflexible parts into very versatile standardized parts, assure quality by design with concurrently designed process controls, and concurrently engineered product platforms and flexible flow-based processes.

Further, product development teams need to eliminate setup by design by specifying common tools, designing versatile fixtures at each workstation that eliminate setup to locate parts or change fixtures and making sure part count does not exceed available tool capacity or space at each work station. Finally, products must be designed to maximize the use of available programmable CNC fabrication and assembly tools, without expensive and time consuming, setup delays.

Spontaneous BTO and mass customization depend on flow manufacturing for efficient lot-size of one production. The one-piece flow aspect of flow manufacturing is especially important for e-commerce, since every piece may be different or even customized.

Flow/lean manufacturing is achieved by eliminating all setup, eliminating WIP inventory with one-piece flow, and arranging spontaneous delivery of parts and materials which are delivered to all points of use “dock-to-stock” without the delays and cost of incoming inspection. To accomplish this, suppliers need to be certified to assure quality at source. Another aspect of flow manufacturing is the dedicated cell or line, which may be arranged to build any variation within a product family without any setup. Each cell has a complete set of “right-sized” inexpensive machines. Utilizing older machine, that have been made “obsolete” by centralized “mega-machines” is a very cost-effective way of building complete cells. The fact that cells consist of dedicated equipment occupying dedicated space often makes this incompatible with outsourcing, unless the outsourcer is strategic partner willing to make this type of commitment. This can become a effective strategy for established companies to compete with "virtual manufacturing" web based startups (Ojha & Gautam, 2008).

### E. The missing link in e-commerce:

The internet and sophisticated software permit manufacturer to process an endless stream of individual orders almost automatically. Out vast transportation infrastructure can deliver individual orders to stores or customers overnight. What is missing and now needed to support e-commerce is the ability to quickly manufacture individual products on demand.

E-commerce poses several dilemmas for companies operating in the mass production mode. Trying to satisfy spontaneous orders from forecasted inventory is not compatible with the pace and breadth of e-commerce. Forecasting demand is becoming an exercise in futility as markets evolve at internet speed. Batch production is becoming inefficient and less demanding that manufacturers resupply stores rapidly and frequently based on real-time store sales.

Some digital strategies accept the deficiencies of mass production and recommend "the illusion of build-to-order" by searching the web for inventory. On the transportation side, overnight suppliers come to the same conclusions when they recommend that the way to reduce inventory levels is to know where the inventory is and how long it will take to ship it.

Another way that manufacturers try to build to order is to order parts upon the receipt of an order and make the customer wait until the parts come in. This may be acceptable for "big ticket" products like airplanes, test equipment, and production machinery. But this would be a flawed strategy for e-commerce. Since customers are coming to expect product to ship within 24 hours and can quickly scan the web for quicker competitors. Further, industrial suppliers need to be able to build products quickly in response to their customer's pull signals so that they can respond quickly to their customers. A third way to build products to order for e-commerce is to draw parts from forecasted inventory and assemble to order modular products. For this to work, the factory, supplier or distributor must either carry large inventories or be good at forecasting the assembler's demand. Ultimately, the customer must pay for carrying cost of inventory which over the last twenty years has averaged about 25 % of inventory value per year. Not only does inventory raise the product cost and make the product less competitive, but it also makes the product's availability subject to outages and delays. This model has been successful for direct sales to personal computer assemblers because: 1) it is superior to the competitors batch production and dealer distribution, 2) the very high volume can justify building a parts warehouse next to assemble, and 3) the shear velocity of parts through the warehouse minimize much of the cost and risk of inventory. However, the assemble from forecasted parts model works only for modular products and may not be viable at low-to-medium production volumes (Ojha & Gautam, 2008).

**F. Total cost measurement:**

Most of the above steps, viewed narrowly, may appear to be more expensive, and therefore, may be resisted. Rationalization may appear to lower sales, standardization and consolidation may appear to require most products to use better materials than they need. The lack of competitive bidding may appear to raise procurement costs. Reintegrating unfamiliar processes may appear to be less efficient than using specialists, small batches, approaching one and dedicated flow lines using simple equipment may appear to be inefficient from a mass production stand point.

However, these programs will really lower the total cost. Therefore, in order to quantify, comprehend, and justify these programs, implementation needs to include total cost measurement, like activity based costing. Fortunately there are quick and easy ways to implement ABC using cost drivers. Even beyond the total cost return of each of these elements, there is a significant value to the complete system being able to efficiently build standard and mass-customized products on-demand for conventional channels or for the unlimited vista of e-commerce (Ojha & Gautam, 2008).

**Mass customization, the proactive management of variety:**

The old paradigm of mass production is no longer suitable for today's turbulent markets, growing product variety and opportunities for e-commerce. What is needed now is mass customization, which proactively manages product variety in the environment of rapidly evolving markets and products, many niche markets, and individually customized products sold through stores or over the internet.

Mass customization can customize products quickly for individual customers or for niche markets at better than mass production efficiency and speed. Using the same principles, mass-customizers can build-to-order both customized products and standard products without forecasts, inventory or purchasing delays (Ojha & Gautam, 2008)..

**A. The M.C. spectrum:**

There is a whole spectrum of ways that mass customization methodologies can benefit companies. At the most visible end of the spectrum, companies can mass customize products for individual customers. The most well known category of individual customization relates to products that people wear as well as bicycles and pagers.

Further along the spectrum is niche market customization. For instance, a company that makes telephones has only a few customers who want several dozen models in many colors all with many niche market products, usually a different set of products for each country exported, and even if the differences seem minor, the sheer variety of stock keeping units(SKUs) can have significant cost and flexibility implications. Almost all companies could benefit from expansion into niche markets if they could do it efficiently.

At the other end of the spectrum are companies that have tremendous varieties of "standard" products, for instance industrial suppliers of values, switches, instruments, electrical enclosures or any company with a catalog over a half an inch thick. As with product customization, there is a great contrast between how mass producers and mass customizers manufacture a variety of standard products. The mass producer has the dilemma of trying to keep large enough inventories to sell a wide variety of products from stock or alternatively using the slow, reactive process of ordering parts and building products in very small batches after receipt of orders. The mass customizer can use flow manufacturing and CNC programmable machine tools to quickly and efficiently make different products in a "batch size of one" either customized products or any standard product from a large catalog (Ojha & Gautam, 2008).

**B. Mass customization depends on flow manufacturing**:

The trend to smaller bathes, approaching one, is what is pushing savvy manufacturers toward flow manufacturing. Mass customization relies on flow manufacturing to provide the batch size of one capability. Whether manufacturing a wide variety of standard products or individually customized products, mass customizers depend on several elements of flow manufacturing to enable them to build products economically in any order quantity, even as low as one.

Setup and its elimination: being able to build in a batch size of one depends on the elimination of setup, for instance, to get parts, change dies and fixtures, download programs, find instructions or any kind of manual measurement, adjustment or positioning of parts or fixtures. Mass producers are forced to make products in bathes to spread setup costs among as many products as possible. If setup can be eliminated, then products could be made to order as orders come in. This is the essence of spontaneous build-to-order. Setup elimination is also an essential prerequisite for mass customization. Since, every product could be different.

Setup and batches can be eliminated by 1) distributing parts at all the points of use to eliminate the kitting or the batching of parts, 2) eliminating tooling setup with versatile tool plates or tooling that can be changed very quickly, 3) consolidating inflexible parts into very versatile standard parts, for instance, for castings, plastic parts, stamping, extrusions, and bane printed circuit boards, 4) using CNC machine tools to programmably make a wide variety of parts from standard shapes of raw material, and 5) eliminating all setup from manual assembly, such as finding and understanding work instructions by displaying instruction on monitors that instantly and clearly show what is to be done at that workstation to any product being worked on (Ojha & Gautam, 2008).

**C. Spontaneous supply chains:**

In order to build products on demand, mass customization must be able to build parts on demand from materials that are always available. This will require a spontaneous supply chain. The first step in supply chain management must be supply chain simplification.

- **Supply chain simplification:**

The simplification steps for supply chain management are standardization, automatic resupply techniques, and rationalization of the product line to eliminate or outsource the unusual low-volume products that contribute to part variety way out of proportion to their profit generation ability. The goal of supply chain simplification is to drastically reduce the variety of parts and raw materials to the point where these materials can be procured spontaneously by automatic and pull-based resupply techniques. Reducing the part and material variety will also shrink the vendor base, further simplifying the supply chain.

Most products are designed around too many different parts and materials for mass customization. Ironically a rampant proliferation of parts is quite unnecessary, but occurs simply because standardization is not emphasized. Part and material variety can be easily reduced with standardization techniques by one or two orders of magnitude.

A key part of the spontaneous supply chain is automatic resupply techniques such as Kanban, Min-Max, Breadtruck. The simplest version of Kanban uses two bins for each part. After parts are depleted from the first bin, it goes back to its source to be filled and could be made in a batch mode if the combination of setup time, run time and delivery time is short enough to return the new bin of parts before the other bin runs out. Min-max is a similar concept usually applied to stacks of raw material like sheet metal, when the "min" level is reached, this triggers the resupply of enough material to reach the "max" level. Breaktruck or free stock makes small inexpensive parts like fasteners freely available at all points of use, these are resupplied automatically by a supplier who simply keeps the bin full and bills the company monthly. This is much more efficient than issuing expensive purchase orders for parts that may cost pennies parts that qualify can be made in batches as long as the response time and bin size is adequate.

- **Spontaneous build to order of parts:**

For the parts that do not qualify for kanban, suppliers or in-house sources would need to implement spontaneous BTO so that they could actually build on demand to pull signals from assembly. Spontaneous BTO of parts may require the development of vendor-partner relationships for suppliers to establish the ability to build parts in any quantity on-demand (Ojha & Gautam, 2008).

**Designing products for mass customization:**

For fast and easy production, mass customization products should be designed for manufacturability. A key element of DFM is designing for lean production, build-to-order and mass customization. Products should be developed in synergistic product families and be designed around aggressively standardized parts and materials. Designed for no setup, and designed for CNC programmable machine tools.

There are three ways to customize products: modular, adjustable and dimensional customization

- **Modular customization:**

Modules are "building block". Usually modules are literally building blocks that can customize a product by assembling various combinations of modules. Examples of modules would include many components in automobiles engines, transmissions, audio equipment, tine/wheel options etc. in electronics, modules would include processer boards, power suppliers, plug-in integrated circuits, daughter-boards and disk drives. In software, code could be written in modules that can be combined into various combinations.

- **Adjustable customization:**

Adjustments are a reversible way to customize a product such as mechanical or electrical adjustments. Adjustments could be infinitely variable. Discrete adjustments or configurations would represent few choices, such as those provided by electronic switches, jumpers, cables or discrete software controlled configurations. These adjustments and configurations make the product customizable by the factory, by dealers, or by customer. Software can be customized by user-defined settings or by table driven programming in which the software is specifically written to accommodate variables that can be customized by entering customer data into a table.

- **Dimensional customization:**

Dimensional customization involves a permanent cutting-to-fit, mixing, or tailoring. Dimensional customization could be infinite or have a selection of discrete choices. Examples of infinite dimensional customization would include the tailoring of clothing, drilling holes in bowling balls, mixing of paints or chemicals, machinery metal parts, and cutting of sheet metal or wire. Examples of discrete dimensional customization would be hole punching, and soldering selected electronic components onto a printed circuit board. Dimensionally customized parts can be made automatically on CNC equipment running program instructions that are generated on demand from data originates in parametric CAD (Ojha & Gautam, 2008).

**4. Part standardization**

Standardization supports the fundamental percepts of build-to-order and mass-customization. All parts must be available at all points of use, not just “somewhere in the plant” which eliminated the setup to find, load or kit parts. as a stand-alone program, standardization can reduce cost and improve flexibility. Standardization makes it easier for parts to be pulled into assembly by reducing the number of parts types to the point where the remaining few standard parts can receive the focus to arrange demand pull just-in-time deliveries. Fewer types of parts ordered in larger quantities reduce part cost and material overhead cost (KC, 2009)

The practical standardization techniques are presented as follows:

**A. The zero based standardization approach:**

This is very effective technique to reduce the number of different parts by standardizing on certain preferred parts. This usually applied to purchase parts but it could also apply to manufactured parts. The methodology is based on a zero-based principle that asks the simple question, “What is the minimum list of part types we need to design new products?” Answering this question can be made easier by assuming that the company has just entered this product line. One of the advantages of new competitors is the ability to “start fresh” without the old “baggage” too many parts. Just image a competitor simultaneously designed the entire product line around common parts, now image doing the same thing internally. This is called the zero-based approach.

