SRM INSTITUTE OF SCIENCE AND TECHNOLOGY ,
KATTANKULATHUR
FACULTY OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

18MEO111T INDUSTRIAL ENGINEERING

VI SEM

UNIT-III WORK DESIGN, TYPES AND FUNCTION OF PRODUCTION AND PRODUCTIVITY MEASUREMENT

Design of Work Systems

is an important component in Production and Operations Management.
It forms the basis and explains the importance of work design.

Basic approaches to job design

i)Efficiency through job specialization
ii)Behavioral approaches to job design.

Design of Work System also entails method analysis which in turn centers on how jobs are performed.
Provides an opportunity to the Organization to develop effective teams who can achieve organizations short and long term objectives.

In short this topic of Design of Work Systems provides the perfect bridge between Production and Operations Management with Human Resource Management.

Work System Design consists of
Job design
Work measurement and
Establishment of time standards and worker compensation.

Like Product or Service design will affect Design of Work Systems.
Layout Decisions will also affect Design of Systems.

Job design involves specifying the content and methods of job.
In general the goal of the job design is to create a work system that is not only productive but also efficient.

Job designers are concerned with

– What will be done
– Who will do the job
– How the job will be done
– Where the job will be done
– Ergonomics

A **successful Job Design must have the following qualities**

1. Carried out by experienced personnel who have the necessary training and background.
2. Consistent with the goals of the organization.
3. In documented form.
4. Understood and agreed by both management and employees.
5. Shared with the new employees.
6. Factors that affect Job Design

FACTORS that affect Job design include

1. Lack of knowledge of the employees.
2. Lack of Management support.
3. Lack of documented job design which often leads to poor audit review and referral.
4. Job Design can be carried out in 2 ways the Efficient School and the Behavior School.
5. Efficiency School was popular in 1950s based on Frederick W Taylor's Scientific Management principles.
6. Behavior school is relatively new concept and focused on

Design of Work Systems

- Specialization
- Behavioural Approaches to Job Design
- Teams
- Methods Analysis
- Motions Study
- Working conditions

Specialization

The term specialization refers to work that concentrates on some aspect of a product or service.

Jobs that have a narrow scope.

Assembly lines, medical specialties, MBA courses.

Specialization jobs tend to yield high productivity, low unit costs and lead to high st andard of living in most of the industrial nations.

Behavioural Approaches to Job Design

• Job Enlargement – Giving a worker a larger portion of the total task by horizontal loading
• Job Rotation – Workers periodically exchange jobs
• Job Enrichment – Increasing responsibility for planning and coordination tasks, by vertical loading .

Teams

Organization adopt teams in order to exploit the benefits of teams
Higher quality
Higher productivity
Greater worker satisfaction.

Methods Analysis

- Changes in tools and equipment
- Changes in product design or new products
- Changes in materials or procedures
- Other factors (e.g. accidents, quality problems)

Developing Work Methods

Eliminate unnecessary motions

- Combine activities
- Reduce fatigue
- Improve the arrangement of the workplace
- Improve the design of tools and equipment

Methods analysis deals with analyzing how a job gets done, begins with overall analysis and then moves to specific details like changes in tools and equipment, Changes in product design or new products, Changes in materials or procedures and Other factors (e.g. accidents, quality problems)

Methods Analysis Procedure is simple and effective and are as follows:

Gets employee input
Studies and documents the current method
Analyzes the job
Proposes new methods
Installs new methods
Follow-ups to ensure improvements have been achieved

Motion Study is the systematic study of the human motions used to perform an operation. The purpose is to eliminate /weed-out unnecessary motions and identify the best sequence of operations for maximum efficiency.
Motion study forms an important part in productivity improvements. It is based on Frank Gilbreths brick laying trade in the early 20th century, through the use of time motion study techniques.

Motion Study Techniques often incorporate the following four types
1. Motion study principles - guidelines for designing motion efficient work procedures
2. Analysis of therbligs -basic elemental motions into which a job can be broken down
3. Micro motion study - use of motion pictures and slow motion to study motions that otherwise would be too rapid to analyze
4. Charts

Motion study principles Gilbreths work laid the foundation for motion study principles, which are
guidelines for designing motion efficient work procedures. The guidelines are divided into threecategories.

1. Principles of the use of body.
2. Principles for the arrangement of the work place.
3. Principles for the designs of tools and equipments.

Developing Work Methods

An operations manager along with an analyst aims for motion efficiency by achieving the following

1. Elimination of unnecessary motions
2. Combination of various activities
3. Reduction in fatigue
4. Improvement in the arrangement of the workplace
5. Improvement in the design of tools and equipmen

Analysis of therbligs - Basic elemental motions into which a job can be broken down

Search implies hunting for an item with eyes or hands.

Select means to choose from a group of objects.

Grasp means to take hold of the object.

Hold refers to retention of an object that has been grasped.

Therblig Techniques

Transport load means movement of an object after hold.

Release load means to deposit the object.

Work Measurement determines how long it should take to do a job.
And the importance of standard time in work measurement.
Standard time is the amount of time taken by a qualified worker to complete a specified task, working at sustainable rate, using given methods, tools and equipments, raw materials and work place arrangements.
It also employs the following common types of work measurement techniques

1. Stopwatch time study
2. Historical times
3. Predetermined data
4. Work Sampling

Desired accuracy is expressed as percentage of the mean of the Observed Time.
N= (zs/a x)2 Where
Z is the number of normal standard deviations needed for desired confidence
S is sample standard deviation
a is desired accuracy percentage
x- (x bar) is the sample mean.

A Mechanical Engineer working for an automobile manufacture in Lahore presents the following information to the Operations Manager. The assembly workers take a mean time of 120 minutes to assemble a single car with a standard deviation of 5 minutes.
The confidence limit if 95%. The Operations Manager will need how many observations if the desired maximum error is + 5%

Solution

Given Data

S= 5 minutes,

Z is 1.96 (since 95 CI)

x- = 120 minutes,

a= 5 %

The formula is N= (zs/a x)2
Substituting the values
N= ((1.96)(5)/(0.05)(120))2
=(96.04)/(36)=2.67 studies = 3 studies

Compensation

An Operations Manager comes across two types of compensation, working for any service or manufacturing based organization:-

.Time-based system, which is the compensation based on time an employee has worked during a pay period.

2. Output-based (incentive) system, which is compensation based on the amount of output an employee produces during a pay period

Operations Manager making use of an Incentive Plan must be able to understand and identify the following characteristics and form of Incentive Plan.

1. Accurate
2. Easy to apply
3. Consistent
4. Easy to understand
5. Fair
6. Compensation

Pakistani organizations have employed various typesof individual incentive plans which find judicious applications in other countries of the world.

1. Group Incentive Plans
2. Knowledge-Based Pay System
3. Management Compensation

Of the three mentioned above, the operations manager should be able to identify the advantages and disadvantages of each type of incentive plan

Various Factors Affecting Job Design

Organizational Factors

Environmental Factors

Organizational Factors : include characteristics of the task, workflow, ergonomics, and work practices.

Characteristics of the task:

Job design requires the assembly of a number of tasks into a job or a group of jobs.

An individual may carry out one main task which consists of a number of interrelated elements or functions.

On the other hand, task functions may be split between a team working closely together or strung along an assembly line.

In more complex jobs, individuals may carry out a variety of connected tasks, each with a number of functions, or these tasks may be allocated to a group of workers or divided between them.

***The internal structure of each task consists of three elements*.**

(i) Planning (deciding the course of action. timing and the resources required),
(ii) Executing (carrying out the plan), and
(iii) Controlling (monitoring performance and taking corrective action when required).

Work Flow

The flow of work in a firm is strongly influenced by the nature of the product or service.

The product or service usually suggests the sequence and balance between jobs if the work is to be done efficiently.

For example, the frame of a car must be built before the fenders and the doors can be added later.

After the sequence of jobs is determined, the balance between jobs is established.

Ergonomics

Ergonomics is concerned with designing and shaping jobs to fit the physical abilities and characteristics of individuals so that they can perform their jobs effectively.

Ergonomics helps employers to design jobs in such a way that a worker's physical abilities and job demands are balanced.

Ergonomics does not alter the nature of job tasks but the location of tools, switches, and other facilities, keeping in view that the handling the job is the primary consideration.

Work Practices

Work practices are set ways of performing works. These methods may arise from tradition or the collective wishes of employees.

Either way, the HR department's flexibility to design jobs is limited, especially when such practices are part of a union-management relationship.

