UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

5265

Distr.
LIMITED

ID/WG.426/8
13 September 1985

ENGLISH

United Nations Industrial Development Organization

Seminar on Furniture and Joinery Industries
Réduit, Mauritius, 6 - 24 August 1984

PRODUCTION PLANNING FOR A MEDIUM-SIZED FURNITURE FACTORY IN A DEVELOPING COUNTRY*

Prepared by

M. M. Maharaullee**

* The views expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

** Owner/manager, MULTICOLLECTION, Eau Coulée, Mauritius

V.85-30871

TABLE OF CONTENTS

Introduction

The subject to be covered in this document is "costing and production planning in a medium-sized furniture factory". It is assumed that furniture factories in developing countries are mostly medium-sized ones because of the limited markets and are run as one-man businesses. Our paper will therefore be limited to the medium-sized firms.

The objective is:

(a) To make readers aware of most techniques and methods of planning and costing in the furniture industry;

(b) thus enabling them to select their own model and thereby increasing the efficiency of their organizations.

For any manufacturing organization in a developed or developing country, its objective is fortunately or unfortunately to make profit. As we strive to become more and more competitive on the market, we inevitably get carried with the trend of mechanization.

Our objective - making a profit - becomes more and more difficult to achieve. Sometimes we may wonder whether it really compensates for all the efforts or simply whether we have become patriotic social workers. In all manufacturing organizations, a sound return on investment depends on the revenue and the revenue is determined by the level of sales.

Various factors determine the marketing success of a furniture factory - such as the quality, the price and the delivery date. Production planning therefore is most determinant. The prototype of drawing of any new design that is to be introduced must pass through the planning department and the revenue is determined by the level of sales.

Various factors determine the marketing success of a furniture factory - such as the quality, the price and the delivery date. Production planning therefore is most determinant. The prototype or drawings of any new design that is to be introduced must pass through the planning department - to enable us to analyse the following:

(a) Is the material used the most economical? For example, would a change in thickness or construction reduce cost without affecting the design itself?

(b) Is the production of the design feasible given the existing machines?

(c) Can existing parts be used in the design chosen, thus exercising variety reduction?

Such questions, as above, can only be answered after the new design has been scrutinized by the production planning department.

Many factories have had to close down after a few years' existence, especially in developing countries, because they refused to acknowledge the relevance of production planning to the furniture industry. A powerful capital does not necessarily guarantee the competitiveness and survival of an organization. History has shown that small units or new-born companies with a dynamic production personnel can become successful within a short time. One big mistake of companies in developing countries is to copy the European model of organization while failing to understand the intricacies of the production planning involved. For this particular reason, I intend to cover various techniques of production planning and costing and I invite the readers to study them more deeply so as to be able to choose one that meets their individual needs.

Once one has mastered the various techniques, one can select the most appropriate technique for one's organization. A company producing on a "one-off" basis needs a different production planning from one producing small batches at a time, or from one engaged in real series production.

Production planning and control is meant at increasing the efficiency of any organization. The aims are as follows:

(a) To ensure that the required product is manufactured at the lowest cost;

(b) To determine realistic delivery dates and to maintain them;

(c) To determine the timing and sequences of production so as to balance the work loads;

(d) To determine quantities to be produced;

(e) To enable the right quality standards to be achieved;

(f) To reduce waste of resources, raw materials, manpower and machines.

Sales forecast

Whatever the production planning system is, a method of sales forecast is a must for all organizations. A company operating without a sales target is as taking a ride without a destination. How many of us have worked ourselves to death only to find out at the end of the financial year that our efforts have brought us very little or nothing? Whatever the size of the organization, it is wise to make a sales plan not necessarily for a five-year period but at least for one year, if not every six months. Our estimates of future events are subject to uncertainty. However, most forecasting techniques aim at reducing the degree of uncertainty.

Once we know our expected sales, we can plan many aspects of the production activities. Though some organizations, given their activities, are in a better position than others to enjoy the benefits of sales forecasts, yet sales forecasts do indicate at least the trend in demand for specific furniture, for example, high demand for large sets in December.

Forecasting methods can be either objective (predictions and projections), subjective (conclusions) or a combination of both. Objective forecasts are obtained from data processing and subjective forecasts are based on intuition, experience, intelligence and judgement.

In the furniture industry, past sales records are most commonly used to forecast sales.

Production methods

Once a sales forecast has been made, a method of production has to be chosen and production planning must aim at realizing that target. We must allow for the fact that actual sales may differ from the sales forecast. Therefore, the planning method must be such that it enables the identification of any discrepancy and renders adjustment possible in time. The volume of production may make the method of preparing, scheduling and controlling production so complex that it justifies the use of computers and specialist personnel whereas a clerk with a simple method of visual aid, eg. blackboard will do.

