CHAPTER- 1: PRODUCTION PLANNING & CONTROL (PPC)

1. **Definition & objective of PPC**

Introduction:

Production is an organized activity of converting raw materials into useful products. But before starting the actual production process planning is done –

- To anticipate possible difficulties.
- To decide in advance – how the production processes be carried out in a best & economical way to satisfy customers.

However, only planning of production is not sufficient. Hence management must take all possible steps to see that plans chalked out by the planning department are properly adhered to and the standard sets are attained. In order to achieve it, control over production process is exercised.

Objective:

Therefore, the ultimate objective of production planning and control is to produce products of

- right quality
- in right quantity
- at right time

By using the best and least expensive methods/procedure.

Definition:

PPC may be defined as the direction and co-ordination of the firms materials and physical facilities towards the attainment of pre-specified production goals in the most efficient and economical way.

<u>Function of PPC:</u>

The various functions of PPC dept. can be systematically written as:

1. Planning phase
   - Prior planning → forecasting, Order writing, Product design information
   - Active planning → Process planning & routing, Materials req. planning, tools req. planning, Loading, scheduling

Action phase – Dispatching

Control phase
- → Progress reporting
- → Corrective action

Explanation of each term

(a) Forecasting: Estimation of quality & quantity of future work.

(b) Order writing: Giving authority to one or more persons to do a particular job.

(c) Product design information: Collection of information regarding specification, bill of materials, drawing.

(d) Process planning and routing: Finding the most economical process of doing work and then deciding how and where the work will be done?

(e) Materials planning: It involves the determination of materials requirement.

(f) Tools planning: It involves the requirements of tools to be used.

(g) Loading: Assignment of work to men & m/c.

(h) Scheduling: When and in what sequence the work will be carried out. It fixes the starting and finishing time for the job.

(i) Dispatching: It is the transition from planning to action phase. In this phase the worker is ordered to start the actual work.

(j) Progress reporting:

i. Data regarding the job progress in collected.
ii. It is compared with the present level of performance.

(k) Corrective action: Expediting the action if the progress deviates from the planning.

(c) Aggregate Planning

Intermediate range planning which is done for a period of 3-12 months of duration is called Aggregate Planning as obvious from the following diagram.

Planning process

Long range planning (= strategic planning)(for 1-5 years of duration)	Intermediate range planning (=aggregate planning)(for 3-12 months)	Short term planning (for scheduling and planning for day to day shop floor activities). (for 1-90 days)

Aggregate plans acts as an interface (as shown below by planning hierarchy) between strategic decision and short term planning.

Planning hierarchy

Strategic decision

(1-5 months)

↓

Aggregate planning

(3-12 months)

↓

Short term planning

(1-90 days)

Aggregate planning typically focuses on manipulating several aspects of operations –

- Aggregate production volume
- Inventory level
- Personal level
- Machinery & other facility level

To minimize the total cost over some planning horizon while satisfying demand and policy requirements.

In brief, the objectives of aggregate planning are to develop plans that are feasible and optimal.

Aggregate Planning

↓ ↓

Aggregate production planning (it indicates the level of output)	Aggregate capacity planning (keep desired level)

Characteristic of aggregates planning

Forecasting:

The aggregate plan is based on satisfying expected intermediate- term demand, so accurate forecasts of these demands are necessary, because seasonal variation patterns are usually important in aggregate planning.

In addition to demand, wage rates, material prices and holding costs can change enough to affect the optimal plans. But these forecasts are relatively easy to obtain because, they are specified in contractual agreements.

Identifying the planning variables

The two most important planning variables are:

- The amount of products to produce during each time period. and
- The amount of direct labours needed.

Two in-direct variables are:

- The amount of product to add to/remove from inventory.
- The amount of workforce/labour should be increased/decreased.

Implementing an Aggregate plan

Aggregate plans are normally generated by using → Optimisation method.

During a planning period

- Employees may produce more/less than expected.
- Actual demand may not be same as predicted.
- More employees leave the company than expected.
- More/less may be hired than expected
- Inventory may sometimes be damaged and so on.

Therefore, the 6-12 months aggregate plan devised for one period may no longer be optimal for the next several months.

We do not simply generate one plan for the next 12months and keep that plan. Until it has been completely implemented. Aggregate planning is a dynamic process that requires constant updating.