Failure to consider work practices can have undesirable outcomes.

Environmental Factors

The external factors that have a bearing on job design are employee abilities and availability, and social and cultural expectations.

Employee Abilities and Availability

Efficiency consideration must be balanced against the abilities and availability of the people who are to do the work. When Henry Ford made use of the assembly line, for example, he was aware that most potential workers lacked any automobile-making experience.

So jobs were designed simple and required little training. Therefore, considerable thought must be given as to who will actually do the work.

Social and Cultural Expectations

There were days when getting a job was the primary consideration.
The worker was prepared to work on any job and under any working conditions.
Not any more. Literacy, knowledge, and awareness among workers have improved considerably, so also their expectations from jobs.
Hence jobs must be designed to meet the expectations of workers.

When designing jobs for international operations, uniform designs are almost certain to neglect national and cultural differences. Hours of work, holidays, vacations, rest breaks.
Religious beliefs, management styles, and worker sophistication and attitudes are just some of the predictable differences that can affect the design of jobs across international borders.

Behavioral factors influencing effective job design

Behavioral factors have to do with human needs and the necessity to satisfy them. Higher-level needs are more significant in this context.

Individuals inspired by higher-level needs to find jobs challenging and satisfying which are high on the following dimensions:

- ***Feedback***

Individuals need to receive meaningful feedback about their performance, preferably by evaluating their own performance and defining the feedback. This implies that they need to ideally work on a complete product or on a significant part of it.

- ***Autonomy***

Autonomy is being responsible for what one does. It is the freedom to control one's responses to the environment. Jobs that give workers the authority to make decisions will provide added responsibilities, which tend to increase the employee's sense of recognition and self-esteem. The absence of autonomy, on the other hand, can cause employee apathy or poor performance.

Use of Abilities

The job must be perceived by individuals as requiring them to use the abilities they value in order to perform the job effectively.

- ***Variety***

Lack of variety may cause boredom. Boredom, in turn, leads to fatigue and fatigue causes mistakes. By injecting variety into jobs, personnel specialists can reduce errors caused by fatigue.

Ergonomics :

"The scientific discipline concerned with understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, methods and data to design in order to optimize human well-being and overall system performance".

Ergonomics means

"fitting the job to the worker," including: Work stations, Tools and Equipment

Ergo = Work Nomos = Law

Why is ergonomics important?

Overexertion leading cause of injuries

- Most costly
- Recurring/Persistent pain may develop in future

Bodily reaction is another leading cause of injuries in workplace

Repetitive motion also within top 10 most common workplace injuries

Common Work-Related MSDs

Musculoskeletal Disorders (MSDs)

- Affect the muscles, nerves, blood vessels, ligaments, and tendons
- Symptoms
  - Discomfort
  - Pain
  - Numbness
  - Loss of motion/flexibility
  - Spasticity
  - Stiff joints
  - Burning
  - Swelling
  - Tingling
  - Inflammation
  - Throbbing
  - Paralysis

Common MSD disorders:

Carpal Tunnel Syndrome
Tennis Elbow
Bursitis
Ischemia
De Quervain's
Sciatica
Herniated Discs
Neck strain/disability
Tendinitis

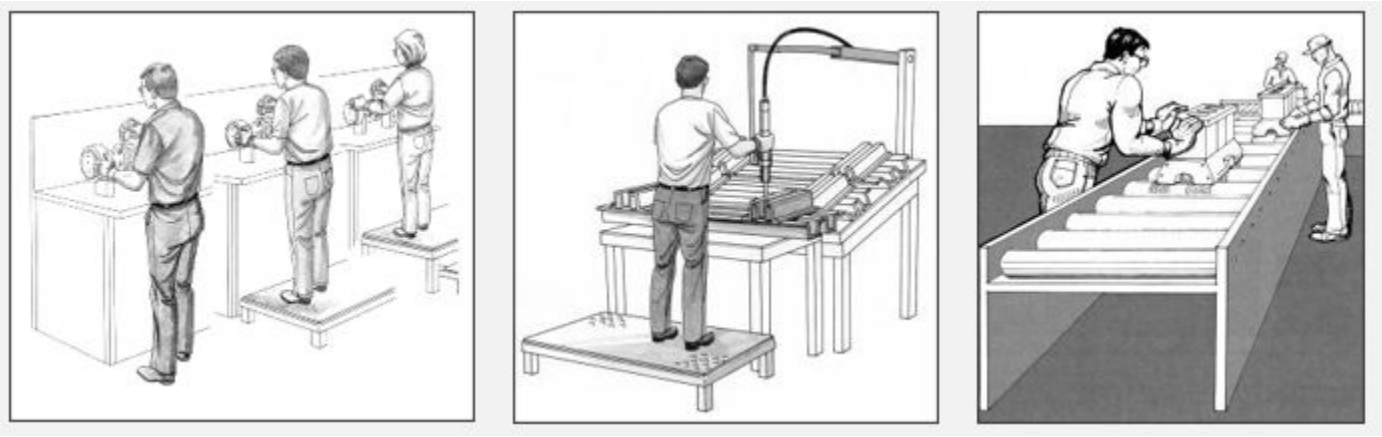
- Rotator Cuff
- Neuritis
- Reynaud's Syndrome
- Trigger Finger
- Thoracic Outlet Syndrome
- Epicondylitis
- Back strain/disability

Most commonly affected areas:

Back Arms, Elbows, and Shoulders
Neck Hands, Wrists, and Fingers
Knees, Ankles, and Feet

Examples of **engineering controls**

Work station design and setup.
Ergonomically designed tools.
Ergonomically designed equipment.
Load weight reduction.



Examples of **proper work practices**:

Proper lifting techniques (NIOSH)
Team lift heavy/bulky/awkward loads
Stretch
Work rotation
Task variety
Increase rest breaks

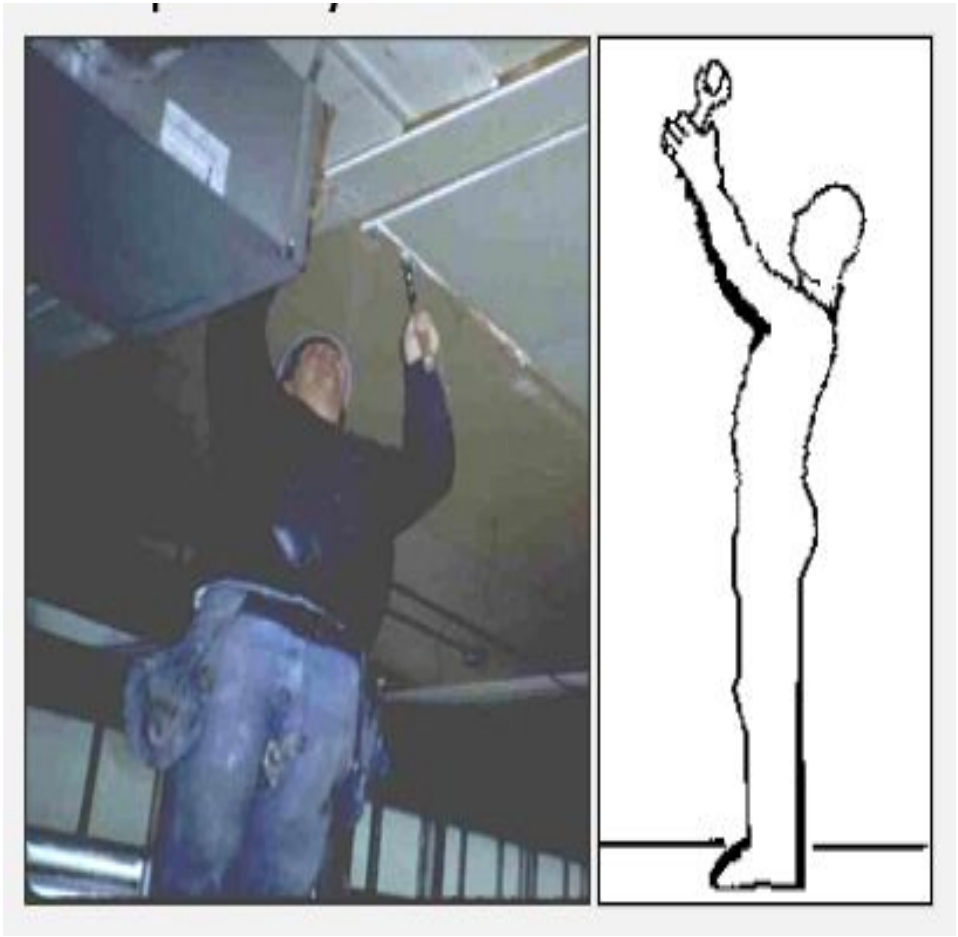
Examples of PPE:

- Gripping gloves
- Knee pads
- Vibration gloves
- Thermal gloves
- Lifting straps
- Shoulder harness
- Lifting braces

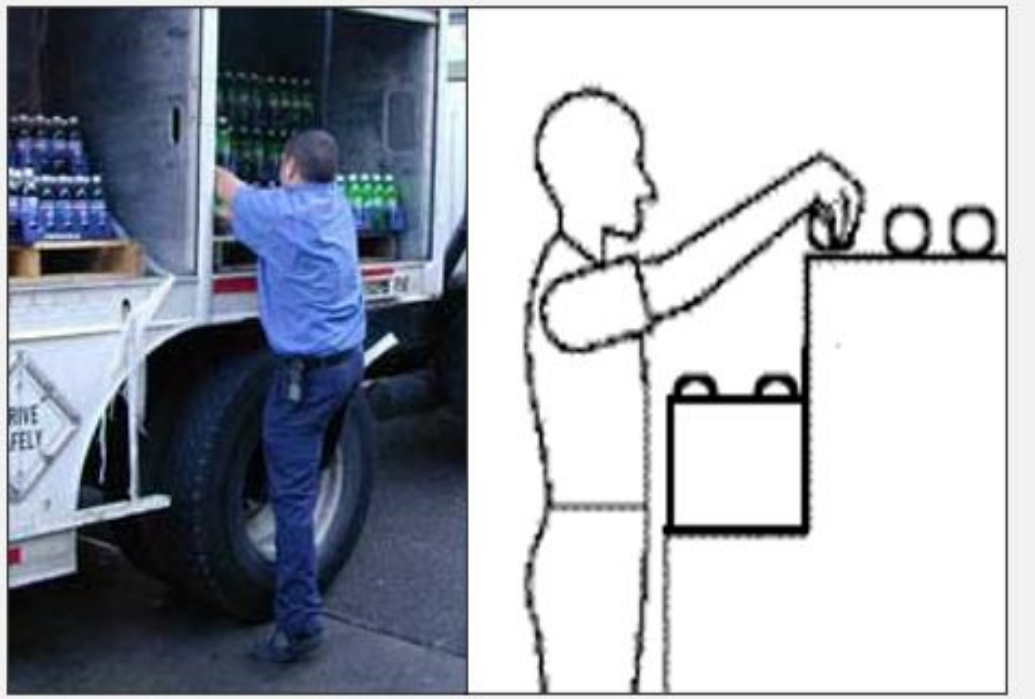
Physical ergonomic hazards and solutions:

Reaching above the head/shoulders – **hazard**

Working with the hands above head for more than 2 hours per day



Working with the elbows above shoulders for more than 2 hours per day



Reaching above the head/shoulders – **solutions**

Keep items within close reach

Elevate work areas

Awkward grips – **hazards**

Gripping 10 or more pounds or force for 2 or more hours per day

Awkward grips - **solutions**

Design work layout to reduce hand-carrying

Reduce amount of items carried at one time

Use non-pinch grip postures

Use ergonomically designed tools/aids

Use job/task rotation

Vibration – **hazards**

Moderate – more than 2 hours per day
High – more than 30 minutes per day
Prolonged

Vibration – **solutions**

Use low-vibration tools and devices that may reduce vibration (tool balancers, extension handles, vibration isolators, damping techniques)
Adequate rest periods
Rotate jobs
Maintenance
PPE

Man-Machine System

A system consisting of a human operator or group of operators and a machine, by means of which the operator performs a task involving.

Example:

The production of material goods.

The management of some type of operation

The processing of information.

Human labor in a manmachine system is based on interaction according to received information with both the object of labor or control and the machine through the mediation of control elements.

Interest in man-machine systems arose in the mid 20th century, when systems of various kinds became with increasing frequency the objects of technical planning and design. The effectiveness of these systems, which included those for the control of production, transportation, communications, and space flights, was largely determined by the activity of the human operators.

The combination of human abilities and capabilities of a machine or complex of technological devices significantly increases the effectiveness of control.
Although there is a joint performance of control functions by the human operator a nd machine, each of the two components of the system is governed in its work by it s own unique rules.
The effectiveness of the system as a whole is determined by the extent to which cha racteristic features of the operator and machine, both limitations and potentials, are identified and taken into account when building the system.
These features are most fully identified in the process of coordinating the external, that is, technological, means of action and the internal means of action, that is, mea ns inherent to the operator.
Coordination includes the construction of information and conceptual models

The information model is a representation, organized according to a definite system of rules, of the states of the object of labor or control, the man-machine system itself , the environment, and the procedures for acting upon these states.
Physically speaking, information models are built using data display equipment.

With an information model at hand, the operator uses his own knowledge and exper ience to formulate a conceptual modelthe aggregate of his own ideas about the goals and objectives of the labor activity and about the states of the object of labor, the manmachine system itself, the environment, and the procedures for acting upon the states.

There are five basic classes of man-machine systems.

1.**The human operator** is included in the technological process, to which he must constantly attend. He is guided in his work by instructions, which cover virtually all possible situations and solutions. Operators at transfer lines and operators who receive and transfer information are part of this type of man-machine system.

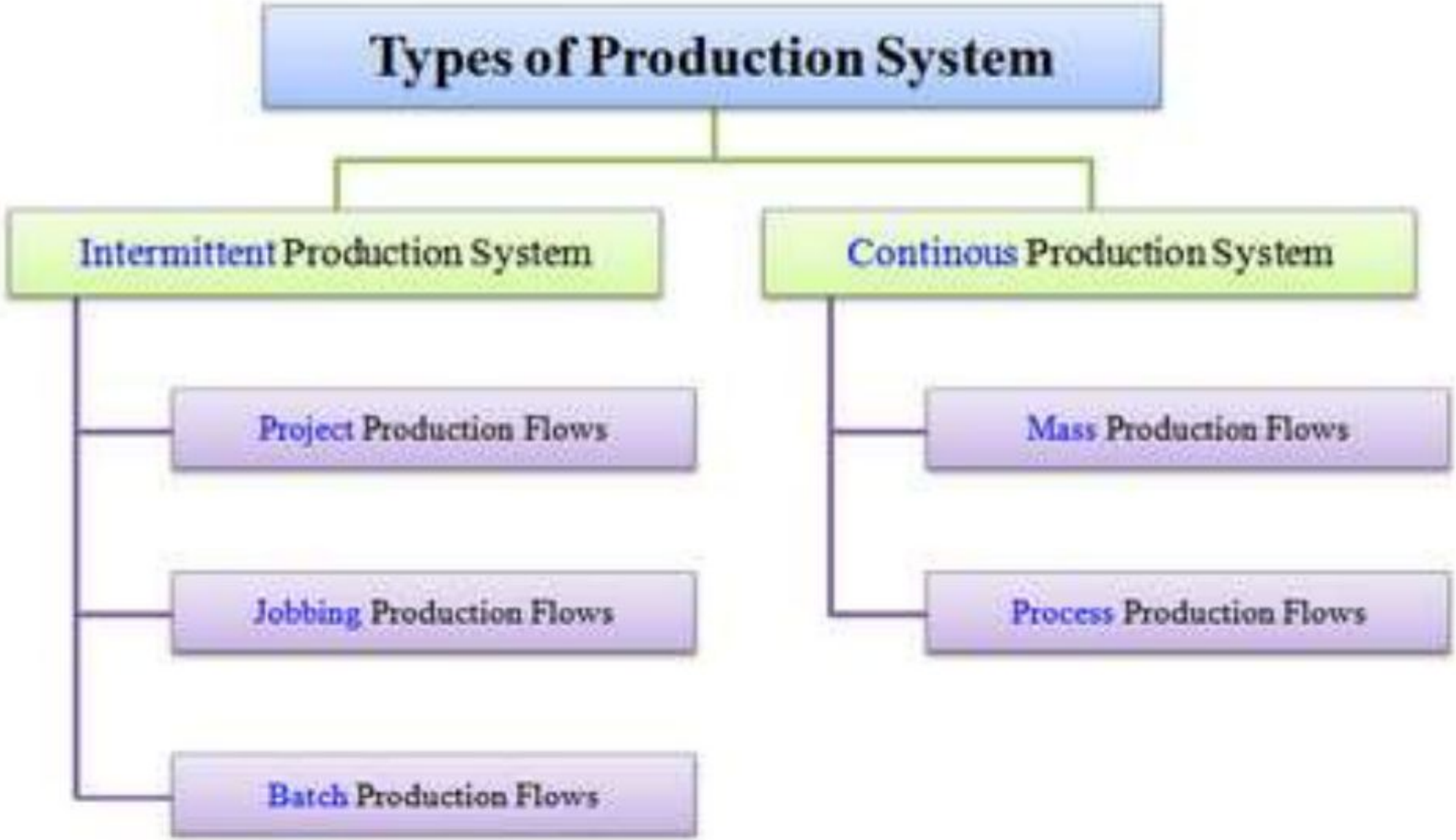
2. In systems of the second class, operators monitor and control a process. Operators in radar systems and traffic controllers in transportation systems are part of these systems.

