Production Planning and Control

A MANAGEMENT GUIDE 9

NATIONAL PRODUCTIVITY COUNCIL

ABOUT NPC

The National Productivity Council is an autonomous organization registered as a Society. It is tripartite in its constitution and representatives of Government, employers, workers and various other interests participate in its working. Established in 1958, the Council conducts its activities in collaboration with institutions and organizations interested in the Productivity Drive. Besides its headquarters at New Delhi, NPC operates through eight Regional Directorates. In addition, there are 49 Local Productivity Councils.

The purpose of NPC is to stimulate productivity consciousness in the country and to provide service with a view to maximizing the utilization of available resources of men, machines, materials and power ; to wage war against waste ; and to help secure for the people of the country a better and higher standard of living. To this end, NPC collects and disseminates information about techniques and procedures of productivity. In collaboration with Local Productivity Councils and various institutions and organizations, it organizes and conducts training programmes for various levels of Management in the subjects of productivity. It has also organized an advisory service for industries to facilitate the introduction of productivity techniques.

Recognizing that for a more intensive productivity effort, the training and other activities of NPC, designed to acquaint management with productivity techniques, should be supported by demonstration of their validity and value in application, NPC offers a Productivity Survey and Implementation Service (PSIS) to industry. The demand for this service has been rapidly growing. This service is intended to assist industry adopt techniques of higher management and operational efficiency consistent with the economic and social aspirations of the community. PSIS is a highly competent consultancy service concerned with the investigation of management and operational practices and problems, and recommendation of measures of improvement and their implementation. NPC has established a special Fuel Efficiency Service. It has set up cells for servicing small scale industries It has introduced a National Scheme of Supervisory Development under which an examination is held and certificates awarded to successful candidates. NPC also conducts a two-year practice-oriented programme for training in Industrial Engineering for first class graduates in Engineering disciplines.

NPC publications include pamphlets, manuals, and Reports of Productivity Teams. NPC utilizes audio-visual media of films, radio and exhibitions for propagating the concept and techniques of productivity. Through these media NPC seeks to carry the message of productivity and create an appropriate climate for increasing national productivity.

A Management Guide . . . 9

Production Planning and Control

BY

R. A. TIWARI

National Productivity Council

Institutional Area, Lodi Road

New Delhi-110003

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PREFACE

Practically the world over, there has been increasing recognition that the development of supervisory skills can significantly contribute to the improvement of productivity of an enterprise. From its inception in 1958, the National Productivity Council has laid stress on supervisory development in its programmes, but since it needed a more concerted drive, it introduced during the Asian Productivity Year—1970 a nation-wide scheme to prepare candidates through self-study and class-room or enterprise-level guidance for a professional qualifying examination leading to the award of the National Certificate in Supervision.

We are happy that the response to the NPC Scheme has been quite good. Management of all forward-looking enterprises have evinced considerable interest, and over four thousand candidates in all have appeared for the Examination during the last three years. In implementing the NPC's Supervisory Development Scheme, some of the Local Productivity Councils have extended their cooperation and support. The success of any self-study scheme ultimately depends on making available adequate study material prepared by competent experts, and written in a lucid and simple style, NPC has brought out as many as 27 *Management Guides* so far which attempt to give a basic understanding of the various topics included in the syllabus.

This Guide, *on Production Planning and Control* has been prepared by Mr. R.A. Tiwari, formerly Deputy Director N.P.C. It has to be stressed that the NPC *Management Guides* are not intended as a substitute for enterprise-level assistance for supervisory development by way of training, demonstration, seminars, etc., but mainly as complementary to these activities.

These Guides are also designed to be of help to managerial personnel as well as students of management who wish to have some basic understanding of the science and practice of management.

G.R. DALVI
Executive Director
National Productivity Council

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I Introduction

Production Planning and Control essentially consists of planning production in an industrial undertaking before actual working starts. It establishes the exact sequence of operations of each individual item, part, or assembly. It sets starting and finishing dates for each important item, assembly, and finished product. It covers the procedures of releasing necessary orders for production and their follow-up to see that they are completed in time with the minimum adjustment. Thus, it is the function of looking ahead, anticipating difficulties and taking steps to remove the causes before they materialise.

The main function of detailed planning is looked after by a department of the concern. This department is usually given the name of "Planning Department", "Production Control Department", or "Production Department". In a developed industry, this department prepares and maintains vital information through elaborate systems and prepares plans by using sophisticated planning techniques with the aim of bringing overall advantage to the company. These systems and techniques are beyond the purview of this guide. It only seeks to impart knowledge that is needed by a person performing supervisory functions.

Importance of Production Planning and Control

No work is done without planning. There are those who plan when the actual work is to be executed. They run about to collect necessary requirements, thus extending the period of working. There are others who plan well in advance and arrange for the necessary requirements before starting the work. The advantages of the latter approach have led managers to develop proper systems of planning in the industry.

In a small company manufacturing a limited number and variety of products, the problem of planning and scheduling production is relatively simple. Most workers in the plant are familiar with the products and the operations through which they must pass for production. The word of mouth is good enough to give instructions for various operations. The volume of work in the plant is small and can be easily centralised under the personal supervision of a few men. In such cases, the system of planning and controlling production can be much simple.

Today, most managements are forced to seek a substitute for the above informal procedure of controlling production. The development of a more formal and systematic procedure seeks to accomplish three aims: (1) maximum quality production at minimum cost through even-distribution of work to available equipment and personnel, (2) added flexibility in equipment and personnel to meet unavoidable emergencies, and (3) harmony and cooperation between departments.

It is a popular belief that written instructions and elaborate procedures of planning and follow-up make further modification in the system difficult. Sometimes it is true also. It happens only where management attempts to make the job fit the system, instead of fitting the system to suit the job. Every procedure and every instruction should be planned with the expectation that it may be modified. On the other hand, a supervisor and the men under him must realise that they are but a part of a large organization and that a change in operations in one department may disrupt the work of numerous other departments.

Responsibility of the Supervisor

The supervisor stands as the connecting link between the management and the worker. He has a direct responsibility to both. He is responsible to the management for getting the work out. He is responsible to the worker for the efficient scheduling of work and the movement of parts and materials in a way that will permit the maximum earnings to the worker as well as the maximum profit to the organisation as a whole.

The supervisor can effectively promote these mutual interests of management and the worker through constructive participation in planning and scheduling. If he has the work of his department under his control, he should be in the best position to advise on combining orders for more economical runs. His suggestions can cover avoidance of extra set-up time, alternative routings of jobs within the department for greater economy and efficiency, and possibilities of providing equipment that may be needed on an emergency order.

The supervisor has also a cooperative responsibility with other supervisors in the plant. A Planning or Production Control Department of an organization should be looked upon as a service department, which helps in the work of the production departments. It carries responsibility and authority for planning, scheduling and following up work in production. Yet it can be effective only if it has the sincere co-operation of those departments which it serves.

If the purpose of planning and scheduling is to be achieved, the supervisor must seek only an honest and fair allocation of time and equipment for the work of a given order. It is a natural tendency for the supervisor to ask for extra allowances of time to avoid getting behind schedule. He knows that a certain amount of breakdown or delay is unavoidable. Some extra time allowance should be recognized as advisable in efficient scheduling. Yet, the supervisor who takes undue advantage of this opportunity is failing in his part of the cooperative effort and is disrupting the planning efficiency of the entire organisation.

A supervisor has the responsibility of keeping prompt, complete, and accurate records of work scheduled and work-in-progress in his department or division. The extent to which he may receive assistance in the performance of these duties will vary in different companies, depending upon the organisation, the size of departments, and the degree of centralization of departments. But, since he is responsible for the work of his department, he must have at his fingertips concrete information regarding the work-in-progress and the work which is scheduled for his department.

Planning and Controlling Functions

The principal planning and controlling activities can be divided into four functions : (i) routing, (ii) scheduling, (iii) despatching, and (iv) follow-up. The note given below is intended only as an introduction.

(i) *Routing:* Routing of operations for the manufacture of a product consists, first, of the determination of operations through which the product must pass and, secondly, the arrangement of those operations in the sequence that will require a minimum of handling, transportation, storage, and deterioration through exposure.

Determination of operations and their sequence, in general, is the function of the Industrial Engineering Department, Methods Department or the Drawing and Design Office depending upon the organisation structure of the company. However, the routing specified by any one of these departments must be subject to alteration as problems of scheduling and actual production are encountered.

(ii) *Scheduling:* A production schedule is a budget of time that provides for the beginning and completion dates of a manufacturing order. Preliminary information needed in the construction of a production schedule is obtained from the following sources: (1) the Forecasting and Planning Department, in cases where standard parts or products are being made to stock; (2) date of delivery specified by the customer in the order; (3) minimum time, in terms of past experience, required for production.

Three other factors to be taken into consideration are: (1) availability of equipment, (2) availability of specially skilled personnel, and (3) availability of the necessary parts and materials.

It is usually possible to anticipate the needs for equipment, personnel, and material considerably in advance. Difficulty arises during abnormal rush periods or when normal conditions have caused shortages. It is at such times that a manufacturer must put forth special efforts in order to obtain the maximum work from men and machines.

(iii) *Despatching:* Despatching provides official authorization and information for (1) the movement of materials to different work places, (2) movement of tools and fixtures necessary for each operation, (3) beginning of work on each operation, (4) recording of beginning and completion time, (5) movement of work in accordance with schedule, (6) control of progress of all operations, and the making of necessary adjustments in the release of operations to conform to emergencies.

(iv) *Follow-up or Progress Chasing:* It is the function of watching and recording the progress of jobs as per schedule and making necessary adjustments in case of emergencies.

Follow-up is probably the most important and most difficult of the functions. It is the tool for knowing what is happening and controlling the variations in schedules. It is one in which the supervisor plays a highly important cooperative role.

Planning and scheduling are of little value unless there is adequate provision for obtaining the necessary information about emergencies which may require information about changes in schedule in order to maintain an even flow of work. The procedure used in the procurement of materials must include provisions for follow-up to ensure that the materials will be on hand for a specific job at the time it is needed. Work-in-process must be checked to determine whether it will be ready for the next operation. A pre-assembly check must be made to determine whether the necessary parts will be ready on the pre-arranged date.

Responsibility for follow-up is usually placed in the hands of special follow-up men. Their function is one of obtaining information. They are essentially "go-betweens", who perform a service for the various departments involved. A follow-up man is usually given a specific responsibility in connection with one phase of the follow-up work.

All the above aspects of Planning and Control will be discussed in greater detail in later chapters.

Relationship with Other Functions

Production is the main function in a factory, and all other functions are closely related to it. They are basically meant for rendering some helping hand in the function of Production. Maintenance is meant for ensuring that machinery and plant are kept ready for production. Tool Room is for providing tools and equipment. Drawing and Design is for providing standards for technical guidance. Industrial Engineering or Work Study is for *determining* methods of manufacture and faculty requirements, as well as fixation of production times. Purchase is meant for ensuring supply of material, and Stores is meant for preserving material. These functions are termed as service functions to production. Inspection may not be treated as a service function in the same manner, as its basic purpose is to maintain the desired quality of the product rather than providing additional help to production.

The basic purpose of Production Planning and Control is to ensure that production is at the optimum. It plans production and followsup until production is over. It has also to control the cost of production. To achieve the aim of its function, Production Planning and Control has to know the actual situation as it prevails in production shops, including the cooperation they receive from the various service departments. Accordingly, Production Planning and Control is concerned with all the functions in a factory. Planning Department receives various information and prepares evaluation reports to highlight the weaker aspects of any function.

