(c) Assignment of work element to stations:

Station/ stations	Elements	Work element time (Sec)	Cumulative time (Sec)	Idle time for station (Sec)
S1	A	40	40	05
	B	80	120	
	D	25	145	
S2	G	120	120	10
	E	20	140	
S3	H	145	145	05
S4	I	130	130	05
	F	15	145	
S5	C	30	30	05
	J	115	145	

(d) Efficiency: $\sum t \times 100/n \times CT = 720 \times 100/5 \times 150 = 96\%$.
(e) Balance delay = 100-96 = 4%.

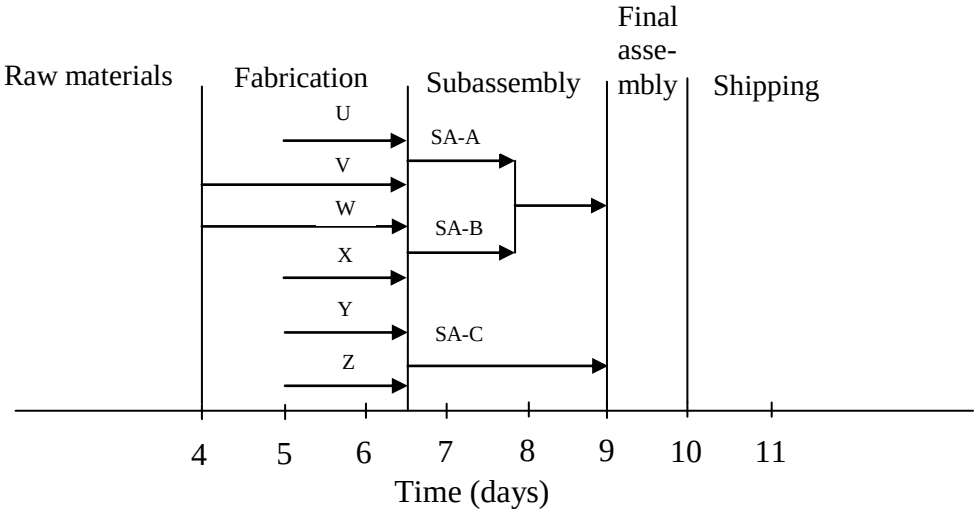
6.6 Flow control

Flow control applies to the control of continuous production as found in oil refineries, bottling works, cigarette making factories, paper making mills and other mass manufacturing plants.

The function of flow control is to match up the rates of flow of parts, subassemblies and final assemblies. Each part should be ready before the time of subassembling and each subassembly should be made available at the time and place of assembly in order to make the final product.

Flow control can be performed through the following:

(a) **Operation time**: It amounts the time required to manufacture each part, to make one subassembly and to execute one assembly. This information is available from the operation sheet.
(b) **Line balancing**: the assembly line should be balanced. Each work station should have the more or less same operating time and the various operations should be sequenced properly.
(c) **Routing and scheduling**: A combination route and schedule chart showing the fabrication of parts, subassemblies and final assembly is shown below.



The chart shows that part V & W started on 4^{th} day and the other parts on 5^{th} day such that all the components become ready for subassembly on 6.5^{th} day and all the subassembly become ready on 9^{th} day for final assembly. The assembly is over on 10^{th} day.

(d) **Control of parts subassemblies and Assembly**: A supervisory function coupled with an appropriate information feedback system keeps a check whether the small parts arriving in lots and big parts coming continuously are available at right time, in proper quantities for making subassemblies as per scheduled plan.

(e) Dispatching: Dispatching is nothing but issuing orders and instructions to start a particular work which has already been planned under routing and scheduling.

Functions of Dispatching

(i) Assignment of work to individual man, m/c or work place.
(ii) Release necessary order and production firm.
(iii) Authorize for issue of materials, tools, jigs, fixtures, gauges, dies for various jobs.
(iv) Required materials are authorized to move from stores or from operation to operation.
(v) Issue m/c loading and schedule chart, route sheet, etc.
(vi) To fix up the responsibilities of guiding and controlling the materials and operation processes.
(vii) To issue inspection order.
(viii) Issue of time tickets, drawing, instruction cards.

Dispatch procedure

The product is broken into different components. For each component, operations are mentioned in order as shown in Figure aside.