3.The third class of man-machine systems requires the operator to issue commands to robots, manipulators, and machines that amplify human muscular energy.

4. In systems of the fourth class, the operator acts as an investigator. Decipher clerks and computer operators are examples of operators in this class.

5. In systems of the fifth class, the operator is called upon to make management decisions. Organizers, planners, and executives work with systems in this class.

In the second, fourth, and fifth classes of systems, the operator can set up a dialogue with the machine. Here, the operator and machine alternate in performance of the ta


Types of Production System
Intermittent Production System
Continous Production System
Project Production Flows
Jobbing Production Flows
Batch Production Flows
Mass Production Flows
Process Production Flows

The types of production system are grouped under two categories viz.,
Intermittent production system, and
Continuous production system

Intermittent production system

Intermittent means **something that starts (initiates) and stops (halts) at irregular (unfixed) intervals (time gaps)**.

In the intermittent production system, goods are produced based on customer's orders. These goods are produced on a small scale.

The flow of production is intermittent (irregular).

In other words, the flow of production is not continuous.

In this system, large varieties of products are produced.

These products are of different sizes.

The design of these products goes on changing.

It keeps changing according to the design and size of the product. Therefore, this system is very flexible

Examples

Features of Intermittent Production System

1. Flow of Production is not Continous.
2. Variety of Products are Produced.
3. Volume of Production is Small.
4. General Purpose Machines are Used.
5. Sequence of Operation changes as per Design.
6. Production Depends on Customer's Orders.

The characteristics of an intermittent production system are listed as follows:

- The flow of production is not continuous. It is intermittent.
- Wide varieties of products are produced.
- The volume of production is small.
- General purpose machines are used. These machines can be used to produce different types of products.
- The sequence of operation goes on changing as per the design of the product.
- The quantity, size, shape, design, etc. of the product depends on the customer's orders.

Continuous production system

Continuous means something that operates constantly without any irregularities or frequent halts.

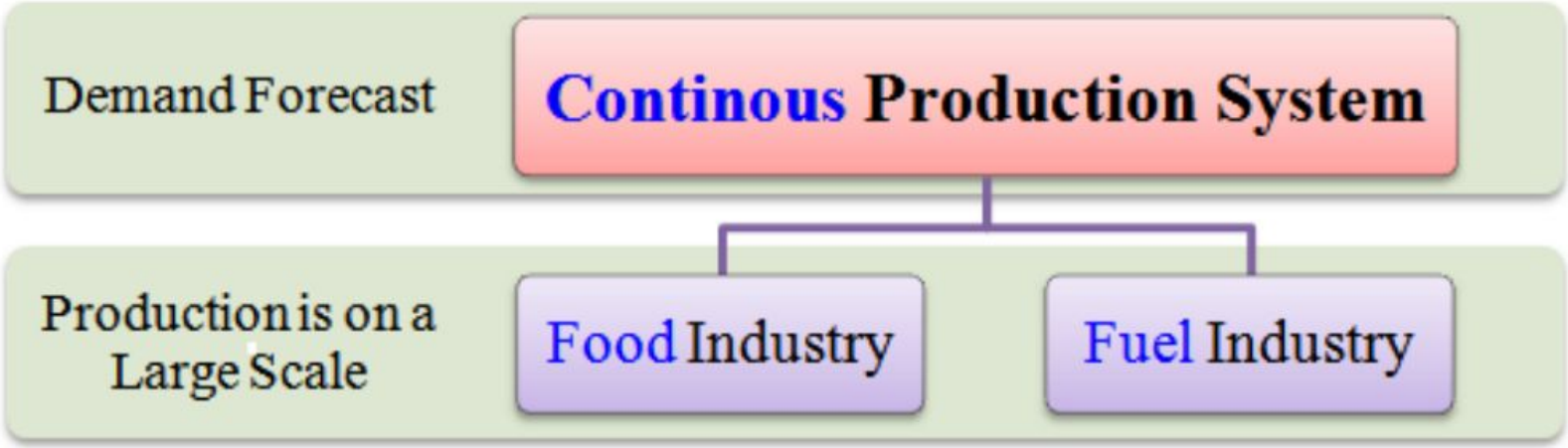
In the continuous production system, goods are produced constantly as per demand forecast.

Goods are produced on a large scale for stocking and selling.

They are not produced on customer's orders.

Here, the inputs and outputs are standardized along with the production process and sequence.

Examples:



Features of Continuous Production System

1. Flow of Production is Continous and not intermittent.
2. Products are Standardized.
3. Products are produced as per Quality Standards.
4. Products are produced in Anticipation of Demand.
5. Standardized routing sheets and schedules are prepared.

Characteristics of a continuous production system are listed as follows:

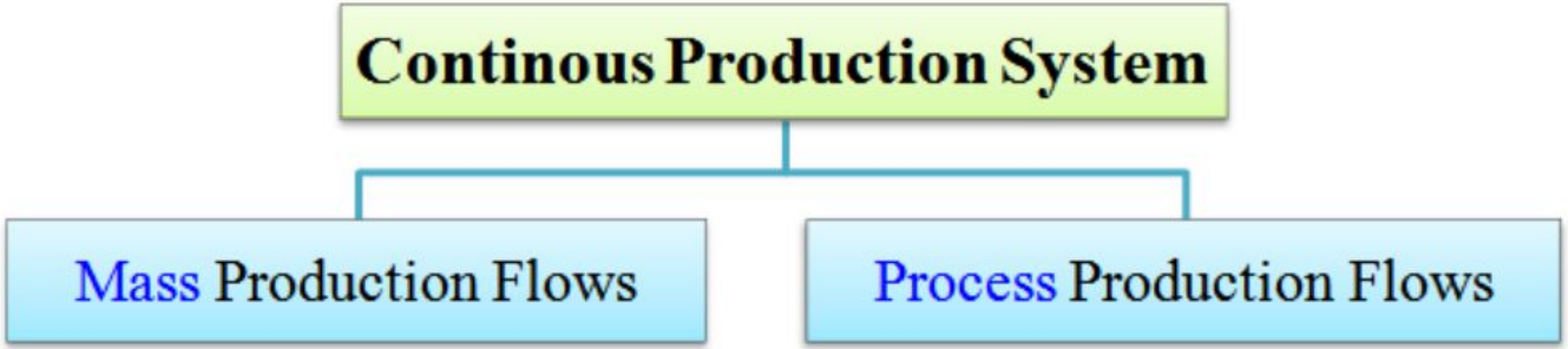
The flow of production is continuous. It is not intermittent.

The products are standardized.

The products are produced on predetermined quality standards.

The products are produced in anticipation(An expectation) of demand.

Standardized routing sheets and schedules are prepared

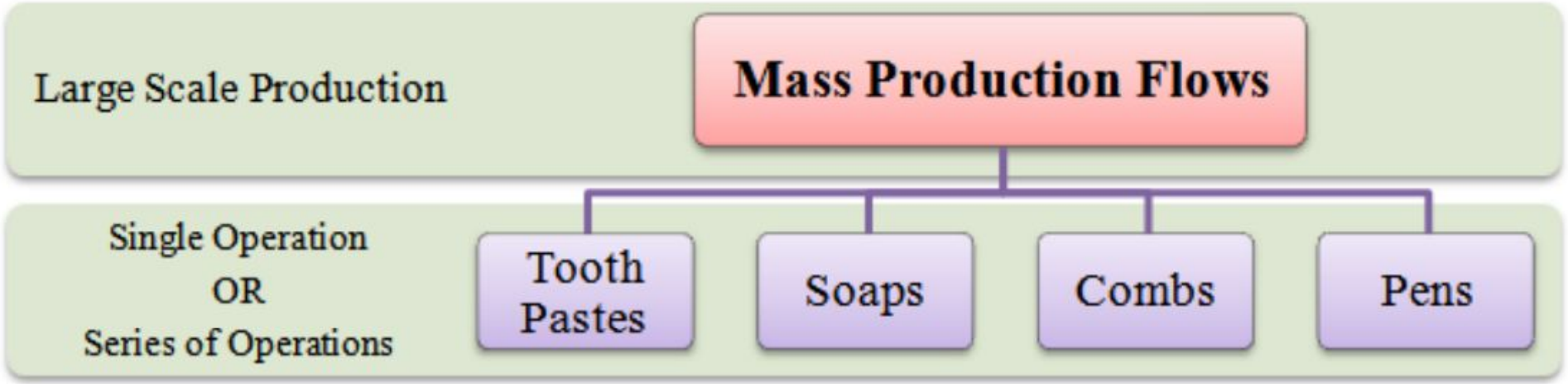


Mass production flows

Here, company produces different types of products on a large-scale and stock them in warehouses until they are demanded in the market.