Perhaps an impression has been created that Production Planning and Control is only for large organisations where work can be distributed to particular persons. In fact it is not essential to have a separate person to look after a separate function. A few or several functions can be performed by the same person, if time permits him to do so. A production engineer or supervisor of a smaller industry may do all the main functions of Production Planning and Control himself or through one or two assistants only.

II Process Planning and Estimation

Need for Process Planning

In order to achieve production coordination in planning, it is essential that the method of working is standardised and the time of work determined:

The method of production of any item should be studied with a view to first improving it. All the aspects of machine capacity, machine capability, feeds and speeds, quality of material, skill of worker, availability of special tool and equipment, etc, are considered. The most suitable method under the circumstances prevailing in the organisation is then listed out as a basic data. The method is specified in the form of standard document normally known as "Process Sheets" or "Operation Layout Sheets".

According to specified methods each operation is expected to take such time which can be determined through Work Measurement Techniques such as Time Study, Work Sampling, etc. These methods are dealt with in a separate guide dealing with Work Study. The time obtained is expressed in the terms of standard minutes or standard hours including allowances for permissible loss of time due to the inherent nature of job, working conditions in shop, and supervision as well as for attending to all personal needs.

Where time has not been determined by special work measurement techniques, even an estimate by the experienced supervisor is a good basis for planning.

A scientific planning and control is based on the time required by the different activities. The more accurate the time estimates, the more realistic will be the planning.

The process sheets are prepared for all the items of production. These are supplied by the Industrial Engineering or Work Study Department and are maintained by the Planning Department. The time required for an operation is also mentioned in the process sheet. These are revised and up-dated in the light of the experience gained by the company.

Preparation of Process Sheet

While preparing a process sheet, a suitable method of working is determined with respect to the quality and quantity of the units to be produced. The following factors are given serious consideration while deciding the plan:—

(i) *Selection of Machine:* It is mostly dependent on the accuracy required on the job, and the quantity of units to be produced at a time. The following example will illustrate the point. If 1/2" BSW Hexagon Bolts made of mild steel are to be produced, the following methods may be found suitable:—

(*a*) If 10 numbers are to be produced, say for repair work, the engine lathe will be a suitable machine. The bolts can be turned, threaded, and chamfered on lathe. The hexagonal bar, if available, can also be used. If it is not available, even an ordinary round bar can be used and the hexagon could be cut on the milling machine.

(*b*) If the quantity to be produced is around 1,000 numbers, a turret or capstan lathe will be a better suited machine. To economise production, the hexagonal bar has to be used.

(*c*) If 20,000 or more numbers are to be produced at a time, the most economical machine will be the auto-lathe where the hexagonal bar could be used.

In the above three instances, the main difference in the suitability of machines has been the quantity to be produced at a time. The latter machines are better suited for faster production, even though they take a longer time for set-up and, therefore, for larger quantities they are found to be economical.

(ii) *Selection of Equipment:* Even when the same machines are used, it becomes more economical, if suitable holding devices, jigs and fixtures, special tools and gauges, are made specially for that job to help a faster rate of production.

To illustrate the point, we may consider the case of different methods of milling on a component. The cost of each method could also be compared taking Rs. 18 per hour as the expenses covering factory charges for milling operation.

(*a*) The components may be machined using the standard milling machine vice for holding the components.

With this scheme no new equipment will be required, but each component is required to be set up individually. The time taken per component may be approximately 30 minutes. Thus, the cost of operation per piece at two components per hour will be Rs. 9.

(*b*) A special fixture may be designed and manufactured to machine one component at a time.

The advantages of a specially designed milling fixture will result in a reduction of clamping time, but not necessarily of cutting time. The initial set-up time will also be reduced. Therefore, the time to produce one piece will be reduced as compared with the method given in (a); this method of operation may reduce the period of working from 30 minutes to 9 minutes. Thus the cost of production is reduced to Rs. 2.70 per piece giving a saving of Rs. 6.30 per component. However, the cost of fixture will also have to be considered. If the cost of fixture is Rs. 450 it could be covered when about 70 components have been manufactured. Therefore, this method can be recommended when a minimum number of 70 components is required.

(*c*) A string milling fixture may be used for holding, say, six components in line.

The provision of a string milling fixture will reduce the time taken per piece still further compared to method (b), but a more elaborate type of equipment will increase the cost of fixture. Assuming that the cost of fixture is Rs. 1,000 and the time taken per component is 7 minutes, we can calculate the cost of operation with this method also. Thus the cost of operation is equal to Rs. 2.10 per piece. The cost of fixture is covered when about 150 components have been machined.

(*d*) A special fixture may be designed and used for gang milling six components together.

The gang milling fixture will be a more complex type than that needed for method (c), specially when it is operated pneumatically. Five additional cutters or sets of cutters will also be required. The equipment, therefore, will cost more considerably. Assuming this cost to be Rs. 2,500 and the time taken per component reduced to one minute, we find that 60 components can be produced per hour. The cost of production per unit is equal to Re. 0.30. The cost of fixture can be covered when about 290 components have been machined.

(iii) *Special Tools and Gauges:* Much time of operation is lost if an operator is to measure the dimensions of the components or other quality specifications by standard measuring devices and equipment. If he is provided with specially designed gauges, the period of checking is considerably reduced and hence a faster rate of production can be expected. Similarly, specially designed form tools and cutters reduce the period of operation. The cost of special gauges and tools will be easily offset by the savings in time. It will follow the analysis similar to that given for selection of equipment.

(iv) *Material:* The quality, size and composition of material have their own effect on the rate of output. A variation in size from batch to batch or from piece to piece of material hampers speed of working and does not permit proper tools and fixtures to be used. At times, additional operations are needed to bring material to required size before it can be used. Similar is the case with other qualities, such as its hardness and composition, making it difficult to machine by certain tools.

There is another aspect of material which is considered at the time of preparation of process sheets. It is called "Scrap Factor". The quantity of material that remains in the finished product may not be equal to the quantity of material that is issued or used for that product. The quantity may get rejected in inspection or get used in trial runs during set up. Some of it may get wasted during machining or processing. The ratio of this scrap quantity to the actual quantity that remains in the product is 'scrap factor'. A high scrap factor indicates that much material is being wasted in that method of processing. Since material normally constitutes high percentage of manufacturing cost, a process having lesser scrap factor is more economical and preferable.

Time Estimation

In an industrial undertaking, there are workers engaged in producing or servicing some items. In order that we can make effective use of these people and also the plant and equipment that they use, we should know the time required to perform them.

The actual time consumed on the job is made up of two factors in all machine tool work and in many other cases. This can be divided into:—

(i) *"Set-up" or "Make Ready":* This is the time needed to get the equipment ready to do the job. It is often difficult to determine this time accurately. It varies considerably from time to time, and only an approximate value can be found out.

A lathe operator works in a general machine shop. When a new job is given to him, he is supplied with drawings, sketches, special tools, gauges etc, as required for doing the job. He gets instructions from the supervisor, gets special tools issued from the store, sets his machine, and makes the trial run. During this trial run, his rate of production is below the normal. The time loss because of all these activities is called set-up or make ready time. It can be determined only approximately. This time is spent every time a new batch of the component is given to him for production. It does not depend on the quantity in the batch.

(ii) *Operation Time:* It is the time taken for performing a job when the man is working at the normal rate of production. During this period, the worker is also required to re-grind and re-set his tools, to take the necessary measurements, to inspect the quality, and to attend to his personal needs. The time required for these miscellaneous activities for which there is a stoppage in work, is considered when the rate of production is determined through work measurement techniques. It is built in the standard time allotted for the job in the form of allowances.

Operation time is proportional to the quantity contained in a batch.

Set-up time may or may not constitute a great portion of the total working time. If it does not constitute a large portion of time and does not fluctuate appreciably from day to day or from one component to another, it could be treated as fixed allowance added to the normal operation time, like other personal and rest allowances. This will eliminate the botheration of calculation of set-up time in each case. However, if operation time constitutes a large proportion, it is necessary to consider it separately.

Economic Batch Quantity

Set-up time is principally a loss of time due to change over from one job to the other. As a policy, the change overs should be kept to the minimum to reduce this loss. This requires that larger quantities are produced at a time, so that the number of set-ups in a year is reduced. On the contrary, by producing larger quantities at a time, the component will have to be *kept* in the store for a longer duration before all of it is used.

We can consider the quantity to be produced at a time on economic consideration. Some of the factors involved are as follows:—

(i) There are costs which *decrease* as the size of a batch is increased. These are:—

(*a*) set-up and make ready costs in the shop. These are obtained by multiplying set-up time with the hourly costs of operations involved in manufacturing.

(*b*) cost that are incurred for planning and issuing shop orders.

The production control people, foremen, cost accounting, inspection, time-keeping and other functions are adversely affected by a larger number of manufacturing orders, there being one order for each batch. It is difficult to determine this cost. An estimate can be evolved taking into consideration the proportionate annual costs on these functions and dividing it by the number of orders issued in the year. The amount is the cost of placing each order on shops.

(ii) There are costs which tend to *increase* as the size of order is increased. These are: Inventory Storage Charges or Carrying Charges.

These are the expenses that are incurred in keeping a component after production in store before it is used in sub-assembly, assembly or is sold to the outside market. These expenses are :—

(*a*) interest on capital that is blocked in the form of inventory

(*b*) all godown expenses

(*c*) handling expenses

(*d*) expenses on staff and workers

(*e*) losses due to spoilage of components, etc.

The above expenses can be determined by determining the total expenses of the company and dividing it by the total value of the items maintained in store.

The above expenses are contrary to each other. If we produce a smaller quantity at a time, we increase the set-up cost and the cost of issuing shop orders. At the same time, we save in the inventory carrying charges. If we produce a larger quantity at a time, we save our expenses in set-up and issue of orders, but increase the inventory carrying charges.

As an illustration, we may consider a case with the following particulars:—

(i) The total sale in a year is equivalent to 240 units, spread over uniformly throughout the year. Thus, sale per month is equivalent to 20 units.

(ii) The normal manufacturing cost per unit is Rs. 1,200.

(iii) The carrying charges per year is estimated at 12% of the value of the product. Thus, carrying charges per unit are Rs. 120 per year at Rs. 10 per month.

(iv) The set-up and order issuing cost is estimated Rs. 1,600 each time a manufacturing order is issued.

With the above figures, the following table can be created by taking different quantities in each batch:

Quantity per batch	No. of batches	Set up cost per unit	Carrying charges per unit	Total cost per unit
240	1	6.67	60.00	66.37
120	2	13.33	30.00	43.33
80	3	20.00	20.00	40.00
60	4	26.67	15.00	41.67
40	6	340.00	10.00	50.00
30	8	53.33	7.50	60.33
20	12	80.00	5.00	85.00

In the above calculation, a unit is expected to remain in stock, on an average, for half the period.

The unit may consist of 1,000 numbers, one tonne, 500 gross or any other quantity in which the manufacturing orders are placed. The selection of unit does not affect our consideration here as all costs vary in the same ratio.

We can plot these expenses on graph paper as indicated in Fig. 1. It has been plotted keeping costs for a unit of product under consideration. We find that the cost of set-up and issue of order keeps on declining initially at a faster rate. The carrying charges per unit gradually increase as a larger quantity is produced per order. We can total these two costs at several points on the graph and draw a curve denoting the sum of the two costs. This has also been shown in Fig. 1. The lowest point on this curve denotes that quantity which should be produced at a time to keep the total expenses to the minimum. This has been shown on the graph by a dotted line which meets the lower axis at a quantity of 80 denoting that 80 units or a quantity nearabout that will be most economical to produce at a time. This quantity is called the "Economic Lot Size" or "Economic Batch Quantity".