The zero based approach, literally starts at zero and adds only what is needed as opposed to reducing parts from a overwhelming list. An analogous situation would be cleaning out the most cluttered drawer in a desk, a purse, or a glove compartment, removing unwanted pieces would take much effort, and still not be very effective. The more effective zero-based approach would be to empty everything and add back only the items that are essential. Where the “clutter” ends up is the difference in the approaches in the drawer purse or glove compartment or in the garbage can. Similarly, parts reduction efforts have to work hard to remove the clutter in the system, whereas zero-based approaches exclude the clutter from the beginning. The clutter is the unnecessary parts that would have not been needed if products were designed around common parts. not only do these excess parts incur overhead costs to administer them, they also lower plant efficiency and machine utilization because of the setup caused by product that are designed to have more parts than can be distributed at every point of use.

This approach determines the minimum list of parts needed for new designs and is not intended to eliminate parts on existing products, except when the common parts are functionally equivalent in all aspects. In this case the new common part may be substituted as an equivalent part or a "better than" substitution, where a common part with a better tolerance can replace its lesser counterpart in existing products (KC, 2009).

**B. Cost saving from standardization:**

- **Purchasing leverage:**

Being able to order larger quantities of standard parts and materials provides purchasing leverage where buyers can be benefited from suppliers economies-of-scale and arrange more frequent deliveries to support just-in-time operations.

- **Lowering material overhead:**

There is far less material overhead to procure standard parts and materials, which are more common, more readily available, and have more sources. Material overhead for standard part is ten times less and the material overhead rate should be structured accordingly.

- Spontaneous resupply possible:

Many costs can be reduced by arranging spontaneous resupply of parts and materials, instead of the more expensive forecast based purchase orders and holding inventories (KC, 2009).

**C. Other forms of standardization:**

- **Total standardization:**

A subject related to part standardization is tool standardization, which determines how many different tools are required for assembly, alignment, calibration, testing, repair and service. Companywide tool standardization can be determined as follows: analyze tools used for existing products, prioritize usage histories to determine the most "common" of existing tools, work with people in manufacturing/service to determine common part selection, issue common tools lists with common parts lists.

- **Feature standardization:**

Features are any geometry that requires a separate tool like a drill, ream, hole punch, and cutting tool bit for machine tools. These tools needed to be standardized using the same procedures as parts.

- **Raw material standardization:**

If raw materials can be standardized, then the processes can be flexible enough to make different products without any setup to change materials, fixturing mechanisms or cutting tools. Raw material standardization can apply to bar stock/tubing, sheet metal, molding/casting, proactive coatings, and programmable chips.

- **Process standardization:**

Standardization processes from the concurrent engineering of products and processes to ensure that the processes are actually specified by the design team, rather than being left to chance or "to be determined later". Processes must be coordinated and common enough to ensure that all parts and products in the mass customization platform can be built without the setup changes that would undermine flexible manufacturing (KC, 2009).

**D. Effect on suppliers:**

Standardization of parts helps part suppliers rationalize their product lines and allow them to:

- Reduce their overhead cost and substitutes, which allow them to be more cost competitive.
- Improve their operational flexibility, resulting in better delivery.
- Simplify their supply chain management.

Free valuable resources to improve operations and quality, implement better product development practices, and introduce new capabilities like build-to-order and mass customization (KC, 2009).

**E. Standardization benefits:**

Standardization benefits to the organization by:

- Reducing the purchasing cost through purchasing leverage reducing the inventory cost, floor space reduction, MRP/ordering expense avoided when common parts are simply drawn as needed from spontaneous resupply, continuous improvement, vendor reduction etc.
- Improving product quality, continuous improvement, vendor reduction etc.
- Eliminating setup, inventory reduction, simplify supply chain management, internal material logistics, breadtruck deliveries flexible manufacturing etc. (Paudel, 2005).

**5. Product line Rationalization:**

Product line rationalization, which could be called profitization, is a powerful technique to improve profits, free valuable resources, and simplify operations and supply chains. It does not this by rationalizing existing product lines to eliminate or outsource products and product variations that are problem prone, do not fit into a flexible environment, have low sales, have excessive overhead demands, are not really appreciated by customers, have limited future potential, may really be losing money (Paudel, 2005).

The practical rationalization techniques, which are presented as follows:

**A. Pareto's law for product lines:**

All companies experience some pareto effect typically with 80% of profits or sales coming from the best 20% of the products.

This happens because almost all companies keep adding products to the portfolio without every removing any. Further, sales incentives and emphasis on growth and market share encourage the mantra "take all orders" thus overloading production operations and the supply chain with too many low volume products that have unusual parts and manufacturing procedures. This causes excessive overhead costs, lowers plant capacity, dilutes manufacturing resources, and complicated supply chain management. Product line rationalization encourages companies to focus on their best products by eliminating or outsourcing the marginal products. The resources that were being wasted on the low leverage products can then be focused on growing the "cash cows" (Paudel, 2005).

### B. How rationalization can triple profits:

The following scenario shows the power of this methodology using the simple example illustrated on the cover. If a company kept the 20% of the product line that was making 80% of the profits and dropped the other 80% of the product line, it would result in only a 20% drop in revenue. However, dropping 80% of the worst products would eliminate 80% or more of overhead and distribution costs because those products are built infrequently with less common parts on older equipment using sketchy documentation by a workforce with little experience on those products. Further, these products may be less well designed for manufacturability and have much higher quality costs (Paudel, 2005).

### C. The rationalization procedure:

The actual procedure divides the product line into four zones. The least profitable products would be dropped. Products that need to be in the catalog would be outsourced, thus simplifying the supply chain and manufacturing operations.

The cash-cows would remain and balance would be improved with a better focus in product development, operations, and marketing. Because these products no longer need to subsidize the losers, they can now sell for less.

Eliminating or outsourcing low-average product will immediately:

- Increase profits by avoiding the manufacture of products that have low profit or are equally losing money because of their high overhead demands and insufficient manufacture/procurement.
- Improve operational flexibility, because typically low average products are inherently different with unusual parts, material setups and processing, often, these are older products that are built infrequently with less common parts on older equipment using sketchy documentation by a workforce with little experience on these products.
- Simplify supply chain management by eliminating the products with unusual parts and materials will greatly simplify supply-chain management.
- Free up valuable resources to improve operations and quality implement better product development practices, and introduce new capabilities like build to order and mass customization.

- Improve quality from eliminating older, infrequently built products which inherently have more quality problems than current, high-volume products that have benefited from improvement and current quality programs and techniques.
- Focus on most profitable products in product development manufacturing, quality improvement, and sales emphasis. Focusing on the most profitable products can increase their growth and the growth of similarly profitable products.
- Stop cross subsidizes: remaining products will no longer have to subsidize the "dogs" and so they can generate more profit or offer a more competitive selling price (Paudel, 2005).

For spontaneous supply chains, purchasing department's role will be to:

- Encourage and maybe drive standardization of parts and raw materials for current products and help new product development teams design around aggressively standardized parts and materials,
- Identify standard raw materials and parts available from multiple sources, arrange breadtruck replenishment.
- Arrange steady flow of standard parts and raw materials, nurture supplier relationships with the focus on delivery.
- Establish Kanban and pull signal arrangement with suppliers

There are two aspects of the spontaneous supply chain: raw material resupply and part resupply.

**a) Spontaneous raw material resupply:**

Too many types of raw materials can thwart spontaneity and present manufacturers with the dilemma of stocking all types of materials or ordering them and waiting for delivery. The effective procedures of standardization should be used to aggressively standardize raw materials. Standardization reduces the incoming variety which helps enable the spontaneous supply chain. Purchasing leverage and other material overhead savings compensate for any cut-off waste and for some products getting better material than they need. Standardization can also protect a manufacturer from shortages, which are more likely to occur if production depends on many unusual materials. Raw materials could be automatically resupplied using the following techniques:

- **Steady flow of standard raw material:**

The ultimate scenario for spontaneous resupply is to reduce the number of raw material types within each category to one, in which case steady flows can be arranged for each standard raw material. Ideally, there should only be one type of each material. Then forecasting multiple types would be unnecessary and ordering would be as simple as matching the tonnage in to the tonnage out. In other words, the incoming flow of the standard raw materials would be equal to the monthly consumption of the plant. These will be used in one or another way. Multiple types of materials in each category would allow the same spontaneity if the ration is constant or predictable and usage is segregated.

- **Linear cut-off:**

Raw material variety can be greatly reduced by cutting off linear materials on demand at the points of use or as Kanban parts resupplied automatically to all the points of use. Linear materials include all forms at bar stock, extrusions, strips, tubing, hose, wire rope, cable, chain and so forth.

- **Min/max stacks:**

In the "min/max" technique, often used for raw material like sheet metal, material is consumed until the stack reaches the "min" level, usually marked on the rack or wall. This triggers a reorder of the material to bring it up the "Max" level without the usual purchasing costs. Price and delivery arrangements, based on average usage data, could be negotiated on a long term basis for grater purchasing leverage.

- **Strategic stockpiles:**

Until the above techniques can be implemented, it may be necessary to have strategic stockpiles of certain materials. The manufacturer could use selective stockpiles to temporarily compensate for any parts or materials that cannot be pulled or for temporary availability problems on standard materials. Stockpile ordering would have to be based on some kind of forecasts, but if the material was standardized, then the forecast would be easier to make for the aggregated demand for all consumption.

- **Order material after receipt of product order:**

Spontaneous resupply may not be feasible for unusual or seldom used raw material, especially on any products with inherently high diversity of materials. If material order times are less than build times, these materials could be ordered after receipt of the product order (Paudel, 2005).

**b) Spontaneous parts resupply:**

The typical response when suppliers are asked to deliver parts just-in-time to their customer's pull signals is to keep building the parts in large batches, try to stock enough in their finished goods inventory and meter them out "on demand". A special case variation of this approach is the Dell model where suppliers warehouse their parts next to the assembler's factories. Not many assemblers are big enough and powerful enough to force their suppliers into such an arrangement.

However, this is not really a pull-based supply chain parts availability would depend on assembler's forecasts which are becoming increasingly less accurate and the suppliers inventory, which is costly to carry and prone to obsolescence part resupply strategy depends on the variety of the parts. At one end of the spectrum, very standard parts that are used in almost all products could arrive in a steady follow like standard raw materials. At the other end of the spectrum parts with high variety would be built-on demand using the techniques presented herein including flexible CNC fabrication and manual equivalents. Parts could be automatically resupplied by the following techniques.

- **Steady flow of parts:**

As with standard materials, steady flows could be arranged for very standard parts, which could be used one way or another. The criteria for steady flow of parts would be standardization and widespread use.

- **Breadtruck resupply:**

The easiest and "lowest hanging fruit" in material logistics is the breadtruck delivery system for small, inexpensive parts, like fasteners. Instead of counting on forecasts to trigger an MRP system to generate purchase orders, all the "jellybean" parts can be made available in bins at all the points of use. A local supplier is contracted to simply keep the bins full and bill the company monthly for what has been used, much like the way bread is resupplied by the breadtruck to a market.

- **Kanban resupply:**

In kanban resupply, parts with limited variety are made, may be in batches, and resupplied automatically to replenish parts bins based on part consumption. This is one of the many pull systems used to “pull” parts into assembly operations. The resupply is automatic once the pull signal gets to the supplier. There are many simple ways to do this without complex information systems such as MRP or ERP. Thus, Kanban resupply avoids the uncertainty of forecasting, the cost of purchasing and cost and risk of inventory.

- **Spontaneous build to order of parts:**

For parts that are too varied for kanban, the assembler or the suppliers themselves would need to implement spontaneous build to order so that they could actually build on demand to their customers pull signals. This is the only way to supply mass customized parts on demand for mass customized products. Parts can be made on demand in house or by nearby agile suppliers. It may be appear that spontaneous build to order of parts may cost more than mass production, but in reality, a complete BTO operation is very cost-effective when measured on a total cost basis.

- **Parts made on demand by suppliers:**

Hopefully, it may be possible to find suppliers who can implement these techniques to make your parts on demand in response to your pull signals. Pull signals need to be initiated early enough and response time needs to be quick enough so that parts arrive without causing assembly delays.

Spontaneous build to order of parts may require the development of suppliers relationships in which suppliers establish the ability to build parts in any quantity on demand. The distance to the supplier must not be so great so that part delivery delays product delivery.

- **Parts made on-demand in house:**

In order for spontaneous build to order to work, all parts must be avoidable on demand. If there are any key parts that are not suitable for kanban and no supplier can build them and ship them quickly enough to your pull signal, then you might have to bring those operations in house.

- **Order parts after receipt of product order:**

Spontaneous resupply may not be feasible for unusual or seldom used parts, especially on capital equipment with an inherently high diversity of parts. If parts order times are less than build times, these parts could be ordered after receipt of the product order (Anderson, David, www.google.com).

### A. Dock to line part deliveries:

To be truly agile, incoming parts and materials must flow directly to the all points of use without all the steps listed above, this is called dock-to-line delivery. Dock to line may be more easy to implement after implementing part and material standardization, product line rationalization, breadtruck deliveries, and Kanban resupply of appropriate parts. freeing up floor space by inventory reduction efforts will make room for internal distribution at all points of use. Lean environments require much less raw materials inventory than batch oriented operations, so there will still be a net reduction in floor space requirements after implementing lean production. In addition, part warehouse space may now be more available.