Route sheet for component C
Material-
Operation 1-
Operation 2-

The various steps of dispatch procedure for each operation are listed below:

(a) Store issue order: Authorise store department to deliver required material.
(b) Tool order: Authorise tool store to release the necessary tools. The tools can be collected by the tool room attendant.
(c) Job order: Instruct the worker to proceed with operation.
(d) Time tickets: It records the beginning and ending time of the operation and forms the basis for workers pay.
(e) Inspection order: Notify the inspectors to carry out necessary inspections and report the quality of the component.
(f) Move order: Authorise the movement of materials and components for one facility to another for further operation.

In addition, there are certain dispatch aspects such as:
(1) All production information should be available beforehand.
(2) Various order cards and drawing with specification should be ready.
(3) Equipment should be ready for use.
(4) Progress of various orders should be recorded.
(5) All production records should be on Gantt chart.

Centralized and decentralized dispatching

(a) Centralized Dispatching:

In centralized dispatching system, a central dispatching department orders directly to the work stations. It maintains a full record of the characteristics and capacity of each equipment and work load against each m/c. The orders are given to the shop supervisor who runs his machine accordingly. In most of the cases, the supervisor can also give suggestions as regards to loading of m/cs under him. A centralized system has the following advantages:

1. A greater degree of overall control can be achieved.
2. Effective coordination between different facilities is possible.
3. It has greater flexibility.
4. Because of urgency of orders, changes in the schedule can be made easily without upsetting the whole system.
5. Progress of orders can be readily assessed at any time because all the information is available is available at a central place.
6. There is effective and better utilization of manpower and machines.

(b) Decentralized Dispatching:

In decentralized dispatching system, the shop supervisor performs the dispatch function. He/she decides the sequence of handling different orders. He/she dispatches the orders and materials to each equipment and worker, and is required to complete the work within the prescribed duration. In case he/she suspects delay, he/she informs the production control department. A centralized dispatching system has the following advantages:

(i) Much of red tape (excessive adherence to official rules) is minimized.
(ii) Shop supervisor knows the best about his shop.
(iii) Communication gap is reduced.
(iv) It is easy to solve day to day problem.

Levels of Dispatch office: At plant manager's level.
At shop superintendent level.
At shop supervisor's level.
At specialist level.

6.7 Expediting

Expediting and dispatching are frequently performed under the same agency, particularly in special project control. An expeditor follows the development of an order from the raw material stage to the finished product. He/she is often given the authority and facilities to move materials or semi-finished products to relieve congestion in production flow.

6.8 Gantt chart

HL Gantt has developed a simplified graph which represents/displays the planned starting and finishing time of each task on a time scale. But it does not show the interrelationship among the tasks. On the left of the chart is a list of the activities and along the top is a suitable time scale. Each activity is represented by a bar; the position and length of the bar reflects the start date, duration and end date of the activity. This allows you to see at a glance:

- What the various activities are
- When each activity begins and ends
- How long each activity is scheduled to last
- Where activities overlap with other activities, and by how much
- The start and end date of the whole project

6.8 Line of balance (LOB)

LOB is a graphical technique used to find out the state of completion of various processes at a given time for a product. This technique is economical when the production volume is limited and applied to the production of aircrafts, missiles, heavy machines, etc.

For drawing the LOB, the following information are required:

- Contracted schedule of delivery
- Key operations in making the product.
- The sequence of key events.
- The expected/observed lead time w.r.t. delivery of final product.

Based on above information, a diagram is drawn which compares pictorically the planned verses actual progress. This is called line of balance (LOB).

6.9 Learning curve

From our everyday experience, we know that the first time we perform a skilled job, it takes much longer time than an experienced worker. But the next time if we perform the same job, we can perform it not only at faster rate but also with higher quality. Each additional time we do the same job, we become faster and better in performing. This improvement in productivity and quality of work as a job is repeated is called quality of work, as a job is repeated is called learning effect.

Similarly, when the number of units produced increases, the direct labour hours required per unit decreases for a variety of reasons such as:

(i) Workers become more and more skilled for a particular set of task.
(ii) Improvement in production methods and tooling takes place.
(iii) Improvement in layout and flow takes place and many other reasons.

While designing jobs, estimating work standards, scheduling production and planning capacity, it is important to know at what rate workers productivity will increase through learning. For example, if it takes a worker 10 hours to make the first 50 units of product, we don't want to plan on it taking 10 hours for every additional 50 units. Otherwise we will underestimate our production capacity and overstaff our operations. The role of worker learning in production, its effect on production costs and ways to measure it were popularized long ago.

The rate of learning and learning curve

The labour content (in person-hrs per unit) requires to make a product, expressed as a function of the cumulative number of units made is called Learning Curve. A typical learning curve is shown below.