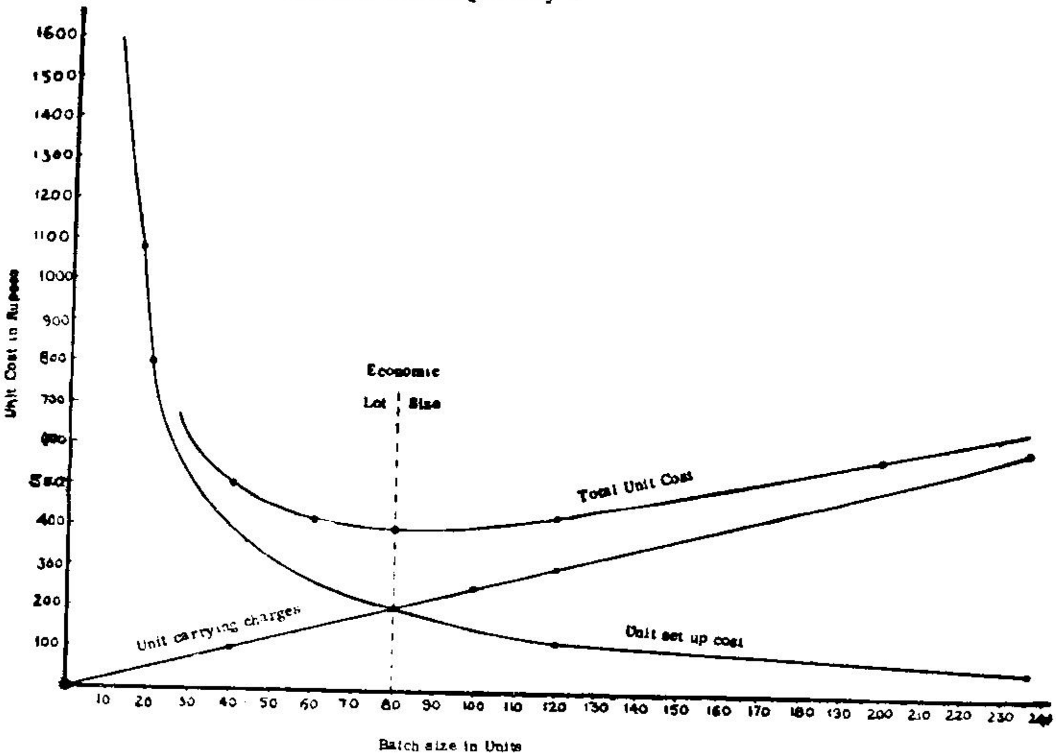

FIG. 1—Economic Batch Quantity

Material Estimation

It is necessary to know the quality and quantity of material needed for any production. The material its specifications, and the quantity needed for quantity on process sheet is also estimated. The size of product determines the size of material.

It may not be available in exact desired sizes. There are many standard sizes available in the market. A size giving the least scrap factor is the most economical.

Example of a Process Sheet

So far, we have discussed the different aspects that are considered while preparing Process Planning Sheets. Fig. 2 gives a sketch of a cone used in the manufacture of cycle hub. Its method of manufacture is determined. A simple process sheet for this component is shown in Fig. 3.

A Process Sheet is prepared for a definite quantity (1,000 numbers in the present case). This is normally the economic batch quantity or a fraction thereof. In practice, production is carried out for this quantity which is a multiple of this quantity, so that calculation of operation time and material is easy. A process may include detailed sketches of each operation. It is prepared for sub-assembly and assembly also.

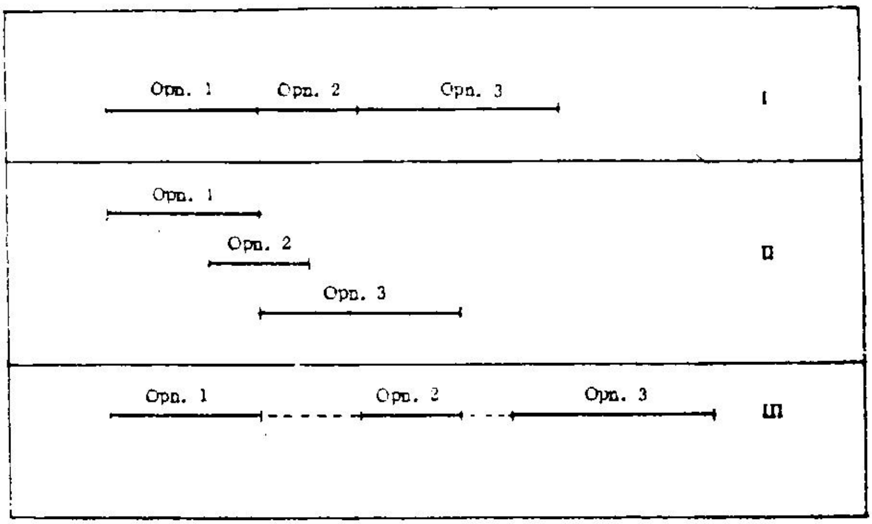

Fig 2 A Component

Estimation of Cost

In another guide, you are informed how manufacturing cost is calculated. The actual cost of production is known only after the production is over. However, an estimate of cost must be known to see how it will affect the financial position. It is also needed for fixation of sale price.

PROCESS SHEET

PRODUCT: Cycle Hub

DRAWING NO. CH-21

COMPONENT
DESCRIPTION: Cone

PART NO. CH-1-3

MATERIAL: M.S. rod $\frac{3}{4}''$ dia

SCRAP% 10%

PER UNIT: 0.825" long

PER BATCH: 68.75 ft. long. 50 kg.

BATCH QUANTITY: 1000 Nos.

Operation No.	Group or Machine	Operation details with speeds & feeds	Tools, Jigs & Fixtures	Set-up Time	Operation Time	Remarks
01	Circular Saw-2	Cut rod in 10 lengths	—	—	15 mts.	
02	Lathe	Turn, Bore and Form —960 RPM, 016"/rev. feed	Turning & Boring Tool-Forming Tool	20 mts	350 "	
03	Lathe-24	Cut threads—320 RPM	' BSW Tap	10 "	300 "	
04	Milling Machine-25	Mill Sides—100 RPM 20/mt.	Milling Fixtures No. 05-06 2' Side Mill cutter	30 "	150 "	

DATE: 1.4.70 DRAWN BY: K.C. Sharma LAYOUT NO: CH-156

CHECKED BY: O.P. Verma SHEET NO: 1

Fig. 3 Process Sheet

There are three salient portions of manufacturing cost. These are:—

(*a*) Direct Labour Cost,

(*b*) Direct Material Cost, and

(*c*) Other Expenses called overhead.

(*a*) *Direct Labour Cost :* It is determined by multiplying hourly cost of direct labour for each operation by the time required for performing it. There may be some turners (lathe operators) of a specified skill, say, semi-skilled, needed for operation. If, on an average, each turner is paid Re. 1 per hour, and the estimated time for the operation is 2 hours, the direct labour cost works out to be Rs. 2.

(*b*) *Direct Material Cost*: It is the cost of material as per material estimate.

(*c*) *Overhead Expenses*: It bears some ratio with the direct labour cost. It is expressed as a percentage of direct labour. In actual situation, it slightly fluctuates from month to month. For purposes of estimation, a fixed percentage of overhead is taken.

III Scheduling and Control

In the previous chapter, we discussed how time required for manufacturing an order is determined after the method is specified. If we also know the total time available on a machine, a group of machines or department, we can plan on what date and time a component can be manufactured or assembled. Determining this specific time and reserving it for manufacturing that component in advance of actual production is termed as "SCHEDULING". It is dependent on the availability of the machine and plan. Scheduling helps in making the maximum use of plant and machines by providing manufacturing orders, materials, tools, etc, to the work spot on the scheduled time.

In an organised industry, the scheduling is done in great detail. However, it is not essential that manufacturing will take place at a time at which it is originally scheduled. There is a likelihood of certain unforeseen delays because of which adjustments will be needed. These adjustments will be found out through the process of follow-up of actual production until manufacturing is over.

The process of making these amendments to smoothen the variation in scheduling is called "CONTROL".

There is a close link between Scheduling and Control. The more realistic the scheduling the lesser will be the problem of controlling. If the scheduling has not been done with a full knowledge of the problems existing in the workshop, there will have to be a lot of progress chasing of jobs, in the form of control, to see that the production takes place with the minimum delays and maximum utilisation of the capacity of plant and machine.

Effects of Manufacturing Methods on Scheduling

Proper scheduling procedures in a plant are determined by its methods of production and degree of control required. Four general situations may be found in industry according to its methods of production :—

(i) *Intermittent or Lot Manufacture,* in which the product is routed through the plant in a lot or job order. Under this general heading, there are two methods of procedures :—

(*a*) *Manufacturing to Order*, where the order goes through shops for individual parts. Parts may be single pieces or a number of pieces put together as a lot. Each part passes through one or several operations called "PROCESS". Assembly is dependent on all parts being ready simultaneously. Examples of this type are simple products, such as castings or stampings, semi-finished or unfinished, both requiring assembly.

Manufacturing orders are not necessarily individual customers' orders. They may represent grouping of several such orders which are for identical items. Manufacturing orders may also represent estimated stock or sales requirements of a particular item or product such as 120 pairs of a particular style of shoes, 50,000 yards of a certain variety of fabrics, or 12 dozens of a particular variety of almirah.

(*b*) *Stock Manufacturing:* This differs from (a), particularly in that a very large number of pieces are involved. It is more convenient to make parts in a large quantity and put them in stock to be withdrawn for assembly as required from time to time. Parts are put through in separate lots at pre-determined intervals over a period of time. Assembly is an independent operation. It can go on as long as parts are available in stock.

(ii) *Continuous Manufacture:* This can also be divided into two kinds :—

(*a*) *Single Product Continuous Manufacture*, where a single product goes through a fixed series of processes without assembly. In this case, the output is usually given in weeks or months instead of by manufacturing orders, the capacity of production being more or less fixed. The only variation is increased or decreased production due to variation in market demands. The chemical and textile industries producing only a few products are proper examples of this type.

(*b*) *Multi- or Assembly-product Continuous Manufacture*, where parts, especially more important parts, are made continuously, each operation having a given output per day. The difference in output of all the parts is increased or diminished together as the market demand fluctuates. For the purposes of scheduling this is equivalent to several lines of continuous manufacture, but sub-assembly, assembly and processes increase or diminish simultaneously with the output of parts. Industries doing assembly of cars, scooters, bicycles, tractors, meters, switchgears, etc, are good examples of this type.

The requirements of an industry need not conform to any of the types given above. In most of the industries, the system of scheduling and control is designed to cover more than one type due to the number and variety of its products.

Basic Data Needed for Scheduling

The following data are needed for proper scheduling :—

(1) Process Sheets
(2) Time estimates
(3) Capacity of production
(4) Sales Forecast
(5) Master Schedule
(6) Process Schedule Chart
(7) Bill of Materials

In the previous chapter we had discussed how process-sheets of components. sub-assemblies, and assemblies can be prepared and time and material can be estimated. We shall discuss here the other aspects.

Capacity of Production

So far we have considered time required for manufacturing or assembly of a given quantity of certain parts or products. It will be helpful if we also see the same thing from another angle. How much of this part or product can be produced in a given time ? The answer to this question gives the quantity which is called the "CAPACITY OF PRODUCTION".

The capacity is normally expressed in production units per hour, per shift or per day. The units differ from industry to industry. Thus, in textile and other fabric industries, it is expressed in tonnes of yarn or metres of fabric. In foundries, it is usually expressed in tonnes. In case of cars or bicyles, it is expressed in numbers.

In case of machine shops and other general engineering workshps, there are many varieties and size of products. Therefore, determination of capacity of production is more difficult. The variations in feed and speeds, material, tools, fixtures, etc, must be taken into account before the actual production rate can be determined. The capacity of machine tools, therefore, cannot be expressed accurately in general terms of product units. It is easy only in those cases where very large quantities of identical pieces allow output to be measured in terms of numbers, dozens or hundreds per hour.