The goods are produced either with the help of a single operation or uses a series of operations.

E.g. of mass production is the production of toothpastes, soaps, pens, etc



Characteristics mass production flows

There is a continuous flow of production. However, this depends on the demand in the market.

Here, there is limited work-in-progress.

Supervision is easy because only few instructions are necessary.

The material handling is done mostly by machines, i.e. conveyors and automatic transfer machines.

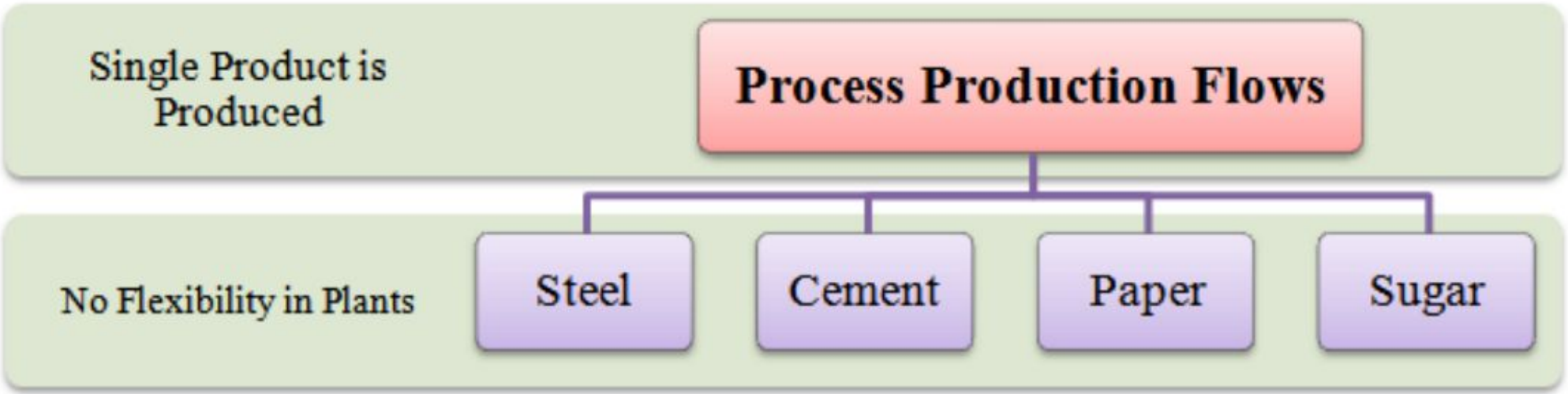
The flow of materials is continuous. There is little or no queuing at any stage of production.

Process production flows

Here, a single product is produced and stocked in warehouses until it is demanded in the market.

The flexibility of these plants is almost zero because only one product can be produced.

Examples of these plants include, steel, cement, paper, sugar, etc



characteristics process production flows

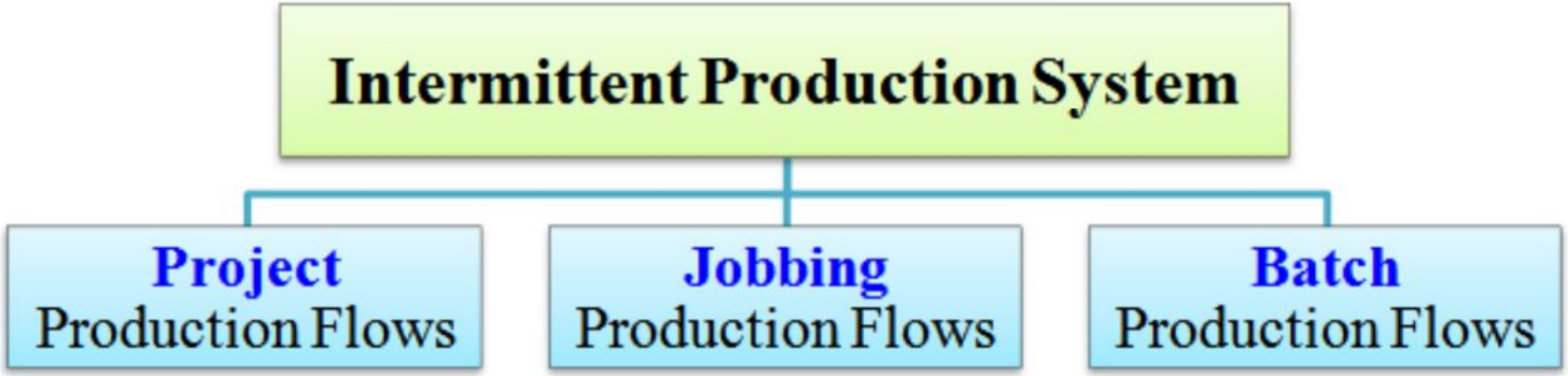
There is a highly mechanized system for handling materials. Conveyors and automatic transfer machines are used to move the materials from one stage to another.

Low-skilled labour and skilled technicians are required.

There is very less work-in-progress because material flow is continuous.

The production planning and scheduling can be decided well in advance.

The full production system is designed to produce only one specific type of item.



The types of an intermittent production system include:

Project production flows

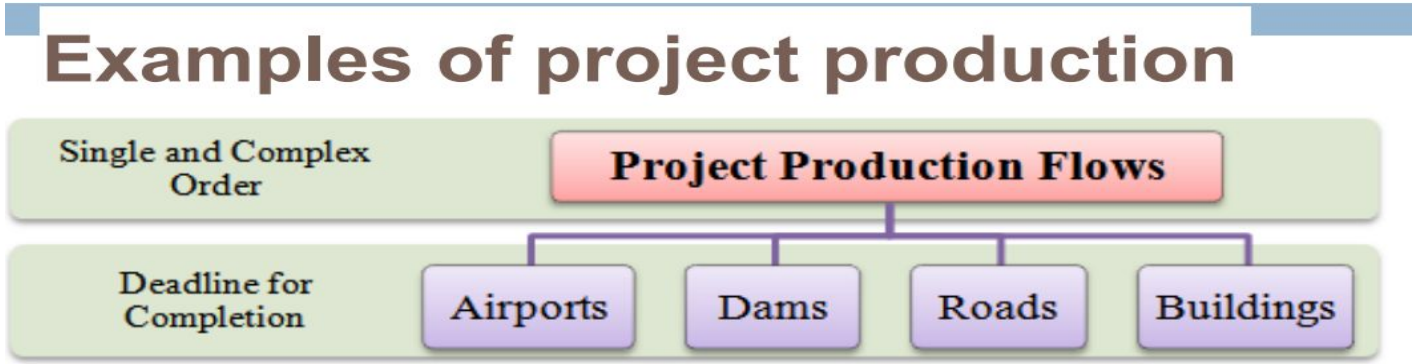
Jobbing production flows, and

Batch production flows

Project production flows

Here, in project production flows, company accepts a single, complex order or contract. The order must be completed within a given period of time and at an estimated cost.