In order for dock to line to work, quality must be assured at the source by suppliers whose processes are so in control that their customers do not need to inspect incoming parts. further supply chain cost could be saved if the suppliers system we so in control that the suppliers did not have to inspect them either. Dock to line, sometime refers to dock to stock which technically means parts go to some kind of internal warehouse, hopefully without incoming inspection before being distributed to the line. Dock to stock deliveries can be either triggered by purchase orders that come from MRP systems or hopefully automatic pull signals like kanban. Dock to line deliveries can be an essential part of a lean production program or may be instituted primarily to save cost and improve throughput.

- **Problems with incoming inspections:**

The big paradigm shift required for dock to line deliveries is the elimination of incoming inspection of parts and raw materials. Incoming inspections are impractical for two reasons: time and cost. Just in time deliveries as the name suggests, should be just in time. Having to go through incoming inspections, usually at central receiving stations, would cause too many delays for a fast moving lean environment. JIT deliveries may be smaller and occur more often than the traditional large order that is delivered infrequently. Consequently, inspecting many small orders would be very inefficient and costly because of the inspection setup which include finding getting up to speed on quality standards and procedures, setting up and calibrating test and inspection equipment, and dealing with problems via MRB (Material Review Boards).

- **Eliminating incoming inspections:**

But incoming inspections cannot simply be eliminated without some way of assuring that the incoming parts and raw materials will have adequate quality. If a manufacturer simply dictated new standards for incoming part quality from suppliers, the suppliers may respond by shifting inspection from the manufactures receiving to the end of the suppliers operations. This may screen out bed parts but at too great a cost in money and agility. In addition, when companies try to achieve quality by rejecting out-of-spec parts from a "wide" bell curve, the result is that the parts that do pass, will have a high proportion close to the "hairy edge" of not working, which may cause more worst case failures.

Suppliers, internal and external, need to adopt the six-sigma philosophy of assuring quality at the source. If part manufacturing and raw material processing is sufficiently in control, quality will be assured by the process, not by subsequent inspections. Statistical process control (SPC) is a proven tool for assuring quality by process controls.

- **Certification:**

Suppliers that can prove that their processes are in control and thus, can deliver good parts directly to the line are certified by the manufacturer. Similar certifications may also be applicable for raw material suppliers to allow them to ship metals, plastics and chemicals directly to the points of use without incoming inspections (KC, 2005).

**7. Cost of quality:**

The low-hanging-fruit in reducing the company's cost of quality is to rationalize products to get rid of low volume, low-profit products that get less kaizen focus and have less sophisticated tooling and procedures. Legacy products and spare parts may need to eliminate or outsourced if they are not synergistic with the current generation of products.

Infrequently built products would have higher cost of quality because of missing or vague instructions, procedures and know-how, and damaged, missing or discarded tooling, build fixtures, test fixtures, or repair tools, resulting in costly and error-prone manual or "plan B" procedures. In addition, infrequently built products will have many defects and scrap before first good units can be successfully built.

Older products, legacy products and spare parts may have worn tooling, less sophisticated diagnostics, test and repair tools, less effective design for manufacturability and quality, old parts that may have deteriorated, especially true in end-of-life buys, and older generation parts that are lower quality because all the above effects apply to older/low-volume parts too (KC, 2005).

**A. Designing in quality:**

The first step to reducing cost of quality for new products in designing in quality and reliability. Eliminating cost of quality begins with designing in quality to avoid costly defects, errors, rework, scrap, procurement of replacement materials, factory/machine capacity degradation, re-qualifications/re-certifications of costs and resources from implementing the overall cost reduction strategy. The methodologies to proactively assure high quality and reliability by design are as follows:

- **Understand past quality problems**:

Thoroughly understand the root causes of quality problems on current and past products to prevent new product development from repeating past mistakes. This includes part selection, design aspects, processing, supplier selection, and so forth. It may be useful to have manufacturing quality and field service people make presentations to newly formed product development teams showing, hopefully with real life examples, some of the past problems that can be avoided in new design.

- Quality function deployments to define products capture the voice of the customer. This ensures that the first design will satisfy the voice of the customer without the cost and risk of changing the design.

- **Use multi-functional teamwork:**

Break down the wall between departments with multi-functional design teams to ensure that all quality issues are raised and resolved early and that quality is indeed treated as a primary design goal.

- Through up front work, so product development teams can optimize quality starting with the concept architecture phase and avoid later quality and ramp problems.

- Simplify the design for the fewest parts, interfaces, and process steps. Elegantly simple designs and uncomplicated processing result in inherently high quality products.
- Select the highest quality processing, automated processing produces better and more consistent quality than manual labor.
- Raise and resolve issues early by learning from the past quality problems, early research, experiment and models generate plan B contingency plans, and proactively devising and implementing plans to resolve all issues early.
- Poka-yake principles applied to product design to prevent mistakes by design in addition to traditional manufacturing techniques to prevent incorrect assembly or fabrication.
- Proactively minimizing all type of risks, not just functionality for critical applications, use Failure Modes Effect Analysis of tools known as “A Design For Six Sigma”.
- Reusing proven designs, parts modules, and process to minimize risk and assure quality, especially on critical aspects of the design.
- Thoroughly design the product right for the first time:

Use design for manufacturability techniques presented herein to ensure that the product is designed for the first time. If quality is not assured by the initial design, then expensive change orders will have to be carried out, wasting valuable engineering resources and possibly inducing further quality problems in the process. Be sure to be able to comfortably satisfy design goals and constraints without having to compromise the product just to get products out the door (Paudel, 2005).

**B. Quality programs:**

If a company is serious about reducing the cost of quality, it must implement serious quality improvement programs like design for manufacturability, lean production, six sigma, concurrent engineering etc (Paudel, 2005).

## 8. KAIZEN system (Continuous Improvement):

Kaizen costing is similar to target costing in its cost reduction mission, except that it focuses on reducing cost during the manufacturing stage of the total life cycle of a product. Kaizen is the Japanese term for making improvements to a process through large innovation. Kaizen goals are responsible because when the product is already in the manufacturing process, it is difficult and costly to make large change to reduce costs. Kaizen costing contrasts with target costing, which allows many more opportunities to effect change because it occurs much earlier in the product's life cycle (Blocher, 1999).

Henry ford realized that the right attitude is important to success. That belief is that continuous improvement is a management technique in which managers and workers commit to a program of continuous improvement in quality and other critical success factors. Its origin is attributed to Japanese manufacturers, with their tireless pursuit of quality. Continuous improvement is very often associated with benchmarking and total quality management, as firms seek to identify other firms as models to learn how to improve their critical success factors (Blocher, 1999).

Kaizen is the Japanese term for making improvements to a process through small incremental amounts rather than through large innovations. The major differences between target costing and kaizen costing is that target costing is applied during the design stage whereas kaizen costing is focusing on the product, and cost reductions are achieved primarily through product design. In contrast, kaizen costing focuses on the production processes and cost reductions are derived primarily through the increased efficiency of the production process. Therefore, the potential cost reductions are smaller with kaizen costing because, the products are already in the manufacturing stage of their life cycles and a significant proportion of the costs will have become in (Drury, 2004).

The aim of kaizen costing is to reduce the cost of components and products by a pre-specified amount. Monden Hamada (1991) describes the application of kaizen costing in Japanese automobile plant. Each plant is assigned a target cost reduction ratio and this is applied to the previous year's actual costs to determine the target cost reduction. Kaizen cost relies heavily on employee empowerment. They are assumed to have superior knowledge about how to improve processes because they are closest to the manufacturing processes and customers and are likely to have greater insights into cost can be reduced. Thus, a major feature of kaizen costing is that workers are given the responsibility to improve processes and reduce costs. Unlike target costing it is not accompanied by a set of technique or procedures that are automatically applied to achieve the cost reductions (Drury, 2004).

There are basically four elements applied for kaizen system. They are PDCA cycle and Progress.

The word PDCA goes for:

P for “plan”

a) Theme selection
b) Reasons for theme selection
c) Analysis of current situation
d) KAIZEN goal setting and action plan

D for “do”

a) Execution

C for “check”

a) Confirmation of the results

A for “act”

a) Standardization
b) Reminding problems and future plans

PDCA cycle is used to identify the problem and the portion of original goals which has been received. So kaizen can be generated to situation. Using PDCA model, the Kaizen is generated as follows:

Step 1: Find a problem and select themes

Step 2: Find the cause for the problem and consider the reasons why the theme was selected.

Step 3: Study what is the most influential factor and analyze the present situation.

Step 4: Consider remedial measure using 5 W, 1 H, principle as follows:

5Ws:

- why (concerning the necessity)
- what (concerning with objective)
- where (concerning with place)
- when (concerning with time and limits)
- who (concerning with person)

1H: How (concerning with method)

Step 5: Implement remedial measure.

- Integration of TQM function and professional function:

TQM function and professional function both should be integrated to kaizen. Kaizen will be effective only if both functions are co-operating.

- Top down and Bottom-up management:

There should be a restriction for upward messaging if kaizen system has to be implemented effectively. Two ways traffic should be entertained for communication. Similarly, employees need to be motivated to participate in 5s activity, suggestion program and quality circle. The 5s activities are follows:

| 5s | Original Japanese word | English Meaning |
|---|---|---|
| 1s | Seiri | Sort out unnecessary item in the workplace and discard them |
| 2s | Section | Arrange all necessary item in good order so that they can be picked for use:<br>a) A place for everything<br>b) Everything in its place. |
| 3s | Seiso | Clean your workplace completely so that there is not dust on the floor, machines or equipment |
| 4s | Sei Ketsu | Maintain a high Standard of housekeeping and a work place Organization at all times. |
| 5s | Sbitsuke | Train people to follow good housekeeping disciplines Autonomously. |

**9. Reengineering:**

Reengineering is a process for creating competitive advantage in which a firm recognizes its operating and management functions, often with the result that jobs are modified, combined, or eliminated. It has been defined as the fundamental rethinking and radical redesign of the business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed. Under the pressure of global competition, many firms look a reengineering as a way to reduce the cost of management and operations, and as a basis for careful reanalysis of the firm’s strategic competitive advantage, cost management supports the reengineering effort by providing the relevant information (Blocher, 1999).

Reengineering is the complete redesign of a process. Wish an emphasis of findings, create new ways to accomplish an objectives reengineering has sometimes been desired as taking blank piece of paper and starting from scratch to redesign a business process. Rather than searching continually for minute improvements, reengineering in value a radical shift in thinking about new objectives should be met (Hilton, 1997).

Reengineering is the fundamental rethinking and radical redesign of business process to achieve contemporary measures of performance, such as cost quality, service and speed.

**Reengineering process:**

Richard B. chase, Nicholas J. Aquilono and Jacobs F. Robert (1997) have presented the following six steps to be taken into consideration for reengineering any product manufacturing:

**Step 1 State a case for action:**

The need for change should be effectively communicated to the company employees through educational and communication campaigns. Two key messages should be articulated:

I. A need for action: Where the company is and this is why we cannot stay here.

II. A vision statement: This is what we as a company needs to become.

III. The objectives for reengineering must be in the form of a qualitative and quantitative vision statement. These objectives can include goals for cost reduction, time to time market quality and customer satisfaction level and financial indicators.

**Step 2 Identify the process:**

All major processes in the organization should be initially identified. However, not all major processes should be reengineered at the same time. The following questions define the criteria for selecting processes for reengineering:

- Which processes are currently most problematic?
- Which processes are critical to accomplishing company strategy and have the greatest impact on the company’s customer?
- Which processes are most likely to be successfully redesigned?
- What is the project scope and what are the costs involved?

**Step 3 Evaluation enablers:**

Information technology and human/organizational issues act as enablers of the reengineering process. Technology evaluation has now become a core competency required of all companies. The company should develop the ability to evaluate current and emerging technology and identify creative application to redesign their existing processes.

**Step 4 Understanding the current process:**

The current process must be studied to understand the activities which are essential to completion. We need to introduce some terminology to describe component activities to add out analysis. All work activities can be classified into three types:

- Value-adding work: It consists of all the activities that create the goods and services that customers want. Value adding work can rarely be eliminated from a process, although it can be improved.
- Non value-adding work: It is mainly administrative overhead such as reporting, checking, supervising, controlling, reviewing and coordinating.
- Waste work: It is pointless work whose absence would, by definition, not be noticed by the customers, producing reports that no one read, doing erroneously, so that it needs to be done and redundant checking activities are waste work. Waste works are needed to be eliminated.

**Step 5 Create a new process design:**

Process design requires beginning with a clean sheet of paper. Reengineers should suspend current roles, procedures and values so as to create new process designs. They also need to utilize the principles of reengineering that have been discerned. The first emphasis reengineering process is to eliminate all waste work. Waste work van often be eliminated immediately during the reengineering effort. Next, focus is on elimination of non value adding work. The consequences of redesigning process, to reduce non value adding work, are significant.