In actual practice, we first develop an aggregate plan that identifies the best things to do during each period of planning horizon to optimize the long term goal of the organization. We then implement only the 1st period of plan; as more information becomes available, we update and revise the plan. Then action is implemented in the first period of the revised plan, gather more information and update again. This is illustrated in the following.

Implement 1st period	Jan	Feb	Mar	April	May	June

↓ Update & revise the plan

Implement 1st period	Feb	Mar	April	May	June	July

↓ Update and revise the plan

Implement 1st period	Mar	April	May	June	July	Aug ↓

Decision option in Aggregate Planning

The decision options are basically of 2 types.

i. Modification of demand
ii. Modification of supply.

i. Modification of demand

The demand can be modified in several ways-

a) **Differential pricing**

It is often used to reduce the peak demand or to increase the off period demand. Some examples are:

- Reducing the rates of off season fan/woolen items.

- Reducing the hotel rates in off season.
- Reducing the electric charge in late night etc.

b) Advertising and promotion

These methods are used to stimulate/smooth out the demand. The time for the advertisement is so regulated as to increase the demand during off period and to shift demand from peal period to the off period.

c) Backlogs

Through the creation of backlogs, the manufacturer ask customer to wait for the delivery of the product, thereby shifting te demand from peak period to off period.

d) Development of complementary products

Manufacturer who produce products which are highly seasonal in nature, apply this technique. Ex- Refrigerator Company produce room heater. TV Company produce DVD etc.

ii. **Modification of supply**

There are various methods of modification of supply

a) Hiring ad lay off employees

The policy varies from company to company. The men power/work force varies from peak period to slack/of period. Accordingly hiring/lay off employee is followed without affecting the employee morale.

b) Overtime and under time

Overtime and under time are common option used in cases of temporary change of demand.

c) Use of part time or temporary labour

This method is attractive as payment for part time/temporary labour is less.

d) Subcontracting

The subcontracting may supply the entire product/some of the components needed for the products.

e) Carrying inventories

It is used by manufacturer who produces item in a particular season and sell them throughout the year.

Aggregate planning strategies

Pure strategy	Mixed strategy
If the demand and supply is regulated by any one of the following strategies. (a) Utilizing inventory through constant workforce. (b) Varying the size of workforce. (c) Sub contracting (d) Making changes in demand pattern.	If the demand and supply is regulated by mixture of the strategies as mentioned aside, it is called mixed strategy.

(C) Materials Requirement Planning (MRP)

In manufacturing a product, the firm has to plan materials so that right quantity of materials is available at the right time for each component/subassembly of the product. The various activities interlinked with MRP is stated in the following.

Objective of MRP

1. **Inventory Reduction**: MRP determines how many of a component are needed and when to meet the master production schedule. It enables the manager to procure that components as and when it is needed. As a result it avoids cost of carrying inventory.
2. **Reduction in production and Delivery Lead Time:**
   MRP co-ordinates inventories procurement and production decision and it helps in delay in production.
3. **Realistic commitment**: By using MRP in production the likely delivery time to customers can be given.

4. **Increased Efficiency**: MRP provides close co-ordination among various departments and work centers as product buildup progresses through them. Consequently, the production can proceed with fewer indirect personnel.

MRP calculation

The terminologies which are involved in doing MRP calculations are:

- Projected requirements
- Planned order release
- Economic order quantity
- Scheduled receipts (receipts)
- Stock on hand

Master production schedule gives particulars about demands of the final assembly for the period in the planning horizon. These are known a projected requirements of the final assembly.

The projected requirements of the subassemblies which are in the next immediate level just below the final product can be calculated only after completing MRP calculation for the final products. Similarly the projected requirements of the subassemblies which are in the 2nd level can be calculated only after completing the MRP calculation for the respective subassemblies in the 1st level. Like this the projected requirements for all subassemblies can be calculated.

Stock on hand is the level of inventory at the end of each period. Generally the initial on hand quality if exists for the final product/each subassembly is given in the input. For each period, the stock on hand is computed by using the following formula.

$SOH_t = SOH_{t-1} + R_t - PR_t$ ------------(1)

Where, SOH_t = Stock on hand at the end of period t.

SOH_{t-1} = Stock on hand at the end of period t-1.

R_t = The scheduled receipt at the beginning of the period t through an order which has been placed at some early period.

PR_t = Projected requirement of the period t.