Examples of project production flows mainly include, construction of airports, dams, roads, buildings, shipbuilding, etc



Characteristics project production

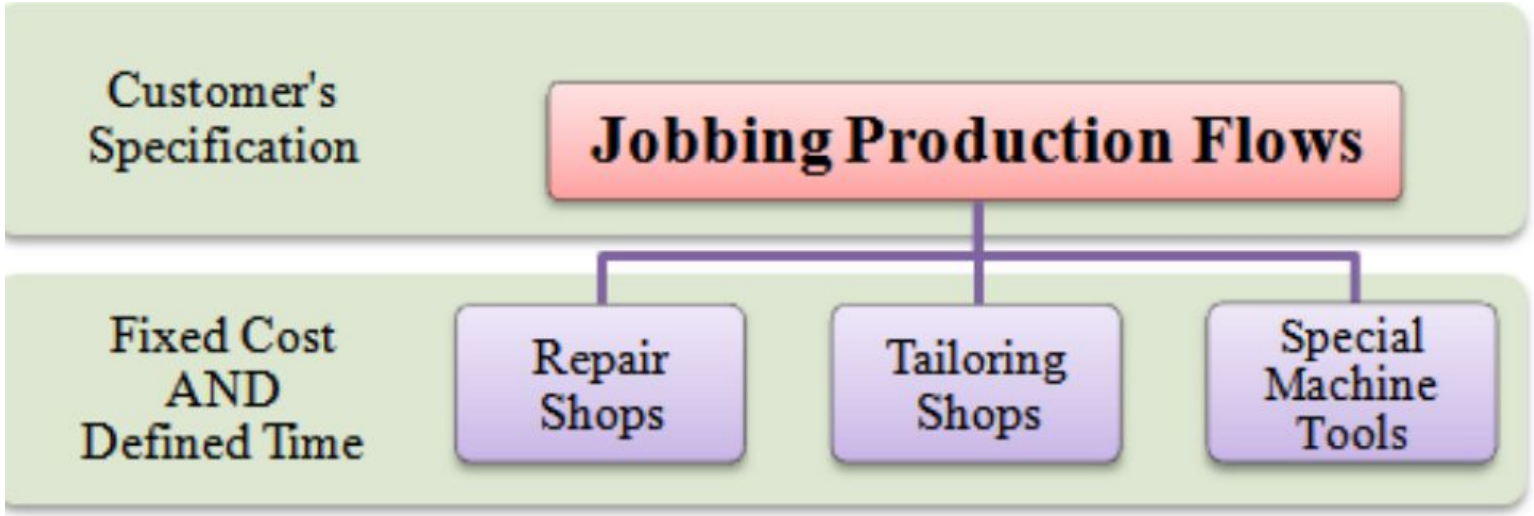
The requirement of resources is not same (it varies). Generally, the resource requirement at the beginning is low. Then in mid of production, the requirement increases. Finally, it slows down when the project is near its completion phase.

Many agencies are involved in the project. Each agency performs specialized jobs. Here, coordination between agencies is important because all jobs are interrelated. Delays take place in completion of projects due to its complexity and massiveness. As routing and scheduling changes with fresh orders, proper inspection is required at each stage of production

Job production

Here, in jobbing production flows, company accepts a contract to produce either one or few units of a product strictly as per specifications given by the customer. The product is produced within a given period and at a fixed cost. This cost is fixed at the time of signing the contract.

Examples of such jobbing production flows include, services given by repair shops, tailoring shops, manufacturer of special machine tools, etc



characteristics job production

The production of items takes place in small lots. Sometimes only one product is produced at one time.

The items are manufactured strictly as per customer's specifications.

Highly skilled labour is required to perform specialized jobs.

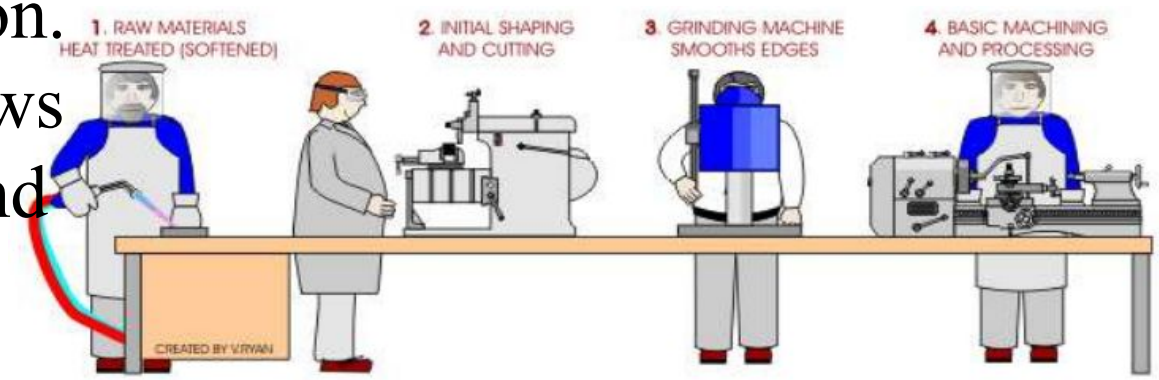
There is disproportionate manufacturing cycle time. For e.g. the time needed to design the product may be more than the manufacturing time

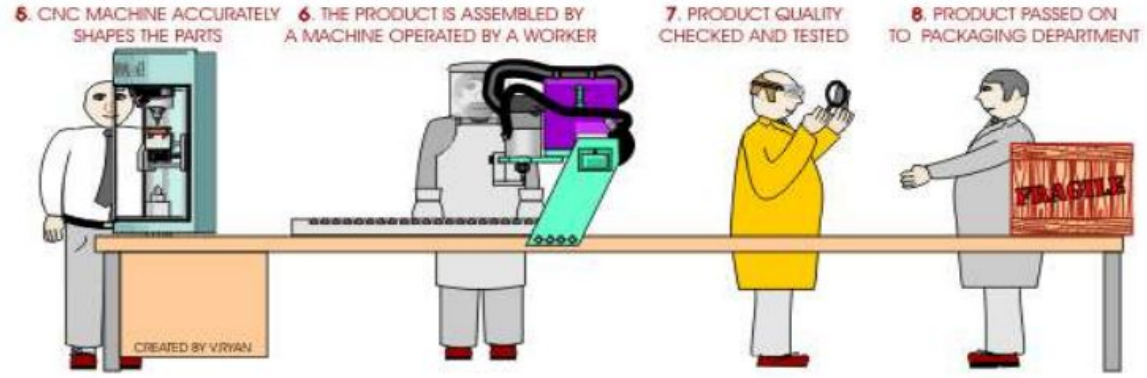
Batch production

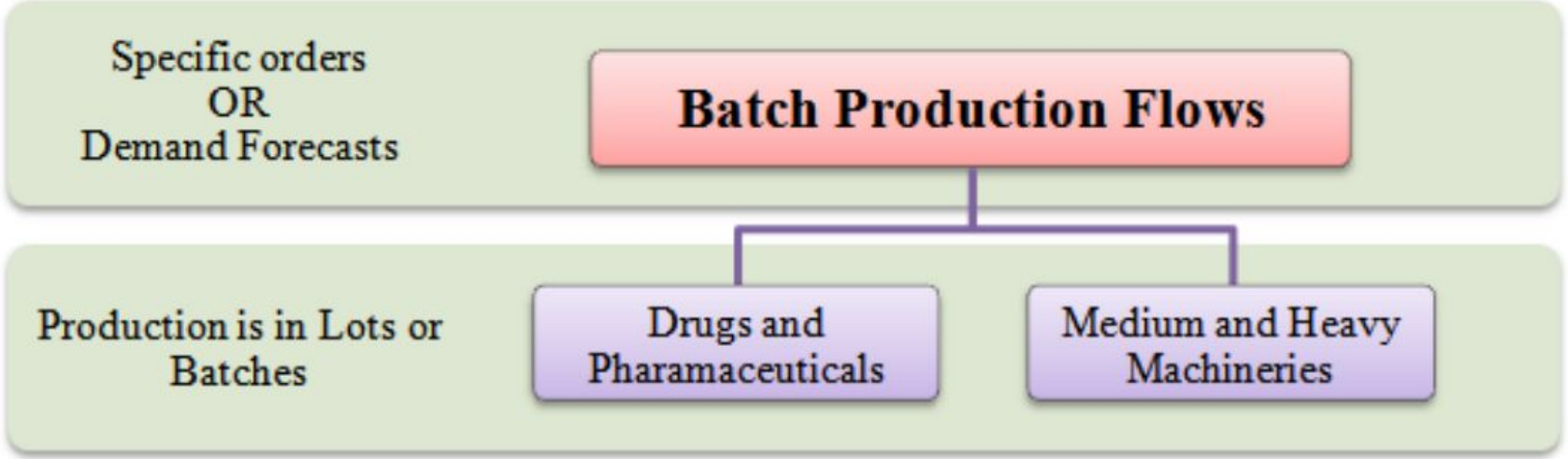
In batch production flows, the production schedule is decided according to specific orders or are based on the demand forecasts.