Due to this difficulty in machine tool industry and in other industries producing many varieties and size (e.g., printing press doing job work) it is more appropriate, if the capacity of production is expressed in terms of "time" in hours instead of production units. In those industries where time required for production has been suitably established through scientific studies, e.g., time study, all the calculations of scheduling, production and wage payments can be made in "Standard Hours" (See Guide on Work Study). The production capacity can also be considered in standard hours.

(i) *Variation in Capacity due to Performance:* If the rate of production determined through works measurement or through the analysis of optimum rate of production is usully found to be higher than what is normally achieved in Indian industries, the difference is due to bad supervision, low level of training of worker, climatic variations, and lack of given time to the quantity that he should produce as per standards in motivation to him. The ratio between the quantity he produces in the same time is termed as his "PERFORMANCE".

The performance of workers can be raised through proper training and motivation in the form of incentive. It can also be considerably raised by proper and planned supervision. A high performance level is a great advantage to an undertaking. It adds to their profitability and competitiveness. Progressive industries devise their own programmes to raise the performance level of their workers. The performance of workers rise only gradually. The expected performance in subsequent months can be predicted reliably.

(ii) *Variation in Capacity due to Absenteeism :* Apart from performance, the rate of absenteeism also affects production capacity. It is immaterial whether the absence is authorised or unauthorised. The worker is not available for production. In India there are seasonal fluctuations from month to month depending on the family background of the workers. Thus the production capacity of departments decreases during those months when the absenteeism is high, a fact which is overlooked by most.

If records of attendance of the past few years, say 3 years, are analysed monthwise, the absenteeism in the coming months can be predicted.

With the knowledge of performance and absenteeism, the capacity of production can be estimated.

The following example may make it clear : Suppose there are 10 fitters in a section, each doing independent work. We are in March making estimates for May. The performance of this group of fitters is expected to be 75% and absenteeism is expected to be 20% during May. We can calculate the production capacity of the group taking 48 hours of working per week per fitter.

Total time per week	10×48	—	480 hours
Time lost due to absenteeism	$480 \times 20\%$	—	96 hours
Total attendance hours		—	348 hours
Time available as per standards	$384 \times 75\%$	—	288 standard hours

Thus work equivalent to 288 standard hours is expected from the group in each week of May. This works out to be only 60% of what is ideally expected. Overlooking this aspect and expecting much more quantum of work will result in wrong planning upsetting scheduling.

Sale Forecasting

Production in an industrial undertaking is carried out to meet the requirements of customers. This means that the required quantities of a given product are available in these quantities at appropriate times. The required quantities can be produced at appropriate times only if the company has necessary facilities to carry out the production such as building, equipment, machine accessories, manpower and materials. Customers' orders are received through the Sales or Marketing departments of the organisation. These orders are consolidated into limited number of orders by grouping orders of individual items together. However, it has been realised in many industries which are producing items on regular basis that they could not wait until orders are actually received.

Production Planning requires that the sale demand for the company's every product during a specific subsequent time period is known well in advance, so that necessary arrangements for creation and utilisation of facilities could be made. This assessment of the future requirements is called "SALES FORECASTING". Although sales forecasting is not usually done by the Production Planning Department, some knowledge of sales forecasting helps in a better understanding of the other aspects of production planning and a better appreciation of the problems of production control. For this reason, we shall consider one of the simplest techniques of sales forecasting being applied by most industries. There are other statistical methods available for determination of sales forecast. Their results are more or less similar to the one mentioned here and hence a discussion on those statistical methods has been avoided in this Guide.

Method of Forecasting

Let us take the case of a company which produces both standard and non-standard products. Standard products are those which the company may produce for stock and sell it as and when the actual sales orders are received. There is a continuing demand for these products. The demand of the market is such that the quantities required in future can be reliably predicted. Examples of this type of products can be automobiles, nuts and bolts, bricks, soft drinks, fibres, cosmetics, etc.

Non-Standard products are those which cannot be normally produced for stock. These items are produced only after receiving firm orders from customers along with their specifications. These are special items and these products differ in quality, quantity and size from one another. Examples of such products would be: Production equipment of special design, custom-made furniture, tailor-made clothes, etc.

While it is easy to forecast the demand for a standard product reliably, the forecast of non-standard products cannot be made without some risk. Therefore, the skill and information required for forecasting non-standard products is much more than those needed for standard products.

With regard to standard products, a company need not forecast the sale of each individual item it manufactures. It may classify its product by putting similar items together and then forecasting a sale for each class. Each class of product generally has a similar design and requires a similar sequence of operations on similar equipment. There is a nominal variation in sizes according to the market demand. Examples of this would be: automobile valves, shoes of different sizes in one shape, etc.

The normal method applied for collecting sales forecast in an industrial undertaking begins with salesmen. They prepare estimates of future sales in their respective territories. In their estimates, they are in a position to reflect the customers' reaction to the product and its sales trend. They submit their estimates to the Branch Sales Managers, who make certain adjustments to reflect his knowledge of individual salesman's judgement. Some of the salesmen might have shown in the past that they are consistently optimistic in their estimates. The Branch Managers will revise the estimates of such salesmen downward to bring it towards reality. Similarly some of the salesmen might have shown in the past that they are pessimistic in their hope of future sales and, therefore, their estimates may be revised upward. The remainder of the estimates prepared by the salesmen can be accepted without alteration by the Branch Managers.

These figures are supplied by the Branch Managers to the Chief Marketing Manager or to a Committee responsible for making the final forecast. They review the estimates in the light of certain factors which are not in the knowledge of salesmen. These factors may include such as: Expected Changes in Product Design, Plans for Increased Advertising, Proposed Increase or Decrease in Selling Price, New Production Methods which may improve the quality of the product, changes in Competition and changes in Economy such as Purchasing Power, Income Distribution, Population Increase, Employment Increase, etc. Consideration of these factors makes it necessary to revise the earlier forecast. This final forecast represents the expected quantities to be sold at different intervals of time.

The sales forecast may be expressed in terms of rupee value or physical units of products. If the forcast is in rupee value, it has to be converted into physical unit for the purpose of production planning and control. This is because the production planners are compelled to think in terms of combining material, manpower, use of equipment, and all other facilities needed per unit of output.

The method given above is the simplest approach which is normally adopted by an industry. It is a simple and straightforward method. One of the chief advantages is that it makes use of the members of organisation who are directly involved in their duties in the activities of sales. It also reflects their implicit acceptance of responsibility to sell the quantity that they estimate.

Most of the firms are interested in making a forecast of monthly sales. Past actual sales of each product class can be analysed to determine what percentage of sales was made during each month of the year. If these percentages vary from year to year, then the average of the last 3 to 5 years can be taken as a guide. These can then be applied to the annual sales forecast and accordingly the monthly forecast can be calculated.

Levelling of Production

After the sales forecast has been determined, the next step in the direction of planning is to see whether the facilities available with the company are sufficient to carry out the production. Normally it is found through the sales forecast figures that the sale of the product is not uniform throughout the year. In certain other months, sales demand is so high that the company cannot produce it. In certain other months, the market demand may be so low that the production capacity cannot be fully utilised. This can be illustrated by the sales pattern of electric fans. Fans are normally required during the period of summer when the climate is warm. They are not required during winter period. Thus the demand for electric fans shows the seasonal variation.

To cope with the fluctuation in market demand, the following four methods are applied in planning:—

1. One of the most common methods of levelling production is to produce to stock during a relatively slack sale period. This has the effect of cutting the peak period in demand and producing the extra quantities earlier. This will, however, mean that the firm will be carrying higher inventory during certain months.

2. The second method of minimising fluctuation is to alter the sales pattern of certain products. This is done through certain steps such as (a) reducing the selling price during the periods of reduced demand; and (b) increasing the amount of sales efforts during these periods.

3. The third method is to promise later delivery dates during the peak period even at the risk of losing some sales.

4. The fourth method calls for introduction of a new product line which has a high demand during the slack sale periods of the earlier product. This would obviously mean that the production capacity of the plant is kept at a level where the peak period demand of any product can be met.

All the above four methods of levelling production involve some financial losses. It is for the management to collect the relevant cost information and decide which of the above methods are acceptable.

Master Schedule

On the basis of sales forecast and levelling of Production, the quantities to be produced in different months of the year are determined. These are given in terms of finished product units. A list containing the quantities to be produced in different months is prepared which is called "MASTER SCHEDULE".

Master Schedule is the first step towards planning of production. It authorises planning sections to make detailed plans for the availability of materials and utilisation of plant capacity with the aim of maximum economy to the company.

Process Schedule Chart

The master schedule mentions the end time at which certain quantities of products are to be ready for sale or for stock after final inspection and acceptance. It may be possible to produce these quantities within the limited period of one month or it may take a longer duration during the process of manufacturing. These may consist of a single part or a group of parts. These may or may not involve assemblies or sub-assemblies. To a planner it is essential to know at what time the products should be started so that they are completed on the stipulated date under normal conditions. The starting dates can be easily found out, if a chart similar to Fig. 4 is prepared for each sub-assembly or assembly.

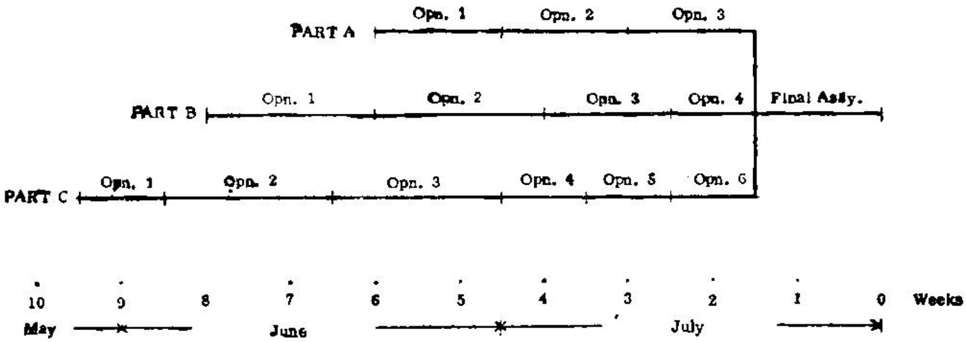

FIG. 4 Process Schedule Chart

In the figure you will find that the bottom scale is given time value (in weeks in the present case) in reverse order. Thus it indicates how much time earlier an operation in a given part is to start so that there is no delay in the processing and completion. In Fig. 4 we find that although the product is to be shipped in July, some of the operations must be carried out in the month of May or June if the shipping date is to be met. It has been possible to prepare this only after the process sheets of all the operations were prepared earlier.

The Process Schedule Chart gives the minimum time that all operations will take. This takes into consideration that necessary machines and workers will always be available to carry out all the operations needed on different parts. In actual situation it may not be so. For instance, we may find that operation 2 of part 'A', operation 3 of part 'B' and operation 4 of part 'C' require use of medium lathes. If the number of medium lathes in the plant is limited to two, it may not be possible to schedule all the three parts in the fourth week at the same time. This makes it evident that the actual time required for starting certain operations may be earlier than what is charted on this figure. From the past experience, a planner is able to find out how much extra time he should allow to compensate for variation in production facility.

Another advantage of this chart is that it can indicate which parts or sub-assembly are to be started earlier. A part that has a longer period on the chart should be given preference over others. For instance in this case operation-l of part 'C' should be started earlier than the first operation of part 'A' and 'B'. If operation-l of part A, part B and part C consists of cutting of material on the same-machine, it will be more advantageous if part C is scheduled to be cut earlier than part A or part B. If part B is taken earlier than C, there will hardly be any advantage in reduction of the total time, as part 'C' will still take the longest time before it is available for final assembly.