Planned order release is the plan (i.e., quantity and date) to initiate the purchase. The planned order release for the period t is nothing but placing an order if the stock on hand (SOH_t) at the beginning of period t is less than the projected requirement (PR_t). Genarally the size of the order = Economic Order Quantity (EOQ).

The EOQ is calculated by using the following formula

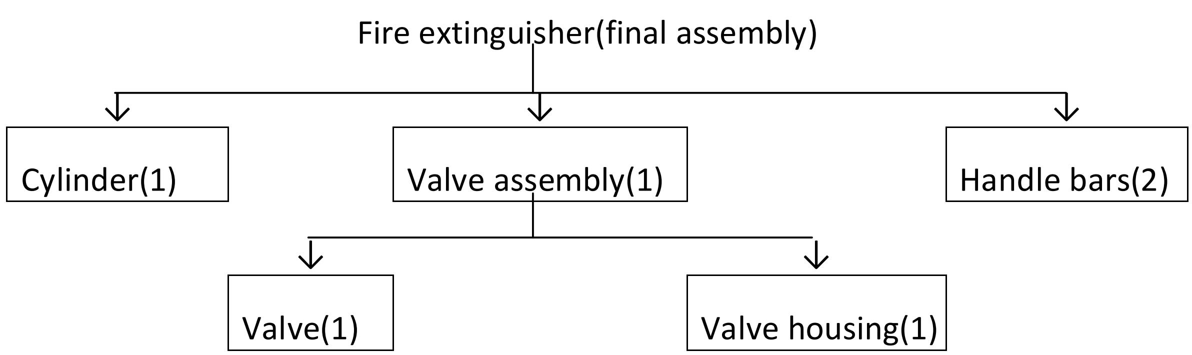
i.e., $EOQ = \sqrt{\frac{2CoD}{Ci}}$

where, D = Average demand/week

Co = ordering cost, Ci = earning same time cost/week

Example (to demonstrate MRP calculation)

In order to demonstrate the working of MRP, let us consider manufacturing of five extinguisher as stated in the following.



The master production schedule to manufacture the fire extinguisher is given in Tab-1.

Tab-1: Master production schedule

Week	1	2	3	4	5	6	7	8
Demand	100		150	140	200	140		300

The details of bill of materials along with economic order quantity and stock on for the final product and subassemblies are shown in Tab-2.

Tab-2: Details of Bill of materials

Parts required	Order quantity	No. of units	Lead time (week)	Stock on hand
Fire extinguisher	300	1	1	150
Cylinder	450	1	2	350
Valve assemblies	400	1	1	325
Valve	350	1	1	150
Valve housing	450	1	1	350
Handle bars	700	2	1	650

Lead time internal between placement of order receipt of materials.

Complete the material requirements plan for the fire extinguisher, cylinder, valve assembly, valve, valve housing, and handle bars and show what they must be released in order to satisfy the master production schedule.

Solution:

(a) MRP calculation for fire extinguisher

The projected requirements for the fire extinguisher is same as master production schedule as shown Tab-1.

One unit of fire extinguisher require

- One unit of cylinder

- One unit of valve assembly, and
- Two units of handle bars.

The MRP calculations for the fire extinguisher are shown in Tab-3.

Tab-3: MRP calculations for fire extinguisher

EOQ = 300, Lead time = 1 week

Period	0	1	2	3	4	5	6	7	8
Projected requirement		100		150	140	200	140		300
Stock in hand	150	50	50	200 (-100)	60	160 (-140)	20	20	20 (-280)
Planned order release			300		300			300	
Receipt				300		300			300

Similarly the MRP calculation may also be carried out for other components.

Routing

Routing may be defined as the "selection of proper follow which each part of the product will follow, while being transferred from raw material to finished products. Path of the products will also give sequence of operations to be adopted while manufacturing."

In other words, routing means determination of most advantageous path to be followed from department to department and machine to machine till raw materials get its final shape.

Routing determines the best and cheapest sequence of operations and to see that this sequence is rigidly followed.

Routing is an important function of PPC because it has a direct bearing on the "time" as well as "cost" of the operation. Defective routing may involve back tracking and long routes. This will unnecessarily prolong the processing time. moreover, it will increase the cost of material handling. Routing is affected by plant layout. In fact, routing and affected by plant layout are closely related. In product layout the routing is short and simple while under the process layout it tends to be long and complex.