Here, the production of items takes place in lots or batches. A product is divided into different jobs. All jobs of one batch of production must be completed before starting the next batch of production.

Examples of batch production flows include, manufacturing of drugs and pharmaceuticals, medium and heavy machineries, etc







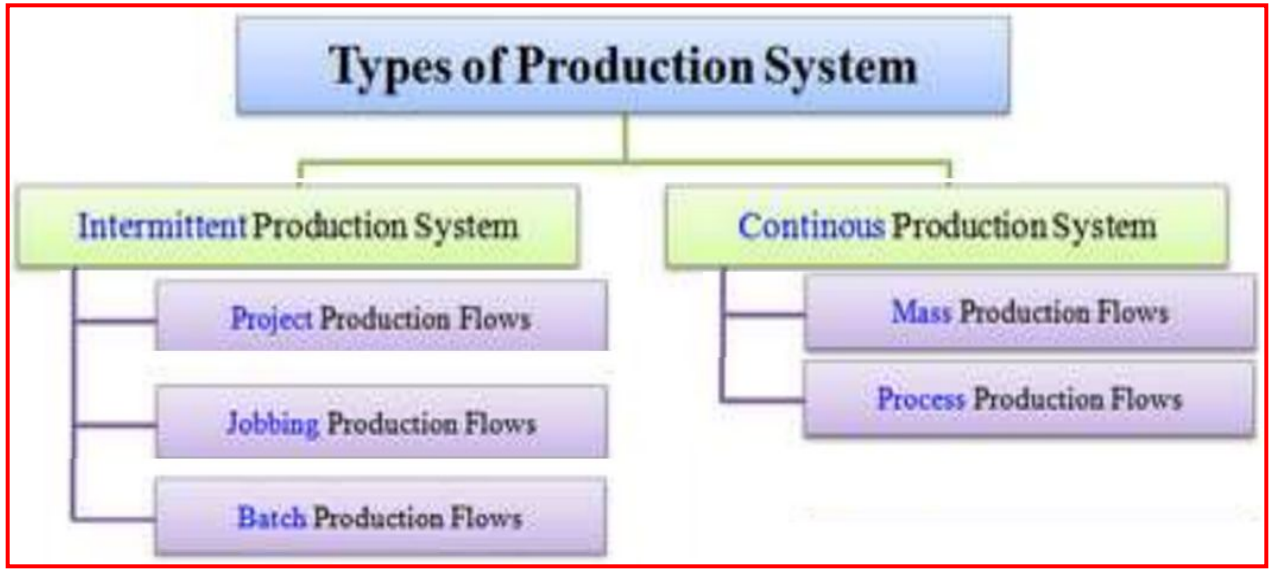
characteristics batch production

The products are made and kept in stock until their demand arises in the market.

General purpose machines and handling equipments, which can do many different jobs quickly are installed. This is because large varieties of items are to be produced.

There is a possibility of large work-in-progress due to many reasons.

There is a need for detailed production planning and control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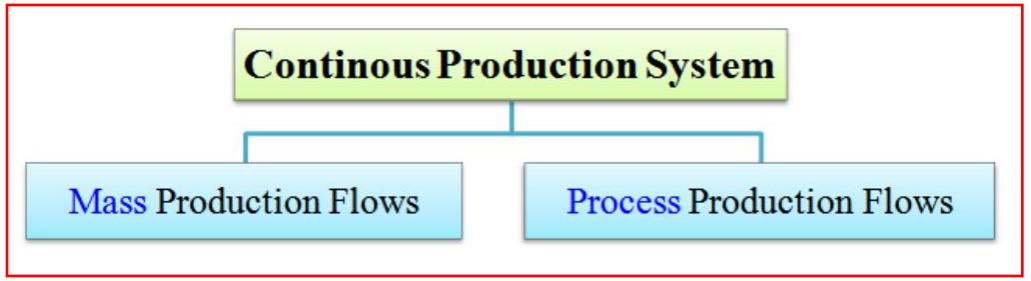
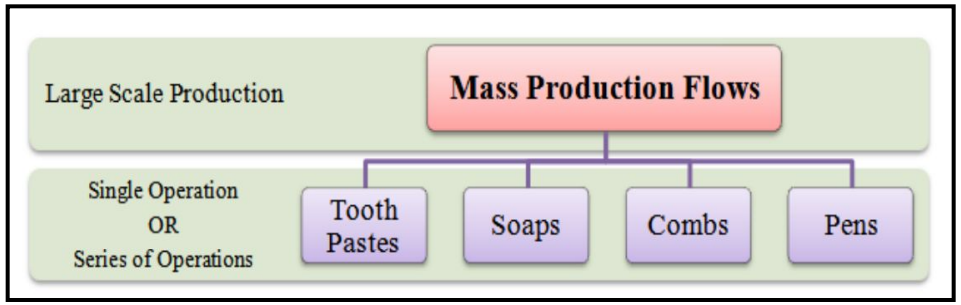
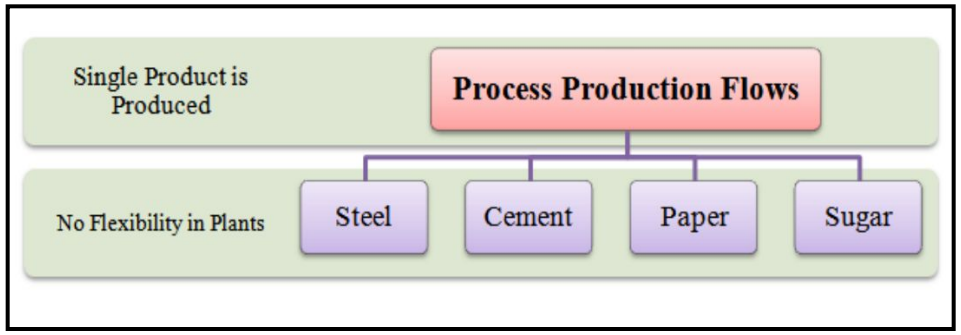
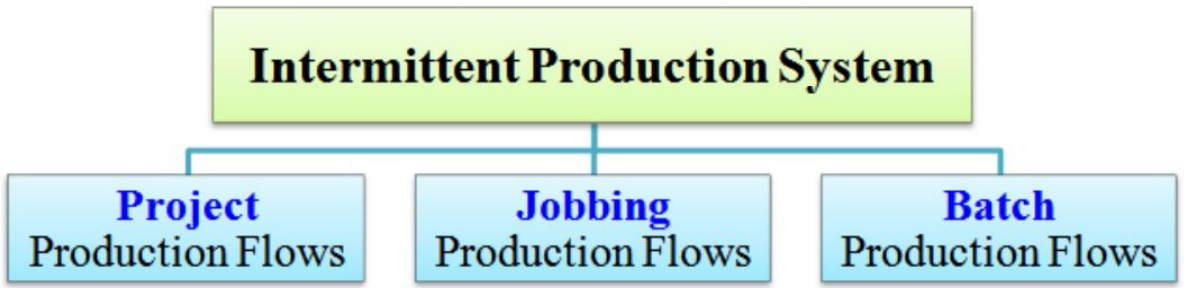
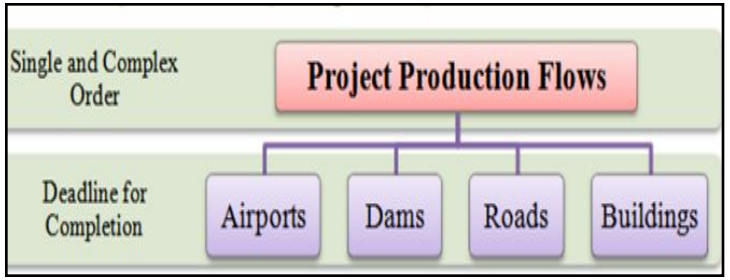
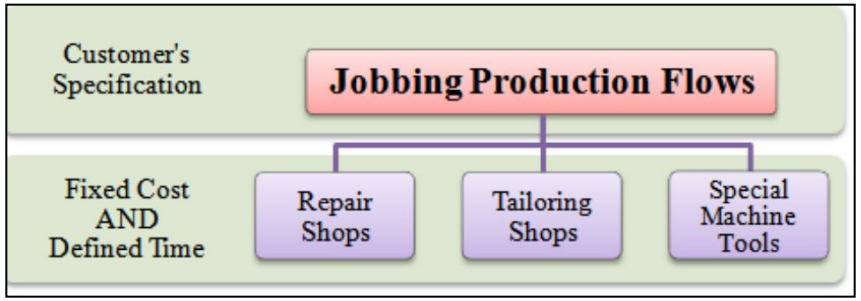