**Step 6 Implement the reengineered process:**

Leadership is critical, not just to the implementation process but to entire reengineering effort. Process engineering teams are typically responsible for implementing the new designs. However, the support from the line managers is crucial to success because implementation changes accountabilities of line managers while expecting them to delivers on the improvements.

**10. Just in time (JIT)**

Think of a situation where we produce the required goods only at the time when they are needed and in the quality that is needed, and where this holds goods for finished products and semi finished products, both. If such a situation materializes, the inventories of the finished goods and work in progress would be almost nil or low, if we make our raw materials supplier agree that they should deliver their goods only at the time and in the quantities we need them to, then we are eliminating raw materials inventories as well. We shall then have virtually zero inventories. This is called the just in time production system founded by Tailichi Ohno (a vice president at Toyota) and first successfully implemented at the Toyota motor company's plants in japan and now being tried at various manufacturing industries all over the world (Bhattacharya, 2004).

The competitiveness of Japanese manufactured products has focused attention on their manufacturing systems since the basis of their success has been high quality, competitively priced products. Indeed, the Japanese market strategy seems to be rooted in their production systems and the literature is filled with reports of remarkable quality levels, achieved along with lower costs through higher productivity and very low in process inventories (Buffa, 1987).

Sepehri (1986) reports on a sample of five Japanese companies that JIT methods producing the necessary parts in the quantities needed at the time they are needed as a basis for comparing the results of 13 U.S. companies that have installed JIT concepts. The summary results of five Japanese companies in providing productivity, reducing set up time, reducing inventory, improving quality, saving space, and reducing lead time. (Buffa, 1987)

JIT manufacturing requires making a product or service only when the customer, internal or external requires it. It uses a product layout with a continuous flow on with no delays once production starts. This means a substantial reduction in setup costs. It is necessary to eliminate the need to produce in batches; therefore processing systems must be reliable (Anthony, 2004)

**Single unit production and conveyance:**

The JIT concept may have been borrowed from the inventory systems of American supermarkets, i.e. only the units that sales are replaced. It is actually a production and material planning system where the production and procurement closely flow the actual demand. And this system is carried down the line from final product to the basic component. It can be perceived as a job order production carried out to the basic component. It can be perceived as a job order production carried out to the extreme of single unit job ordering yet retaining to convey or line system and its advantages. There are no lot size productions anywhere. As and when the item is produced it is conveyed to the next process so that there is no "waiting" involved at any place. Of course, the operation time at each work place are also equalized. In short, JIT we have: i) no delay either due to lot size production or due to unequal production time of different work places and ii) conveyance times are also balanced. JIT is a combination of single unit production and conveyance system and is also called "IKKO Nagare" in Japanese meaning (Chary, 2004).

**Eliminating the waste and adding value:**

Just in time requires a great deal of organizational discipline. As in the case of material requirement planning (MRP), JIT requires not only changes in the may a company handles its inventory but also changes in its culture. JIT also encompasses the Japanese managerial characteristics (Adam, 2005).

The seven wastes –shigeo shingo, as recognized JIT authority and engineer at the Toyota motor company identifies seven wastes as being the targets of continuous improvement in production process. By eliminating these wastes, improvement can be achieved (Adam, 2005).

- Waste of overproduction: eliminate by reducing setup times, synchronizing qualities and timing between processes, compacting layout visibility, and so forth make only what is needed.
- Waste of waiting: eliminate through synchronizing work flow as much as possible, and balance uneven loads by flexible workers and equipment.
- Waste of transportation: Establish bay outs and locations to maker transport and holding unnecessary if possible. Then rationalized transport and material handling that can not be eliminated.
- Waste of processing itself: First question is why this part or product should be made at all, then why each process is necessary, extend thinking beyond economy of scale or speed.
- Waste of stocks: Reduce by shorting setup times and reducing lead times, by synchronizing work flows and improving work skills, and even by smoothing fluctuations in demand for the product. Reducing all the other wastes reduces the waste of stocks.
- Waste of motion: Study motion for economy and consistency. Economy improves productivity. First improve the motions, then mechanize or automate. Otherwise there is danger of automating waste.
- Waste of making defective products: Develop the production process to prevent defects from being made so as to eliminate inspection. At each process accept no defects and make defects. Make processes failsafe to do this. From a quality process quality product can be received automatically.

**Value added manufacturing:**

JIT'S seven wastes are at the root of what U.S. companies term value added manufacturing. Any step in the manufacturing process that does not add value to the product for the customer is wasteful. Examples of wasteful steps include the process delays, process inventories, finished goods inventories, excessive paper processing, and many other activities that do not add value to the product. Wasteful tasks increase costs and reduce competitiveness. To identify and delete wastes, each aspect of manufacturing is analyzed to confirm or refute its value (Adam, 2005).

**Kanban production information system:**

A JIT production system uses a particular material withdrawal and work ordering system. This is called the kanban system. As we have so far noted, the JIT system works, based on the requirements at final product level. Basically it believes in producing at a time only that many items as have been withdrawn. This chain of withdrawal- and production is continuous from the end product to the beginning process. This is the way the work in process inventory is kept in very low. The withdrawal of material from the preceding process and the production of items to replace this ordered through a withdrawal and production kanban. It is physical control system, and is visual in nature which is an advantage over the conventional production control paper work which could be quite confusing at times (Chary, 2004).

**JIT as a business philosophy:**

JIT should not be viewed as a mere production system. It expresses, in fact, an organization's philosophy of customer orientation. Service to the customer is the focus of JIT system. The production system is a consequence of this business philosophy. Service includes providing to customer the product in time, providing him variety of products, allowing him to choose as per his performances, providing him with quality products, and communicating with him more intensely than before almost including him in your own facility or vice versa and above all providing product or service at a price affordable and perceived as reasonable by the customer. Such sevice- orientation generates the need for an appropriately responsive production system such as a JIT system. (Chary, 2004)

As the customers are to be provided a variety of products and in time, the production of the finished goods should be in very small in lots. For the same reason, the upstream production system should also produce equally small lots just to meet the downstream needs. Going upstream in this manner, it is obvious that the vendors too have to supply items in small numbers and just in time (Chary, 2004).

**Implication of Just In Time manufacturing:**

Just in time manufacturing is a simple theory but hard to achieve in practice. Some organizations hesitate to implement JIT because with no work in process inventory, a problem anywhere in the system can stop all production. For this reason organizations that use just in time manufacturing must eliminate all sources of failure in the system. The production process must be redesigned so that it is not prohibitively expensive to process one or small number of items at a time. This usually means reducing the distance over which very adaptable people and equipment that can handle all types of job (Anthony, 2001)

As the core of the JIT process is a highly trained workforce whose task is to carry out activities using the highest standards of quality. When the employee discovers a problem with a component he or she has received, it is the responsibility of that employee to call immediate attention to the problem so that is can be corrected. Suppliers must be able to able and deliver free materials and components just when they are required. In many instances, companies compete with the suppliers of the same components to see who can deliver the best quality. At the end of a performance period, the supplier who performs the best will obtain the long term contract. Preventive maintenance is also employed so that equipment failure is a rare event (Anthony, 2004).

Consider how just is time manufacturing can be used at a fast food restaurant, some use a just in time, continuous flow product layout, while others use batch production in a production layout process. In fact, some fast food restaurants combine both approaches into hybrid systems that use a batch approach to production and keep inventories at predefined levels. For example, the restaurant may use racks or bins to hold food ready to be sold to the customer and have employees start another batch of production when the existing inventory falls below a line drawn on the bin or rack. At off-peak times the restaurant may produce to order. (Anthony, 2004).

The motivation to use the JIT approach is to improve the quality of the food and to reduce waste by eliminating the need to discard food that has been held in the bin too long. The motivation to use batch production is to sustain a certain level of inventory to reduce the time the customer has to wait for an order. As processing time and set up costs drop, the organization can move closer to just in time manufacturing and reduce the wastes and quality problems that arise with batch production (Anthony, 2004)

## 2.2 Review of Previous Study

Dahal (2004) has carried out a study entitled "Cost Reduction Tools: A Study on Applying to Strength Manufacturing Enterprises of Nepal." His main objective was to evaluate the application of the cost reduction tools in Nepalese manufacturing organizations. And the study has shown eh following findings:

- The main reason behind less use to JIT in Nepalese business environment I slack of information about JIT and non-availability of suppliers.
- There is the lack of skilled manpower and internal failure cost in applying TQM.
- The more useable cost reduction tools in business enterprises is training.
- The main cause of not applying benchmarking is lack of proper direction and coordination.
- The constraint cause of ABM is poor organizations culture.
- Nepalese manufacturing firms believe in scientific management of cost.

Paudel (2005) has conducted a study on "Cost Reduction Tools: A Study on Applying to Strength Manufacturing Enterprises of Nepal." Main objective of the study was to evaluate the application of the cost reduction tools in Nepalese manufacturing organizations. His study has shown the following findings.

- The research works have found that about 50.59% of the firms were practicing cost management/reduction. This shows the manufacturing sector in Nepal is not widely practicing cost reduction.
- Research made among the firms has shown that existing cost reduction practice is different between the sectors. The average figure shows that 61.67% of the samples form Chemical sub-sector were practicing cost reduction, which is the highest among all the sub-sectors.
- Similarly, about 61.11% of the textile firms were found practicing cost reduction. Hence there is lack of mass participation for cost reduction practice in the manufacturing sector.

- About 92% of the samples taken were found conducting training programs. The second highest cost reduction tools being applied has been found benchmarking (79.56% of the samples) and subsequently, M-Audit, ABM, TQM, VA, Reengineering, Target costing, lifecycle costing, time and motion study, JIT system and Kaizen costing.

K.C. (2009) has made study about “An application of cost reduction tools: A survey study in Nepalese manufacturing organization”. And his study has shown the following findings and recommendations:

Findings:

- The main reason behind less use to JIT in Nepalese manufacturing organization is the lack of information about JIT, and non-availability of suppliers.
- There is the lack of skilled manpower and internal failure in applying TQM.
- The more useable cost reduction tool in business enterprises is training.
- The main cause of not applying not applying benchmarking is lack of proper direction and co-ordination.
- The constraint cause of ABM is poor organization culture.
- The companies are trying to achieve objective by means of increasing selling price.
- Majority of the companies are not applying the JIT system currently. Major problem of the failure of the system is due to lack of skilled and experienced manpower. In order to make success of the system properly, Nepalese manufacturing companies should establish the long term stable relationship with the employees.

Karki (2010) has done a research study on “Practice of Cost Reduction Tools and Techniques in Selected Nepalese Manicuring Companies.” The main objective was to evaluate the application of the cost reduction tools in selected Nepalese manufacturing organizations. Major findings of the study are presented below:

- The major cause of suffering the loss by Nepalese manufacturing companies is due to lack of proper supervision and management.
- Majority of the companies are not applying the JIT system currently. Major problem of the failure of the system is due to lack of skilled and experienced manpower. In order to make success of the system properly, Nepalese

manufacturing companies should establish the long-term stable relationship with the employees.

- The companies are trying to achieve objective by means of increasing selling price. They are trying to reduce the purchasing cost by means of managing cost in proper way.
- Major of the companies are not using TQM system currently. They are bearing the internal costs as the quality related cost at present and giving first priority to the quality design as the improvement technique to TQM system.

## 2.3 Research Gap

It is observed that the previous researcher mostly focuses on the common cost reduction tools that are benchmarking, Total quality management, ABM, target costing, life cycle costing, balance scorecard, theory of constraints etc. But this study focuses on new cost reduction tools such as Design for manufacturability and concurrent engineering, on demand lean production, Mass customization the proactive management of variety, Build to order, Product line rationalization, supply chain management etc. so new cost reduction tools are used to analyze the cost situation of Nepalese manufacturing organizations in this study. So, this study will be fruitful to those interested person, scholars, businessman, students, teachers, civil society, stakeholder, and government for academically as well as policy perspective.

# CHAPTER III

# RESEARCH METHODOLOGY

Research is a systematic method of finding right solution for the problem whereas research methodology refers to the various sequential steps to adopt by a researcher in studying a problem with certain objectives in view. In other words research methodology refers to the various methods of practices applied by the researcher in the entire aspect of the study. It is the plan, structure and strategy of investigations conceived to answer the research question or test the research hypothesis. Research design is used to control variance (Wolff and Pant; 2002: 51). It includes different dependent and independent variables, types of research design, research questions and hypothesis sample, data collection procedures, tools and technique of analysis etc.

In this regard, the chapter research methodology consists of research design, source of data, population and sample, methods and tools of data analysis. The main contents of research methodology in course of this study are as follow:

## 3.1 Research Design

Research design describes the general framework for collection, analyzing and evaluating data after evaluating data after identifying 1) what the researcher want to know, and 2) what has to be dealt with, in order to obtain required information (Paudyal, Basnet and Pant, 2069). In order to make the research planned and systematic, research design is necessary to fulfill the objectives of the study. The research design of the study is analytical as well as descriptive approaches.

## 3.2 Nature and Sources of Data

The main source of data for this study is primary. The information has been collected through unit visits. It, therefore, means that primary data have been collected. A questionnaire with multiple choice answers was prepared before the visit, and distributed during the visit to the unit under study.