Preparation of operation schedule is one of the most difficult tasks in production control. The process sheets tell the production control department what sequence of operations should follow and what factors of production are required to perform each operation. The study of capacity of production tells the production control department the time at which the required factor of production will be available. With these two informations, a variety of operation schedule is possible and there is no way of knowing which is the best. To illustrate the point, let us consider a simple case in which 3 operations are required on a single part. The availability of the

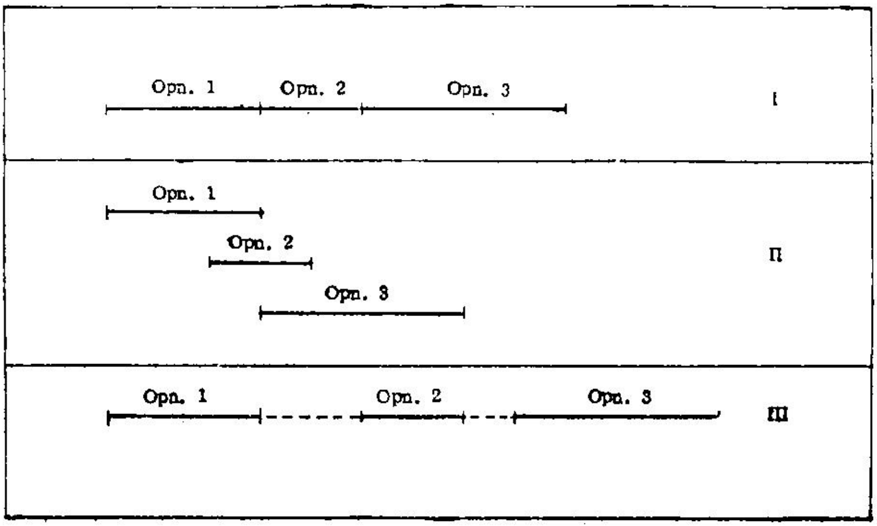

Fig. 5

required factor of production is such that three alternatives shown in Fig. 5 are possible. These three alternatives are only representative of a number of other alternatives which are possible.

In general, there are two basic approaches that can be applied in operation scheduling. One is to start with the desired delivery date and the last required operation and work backward by scheduling each preceding operation on the basis of the availability of the factor of production until the starting date for the first operation on the first part is reached. The result may be shown in Fig. 6.

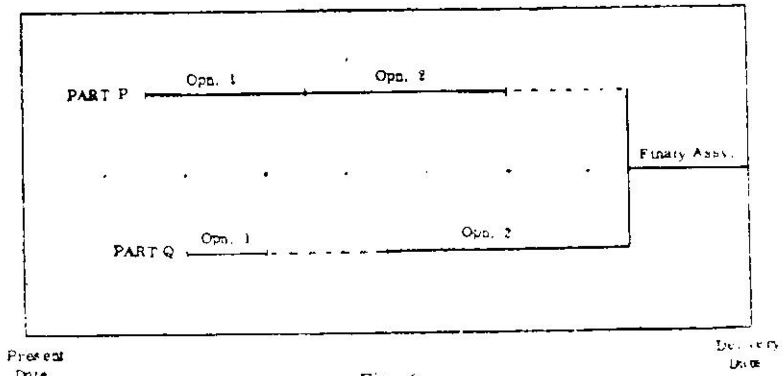

Fig. 6

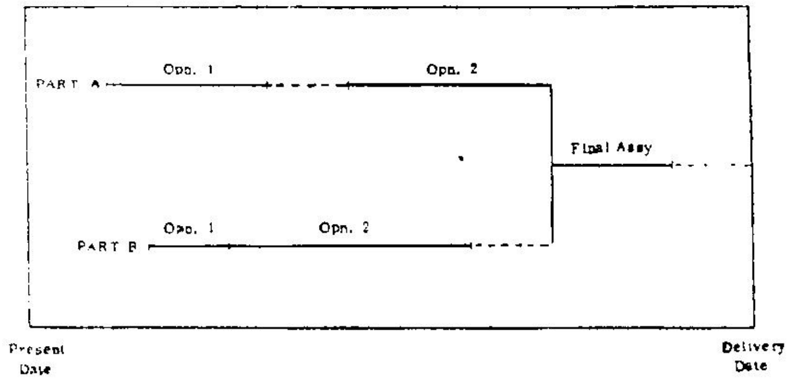

Fig. 7

The second alternative is to schedule the first operation on the first part when the required factors of production are available and then work forward by scheduling each operation on the basis of the availability of concerned factor until the completion date of the last operation on the last part is reached. The result of this procedure has been shown in Fig. 7. In general you will find that most firms follow this second approach.

Bill of Materials

All the materials needed for a product for manufacturing its components, subassemblies and assembly are listed together as a consolidated information. This list is called "BILL OF MATERIALS". An example has been shown in Fig. 8.

A Bill of Materials includes all components or semi-finished parts procured from outside. Whenever the product is to be manufactured, the materials needed for it are readily found out from Bill of Materials.

COMPANY A B C			ORDER NO. 05021		BILL OF MATERIALS
Name Motor Driver		Date	Sheet 'OF' SHEETS	Part No. UNIT 26012	Drawing if any MD-21

Quantity Total	Per Unit	Part number	Name of material	Remarks
1	1	MD—101	Adjusting Bracket	
2	2	MD—102	Eye Bolt	
1	1	MD—103	Motor Bracket Support	
1	1	MD—104	Motor Bracket Shaft	
1	1	MD—105	Motor Bracket	
1	1	MD—106	Bolt Guard-Motor	
1	1	MD—107	Back Plate	
1	1	MD—108	Hub	Purchased
4	4	MD—501	Vee Belt	Purchased
4	4	MD—1001	5/8' Nuts	Purchased

Approved by Prepared by

Fig. 8 Bill of Materials

IV Techniques of Scheduling and Control

Scheduling and control can be done for each group or department. In a jobbing factory where the variety of products is very large, the flow of work from one work-place to another is not uniform. It requires the scheduling and control in much more detail covering each worker or every machine.

Where hand operations are more important than the use of machine such as fitting work, sub-assembly and assembly, it is more economical to consider the best utilisation of worker rather than the machine. In such processes the labour cost is much higher than the machine cost. The productivity of the department is very much affected by the productivity of the workers. Incidentally the machines and equipment will automatically get a good utilisation because of better use of workers.

Where utilisation of plant and machine is a greater source of productivity and the labour cost does not constitute a major cost compared to the cost on plant and equipment, it is essential to do the scheduling of plant or machines. No doubt, the utilisation of plant and machines can be achieved only through better utilisation of workers engaged on them.

Thus, in an organisation we are faced with the following problems as far as scheduling is concerned :—

1. To schedule for group of workers doing similar jobs,
2. To schedule for a group of machines doing similar jobs,
3. To schedule for individual worker,
4. To schedule for each machine, and
5. To schedule for a plant producing one product on a continuous basis.

The first two methods are used in the planning department for the purposes of overall scheduling for individual group, leaving scheduling of work on individual worker and machine to the concerned shop. This is called "Decentralised Planning". It is essential in cases where shop conditions such as availability of materials, tools, delays due to unscheduled maintenance, breakdowns, frequent power failures, unreliable time standards, erratic absenteeism, etc, are prevalent. In "decentralised planning" also schedules are prepared by a group of persons attached to the foreman of the shop. Since they are very near to the work-place and in contact with shop supervisors, adjustments in schedules are easy and quick.

The third and fourth methods are applied for detailed planning. Where the planning department breaks down the schedules into much minute details, it is called as "Centralised Planning". If schedules are not prepared in great details giving hour to hour loading, it should be prepared by a group of people in each department or it can be done by the supervisors themselves.

A detailed scheduling for each worker or machine is essential for its maximum utilisation. The scheduling of work, only when a worker has completed his previous work, must be avoided. It takes away the sense of urgency that the worker attaches to his jobs. He wastes considerable time when he waits for necessary materials, tools, drawing and other requirements arranged for his next job. If the factory is not efficiently organised, these losses of time go unrecorded. It discourages the worker from putting in his best efforts.

The fifth method is applied only where continuous production takes place. It may be a single product manufacture or an assembly work. The continuous production makes the problem of scheduling easy. If the initial operation is fed with order and material, production is carried on uninterrupted upto the last stage. The operations follow one after the other. The machines and workers are distributed in such a way in the line that the rate of production in each operation is almost the same. Thus the utilisation is affected only when the first operation is not started.

Manufacturing Orders

The items to be produced are divided into manufacturing orders. One order is issued for a certain quantity of each item. It is an authorization to the production shop to manufacture the item and incur necessary expenses. This order serves as reference for co-relating planning, issue of materials and tools, inspection and accounting. Thus the total production is the sum of all the orders producing different items. In scheduling also this reference to order serves as an aid. A manufacturing order is also known as "Work Order" or "Job Order".

As discussed earlier, a knowledge of the capacity of production in product units or time units is essential for a scheduling. We shall discuss how the problem of scheduling is considered in respect of the available capacity and manufacturing orders.

Loading

In scheduling we have to allocate and reserve a certain capacity of production for a specific manufacturing order. Other orders can be taken up earlier or later. This process of finding time for each order continues until a satisfactory distribution of orders is found out where the capacity of production can also be utilised to the maximum. The procedure of distribution of jobs on specific workers, machines or plants is called "Loading". Detailed scheduling and loading go together when an order is scheduled load equivalent to the requirement in that order is added on that facility. It is expressed in the same units as the capacity of that facility. If expressed in terms of time, "Man-hours" or "Machine-hours" is used as unit. Units other than time are really translations of production time requirement into figures which are more easy to collect.

Gantt Charts

We, in India, are very much used to arithmetical calculations and numerical figures. These help to get a mental picture of the quantities involved. However, if we represent these figures on graph paper, it presents an easy visual picture of the quantities. It is more so when a comparison in figures is involved, as in the case of scheduling.

Henry L. Gantt devised a method of presentation on graph paper on the basis of his long experience in a wide range of industries. His method is usually called "Gantt Chart". The principle involved in Gantt Chart is very convenient, yet effective. In modern industries the same principle is applied, but the charts are modified to suit individual needs.

Gantt Chart uses the following two fundamental factors in scheduling, despatching and control :—

(i) The *facility* e.g. worker, machine or plant which does the production, and

(ii) The *time* against which production is carried out. It also represents an amount of work to be done in that time.

It is customary to list the facilities in the left hand column and to use the remaining sheet for time ruling. Charts can be drawn on graph paper by the user giving some scale per division of time. Printed charts on 43×28 cm sheets are also available.

Gantt Charts are used for planning and recording the progress during the production of individual items or orders also. In such charts, the space for facility is changed to the name of item or its manufacturing order number. The value of Gantt Chart lies in its ability to show clearly and quickly, the relationships amongst several factors. The picture presented by these charts focuses attention on those situations which need attention. Even though considerable clerical effort is required to draw and maintain a Gantt Chart, it is still a great source of advantage to the management.

Planning Load and Progress Charts used for machine loading, scheduling and recording results could be drawn in any form desired. The usual chart has 12 main divisions across the time ruling to provide for two weeks of 6 working days each. These divisions may also be used to represent months covering one year. The main time divisions are sub-divided into various ways. If a division represents a day, it could be divided into 4 sub-divisions each representing two hours for a 8-hour shift. If a 2-hour overtime is the normal practice, a day could be divided into 5 divisions each representing two hours. Similarly, if 2-shift working is usual, each sub-division could represent 4 hours, or else the number of sub-divisions could be increased.