Continous Production System
Mass Production Flows
Process Production Flows

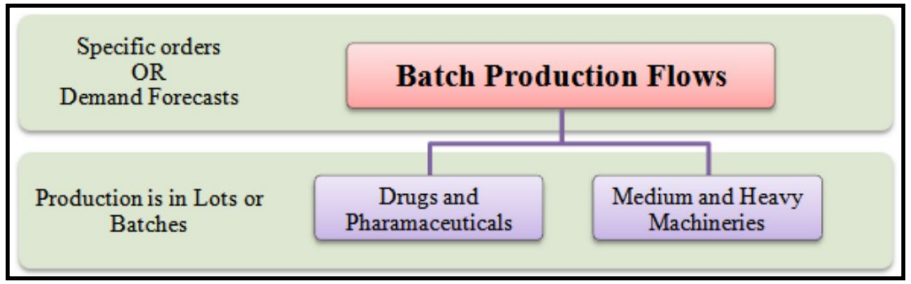

Large Scale Production
Mass Production Flows
Single Operation
OR
Series of Operations
Tooth Pastes
Soaps
Combs
Pens


Single Product is Produced
Process Production Flows
No Flexibility in Plants
Steel
Cement
Paper
Sugar


Intermittent Production System
Project Production Flows
Jobbing Production Flows
Batch Production Flows


Single and Complex Order
Project Production Flows
Deadline for Completion
Airports
Dams
Roads
Buildings


Customer's Specification
Jobbing Production Flows
Fixed Cost AND Defined Time
Repair Shops
Tailoring Shops
Special Machine Tools


Specific orders OR Demand Forecasts
Batch Production Flows
Production is in Lots or Batches
Drugs and Pharamaceuticals
Medium and Heavy Machineries

Productivity

Productivity is the **output of any production process, per unit of input**.

To increase productivity means to produce more with less.

In factories and corporations, **productivity is a measure of the ability to create goods and services from a given amount of labour, capital, materials, land, resources**, knowledge, time or any combination of those.

Output per unit of input employed.

Increase productivity on the part of capital and labour.

Productivity can be **measured**, The **amount of output per unit of input**.

In a factory, it might be **measured based on the number of hours** it takes to **produce a good**.

While in service industry, might be **measured based on the income generated by an employee divided by his/her salary**.

Definition and Equation

Productivity is the ratio of output and input in any organization.

Productivity = Output /Input .

Output is in the form of product quantity and

input is in the form of resources.

The resources are in the form of

- Land acquired
- Salaries paid to employees
- Amount paid to purchase material
- Amount spent in infrastructure

Examples

In case A, 10 products are made by spending 1000 rupees and in case B, 15 products made by spending 2000 rupees.

Productivity in case A = 10 / 1000

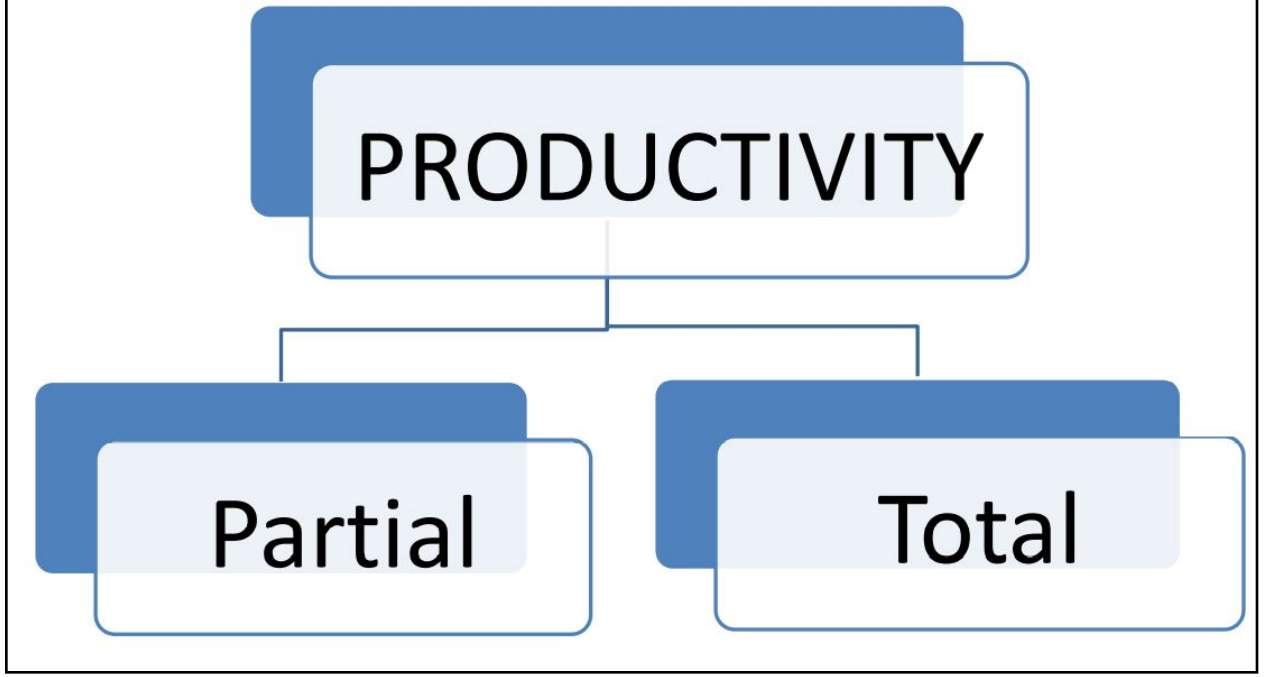
Productivity in case of B = 15 / 2000

In case B, it is an indication of reduced productivity

Partial Productivity

The resources of productivity when measured separately are called partial productivity.

“Apple to Apple” comparison.



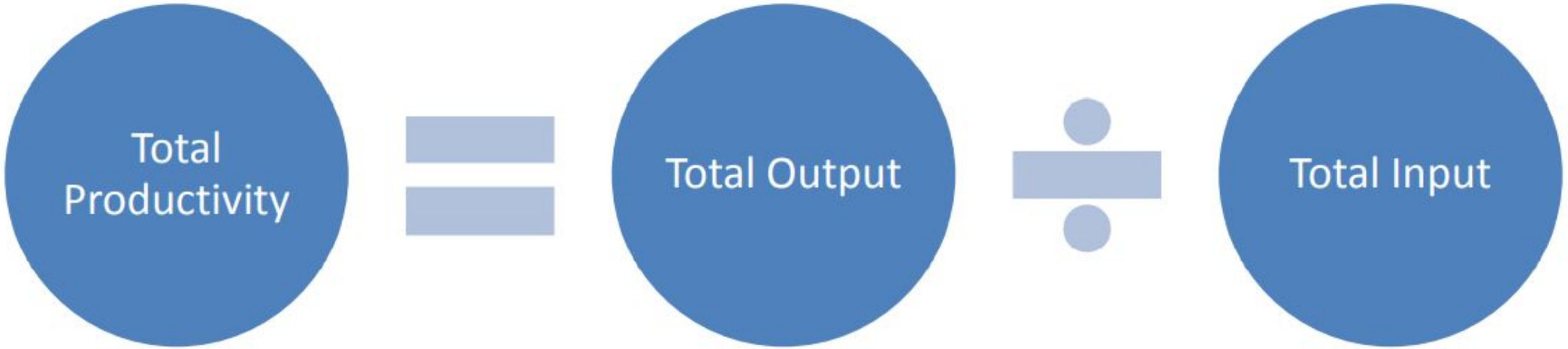
Total Productivity

The method of calculating productivity considering all the resources is called total productivity.

Innovated by David j. Sumanth.

It is systematic and qualitative approach to compete in quality, price and Time.

Total productivity provides systematic framework and structure to an organization and increase profitability



Productivity Benefits

- Increase in income/profitability.
- Lowering running cost/operational costs.
- Maximising the use of all of the company's resources such as land, equipments/machineries, factory, workers, and etc.
- Gaining a greater share of the market.
- More cash flows mean more opportunity for the company to expand and grow.

PRODUCTIVITY MEASUREMENT

A high level of productivity can be achieved if the following factors are managed properly on construction sites and at the head office.

These are as follow:

Pre-construction activities

Site/project manager Characteristics

Management Factors

Resource Management

Management Systems