### 3.3 Population and Sample

All the manufacturing organizations established and operating in Nepal have been taken as population of the research study. The samples have been taken using stratified, convenient, random, and judgmental sampling procedure. The sample will be stratified as follows:

- Food industries
- Beverage industries
- Gas, polypipe, and Gas industries
- Dairy industries

All those manufacturing organizations having Butwal based head offices or contact offices have been taken as target population. Out of target population at least 10 organizations have been sampled selecting three samples from each strata are as follows:

- Shree Quality Food Products, Butwal-13, Kalikanagar
- Sagarmatha Bakery Udhyog, Butwal-11
- Surya Bakery Udhyog, Butwal-3, Mainabagar
- Inter-Tech Pipes nad Fitting, Butwal Industrial District
- Tinau Plastic Industries, Butwal-13, Nayagaun
- Arman Plastic Industries, Butwal Industrial District
- Butwal Gas Pvt. Ltd., Karuwani-8, Hatipharsatikar
- Siddhartha Gas Udhyog Pvt. Ltd., Madhwaliya-2
- Pabitra-Dairy Udhyog, Butwal-8
- Pandaw Dairy Udhyog, Butwal-7

### 3.4 Data Collection Procedure

For the collection of necessary data, questionnaires and schedules were distributed to the respondents or the sample firms. Answers received from thereon, have been changed into numerical data. Respondents are offered for multiple answers to the questions.

### 3.5 Data Analysis Procedure

The collected information has been tabulated in a frequency distribution for the purpose of data presentation, analysis and extract of findings. As the respondents are given opportunities for giving more than just one answers to the questions, the column total reflects sampled organizations from each subsectors and the row total shows the total number of organizations choosing a particular answer. For the analysis of data, percentage analysis method has been adopted.

### 3.6 Testing Hypothesis

The hypothesis taken in the research is that the cost reduction practices among the subsectors and among the tools of reduction is identical. For this purpose, F-test (Two way ANOVA) test has been chosen to answer the question.

### 3.7 Research Variables

This research has been conducted using the following research variables:

- Design for manufacturability and concurrent engineering
- On demand lean production
- Build-to-order
- Mass-customization, the proactive management of variety
- Part standardization
- Product line rationalization
- Supply chain management cost reduction
- Cost of quality
- KAIZEN System (Continuous improvement)
- Reengineering
- Just in time production system

# CHAPTER-IV

# PRESENTATION AND ANALYSIS OF DATA

## 4.1 Introduction

The objective of this chapter is to study, evaluate and analyze those major calculated results, which are mainly related to the Cost Reduction Tools and its impact on performance are made.

## 4.2 Analysis of Primary Data

An empirical investigation has been conducted in order to find out various aspects of cost reduction tools. The major tool used for this purpose is an opinion questionnaire. A total 12 set of questionnaires were distributed to the production managers of various manufacturing organizations, but only 10 sets of questionnaire were returned back from these organizations. The organization related with study or primary data collection are Shree Quality Food Products, Butwal-13, Kalikanagar, Sagarmatha Bakery Udhyog, Butwal-11, Surya Bakery Udhyog, Butwal-3, Mainabagar, Inter-Tech Pipes nad Fitting, Butwal Industrial District, Tinau Plastic Industries, Butwal-13, Nayagaun, Arman Plastic Industries, Butwal Industrial District, Butwal Gas Pvt. Ltd., Karuwani-8, Hatipharsatikar, Siddhartha Gas Udhyog Pvt. Ltd., Madhwaliya-2, Pabitra-Dairy Udhyog, Butwal-8 and Pandaw Dairy Udhyog, Butwal-7. The response received from the various respondent organizations have been arranged, tabulated and analyzed in order to facilitate the descriptive analysis of the study.

### 4.2.1 Cost Reduction Practice in Nepal

#### 4.2.1.1 Profit and Wealth Maximization Practice

A survey was conducted over ten manufacturing organizations in Butwal to explore about how they are trying to maximize profit cum wealth objective. The following results have been found.

**Table No. 1**

**Profit cum Wealth Maximization Practice Sub-Sectorwise Observation**

| Particulars | Food industries | Beverage industries | Gas, polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Increase in volume of sales | 2 | 1 | 2 | 1 | 6 | 60 |
| Increase in selling price | 0 | 0 | 0 | 0 | 0 | 0 |
| Reduction in cost | 1 | 1 | 1 | 1 | 4 | 40 |
| Total | 3 | 2 | 3 | 2 | 10 | 100 |

Source- Field survey, 2013

The above data can be presented with the help of following pie

The result shown in Table No. 1 reveal that out of the ten manufacturing organization sampled, six (60%) have been found going for increasing the volume of sales and 4 (40%) have been found emphasizing reduction in their costs for maximizing profit. And it was found that no organizations have been increasing their selling price for maximizing their profit.

Based on the above analysis, it can be found that most of Nepalese manufacturing organizations want to maximize their profit by increasing their sales volume. They think that there is huge demand of product in the market and profit can be increased through the increase of sales.

### 4.2.1.2 Managing Lower Price of Products

Study over those fifteen manufacturing organizations reveal the following results regarding the current practice of those organizations for setting lower price of the product.

**Table No. 2**

**Measures applied for lowering price of the products: sub-sector wise observation**

| Particulars | Food industries | Beverage industries | Gas, polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Bargaining with the suppliers of materials | 2 | 0 | 2 | 1 | 5 | 50 |
| Managing the cost in scientific way | 1 | 1 | 1 | 1 | 4 | 40 |
| Minimizing its profit margin on sales | 0 | 1 | 0 | 0 | 1 | 10 |
| Total | 3 | 2 | 3 | 2 | 10 | 100 |

Source: Field survey, 2013

The above data can be presented through the following Pie-chart

The Table No. 2 show that about 40% manufacturing organizations out of sampled organization were favoring scientific management techniques. About 50% organizations were found for bargaining with the suppliers for lowering the cost of material to reduce the price of product. Similarly, 10% organization were found going for minimizing the profit margin on sales to reduce their price of product.

Based on the above data, it can be analyzed that the bargaining with the suppliers for material plays an important role to reduce the cost. Only few organizations found to be managing the cost in scientific way for lowering their product's price.

### 4.2.1.3 Areas Selected for Cost Reduction

There are many areas which are required to apply the cost reduction program. A survey was conducted to gather information about areas on which organizations are suffering from cost related problem and applying cost reduction program. The study revealed the following results:

**Table No. 3**

**Areas selected for Cost Reduction**

| Particulars | Food industries | Beverage industries | Gas, polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Product design | 0 | 0 | 1 | 0 | 1 | 10 |
| Production planning and control | 1 | 2 | 0 | 0 | 3 | 30 |
| Equipment and plant layout | 0 | 0 | 1 | 0 | 1 | 10 |
| Selling and distribution | 1 | 0 | 0 | 0 | 1 | 10 |
| Purchase of material and control | 1 | 0 | 1 | 2 | 4 | 40 |
| Total | 3 | 2 | 3 | 2 | 10 | 100 |

Source: Field survey, 2013

The above data can be presented by following pie-chart:

The Table No. 3 show that most of the manufacturing organizations have selected the purchase of raw material and control as the area of cost reduction. 40% of the organization out of sampled have favored the purchase of raw material in lower price as the cost reduction program. Similarly, 30% organizations have considered the production planning and control as the cost reduction program. Likewise, 10% favored the product design, 10% favored the equipment and plant layout, while 10% favored the selling and distribution as the area of cost reduction from which price of the product can be lowered.

From the above result, it can be analyzed that no organization gives priority for product design as the area of cost reduction. Most of the organizations give more emphasis on purchase of raw material and control as the cost reduction areas.

### 4.2.1.4 Application of Cost Reduction Tools

As described earlier, there are various types of cost reduction tools, which are using by Japanese manufacturing organizations at present. This study deals whether

Nepalese manufacturing organizations are applying the cost reduction program or not. If they are not applying such tools then it reveals the causes of higher cost.

#### 4.2.1.4.1 Application of design for manufacturability and concurrent engineering

**Table No. 4**

**Application of Design for manufacturability and concurrent engineering: sub-sector wise observation**

| Particulars | Food Industries | Beverage industries | Gas, polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Applying (yes) | 0 | 2 | 1 | 1 | 4 | 40 |
| Not applying (No) | 3 | 0 | 2 | 1 | 6 | 60 |
| Total | 3 | 2 | 3 | 2 | 10 | 100 |

Source: Field survey, 2013

The Table No. 4 reveals that only 40% organization are using the Design for manufacturability and concurrent engineering as the cost reduction tool, while 60% organizations are not adopting the this tool for reducing cost.

**Table No. 5**

**Practical difficulties in applying the Design for manufacturability and concurrent engineering: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas, polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Lack of skilled manpower | 1 | 0 | 0 | 0 | 1 | 16.7 |
| Lack of information about this tool | 2 | 0 | 2 | 1 | 5 | 83.3 |
| Non availability of modern technology | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 3 | 0 | 2 | 1 | 6 | 100 |

Source: Field survey, 2013

The above data can be presented in the following Pie-chartFigure

From the Table No. 5 it can be analyzed that the main practical difficulty in applying the Design for manufacturability and concurrent engineering as the cost reduction tool is lack of information about this tool. 5 manufacturing organization out of 6 sampled organizations which are not using the DFM and concurrent engineering due to lack of knowledge and information about this cost reduction tool. One manufacturing organization out of 6 sampled organization which is not adopting DFM and concurrent engineering due to the lack of skilled manpower.

In conclusion, it can be said that there is no information and knowledge about the Design for manufacturability and concurrent engineering cost reduction tool. There is no knowledge about how to design product and process concurrently.

#### 4.2.1.4.2 Application of on demand lean production

The status of application of on demand lean production in Nepalese manufacturing organization can be presented as follows:

**Table No. 6 Application of on demand lean production: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas, polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Applying (yes) | 0 | 1 | 1 | 1 | 3 | 30 |
| Not applying (No) | 3 | 1 | 2 | 1 | 7 | 70 |
| Total | 3 | 2 | 3 | 2 | 10 | 100 |

Source: Field survey, 2013

The Table No. 6 reveals that 30% organizations are applying on demand lean production and 70% organization out of sampled are not adopting this tool as the cost reduction.

**Table No. 7**

**Practical difficulties in applying on demand lean production system: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas, polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Lack of skilled manpower | 0 | 0 | 1 | 0 | 1 | 14.3 |
| Lack of information about this tool | 3 | 1 | 1 | 1 | 6 | 85.7 |
| lack of top management support | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 3 | 1 | 2 | 1 | 7 | 100 |

Source: Field survey, 2013

Practical difficulties in applying on demand lean production system can be shown in pie chart as follows:

From the Table 7 it can be seen that 14.3% organizations are not using the On demand lean production system due to the lack of technical manpower, while 85.7% organizations are not using due to the lack of information and knowledge about this cost reduction tool.

From the above data it can be seen that there is the lack of knowledge and technical manpower in using the cost reduction tool

### 4.2.1.4.3 Application of Build to Order

The results on application of Build to Order as the cost reduction tool in Nepalese manufacturing organizations can be presented in following table:

**Table No 8**

**Application of Build to Order: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas , polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Applying (yes) | 0 | 1 | 0 | 1 | 2 | 20 |
| Not applying (No) | 3 | 1 | 3 | 1 | 8 | 80 |
| Total | 3 | 2 | 3 | 2 | 10 | 100 |

Source: Field survey, 2013

The Table No 8 shows that 20% of the organizations out of sampled organizations are using build to order as cost reduction tool, while 80% of the organizations are not applying this tool as the cost reduction.

It can be said that most of the Nepalese manufacturing organizations are not using the Build to Order as the cost reduction.

**Table No: 9**

**Practical difficulty in applying Build to Order: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas , polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Non availability of suppliers for using spontaneous supply | 2 | 1 | 1 | 1 | 5 | 62.5 |
| lack of information and knowledge about this tool | 0 | 0 | 1 | 0 | 1 | 12.5 |
| lack of skilled and technical manpower | 1 | 0 | 1 | 0 | 2 | 25 |
| lack of top management support | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 3 | 1 | 3 | 1 | 8 | 100 |

Source: Field survey, 2013

The practical implication in using Build to Order can be shown from the following pie chart:

From the Table No 9 it can be seen that 62.5% of the organization out of the sampled which are not using the Build to order as the cost reduction tool due to non availability of suppliers for using spontaneous supply. 25% organization out of sampled are not applying build to order due to the lack of skilled and technical manpower, while 12.5% organizations are not using due to the lack of information and knowledge about the build to order system.

From the above figure it can be seen that most of the Nepalese manufacturing organizations are not using Build to Order due to the non availability of suppliers for spontaneous supply.