The following symbols may be used in a Gantt Chart :

1. An angle (⌈) opening to the right indicating the date or hour when work is to begin ;
2. An angle (⌉) opening to the left indicating the date or hour when work is to be completed ;
3. A thin horizontal line (————) indicating schedule ;
4. A thick line (- — ——) super-imposed on thin line or made parallel to it indicating relation of work actually done in scheduled time to the amount scheduled ;
5. A figure (120 1) placed at the left side of a space indicating the amount of work scheduled for any period of time ;
6. A figure (1 801) placed at the right side of a space indicating the amount of work done upto any specified time.

The following problem explains how the principle of Gantt Chart is used for graphical presentation. In all the charts, a thin line indicates the plan as per original schedule and thick line shows the achievement or portion of job carried out. The date on which a review is done is indicated by a mark of arrowhead 'V' on the top where the concerned date is written.

Problem

An A B C company manufactures certain components as per orders received. The operations involved are being carried on lathes, drills and milling machines. The company has 6 lathes, 4 drills and 3 milling machines. The orders at hand are as given. The timings required for different operations for each order have been estimated as in the table below: (Assuming 6.5 hour as effective working time of an 8 hour shift of a day)

Date	Order No.	Lathe Time in hrs.	Drilling Time in hours	Milling time in hours
28·4·70	1405	117 hrs.	65 hrs.	39 hrs.
28·4·70	1406	91	39	19·5
30.4.70	1407	52	26	58.5
3.5.70	1408	26	26	19.5
5.5.70	1409	39	52	39
7.5.70	1410	39	39	19.5

LOAD SCHEDULE CHART

Date of receipt of Orders	Order No.	Lathes (234 hrs/wk)					Drills (156 hrs. wk)					Milling m/cs (19.5 hrs/wk)					REMARKS
		Est.	B. F.	Total due	Actual	Remain	Est.	B. F.	Total due	Actual	Remain	Est.	B. F.	Total due	Actual	Remain	
28/4/70	1405 1406	117 91	221	429	117	312	65 39						39 19.5				
30/4/70	1407	52	312	364	78	286	26						58.5				
3/5/70	1408	26	286	312	78	234	26						19.5				
5/5/70	1409	39	234	273	78	195	52						39				
7/5/70	1410	39	195	234	78	156	39						19.5				

Fig. 9 Load schedule chart ·

Group Load Chart

The above problem provides work on lathe, drilling and milling groups of machines. Load equivalent to the problem is being added to the groups whenever an order is issued. It is essential to know how much load has been added and how long it will take to complete.

Fig. 9 shows a table meant for recording load on these groups. Whenever new orders are being issued, the load equivalent to that order is added on the chart. The load equivalent to work done is reduced as shown in "Actual Done" column.

The above chart does not usually indicate how the position is with respect to machine days. It can be presented by using the Gantt Chart principle as shown in Fig. 10. On the date of review shown by an arrowhead (May 9) in the figure, we find that there is work upto middle of May 13, on lathe and drill, while for milling, the work may extend beyond May 14 (to be seen in the succeeding chart). The thicker lines for the three groups show that work is progressing behind schedule for half day in lathe and milling groups and for more than one day in drill groups.

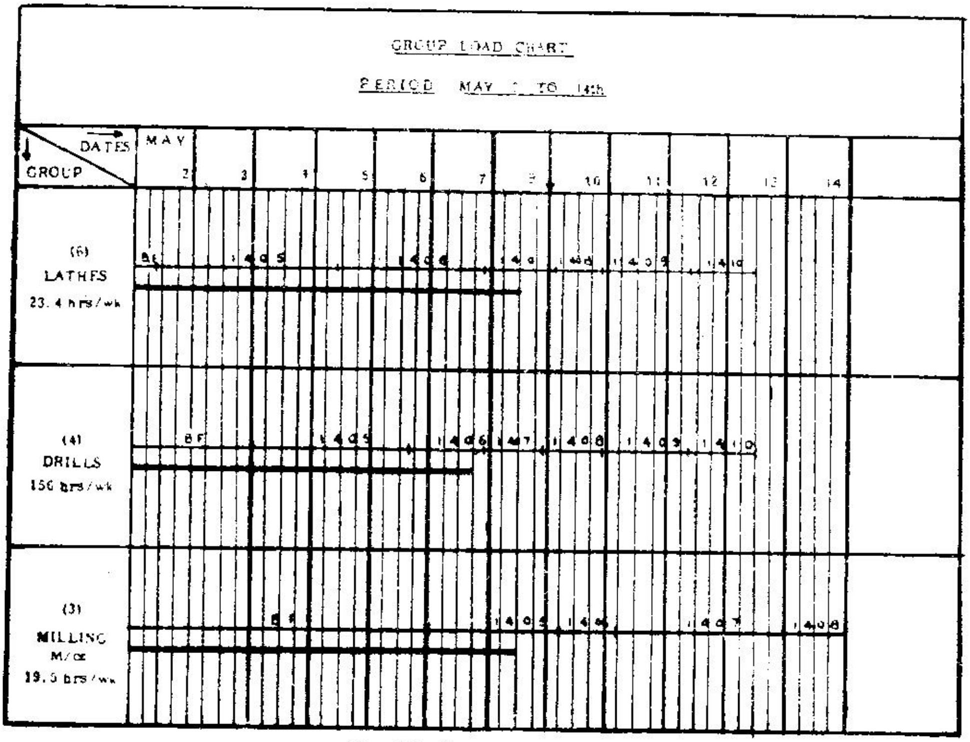

Fig. 10 Group Load chart

Whenever a new order is added on a group, the thinner line is extended and whenever an order is completed, the thicker line is extended. The difference between the two lines shows the load in hand in each group. Some organisations prefer the use of coloured lines instead of thin and thick lines.

Machine Load Chart (Fig. 11)

After allotting load on groups, we may consider scheduling on individual machines.

There are six lathes. A few of the orders involve more than one component and operations to be performed on lathes. Therefore, more than one lathe can also be used for those job orders.

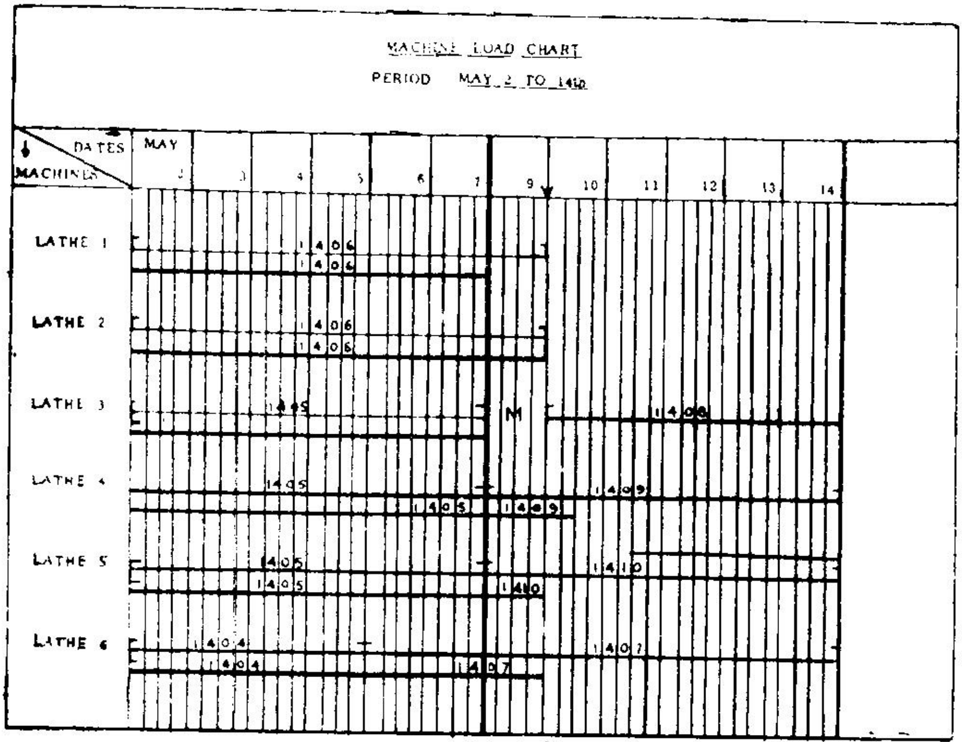

Fig 11 Machine Load chart

The chart shown in Fig. 11 is self-explanatory. It shows that some operations of order No. 1406 have been scheduled on Lathe No. 1 to be completed by the closing of 9th May. On this day, when a review is taken, as indicated by arrowhead, the operations on this lathe are falling behind by one day. The portion of work completed is equivalent to what it should have been done upto 7th May. The mark of "M" (a symbol) on Lathe No. 3. indicates that, it will be required for periodic check up and maintenance on 9th May. As revealed on the day of review, in the case of Lathe No. 4, more work, equivalent to half day, has been done while in other cases it is proceeding satisfactorily.

Load Charts for Drilling and Milling machines can also be made in the same way. Charts for scheduling work of manual workers such as fitters can also be made in the same way.

Progress Chart (Fig. 12)

Loading of groups and machines is done with the aim of their maximum utilisation for economic production. The Planning Department has another responsibility also to see that work progresses through operations in such a way that a job is completed on the desired day. A progress chart shows the position of progress of each job from one stage to the next, both as per schedule and as per actual work

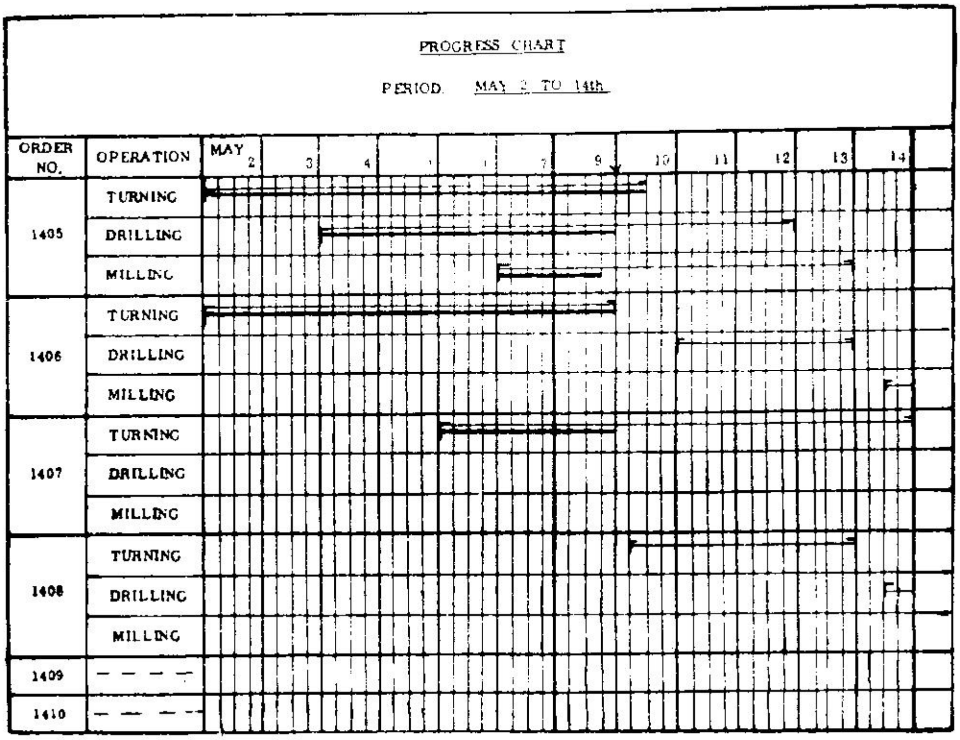

Fig. 12 Progress chart

completed. Fig. 12 shows such a chart for the jobs given in the problem. The operations on each order and the time when it is scheduled to be performed are indicated.