Routing Procedure

1. **Analysis of the product:** the finished product is analysed and broken into number of components required for the product.
2. **Make and buy decision:** It means to decide whether all components are to be manufactured in the plant or some are to be purchased from outside. make and buy decision depends upon
   - The work load in the plant already existing
   - Availability of equipments
   - Availability of labour
   - Economy consideration
3. **Raw materials requirements**

   A part list and bill of materials is prepared showing name of part, quantity materials specification, amount of materials required etc.

4. Sequence of operations which the raw materials are to undergo are listed.
5. Machines to be used, their capacity is also listed.
6. Time required for each operation and subassemblies are listed.
7. The low size is also recorded.

The data thus obtained is utilized for preparing master route sheets and operation charts. the master route sheets give the information regarding the time when different activities are to be initiated and finished, to obtain the product and required time.

The next step is to prepare the route sheet for the individual item or component.

Route sheet

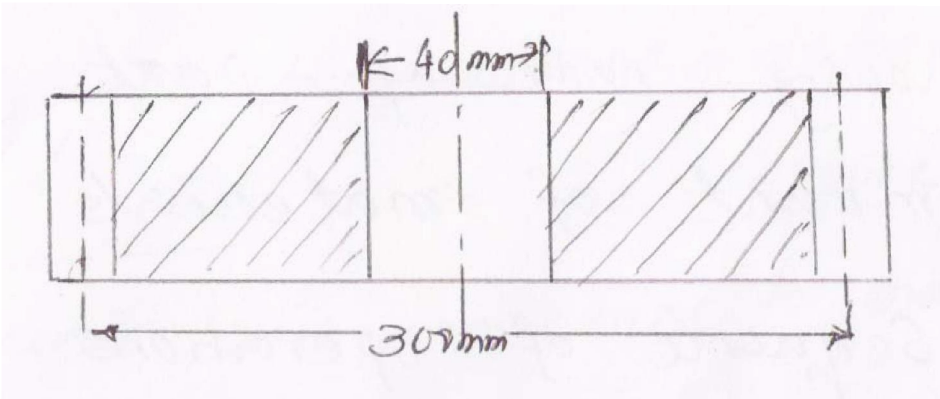
The operation sheet and the route sheet differs only slightly. An operation sheet shows everything about the operation i.e. operation descriptions, their sequence, type of machinery, tools, jigs & fixture required, setup & operation time etc. whereas, the route sheet also details the section (or department) and the particular machine on which the work is to be done. the operation sheet will remain the same if the order is repeated but the route sheet may have to be revised if certain machines are already engaged to order. except thin small difference, both seets contain practically the same iformation and thus generally combined into one sheet known as operation and route sheet as shown in fig 1.1.

Part no. – A/50

Name – Gear

Material – m.s.

Quantity – 100 Nos



Department	Machine	Operation	Description	Tool	Jigs/Fixture	time	
						setup	operation
Smithy	Power hammer PH/15	1 2	Forging Punching hole	- -	- -	4hrs 1hrs	30 min. 25 min.
Heat treatment	Furnace F/H/4	3	Normalizing	-	-	4 hrs	4 hrs.
Machine shop	Centre lathe CL-5	4	Face 2 end. Turn onter & inner face	Lathe tool	Chuck	15 min	1hr.
	Milling m/c Mm/15	5	Cut teeth	Side & face cutter	Dividing head	40 min	5 hrs
	Slotter SL/7	6	Make the key way	Slotting tool	-	10 min	30 min.

Advantages of Routing

1. Efficient use of available resources.

2. Reduction in manufacturing cost.
3. Improvement in quantity and quality of the o/p.
4. Provides the basis for scheduling and loading.

Scheduling

Scheduling may be defined as the assignment of work to the facility with the specification of time, and the sequence in which the work is to be done. Ex- time Table scheduling is actually time phasing of loading. the facility may be man power, machines or both. scheduling deals with orders and machines. it determines which order will be taken up on which machine in which department at what time and by which operator.

Objectives Loading and Scheduling

1. Scheduling aims to achieve the required rate of o/p with a minimum delay and disruption in processing.
2. To provide adequate quarters of goods necessary to maintain finished product at levels predetermined to meet the delivery commitment.
3. The aim of loading and scheduling is to have maximum utilization of men, machines and materials by maintaining a free flow of materials along the production line.
4. To prevent unbalanced allocation of time among production departments.
5. To keep the production cost minimum.

Factors Affecting Scheduling

(A) **External Factors**
1. Customers demand
2. Customers delivery dates
3. Stock of goods already lying with the dealers & retailers.