**4.2.1.4.4 Application of mass customization, the proactive management of variety**

The data relating to the application of mass customization of product that can reduce the cost can be shown in the following table:

**Table No. 10**

**pplication of mass customization, the proactive management of variety: subsector wise observation**

| Particulars | Food industries | Beverage industries | Gas , polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Applying (mass customized product) | 0 | 0 | 0 | 0 | 0 | 0 |
| Not applying (standardized product) | 3 | 2 | 3 | 2 | 10 | 100 |
| Total | 3 | 2 | 3 | 2 | 10 | 100 |

Source: Field survey, 2013

From the Table No 10, it can be seen that none of the sampled manufacturing organizations are producing the mass customized product. From the above data all of sampled organizations are producing standardized products only. They are not producing mass customized product for customer.

**Table No. 11**

**Practical difficulties in producing mass customized product: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas , polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Lack of technical and skilled manpower | 1 | 0 | 1 | 0 | 2 | 20 |
| Lack of modern technology | 2 | 1 | 2 | 2 | 7 | 70 |
| Lack of knowledge about mass customization | 0 | 1 | 0 | 0 | 1 | 10 |
| Lack of suppliers for spontaneous supply chain | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 3 | 2 | 3 | 2 | 10 | 100 |

Source: Field survey, 2013

From the Table No 11 it can be seen that 70% of the organizations are not using the mass customization as the technique of cost reduction due to the lack of modern technology, while 20% organization can not adopted the mass customization technique due to lack of technical and skilled manpower. Likewise, 10% organizations are not adopting this tool due to the lack of knowledge about mass customization.

It can be said that most of the Nepalese manufacturing organizations lack the modern technology to adopt the mass customization technique as the cost reduction tool from which varieties of products can be produced for job order according to the needs and wants of the customer.

### 4.2.1.4.5 Application of Part Standardization

Primary data collected from different manufacturing organizations related to the application of part standardization can be presented as follows:

**Table No. 12**

**Application of part standardization: sub sector wise observation**

| Particulars | Food Industries | Beverage industries | Gas, Polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Uses of standardized parts (Applying) | 0 | 1 | 1 | 2 | 4 | 40 |
| Uses of varieties of parts (Not applying) | 3 | 1 | 2 | 0 | 6 | 60 |
| Total | 3 | 2 | 3 | 2 | 10 | 100 |

Source: Field survey, 2013

From the Table No 12 it can be seen that only 40% of the organizations are using the standardized parts, while 60% of the sampled organizations are using the varieties of parts

The primary data relating to the practical difficulties in applying part standardization as the cost reduction technique is presented as follows:

**Table No. 13**

**Practical difficulties in using the standardized parts: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas , polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Lack of suppliers supplying standardized parts | 3 | 0 | 1 | 0 | 4 | 67% |
| Lack of support of top management | 0 | 0 | 0 | 0 | 0 | 0% |
| Lack of knowledge about the part standardization | 0 | 1 | 1 | 0 | 2 | 33% |
| Total | 3 | 1 | 2 | 0 | 6 | 100 |

Source: Field survey, 2013

From the Table No 13 it can be seen that most of the organizations are not using the standardized parts due to the lack of suppliers supplying standardized parts. about 68% organizations out of sampled which are not using standardized parts due to the lack of suppliers supplying standardized parts, while 33% organization are not using the standardized parts due to the lack of knowledge about the part standardization.

#### 4.2.1.4.6 Application of Product Line Rationalization

The primary data relating to the application of product line rationalization can be presented as follows:

**Table No. 14**

**Application of product line rationalization: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas , polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Applying (yes) | 2 | 1 | 3 | 1 | 7 | 70 |
| Not applying (No) | 1 | 1 | 0 | 1 | 3 | 30 |
| Total | 3 | 2 | 3 | 2 | 10 | 100 |

Source: Field survey, 2013.

From the Table No 14, only 70% of the manufacturing organization are using the product line rationalization as the technique of cost reduction, while 30% organization out of sampled organization are not applying this technique due to different reasons such as due to the fear of losing customer, due to the fear of decreasing sales volume etc.

The primary data relating to the practical difficulties in applying product line rationalization can be presented in the follows:

**Table No. 15**

**Practical difficulties in applying product line rationalization: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas, polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Due to the fear of decreasing sales | 1 | 1 | 0 | 1 | 3 | 100% |
| Due to the fear of loosing customer | 0 | 0 | 0 | 0 | 0 | 0% |
| Lack of top management support | 0 | 0 | 0 | 0 | 0 | 0% |
| Total | 1 | 1 | 0 | 1 | 3 | 100 |

Source: field survey, 2013

From the Table No 15 it can be seen that 100% organizations which are not applying product line rationalization technique as the cost reduction tool due the fear of decreasing sales. No one organization is the applying product line rationalization due the fear of losing customer, or lack of top management support.

From the above analysis it can be said that most of the Nepalese manufacturing organizations which are not applying product line rationalization due to the fear of decreasing sales.

#### 4.2.1.4.7 Application of Supply Chain Management as the Cost Reduction Tool

The primary data relating to the application of supply chain management as the cost reduction technique can be shown in the following table:

**Table No. 16**

**Application of supply chain management: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas, polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Applying (yes) | 2 | 2 | 2 | 2 | 8 | 80 |
| Not applying (No) | 1 | 0 | 1 | 0 | 2 | 20 |
| Total | 3 | 2 | 3 | 2 | 10 | 100 |

Source: Field survey, 2013.

From the Table No 16, it can be seen that 80% of the sampled organizations are managing their supply chain as the cost reduction tool, while 20% of the sampled organization could not applying the supply chain management technique.

The data relating to the practical implications in applying supply chain management as the cost reduction tool can be shown in the following table:

**Table No. 17**

**Practical implications in applying supply chain management as the cost reduction tool: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas, polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Lack of suppliers for spontaneous supply chain | 0 | 0 | 1 | 0 | 1 | 50 |
| Lack of modern technology | 0 | 0 | 0 | 0 | 0 | 0 |
| Lack of knowledge about supply chain management | 1 | 0 | 0 | 0 | 1 | 50 |
| lack of top management support | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 1 | 0 | 1 | 0 | 2 | 100 |

Source: Field survey, 2013

From the Table No 17 it can be seen that 50% of sampled organizations are not using supply chain management due to the lack of suppliers for spontaneous supply chain, while 50% organizations are not applying supply chain management as the cost reduction tool due to the lack of knowledge about supply chain management. It can be said from the above analysis most of the Nepalese manufacturing organization are not applying supply chain management technique due to lack of suppliers for spontaneous supply chain, and lack of knowledge about supply chain management.

#### 4.2.1.4.8 Application of total quality management as the technique of cost reduction

The data relating to the applying total quality management as the tool of cost reduction can be shown in the following table:

**Table No. 18**

**Application of total quality management: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas , polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Applying (yes) | 3 | 2 | 3 | 2 | 10 | 100 |
| Not applying (No) | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 3 | 2 | 3 | 2 | 10 | 100 |

Source: Field survey, 2013

From the Table No. 18 it can be seen that all of the sampled Nepalese manufacturing organizations are applying the Total quality management as the cost reduction tool.

#### 4.2.1.4.9 Application of KAIZEN (Continuous Improvement) system as the technique of cost reduction

The primary data collected from different Nepalese manufacturing organizations relating to the application KAIZEN system can be presented in the following table:

**Table No. 19**

**Application of KAIZEN system as the technique of cost reduction: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas, polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Applying (yes) | 2 | 1 | 3 | 2 | 8 | 80 |
| Not applying (No) | 1 | 1 | 0 | 0 | 2 | 20 |
| Total | 3 | 2 | 3 | 2 | 10 | 100 |

Source: Field survey, 2013

From the Table No 19, it can be seen that 80% of the sampled organizations are continuously improving their organization by solving problem step by step, while 20% of the sampled organization are not adopting the KAIZEN system to improve their organization. From the above analysis it can be said that most of the organizations are going to improve their organization in a evolutionary manner.

The data relating to the practical difficulties in applying KAIZEN system can be shown in the following table:

**Table No. 20**

**Practical difficulties in applying KAIZEN system: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas, polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Lack of managerial manpower | 1 | 0 | 0 | 0 | 1 | 50 |
| Lack of knowledge about KAIZEN system | 0 | 1 | 0 | 0 | 1 | 50 |
| lack of top management support | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 1 | 1 | 0 | 0 | 2 | 100 |

Source: field survey, 2013

From the Table No 20 it can be seen that most of the organization are using the KAIZEN system out of sampled organization. But some of the organizations are not applying due to lack of managerial manpower and lack of knowledge about the KAIZEN system. From the above figure it can be seen that 50% organization are not applying KAIZEN system due to the lack of managerial manpower, while 50%

organizations are not using this system due to the lack of knowledge about KAIZEN system.

### 4.2.1.4.10 Application of Just In Time production system as the cost reduction tool:

The primary data relating to the application of Just In Time production system of Nepalese manufacturing organization are presented as follows:

**Table No. 21**

**Application of Just In Time production system as the cost reduction tool: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas, polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Applying (yes) | 0 | 0 | 0 | 1 | 1 | 10 |
| Not applying (No) | 3 | 2 | 3 | 1 | 9 | 90 |
| Total | 3 | 2 | 3 | 2 | 10 | 100 |

Source: field survey, 2013

From the Table No 21, it can be seen that only the 10% of the sampled organizations are applying the Just In Time production system as the cost reduction tool, while 90% of the sampled organization are not applying this technique as cost reduction tool. Form the above analysis it can be said that most of the Nepalese manufacturing organizations are not applying the Just In Time production system due to various reasons such as lack of modern technology, lack of technical manpower, lack of knowledge about Just In Time production system etc.

The data collected from different manufacturing organizations relating to practical difficulties in applying Just In Time production system are presented in following table:

**Table No. 22**

**Practical difficulties in applying Just in Time production system: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas, polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Lack of technical manpower | 1 | 0 | 0 | 0 | 1 | 11.11 |
| Lack of knowledge about Just In Time production system | 0 | 1 | 0 | 1 | 2 | 22.22 |
| Lack of modern technology | 2 | 1 | 3 | 0 | 6 | 66.67 |
| Lack of will of top management | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 3 | 2 | 3 | 1 | 9 | 100 |

Source: field survey, 2013

From the Table No 22, it can be said that most of the sampled organizations which are not applying Just in Time production system due to lack of modern technology. 67% of the sampled organizations are not applying this tool due to lack of modern technology, while 22% organizations are not using this technique due to the lack of knowledge about just in time production system. Likewise, 11% sampled organizations are not applying Just in Time production system due to lack of knowledge about JIT.

#### 4.2.1.4.11 Application of Reengineering as the cost reduction technique

The primary data collected from the different 10 manufacturing organizations located in Butwal relating to the application of Reengineering as the cost reduction tool are presented in the following table:

**Table No. 23**

**Application of Reengineering as the cost reduction technique: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas, polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Applying (yes) | 2 | 2 | 3 | 1 | 8 | 80 |
| Not applying (No) | 1 | 0 | 0 | 1 | 2 | 20 |
| Total | 3 | 2 | 3 | 2 | 10 | 100 |

Source: Field survey, 2013

From the Table No 23 it can be seen that most of the organizations are applying the Reengineering business process as the technique of cost reduction. 80% of the sampled organizations are applying the Reengineering technique as the cost reduction tool, while 20 percent of the sampled organizations are not applying this tool for the reduction of cost.

The data relating to the practical complications in applying Business process Reengineering as the technique of cost reduction are presented in the following table:

**Table No. 24**

**Practical difficulties in applying Reengineering as technique of cost reduction: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas, polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Lack of managerial manpower | 0 | 0 | 0 | 0 | 0 | 0 |
| Lack of knowledge about Reengineering | 1 | 0 | 0 | 1 | 2 | 100 |
| lack of top management support | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 1 | 0 | 0 | 1 | 2 | 100 |

Source: Field survey, 2013

From the Table No 24 it can be seen that 100% of the organization which are not applying Business process Reengineering is due to lack of knowledge about the Business process Reengineering.

#### 4.2.1.4.12 Management views regarding necessity for applying cost reduction tools in organizations

This survey collects the primary data relating to the management views regarding the necessity of applying cost reduction technique to become success in the business world:

**Table No. 25**

**Management views regarding the necessity of applying cost reduction tools: sub sector wise observation**

| Particulars | Food industries | Beverage industries | Gas , polypipe and plastic industries | Dairy industries | Total | |
|---|---|---|---|---|---|---|
| | | | | | No | % |
| Required | 3 | 2 | 3 | 2 | 10 | 100 |
| Not required | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 3 | 2 | 3 | 2 | 10 | 100 |

Source: Field survey, 2013

The Table No. 24 shows that 100% of the sampled organizations think that there is necessity of applying cost reduction tools to compete in the global market, but there is lack of managerial, technical manpower, lack of knowledge about the different cost reduction tools, lack of modern technology etc, which may restrict in the application of this technique.

### 4.3 Testing of Hypothesis

The hypothesis is that application of cost reduction tools is identical i.e. there is no significant difference between sub-sectors in applying cost reduction tools and between tools of cost reduction applying in different sub-sectors.