Schedule Chart for Continuous Manufacture (Fig. 13)

In continuous manufacture the sequence of operations remain the same and scheduling is done in product units instead of time unit.

PROCESS	MAR 2 MON	3 TUES	4 WED	5 THUR	6 FRI	7 SAT
ASSEMBLE ARMATURE (300 Units per day)	200 200	150 350	250 600	300 900	300 1200	300 1500
etc						

Fig. 13 Outline of Schedule Chart for Continuous Manufacture

Note: 1. Quantity scheduled for a day is shown on left side of space. Thin line indicates its ratio with actual capacity.

2. Cumulative quantity upto one day is shown on the right side of space and is indicated by thick line.

V System of Production Planning and Control

In the foregoing chapters, we have discussed some underlying ideas of production planning and control. The system of using these ideas varies greatly from one industry to the other. It is dependent on the background of the company and its officers. A progressive company maintains the records to the minute details and also analyses them for taking intelligent decisions based on facts. In other industries, the system may be simple where only broad information is available.

In general, the system of planning and control normally involves the following steps :—

Step One

Policy Decision: On the basis of information available, such as sales forecast and future plans of the company, it becomes essential that a decision is taken for the quantities to be manufactured in the different months of the year. We have seen earlier how sales forecast of different products is collected. A meeting consisting of Chiefs of Marketing, Finance, Planning, Production and other allied departments considers the sales forecast and other financial implications and sets the target of quantities to be manufactured for each product group.

On the basis of these decisions, sales and financial budgets are prepared for the year. The decisions of the committee are communicated in the form of Master Schedule to the Planning Department. Thereafter the Planning Department is entrusted with the responsibilities of arranging necessary facilities, so that products are available at the time of sales requirements.

Step Two

Compilation of Sales Orders: A decision given in Step One reflects an overall estimate of sales even when firm sales orders are not received. In actual situation, sales may not be equivalent to the decision taken earlier. There is always the possibility of upward or downward variation. The Planning Department must consider that its plans are varied in relation to the actual sales from time to time. It is, therefore, essential that actual sales demand is watched carefully.

Each sale order is given a number. It may consist of more than one item. The quantity required for each item is transferred to its ledger where production and sale of that item is maintained. Thus, for each item there is a record of sale order number, quantity ordered and quantity despatched showing quantity for which production is due. The company might have taken a decision to produce certain items and keep in stock so that despatches are made as soon as sales orders are received. In that case also, it is essential for the Planning Department to see that the total production is varied from the initial target according to the quantities being sold.

In some industries, the consolidation of sales orders is done by the Marketing Department itself. It revises the targets and informs the Planning Department to adjust its schedules accordingly.

Step Three

Preparation of Necessary Data: If the sales order is for an item with special specifications and instructions from the customer it is as good as developing a new product. In that case drawings and specifications are prepared, method of production is to be determined and process sheets showing methods of manufacture, estimate of material and time are prepared. Process schedule chart may also be prepared. These are prepared by the Drawing and Design Office and Industrial Engineering Departments and are provided to the Planning Department.

Where the product is of routine type, process sheets and necessary estimates are already available with the Planning Department.

Step Four

Issue of Orders: Once the necessary data are available, it is the responsibility of the Planning Department to see that the required material, tool and special equipment, etc, are available in time. It has to check these from the relevant records. It has also to decide whether certain parts or sub-assemblies are to be procured from outside.

A manufacturing order or job order (Fig. 14) is prepared on the basis of the data mentioned earlier. Apart from the above order, the following information is also given :—

(i) Materials requisition slip (Fig. 15) which authorises issue of material from godown to the production shop. It shows quality and quantity of the material needed. It is prepared on the basis of bill of materials.

(ii) Job Card (Fig. 16) which shows operations to be performed by different workers. This is meant for recording of starting and completion time

Fig. 14

JOB ORDER

Description Cycle Hub Cor

Drng. No. CH-21 **Part No.** CH-1-3

Starting Date 1.7.70

Completion Date 3.7.70

Job Order No. 59/70

Quantity: 1000

Date: 25.6.70

Approved By : *Manager (Planning)*

Opern. No.	Group & Machine	Operation	Date	Start Time	Finish Time	Qty. done	Qty. Accepted	Qty. Rej.		Sig. of Insp.	Qty. Recd. Stores	Sig. of Store-keeper	Remarks
								BM.	BW.				
01	CS-2	Cut rod	1.7.70	11.00 A.M.	11.30 A.M.	7	7	—	—	—	—	—	
02	L-21	Turn, Bore & Form	2.7.70	6.00 A.M.	1.30 P.M.	1000	1000	—	—	—	—	—	
03	L-24	Cut threads	3.7.70	7.00 A.M.	2.00 P.M.	1000	950	—	50	—	—	—	
04	M-25	Mill sider	4.7.70	6.00 A.M.	11.00 A.M.	950	950	—	—	—	950	—	

SUPERVISOR PROD. I.C.

Information above table to be filled by planner/prod. I/C.
Information in the table to be filled by Supervisor.

SYMBOLS BM: **Bad Material**
BW: **Bad Workmanship**

Fig. 15

MATERIAL REQUISITION SLIP

Order No............................ Date......................................

Item................................. Saop....................................

S. No.	Material with Specifications	Unit	Qty.	L.F.No.	Rate	Cost	Remarks

in each operation. There may be one job card for each operation or a group of operations being performed at one work-place during the same period. Job cards are the source for calculation of work done by workers and payment to them, if they are working on incentives. If job cards are not prepared by the Planning Department, they are to be prepared by the Production Shops. Job cards may not be needed in case of continuous production where inspection records are enough to record the quantities produced in a day.

Fig. 16

JOB CARD

Order No.......................... Date......................................

Item.................................

Group No.	Opn. No.	Operation	Qty.	Allowed Time		Quantity	
				Set up	Working	Accepted	Rejected

Starting Time............................ T. No. of operator............................

Ending Time............................ Name..

Time Taken............................

.... Signature of Supervisor

.... Signature of Inspector

Step Five

Scheduling: On the basis of completion data of different parts, sub-assemblies or assemblies including inspection, as determined by process schedule chart, the Planning Department prepares schedule of production. It has to see the capacity of production of each group, the load that is already given to it and the load that is given as a result of loading this work. Scheduling may be done for individuals as well as for groups of workers. Load charts are used to depict the load.

Step Six

Despatching: The job order is issued to the Production Department along with the Job Cards and Materials Requisition Slips. It also includes Requisition Slips for special tools and equipment, if any. The Production shop receives the material and executes production as per schedule to the extent possible. Normally, the job card is handed over to the worker along with the materials, drawings and specifications, special instructions, etc. When the job is handed over to the worker, the starting time is punched on the job card by a clock. Where such arrangement does not exist, the starting time may be recorded manually. Similarly, on completion of work, time is again recorded.

When the job consists of continuous manufacture and the line is balanced, loading of first operation is enough. The job progresses through several operations including stage inspection, if any. The final inspection takes place after the last operation is completed and a record of results is maintained. In such a case job cards are not used.

Step Seven

Inspection Reporting: In order to maintain the desired quality of product, it is essential to inspect the product. The purposes of inspection is to determine which of the pieces are acceptable as per standard, which are to be rectified before they can be accepted, and which are to be rejected as being unsatisfactory. Inspection may be carried out in stages after completion of a few operations each time. This is called "STAGE INSPECTION". Inspection may be carried out after all the operations are completed. This is called "FINAL INSPECTION". In continuous manufacturing concerns, results of inspection are reported to the higher management on day-to-day basis in the form of Inspection Reports (Fig. 17). In these cases, inspection reports can form a basis for payment to the group of workers who have performed the operations. Inspection reports can also be used by the Planning Department for the purposes of follow-up or progress chasing. Where a separate Inspection Report is not prepared, results of inspection are entered in the Job Card by the inspector.

There may be a number of reasons for rejection. Broadly speaking, they are either due to bad material or bad workmanship. Whenever a material is found defective after performing some operations, the rejection is due to bad material. The worker is not responsible for such rejections. All other rejections are due to bad workmanship for which the worker is wholly or partly responsible.

Fig. 17

INSPECTION REPORT

Production of Shift..........................

Dated..............................

Item.....................................

Machine No.	Production	O.K.	Shank				Stalk Threads				Collar				Cut Mark	Remarks
			U.S.	O.S.	S.	T.	Tight	Loose	S.	T.F.	U.S	O.S.	Thin	Thick		

U.S. : Undersize in dia.

O.S : Oversize in dia.

S. : Short in length.

T. : Threads

T.F. : Thread Flat

Checked by..

In Shift..

Shift Incharge.......................................

Step Eight

Follow-up or Progress Chasing: In an organised industry, it is expected that production will be carried out as per schedule with very nominal adjustments. These adjustments can be carried out by the shop management without dislocating other schedules. However, it is essential that the production is carried out as per schedule only. The Planning Department must find out through feedback information whether variations in schedule have taken place. Inspection report or job cards are very good indicators. These are the informations after completion of operations and hence denote a state of progress of job. A job card or inspection report not being received in planning department as per schedule indicates that some delays have taken place and the job is not progressing as per schedule. Therefore, a remedial measure is called for which may involve sending some representatives of Planning Departments to ensure that the cause of delay is removed as early as possible or else the schedule is readjusted with minimum dislocation. This is called "Progress Chasing" and forms the backbone of "Control" function of Planning Department.

A special group in the Planning Department looks after the work of progress chasing. Each individual is allotted to see the progress of certain items from whatever production shop they pass through. He is in touch with the concerned shops through reports or by his personal contacts and knows the progress of each order. There is another approach also wherein each individual is given the responsibility to look after the progress of all the jobs in a particular shop. Whenever a job is given to that production shop, he is informed and whenever it is completed he informs the next department.

In a factory, with a developed planning system based on realities, there will be less work of progress chasing. In other cases where planning is not realistic, there will be heavy work of progress chasing.

Step Nine

Calculation of Cost: When all the quantity on the job order in completed, the order is closed and the cost of manufacture is determined.

The two main factors for determining the cost of manufacture are:—

(1) Cost of material, and

(2) Cost of direct labour

Cost of material is determined by the quantity of material consumed in that order. It is determined from Material Requisition Slips. Cost of direct labour is proportional to the time spent by direct workers. The time spent by them is calculated from the job card. In a continuous manufacture, it may be calculated from the attendance hours after reducing idle time due to any reason.

The rate of charges for material and direct labour are determined by the Cost Accounts Department separately using the methods given in another Guide. The only other cost relates to overhead which is also compiled by the Cost Accounts Department for different periods of time.

Some Special Cases

So far we have been discussing the systems and procedures normally followed in an industry for regular production. However, some abnormal situations also arise necessitating adjustments in the above systems. Two such special cases are:

(1) Changes in schedule due to rush orders, and

(2) Abnormal rejections.

Changes in Schedule Due to Rush Orders

Rush orders create big problems in planning, throwing the system out of gear. We have seen that Planning and Scheduling is done with the main aim that production facilities are used to the maximum. If there is extra demand of production from the same facilities, it can be done only by dislocating certain schedules. Any dislocation has its chain reaction on other schedules. A rush order or a priority order creates this problem.

To reduce this problem to the minimum, a good method will be to allocate some portion of the capacity of production for these rush orders and not to schedule anything in that capacity. The remaining production capacity can be scheduled for other regular orders. A study of past records may reveal that rush orders fluctuate from month to month. It is easy for the management to determine the approximate capacity that should be kept reserved to cope with the rush orders. All the rush orders must be scheduled within this reserved capacity only. In order that this system works, the priority must be allotted by only high officers of the concern who must take responsibility of allowing only those orders to be treated as priority which are of essential nature and can be carried out within that reserved capacity. There should not be any tendency to reserve a high percentage of capacity for priority items as it will affect the regular production capacity and the regular orders will get delayed. It will, therefore, mar the utility of the planning system.