(B) **Internal Factors**
1. Stock of finished good with firm
2. Time interval to manufacture each component, subassembly and then assembly.
3. Availability of equipments & machinery their capacity & specification.

4. Availability of materials
5. Availability of manpower

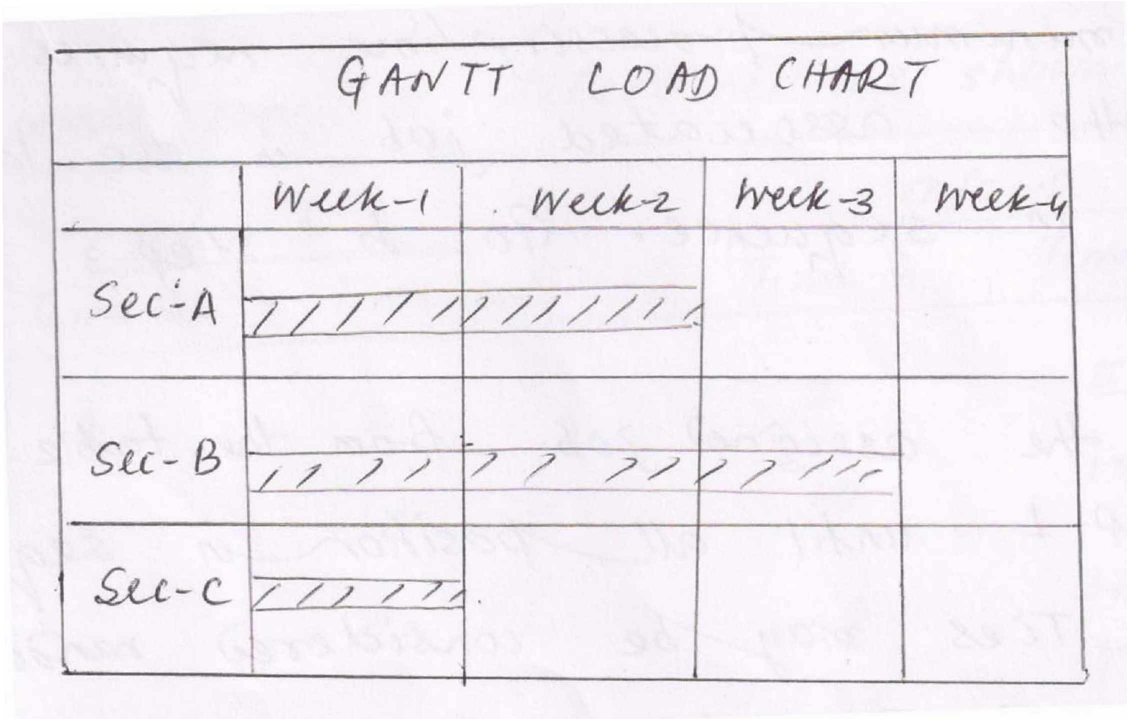
Scheduling Procedure

Scheduling normally starts with mater schedule. The following table shows master schedule for a foundry shop.

MASTER SCHEDULING FOR FOUNDRY SHOP. Maximum production capability/week = 100					
Order no.	Week-1	Week-2	Week-3	Week-4	Week-5
1.	15	18	20	15	18
2.	25	25	20	25	20

After master production schedule is made, the detailed schedules are thought of and made for each component, subassemblies, assemblies. The Gantt chars is a popular method commonly used in scheduling technique.

An example of Gantt chart is shown below. The hatched zone indicates actual work load against each section.



Instead of section, it may be m/c / other facilities. now a days computers are used to do this chart for different components/ m/c etc through readily available production software.

Machine loading using johnson's Rule

Loading may be defined as the assignment of work to a facility. the facility may be people, equipment, machine work groups or an entire plant. Therefore, machine loading is the process of assigning work to machine.

Johnson's Rule is most popular method of assigning jobs in a most optimum way such that the job can be produced with a minimum time & minimum idle time of the machine.

Case @ n Jobs in 2 machines

Job (s)	Machine-1	Machine-2
1	t_{11}	t_{12}
2	t_{21}	t_{22}
3	t_{31}	t_{32}
:	:	:
i	ti_1	ti_2
:	:	:
n	tn_1	tn_2

Methodology/Procedure

Step – 1. Find the minimum time among t_{i1} & t_{i2}

Step – 2 If the minimum processing time requires m/c-1, place the associated job in the 1st available position in sequence.