The total numbers of sampled Nepalese manufacturing organizations are fifteen from different sub sectors. From Food sector total three organizations were sampled, whereas two organizations were sampled from each Beverage sector and Dairy industries. Similarly, three organizations were sampled from Gas, Polypipe and Plastic industries.

To give equal justice, to all sub sector, LCM has been computed which comes 6. Then weight has been calculated by dividing 6 by the number of samples taken from each sector and assigned to them. Based on the weight assigned, the data regarding the number of organizations from different sub-sectors applying different cost reduction tools has been restructured. The work has been shown in the following restructured data as follows:

**Table No. 26**

**Weighted application of cost reduction tools: sub sector wise observation**

| Sub sector / Tools | Food Industries (XA) | Beverage Industries (XB) | Gas, Polypipe and Plastic Industries (XC) | Dairy Industries (XD) | Total |
|---|---|---|---|---|---|
| DFM & CE (X1) | 0 | 6 | 2 | 3 | 11 |
| On Demand Lean Production (X2) | 0 | 3 | 2 | 3 | 8 |
| Build to Order (X3) | 0 | 3 | 0 | 3 | 6 |
| Mass-customization (X4) | 0 | 0 | 0 | 0 | 0 |
| Part Standardization (X5) | 0 | 3 | 2 | 6 | 11 |
| Product Line Rationalization (X6) | 4 | 3 | 6 | 3 | 16 |
| Supply Chain Management (X7) | 4 | 6 | 4 | 6 | 20 |
| Total Quality Management (X8) | 6 | 6 | 6 | 6 | 24 |
| KAIZEN System (X9) | 4 | 3 | 6 | 6 | 19 |
| JIT Production System (X10) | 0 | 0 | 0 | 3 | 3 |
| Reengineering(X11) | 4 | 6 | 6 | 3 | 19 |
| Total | 22 | 39 | 34 | 42 | 137 |

Assuming level of significance is 5%

i) Null Hypothesis: $H_0$: $\mu_A = \mu_B = \mu_C = \mu_D$

(i.e. There is no significant difference in applying cost reduction tools between different sub sectors)

Alternative Hypothesis: $H_1$: $\mu_A \neq \mu_B \neq \mu_C \neq \mu_D$

( i.e. There is significant difference in applying cost reduction tools between different sub sectors)

ii) Null Hypothesis:$H_0$: $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = \mu_6 = \mu_7 = \mu_8 = \mu_9 = \mu_{10} = \mu_{11}$

(i.e. There is no significant difference in applying different types of cost reduction tools)

Alternative Hypothesis: $H_1$: $\mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4 \neq \mu_5 \neq \mu_6 \neq \mu_7 \neq \mu_8 \neq \mu_9 \neq \mu_{10} \neq \mu_{11}$

(i.e. There is significant difference in applying different types of cost reduction tools)

All values are presented below:

**Table No. 27**

**Two-Way ANOVA Table**

| Source of variation | Sum of squares | Degree of Freedom | Mean sum of Squares | F- Ratio |
|---|---|---|---|---|
| Due to column factor ( sub sector) | 21.46 | 4-1= 3 | $\frac{21.46}{3} = 7.15$ | $F = \frac{7.15}{2.043} = 3.50$ |
| Due to Row Factor (Types of tools) | 149.98 | 11-1=10 | $\frac{149.98}{10} = 15$ | $F = \frac{15}{2.043} = 7.34$ |
| Due to Error | 61.29 | 3×10 = 30 | $\frac{61.29}{30} = 2.043$ | |

i. The variance ratio for column/ sub-sector is 3.50. The critical value of F at 5% level of significance for (3, 30) d.f. is 2.92.

Decision: since, the calculated value of F is greater than the tabulated value for d.f. (3,30). Thus Null Hypothesis is not accepted. Therefore, it is concluded that there is significant difference in applying cost reduction tools between different sub sectors.

ii. The variance ratio for Row/ cost reduction tools is 7.34. The critical value of F for (10, 30) d.f. is 2.16.

Decision: since, the calculated value of F is greater than the tabulated value for (10,30) d.f. Thus, Null Hypothesis is not accepted. Therefore, it is concluded that application of cost reduction tools is not identical among cost reduction tools.

## 4.4 Percentage of Applying and not Applying Cost Reduction Tools, A Toolswise Observation

**Table No. 28**

**Percentage of applying and not applying cost reduction tools: tools wise observation**

| Tools | Applying % | Not Applying % | Total % |
|---|---|---|---|
| DFM & CE | 40 | 60 | 100 |
| On Demand Lean Production | 30 | 70 | 100 |
| Build to Order | 20 | 80 | 100 |
| Mass-customization | 0 | 100 | 100 |
| Part Standardization | 40 | 60 | 100 |
| Product Line Rationalization | 70 | 30 | 100 |
| Supply Chain Management | 80 | 20 | 100 |
| Total Quality Management | 100 | 0 | 100 |
| KAIZEN System | 80 | 20 | 100 |
| JIT Production System | 10 | 90 | 100 |
| Reengineering | 80 | 20 | 100 |

Source: Field survey, 2013

The Table No 27 shows the application of individual cost reduction tools. Total quality management has been applied by all sampled organizations, while mass-customization has not been applied by any sampled organizations. All the other facts concluded are shown in the above figure.

## 4.5 Percentage of Applying and not Applying Cost Reduction Tools, An Overall Observation

The aggregate percentage of applying and not applying cost reduction tools of all organization are presented in the following table:

**Table No. 29**

**Percentage of applying and not applying cost reduction tools: overall observation**

| Particular | Percentage |
|---|---|
| Applying | 50% |
| Not applying | 50% |
| Total | 100% |

Source: Field survey, 2013.

From the above table, it is shown that on average the percentage of applying cost reduction tools by the sampled organizations is 50%, and the percentage of not applying cost reduction tools is also 50%.

The Table No. 28 shows that 50% cost reduction tools are applying by sampled manufacturing organizations on average, while on aggregate 50% cost reduction tools are not applied by the sampled organizations.

## 4.6 Major Findings of the Study

Based on the above analysis and interpretation of data relating to application of cost reduction tools in Nepalese manufacturing organizations has found the following major findings have been obtained:

- Only 40% organizations are applying the design for manufacturability and concurrent engineering as the cost reduction technique, while 60% organizations are not applying. The main practical difficultly in not applying this tool is the lack of knowledge and information about this tool, while second difficulty is the lack of technical manpower which is restricting the uses of this tool.
- Average 50% of cost reduction tools are applied by the sampled manufacturing organizations, while on aggregate 50% of the cost reduction tools are not applying by the sampled organizations.
- Only 30% of the sampled organizations are applying on demand lean production system as the cost reduction tool, while 70% of the organizations are not applying this cost reduction tool. It is found that the main difficulty in applying cost reduction tool is the lack of information and knowledge about this tool, while second reason of not applying tool is lack of skilled and technical manpower.
- Only 20% of the sampled manufacturing organizations are applying build to order as cost reduction tool, while 80% of the organizations are not applying this cost reduction tool. 62.5% organizations are not applying this tool due to non availability of using spontaneous supply, while 25% organizations are not using build to order as the cost reduction tool due to the lack of technical manpower. Likewise.12.5% organizations are not using this tool due to the lack of information and knowledge about this tool.
- No one out of the sampled organizations are not applying mass customization as the cost reduction tool. All 100% of the organizations are not using this tool. 70% of the organizations are not applying mass customization as the

technique of cost reduction due to the lack of modern technology, while 20% of the organizations are not using this tool due to the lack of technical manpower. Likewise, 10% of the organizations are the applying due to the lack of spontaneous supply chain.

- 40% of the sampled manufacturing organizations are applying part standardization as the technique of cost reduction, while 60% of the organizations are not using this tool to reduce the cost. Main practical difficulty in not applying part standardization is due to the lack of suppliers supplying standardized parts. 67% of the organizations are not using this tool due to lack of suppliers supplying standardized parts. 33% of the organizations are not applying due to lack of knowledge about part standardization.
- 70% of the organizations are applying product line rationalization as the technique of cost reduction, while 30% of the organizations are not applying this tool. 100% of the organizations which are not applying this tool is due to the fear of decreasing sales.
- 80% of the organizations are using supply chain management as the tool of cost reduction, while 20% of the organizations are not applying. 50% organizations are not applying this tool due to the lack of spontaneous supply chain, while 50% organizations are the using due to the lack of knowledge about supply chain management.
- All of the organizations are applying Total quality management as the cost reduction tool i.e. 100% sampled organizations are applying the total quality management.
- 80% of the sampled organizations are using the KAIZEN system as the cost reduction tool, while 20% of the organizations are not applying. The main practical difficulties in applying KAIZEN system as the technique of cost reduction are lack of managerial manpower and lack of knowledge about KAIZEN system.
- Only 10% of the organizations are applying Just in Time production system, while 90% of the organizations are not using this tool. 66.7% organizations are not applying this tool due to lack of modern technology, while 22.2% organizations are not using due to lack of knowledge about this tool. Likewise, 11.1% organizations are not applying due to the lack of technical manpower.

- 80% of the organizations are using the Reengineering process as the technique of cost reduction tool, while 20% of the organizations are the applying this tool. Only the reason of not applying this tool is due to lack of knowledge about reengineering process.
- It is found that cent percent of the organization think that there is needed of applying cost reduction tools to compete in the global market.
- 60% of the sampled organizations are increasing sales volume to increase their profit, while 40% of the organizations are reducing their cost to increase the profit of their organization.
- From the study, it is found that 40% of the organizations are selecting purchase of material and control as the area of cost reduction, while 30% of the organizations are selecting production planning and control as the area of cost reduction. Likewise, 10% of the organizations are using equipment and plant layout as the area of cost reduction, while 10% of the organizations are selecting selling and distribution as the area of cost reduction.
- It is found that 50% of the organizations are lowering the price of their product by bargaining with suppliers, while 40% of the organizations are managing the cost in scientific way to reduce the price of the product. Only 10% of the organizations are lowering their profit margin to manage the price of their product.

# CHAPTER V

# SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter highlights some selected actionable conclusion and recommendations on the basis of the major findings of the study derived from the survey of uses of cost reduction tools in Nepalese manufacturing organizations.

## 5.1 Summary

Nepalese organizations are suffering from various problems. The major problems facing the industrial units can be cost related, government related, demand related, finance related, infrastructure related, labor related etc. Most of the business firms, after the liberalization of the economy, have been finding themselves in a vulnerable position. This vulnerability in most cases has arisen due to emerging competition and lack of cost efficiency.

The main problem of Nepalese manufacturing organization is incurrence of high cost during the product production process. Due to this, many of the firms are being shut-down. It is a very miserable condition for industry as well as nation too. Most of organizations think that they have to buy raw materials in very low cost from their suppliers. The purchase manager only concerns with this topic. So, other managers show less responsibility toward cost minimization. This is why, organizations have to face high cost problem.

Nepalese manufacturing organizations are facing the problem of high cost of materials and lack of materials. Similarly, they also do not have proper knowledge of management and other ideas about running the business successfully. High cost of production is headache for Nepalese manufacturing organizations. There are lots of tools and techniques to reduce the cost of productions. Most of the tools have been innovated by Japanese manufacturing organizations. And these tools are applying by Japanese manufacturing organizations at present. So, it is needed to understand that the key success of Japanese manufacturing organizations is proper application of such tools. This research work has been done with the objective of identifying the current state of the application of cost reduction tools in Nepalese manufacturing organizations, pointing out and finding the practical difficulties of applying cost reduction tools in Nepalese manufacturing organizations and providing suggestions for the application of cost reduction tools to the organizations.

As Nepal has entered into WTO membership and has signed the protocol of SAFTA, it has to liberalize its market and from this the products of foreign manufacturing organization freely move within the country. Hence, Nepalese manufacturing organizations have to further compete with their foreign competitors. The work for the country is now for making Nepalese products cheaper than imported products. This necessitates cost reduction practice in Nepalese industries sectors. Mass participation, wide communication and effective training within the organization can only help to use cost reduction tools in organizations. Management tools like leadership, motivation etc should be used. There are several areas where cost reduction works can be exercised. Some of these areas are product design, production planning and control, equipment and layout, purchase and control of materials etc. For cost reduction, the modern cost reduction tools are being used which are Design for manufacturability and concurrent engineering, On demand lean production, Build to order, Mass customization, Part standardization, Product line rationalization, Just in Time production system, Business reengineering, KAIZEN system etc.

One of the main factors of success of Japanese manufacturing organization is application of JIT as a cost reduction tool. JIT philosophy made famous by Toyota which has been credited with success of many of the world’s leading manufacturers. But in Nepal, non of the organizations are applying JIT as the cost reduction tool. So, it is very miserable condition for Nepalese manufacturing organizations.

In 1980s, most of the European and American companies considered quality to be an additional cost of manufacturing, but by the end of the decade, they began to realize that quality saved money. Companies discovered that it was cheaper to produce items correctly the first time rather their responses by making substandard items that have to be detected, reworked, scrapped, or returned by customers. In other words, the emphasis of TQM is to design and build quality rather than trying to inspect it in, by focusing on the causes rather than symptom of poor quality.