Abnormal Rejections

We have already indicated earlier that while an estimate of material is prepared, some additional material is already provided as scrap factor. This is meant for compensating the normal rejections that take place during processing or set up. As long as rejection is limited within this scrap factor, there is no dislocation in planning and control. However, if due to any reason, an abnormal rejection takes place, it is very essential to replenish material and carry out certain operations so that the desired quantity is produced. Cost of this additional material and operation is a loss to the company and, therefore, the management always takes pains to investigate the reasons so that remedial measures can be taken later on.

The shop is authorised to receive material and carry out operation for compensating the rejected quantities through a "Replacement Order" bearing the same job order number on which the rejection has taken place. The cost of this is also treated as a manufacturing cost of the same job order.

VI Evaluation of Utilisation and Performance

The basic purpose of Production Planning and Control is to get maximum output out of the given resources of men, machines and plant. This can be achieved through better utilisation of these resources and by getting a higher rate of production. In this chapter we will consider how these are evaluated.

Reasons of Low Utilisation

The worker may attend his factory for the full shift, say 8 hours. It is not essential that he is busy in work for full 8 hours in the day taking only permissible time for taking rest or attending to his personal needs. We have seen that an allowance for rest and attending to his personal needs has already been included in the calculation of standard time. Thus, under the normal circumstances, we expect 8 standard hours of work from the person. This will be possible only when the worker is provided with all the necessary facilities for doing the job and he has picked up the normal rate of production. If he is not provided with the necessary facilities due to any reason, his work cannot be expected to be equivalent to 8 standard hours.

If the worker is not provided with necessary facilities for some period of the day, say 2 hours, he has been provided with work only for a period of 6 hours and hence his utilisation in th day is equivalent to 75%.

A Worker cannot be responsible for his low utilisation. It is not in his control. Providing necessary facilities is the function of management. They are not provided only when some departments have not been able to get their facilities ready in time.

Given below are a few of the reasons for which there is lower utilisation of workers. The sections which are normally expected to take care of the concerned reasons are also given.

(1) *No Work:* Work is not provided to the operator as there is no job. It may be due to bad planning or insufficient work. It may also be caused when material is not made available to the operator. Thus time lost in "No Work" reflects the deficiency in planning or progress chasing.

(2) *No Machine:* An operator may remain idle as no machine is provided

to him. This can be due to more number of operators attending the shift than the machines can engage or more machines may be under breakdown or repairs. Normally when the machines remain under repairs for more than one day, it is treated as breakdown. It reflects deficiency in shop planning and maintenance.

(3) *No Power* : This is due to power and light failures.

(4) *Machines under Repairs* : An operator may remain idle due to time spent in repair of machines. Normally when the period of repair is high, the worker is to be provided with an alternative job on other machine.

(5) *Periodic Cleaning* : A plant may be kept idle for the purposes of periodic cleaning or plant maintenance. It is a good practice to devote time on this as it reduces the losses due to breakdowns and repairs.

(6) *Set up of Machines* : Setting up of machines takes time whenever the job is changed.

(7) *Instructions* : Whenever a new job is given to the worker, instructions are given to him through the supervisor so that production is carried out most economically. Information in the form of process sheet and standing instructions help in giving correct instructions in much shorter period.

Reasons of Low Performance

A worker may not be able to produce work within standard time. Thus in 8 house of working, he may not give work equivalent to 8 standard hours. This happens due to one or more of the following reasons :—

(1) Lack of training in doing the job or improper training,

(2) Lack of supervisory guidance,

(3) Personal handicap such as age, education, family background, etc, and

(4) Lack of motivation

Utilisation of worker can be improved by reducing time spent due to any of the reasons given earlier. The performance of worker can be increased by training him and motivating him through suitable incentive schemes.

In order to calculate utilisation and performance, the system being discussed here is simple as well as effective.

Daily Production Report (Fig. 18)

Normally there is a practice to record the work done by the workers in a day at the close of the shift. In many of the industries, effective use of this information is not made. Instead of collecting this information at the close of the shift, a proper method would be to record all the time losses due to any reason on a daily production report. A simple proforma is given in Fig. 18 which has been prepared for a group having 6 lathes. One daily production report is prepared for each shift. It mentions the job carried out by the worker, the quantity he has produced, the quantity that we found acceptable to the inspection and the quantity rejected due to bad material or bad workmanship. The details of rejection are available separately in inspection reports.

This daily production report also shows the idle time spent and the reasons thereof. This report must be checked and signed by the supervisor before it is submitted for analysis.

Daily Production Reports for certain period, say a week may be collected and the information may be consolidated to give an analysis for the work done during the week.

Weekly Performance Analysis (Fig. 19)

The purpose of the analysis is to find out what has been the performance of the worker and utilisation. In many cases utilisation of the workers is the same as the utilisation of the machine on which he works. Weekly performance analysis is a report prepared at the end of every week after collecting information from Daily Production Reports. Machine ineffective time analysis is the break-up of idle time losses. It pinpoints the causes where excessive time is lost. Its knowledge helps management in taking remedial measures in future working to reduce it to the minimum.

Weekly performance analysis reflects the outcome of working in a particular week. A good management takes decisions after comparing the performace of a particular week with the performance of earlier weeks or with what is expected. In other words the management is also interested in finding out the variations in performance. Graphs are prepared on the basis of weekly performance analysis showing the variations.

In India, very few managements are enlightened enough to collect information, analyse and use it for future decisions. They have a lot of information in their record which are not compiled in a presentable form. The system of evaluation goes a long way in improving the management skill towards higher goals of achievements.

Fig. 18

DAILY PRODUCTION REPORT

Lathe Group ________ **Date**________ **Shift:**________ **Day/Night**

Machine Name and Number	Ticket No. of Operator	Job Order No.	Operation	Qty. Done	Qty. Accepted	Rejection due to		No. of Hours		Break-down of Idle Hours	Remarks
						BM	BW	Worked	Idle		
6′ Lathe No. 1	151	0537 0541	Turn 2″ dia-drill 3/4″ dia and cut threads Turn 21/4′ dia.	5 12	4 12	0 —	1 —	6.00	2.00	O.A. N.R. S.U. 2 J.N./ B.D. T.N./AA	
6′ Lathe No. 2	157	0572	Turn and bore 1/2″ dia.	160	148	3	9	8.00	—	O.A. N.R. S.U. 2 J.N./A B.D. 1 T.N./A	
6′ Lathe No. 3	139	0671	Finish turn 1/2″ dia and drill 1/8″ dia.	360	300	—	60	5.00	3.00	O.A. N.R. S.U. J.N./A B.D.= T.N./A	
6′ Lathe No. 4	73	0374	Drill 3″/16″ and part off	480	480	—	—	6.00	2.00	O.A. 2 N.R. S.U. — J.N./AA B.D. T.N./	

Signature of Supervisor Signature of Manager

Symbols: J.N./A—Job Not Available
B.D.—Breakdown
T.N./A—Tools Not Available
N.R.—Not Reqd.
O.A.—Operator Absent
S.U.—Set Up

Fig. 19

WEEKLY PERFORMANCE ANALYSIS

Department : Lathe Group **Date** 20.1.70 **From** 13.1.70 **To** 18.1.70

Machine Number	WORKMAN ANALYSIS			MACHINE ANALYSIS			MACHINE INEFFECTIVE TIME ANALYSIS							REMARKS
	Actual Hours Worked	Effective Work in	Performance	Available	Utilised	Ineffective*	Breakdown	Set up	Operator Absent	Job Not Available	Tools Not Available	Not Reqd.	Misc.	
		Hours		Hours	Hours	Hours	Hours	Hours	Hours	Hours	Hours	Hours	Hours	
Lathe 1	36.00	25.00	70.0%	48.00	36.00	12.00	—	4	8	—	—	—	—	
,, 2	38.00	25.30	66.6%	48.00	38.00	10.00	6	4	—	—	—	—	—	
,, 3	35.00	24.20	69.9%	48.00	35.00	13.00	3	3	—	4	3	—	—	
,, 4	42.00	34.50	82.0%	48.00	42.00	6.00	—	2	—	4	—	—	—	
Total	151.00	109.00	72.2%	192.00	151.00	41.00	9	13	8	8	3	—	—	

Prepared By Manager General Manager

Model Questions

1. What is the purpose of production planning and control ? How do they serve the interests of various groups in a factory ?

2 Discuss the importance of production planning and control and enumerate the responsibilities of a supervisor in planning and controlling functions.

3. What do you consider as the basic information in a production planning and control programme ?

4. Discuss the use of sales forecasting in production planning and control functions. What are the popular methods of sales forecasting ?

5. Discuss the effects of manufacturing methods on scheduling and point out the basic data needed for the same.

6. Write short notes on the following :—

   (a) Time Estimation
   (b) Economic Batch Quantity
   (c) Material Estimation
   (d) Estimation of Cost
   (e) Process Sheet

7. What do you understand by the following :—

   (a) Master Schedule
   (b) Process Schedule Chart
   (c) Bill of Materials
   (d) Manufacturing Orders
   (e) Loading

8. What are the factors—internal and external—that influence production scheduling?

9. What are the techniques of scheduling and control?

10. How are raw material and parts inventory control related to production planning?

11. Discuss the use of the Gantt Chart for Scheduling, Despatching and Control.

12. What are the points to be considered for efficient loading ?

13. Discuss the procedures for effective loading when groups of machines are involved.

14. Discuss the use of machine load charts.

15. Discuss the relationship of production planning and control functions with the following :—

    (a) Industrial Engineering
    (b) Inventory Control
    (c) Quality Control
    (d) Accounting

16. Discuss the role of systematic recording in production planning and control and mention the requirements of a good recording system.

17. What elements comprise the function of control ? Discuss these elements briefly.

18. Mention the steps involved in organising a system of planning and control and describe these steps briefly.

19. Discuss in general terms the reasons of low utilisation and performance in a factory. How can a supervisor help in their identification and elimination ?

20. What is the purpose of evaluation ? What sort of reports would be helpful in this connection ?

SUGGESTED READING

Sl. No.	*Title*	*Author*	*Publisher*
1.	Production Control	Moore	McGraw Hill Book Co., 330, West, 42nd St., New York.
2.	Production Forecasting, Planning & Control	E. H. McNiece	John Willy & Sons Inc. 605. Third Avenue, New York.
3.	The Gantt Chart-A Working Tool of Management	Wallace Clark	Sir Issac Pitman & Sons Ltd., London.

ADDRESSES OF NPC HEADQUARTERS AND REGIONAL DIRECTORATES

HEADQUARTERS

National Productivity Council
Productivity House,
5-6 Institutional Area,
Lodi Road, New Delhi-110003

REGIONAL DIRECTORATES

1. Regional Directorate
National Productivity Council
Government Polytechnic Building
Old Sachivalaya, Ambawadi
Ahmedabad-380015

2. Regional Directorate Director,
Supervisory Development
National Productivity Council
21, 9th Main Road, Jayanagar
Bangalore-560011

3. Regional Directorate
National Productivity Council
Novelty Chambers (7th Floor)
Grant Road, Bombay-400006

4. Regional Directorate
National Productivity Council
9, Syed Amir Ali Avenue,
Calcutta-700017

5. Regional Directorate
National Productivity Council
7/155, Swarup Nagar, Kanpur

6. Regional Directorate
National Productivity Council
1037, Sector 27 B, Chandigarh

7. Regional Directorate
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UTPADAKATA (Monthly)

An informative Hindi journal specially devoted to the development of workers and supervisors (Annual Subscription : Rs 2.00 yearly).