Step – 2 If the minimum processing time requires m/c-2 place the associated job in the last available position in sequence. Go to Step – 3.

Step – 3. Remove the assigned job from the table and return to step – 1 until all position in sequence are filled. (Tiles may be considered read only)

The above algorithm is illustrated with following example.

Example.- Consider the 2 machines and Six jobs follow shop scheduling problem. Using John son's algorithm obtain the optimal sequence which will minimize the make span. Find the value of make span.

Job	Time taken by m/cs, hr	
	1	2
1.	5	4
2.	2	3
3.	13	14
4.	10	1
5.	8	9
6.	12	11

Solution - The working of the algorithm is Summerised in the form of a table which is shown below.

Stage	Unscheduled	Min, tik	Assignment	Partial/full sequence
1. →	123456	t_{42}	Job 4 → [6]	*****4
2. →	12356	t_{21} →	Job 2 → [1]	2****4
3. →	1356 →	t_{12} →	Job1 → [5]	2***14
4. →	356 →	t_{51} →	Job 5 → [2]	25**14
5. →	36 →	t_{62} →	Job 6 → [4]	25*614
6. →	3 →	t_{31} →	Job 3 → [3]	253614

Now the optimum sequence – <u>2-5-3-6-1-4.</u>

The make span is determined as shown below

Job	m/c – 1		m/c – 2		Idle time on m/c - 2
	Time in	Time out	Time in	Time out	
2	0	2	2	5 →	2
5	2	10	10	19 →	5
3	10	23	23	37 →	4
6	23	35	37	48 →	0
1	35	40	48	52 →	0
4	40	50	52	53 →	0

The make span for this optimum schedule/assignment is 53 hrs.

Case (b) n jobs in 3 machines as shown is the following

Job	m/c-1	m/c-2	m/c-3
1	t_{11}	t_{12}	t_{13}
2	t_{21}	t_{22}	t_{23}
3	t_{31}	t_{32}	t_{33}
:	:	:	:
:	:	:	:
:	:	:	:
n	t_{n1}	t_{n2}	t_{n3}

One can extend the Johnson's algorithm to this problem if any of the following 2 conditions is satisfied.

If min of $t_{i1} \geq$ max t_{i2}

If min $t_{i3} \geq$ max t_{i2}, then an hypothetical problem with 2 machines and n jobs (as shown below) can be treated. the objective is to obtain optimal sequence for the data given in the following table. later the make span can be obtained (for the optimal sequence) using the data of original table.

Hypothetical 2 m/cs Problem

Job	Hyp m/c-A	Hyp m/c-B
1	$t_{11}+t_{12}$	$t_{12}+t_{13}$
2	$t_{21}+t_{22}$	$t_{22}+t_{23}$
:	:	:
i	$t_{i1}+t_{i2}$	$t_{i2}+t_{i3}$
:	:	:
n	$t_{n1}+t_{n2}$	$t_{n2}+t_{n3}$

Dispatching

It is concerned with starting the processes. It gives necessary authority to start a particular work, which has already being planned under Routing and scheduling. For starting the work, essential orders and instructions are given. Therefore, the complete definition of dispatching →

"Released of order and instructions for the starting of production for any item in accordance with the route sheet and scheduled chart."

<u>Function of Dispatching</u>

1. After dispatching is done, required materials are moved from stores to m/c(s) and from operation to operation.
2. Authorizes to take work in hand as per schedule.
3. To distribute m/c loading and schedule charts route sheets and other necessary instructions and forms.

4. To issue inspection orders, clearly stating the type of inspection required at various stages.
5. To order too section for issuing proper tools, jigs, fixtures and other essential articles.

Forms used in Dispatching

Following are some of the more common forms used in dispatching.

(a) Work orders: while starting the production, work orders are issued to departments to commence the desired lot of product.
(b) Time cards: Each operator is supplied with this card in which he mentions the time taken by each operation and other necessary information's. there are helpful for wage payment.
(c) Inspection Tickets: These tickets are sent to the inspection department which shows the quality of work required and stages at which inspection is to be carried out.
(d) Move Tickets: These tickets are used for authorizing over the movement of material from store to shop and from operation to operation.
(e) Tool & Equipment Tickets: It authorizes the tool department that new tools, gauges, jigs, fixtures and other required equipment may be issued to shop.