Similarly, DFM & CE, Build to Order, On Demand Lean production, Mass customization, Product line rationalization, KAIZEN, Reengineering etc also help to reduce the cost of production. Most of these tools are innovated from Japan. So, Japanese manufacturing organizations are getting success. It is needed to apply such tools in Nepalese manufacturing organization also.

### 5.2 Conclusion

Everyday we hear news regarding the shut-down of many big corporations. Although the reason whatever, the cost can be sometimes explained reasonable. Every business organization wants its contribution in the society. It wants to niche at least a sustainable margin for it. But it is not reachable when organizations fail to manage its cost. Then it becomes very miserable condition for organization. Most of organization think that to purchase at lower price from supplier is only the key factor to reduce the cost.

Most of the organizations are applying product line rationalization, supply chain management, KAIZEN system, reengineering as the technique of cost reduction. Nepalese manufacturing organizations prefer to increase in sales volume and reduction in cost for increasing profit of their organization. Most of the Nepalese manufacturing organizations are selecting the purchase of raw material, production planning and control as the area of reducing their cost  No one organization is applying the mass customization as the tool of cost reduction. The main cause of not applying this tool is the lack of modern technology. Most of the Nepalese manufacturing organizations based in Butwal prefer the measures such as bargaining with the suppliers of materials and managing cost in the scientific way to lower the price of their product. All of the organizations are conscious about TQM as the technique of cost reduction. Most of the organizations are not applying the Design for manufacturability and concurrent engineering, on demand lean production, build to order, part standardization, Just in Time production system as the tools of cost reduction. It can be concluded from the ANOVA test that there is significant difference in applying cost reduction tool between sub sectors and between different cost reduction tools. It can be concluded that on aggregate the percentage of applying cost reduction tools is 50%, while on average the percentage of not applying cost reduction tools is also remains 50%.

### 5.3 Recommendations

As we know, there are so many cost centers in one manufacturing organization. All cost centers should be responsible for managing the cost. So, management should know that using many cost reduction tools other than direct bargaining for costs with the suppliers to reduce cost of goods and services. Lack of well educated human resources and experienced management team are the problem in every business organization. So, the organization should focus its attention for competitive human resources.

Despite the peaceful political transition, the political environment in Nepal has deteriorated over the months. The country has now passing through the situation of disturbance and turbulences. Mass rallies, chakka jams, bandhs have been the regular phenomena. So, the Nepalese manufacturing organizations are waiting the full fledge government policy regarding manufacturing organizations.  On the other side, Nepal is now become the member of WTO, SAFTA, BIMSTEC etc. So the Nepalese manufacturing organizations are facing the global competition. Nepalese market is flooded by the quality product in cheaper price produced by multinational companies. This has leading to the pressure in Nepalese manufacturing organizations to reduce cost and produce quality product. Most of the Nepalese manufacturing organizations have closed down due to the lack of cost competitiveness. Due to the lack of knowledge about cost reduction tools, most of the organizations are not applying these tools properly. It is recommended to use cost reduction tools to become competitive in the global market. For this purpose Nepalese manufacturing organizations have to invest in modern technology.  It is also recommended that they have to invest in building human capital that means investing in building technical and managerial manpower, which would help in using these cost reduction tools.

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# APPENDIX - I

## RESEARCH QUESTIONNAIRE

Dear sir,

I, Mr. Madhu Pd. Khanal, student of Lumbini Banijya Campus is going to conduct a research entitled "Uses of Cost Reduction Tools in Nepalese Manufacturing Companies: A Case Study of Butwal Area", as a partial fulfillment of the Masters of Business Studies. Your individual response will be kept confidential and will be used only in an aggregate level. I would be grateful if you could spend few minutes to respond to this survey questionnaire.

Sincerely yours
Madhu Pd. Khanal
Lumbini Banijya Campus

Name of the Organization :-
Name of the Respondent (optional) :-
Age :-
Gender :-
Department :-
Experience :-

Please tick (√) only one option out of the different alternatives:

1. What is your opinion on applying cost reduction tools in Nepalese manufacturing organizations
   a) Highly needed b) Needed c) undecided
   d) Rarely needed e) Not needed
2. Have you adopted the cost reduction tools in your organizations?
   a) Fully adopted b) partially adopted c) planning to adopt
   d) Not adopted at all
3. From what practice you are increasing profit in your organization?
   a) Increasing in volume of sales
   b) Increase in selling price
   c) Reduction in cost
4. What measures you are applied for lowering price of products?
   a) Bargaining with the suppliers of materials
   b) Managing the cost in scientific way
   c) Minimizing its profit margin on sales

5. What areas you have selected for cost reduction?
    a) Product design
    b) Production planning and control
    c) Equipment and plant layout
    d) Selling and distribution
    e) Purchase of materials
6. Whether your organization has adopting the design for manufacturability and concurrent engineering as cost reduction tool?
    a) Applying (yes) b) Not applying (No)
7. If not, what is the practical difficulty of not adopting design for manufacturability and concurrent engineering?
    a) Lack of skilled manpower
    b) lack of information about this tool
    c) non availability of modern technology
8. Whether your organization adopting the on demand lean production system to reduce the cost?
    a) Applying (yes) b) Not applying (No)
9. If not, what are the main problems in not using the on demand lean production system?
    a) Lack of skilled manpower
    b) Lack of knowledge about the on demand lean production system
    c) Lack of top management support
10. Whether your organization builds the product for order or produce in batches on mass quantity?
    a) Producing for job order (applying)
    b) Producing in batches on mass quantity (not applying)
11. If not what are the practical problems in using build to order?
    a) Non availability of suppliers for using spontaneous supply
    b) Lack of knowledge about build to order
    c) Lack of skilled manpower for designing product and process concurrently
    d) Lack of top management support
12. Whether your organization producing the mass-customized product or standardized products?
    a) Mass customized product b) Standardized products

13. If not what are the main problems in not using the technique of mass customization of product as a cost reduction tool?
    a) Lack of technical manpower for designing mass customized product
    b) Lack of modern technology
    c) Lack of knowledge about mass customization
    d) Lack of suppliers for spontaneous supply chain?
14. Whether your organization purchases the standardized parts from which cost can be reduced by purchasing standardized parts in bulk quantities or varieties of parts?
    a) Uses standardized parts   b) Using the varieties of parts
15. If not, what are the main difficulties in not adopting the part stardization as the cost reduction tool?
    a) Lack of suppliers providing standardized parts
    b) Lack of support of top management
    c) Lack of knowledge about part standardization
16. Whether your organization adopting the product line rationalization from which unprofitable product could be eliminated from the product line?
    a) Applying   b) Not applying
17. If not, what are the main difficulties in adopting product line rationalization
    a) Due to the fear of decreasing sales
    b) Due to fear of losing customer
    c) Lack of will of top management
18. Whether you are using the supply chain management as the cost reduction tools?
    a) Applying   b) Not applying
19. If not, what are the main implications of not being able to adopt the supply chain management as the cost reduction tool?
    a) Lack of suppliers for spontaneous supply chain
    b) Lack of modern technology
    c) Lack of knowledge about the supply chain management
    d) Lack of support from the top management
20. Whether your organization adopting the Total quality management techniques as the cost reduction tool?
    a) Applying   b) Not applying
21. If not what are the main difficulties in applying the Total quality management techniques?
    a) Lack of technical manpower in designing product in quality
    b) Lack of highest quality processing, or automated processing

c) Lack of desire of top management in using Total quality management technique

22. Whether your organization using the KAIZEN (Continuous improvement) system for the reduction of cost?

a) Applying b) Not applying

23. If not, what are the main problems in not adopting KAIZEN System?

a) Due to the lack of managerial manpower
b) Lack of knowledge about KAIZEN system
c) Lack of support of top management

24. Whether your organization adopting the Just In Time production system to reduce the cost of your organization?

a) Applying b) Not applying

25. If not, what is the main practical difficulty in using the Just In Time (JIT) production system?

a) Lack of technical manpower
b) Lack of knowledge about the Just In Time production system
c) Lack of modern technology
d) Lack of will of top management

26. Whether your organization using the Reengineering technique to redesign the business processes that modified, eliminated, combined the jobs?

a) Applying b) Not applying

27. What is the main difficulty in redesigning the business processes?

a) Lack of managerial manpower
b) Lack of knowledge about Reengineering
c) Lack of support from top management

**Thanks for your kind co-operation**

# APPENDIX - II

1. Computation of weight:
   i. LCM comes to 6 from 3,2,3,2
   ii. Weight of each sub-factor = $\frac{\text{LCM}}{\text{Respective Number of Sample}}$
   iii. Value of each sub-factor = weight × No. of sample applying cost reduction tools.
2. Data has been restructured as follows:

| Particulars | Food (A) | Beverage (B) | Gas, Polypipe &plastic (C) | Dairy (D) | $X^2_A$ | $X^2_B$ | $X^2_C$ | $X^2_D$ | $\Sigma X_R$ | $\Sigma X^2_R$ |
|---|---|---|---|---|---|---|---|---|---|---|
| DFM & CE | 2x0=0 | 3x2=6 | 2x1=2 | 3x1=3 | 0 | 36 | 4 | 9 | 11 | 49 |
| On Demand Lean Production | 2x0=0 | 3x1=3 | 2x1=2 | 3x1=3 | 0 | 9 | 4 | 9 | 8 | 22 |
| Build to Order | 2x0=0 | 3x1=3 | 2x0=0 | 3x1=3 | 0 | 9 | 0 | 9 | 6 | 18 |
| Mass-customization | 2x0=0 | 3x0=0 | 2x0=0 | 3x0=0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Part Standardization | 2x0=0 | 3x1=3 | 2x1=2 | 3x2=6 | 0 | 9 | 4 | 36 | 11 | 49 |
| Product Line Rationalization | 2x2=4 | 3x1=3 | 2x3=6 | 3x1=3 | 16 | 9 | 36 | 9 | 16 | 70 |
| Supply Chain Management | 2x2=4 | 3x2=6 | 2x2=4 | 3x2=6 | 16 | 36 | 16 | 36 | 20 | 104 |
| Total Quality Management | 2x3=6 | 3x2=6 | 2x3=6 | 3x2=6 | 36 | 36 | 36 | 36 | 24 | 144 |
| KAIZEN System | 2x2=4 | 3x1=3 | 2x3=6 | 3x2=6 | 16 | 9 | 36 | 36 | 19 | 97 |
| JIT Production System | 2x0=0 | 3x0=0 | 2x0=0 | 3x1=3 | 0 | 0 | 0 | 9 | 3 | 9 |
| Reengineering | 2x2=4 | 3x2=6 | 2x3=6 | 3x1=3 | 16 | 36 | 36 | 9 | 19 | 97 |
| $\Sigma X_C$ | 22 | 39 | 34 | 42 | 100 | 189 | 172 | 198 | 137 | 659 |

3. The computation of correction factor:

Correction factor, total sum of squares (TSS), sum of squares due to sub sector (SSC) and sum of squares due to types of tools (SSR), sum of squares due to errors (SSW) have been calculated below:

i. Correction factor (C.F) = $\frac{T^2}{N}$ = $\frac{137^2}{11X4}$ = 426.57

ii. Total sum of squares (TSS) = Σx2rc - C.F. = $0^2 + 6^2 + 2^2 + 3^2 + 0^2 + 3^2 + 2^2 + 3^2 + 0^2 + 3^2 + 0^2 + 3^2 + 0^2 + 0^2 + 0^2 + 0^2 + 0^2 + 3^2 + 2^2 + 6^2 + 4^2 + 3^2 + 6^2 + 3^2 + 4^2 + 6^2 + 4^2 + 6^2 + 6^2 + 6^2 + 6^2 + 6^2 + 4^2 + 3^2 + 6^2 + 6^2 + 0^2 + 0^2 + 0^2 + 3^2 + 4^2 + 6^2 + 6^2 + 3^2$ - 426.57= 659-426.27 = 232.73

iii. Sum of squares between column/ sub sector (SSC) = $\frac{\Sigma(Xc)^2}{NR}$

$= \frac{22^2}{11} + \frac{39^2}{11} + \frac{34^2}{11} + \frac{42^2}{11} - 426.27$

= 21.46

iv. Sum of squares between rows/ types of tools (SSR) = $\frac{\Sigma(Xr)^2}{NC}$

$= \frac{11^2}{4} + \frac{8^2}{4} + \frac{6^2}{4} + \frac{0^2}{4} + \frac{11^2}{4} + \frac{16^2}{4}$

$\frac{20^2}{4} + \frac{24^2}{4} + \frac{19^2}{4} + \frac{3^2}{4} + \frac{19^2}{4} - 426.27$

= 576.25-426.27

= 149.98

v. Sum of squares due to errors:

SSE = TSS – SSC – SSR

= 232.73 - 21.46 - 149.98

SSE = 61.29