In fact, there are three distinct methods of production:

(a) Job production or one-off or piece work;

(b) Batch production;

(c) Flow or series production.

Here, although the marketing men, the production planner and the cost accountant have conflicting interests, they must reach a compromise to establish a production plan so that, as far as possible, larger batches can be produced. At the same time, they must see to it that their sales forecast is as accurate as possible. It is obvious that planning a production run for one hundred similar chairs is very much easier than for one producing hundred chairs in ten different designs.

There are several important factors that dictate our production method. Sometimes we do tend to ignore that each production method has its advantages and disadvantages. For example, we would prefer to produce larger batches for its cost benefit. On the other hand, we would prefer to have a wider product mix so that we can obtain a larger share of the market and avoid the dip in production because of life cycle of any design. Moreoever, product mix would involve scarce capital tied down, we may then not be able to meet our delivery dates. As we do see, various factors tend to influence the choice of our production systems simultaneously only because of their respective advantages, thus creating chaos in our factory.

The following factors and constraints must be considered when choosing a production method in the furniture industry:

(a) Orders are not normally known in advance;

(b) A large product mix must be kept;

(c) Demand of furniture is seasonal;

(d) Minimum finished stock is desirable;

(e) All designs have a life cycle;

(f) The risk of obsolescence of parts and finished products is high;

(g) Delivery dates should be predetermined and near;

(h) The system should allow for readjustment;

(i) Scheduling should be done according to the delivery date of orders for any product, any quantity and at any time;

(j) Maximum utilization of resources should be achieved;

(k) Men should not be laid on and off;

(l) Batch size should be as large as possible but it is controlled by demand;

(m) Parts require storage space;

(n) Budgeted profit must be met;

(o) Holding cost is high and running out of stock also costs a lot;

(p) Selling price is fixed and contribution to net profit differs according to product mix.

We tend to assume that in the furniture industry, with a set of machines, we can manufacture different types of furniture - furniture from board materials and from solid timber, joinery, upholstered furniture, contract furniture, school and office furniture, etc. Competitiveness and the size of the market have spurred and enabled firms in developed countries to specialize in one particular line of production, for example chair manufacturing. However, given the smallness of the market, such as the Mauritian, we are doomed to produce different types of furniture in the same manufacturing plant. Consequently, we must equip ourselves with basic machines meant to produce on a one-off basis either in board materials or solid timber. Having sophisticated machinery for specialized work is simply a waste if we cannot have a production run and the more so if we have to rely on skilled cabinet-makers as our manpower. The options are well defined - choose basic machinery and employ skilled cabinet makers to produce on a one-off basis or choose sophisticated machinery and operate with unskilled labour to produce batches or series.

1. <u>One-off production</u>

The simplest production method is the "one-off", but we must bear in mind the following problems:

Labour: Skilled workers are needed. Skilled workers are getting scarce, very expensive and their replacement is difficult. The system is dependent on skilled workers.

Advantages of specialization foregone: Machining of parts is inaccurate. Quality control is not practical. Idle time is high for both labour and machines. The life cycle of tools and equipment is short and the use of raw materials is often uneconomical. Average cost of furniture high and profit margin low.

Scope of expansion: The volume of operation is limited by the span of control.

Delivery problems: Delivery dates are often unpredictable.

However, we cannot ignore the advantages of the one-off system.

Economic: Very low capital investment as basic machines are needed; overhead costs practically non-existent, no capital tied down into part.

Production: Scale of production small, flexibility and adaptability to changing demand and conditions. No risk of design becoming obsolete.

Market: Production of one-off on a large scale complex and costly, and hence not usually favoured by furniture producers. As a result, high demand prevails for one-off furniture.

In fact, many factors favour the choice of the one-off system. Let us take Mauritius as an example - we have a plural society, the population is approximately one million, made up of two hundred and twenty-five thousand families. The population is divided into four ethnic groups which in turn are subdivided into different classes (economic groups). The ethnic groups, because of their origin differ in their tastes of timber species, colour and design. The different classes differ in terms of purchasing power. Given the particular characteristics of the Mauritian market, series production is justified only if export possibilities exist.

In this very difficult market situation where the method of production is restricted to the one-off system, however, there is still room for scheduling and planning the production:

(a) As most furn;iture in Mauritius are carcass constructions, requirements of timber of standardized thicknesses can be planned well in advance;

(b) Various technical specifications can be standardized - for example, those of mortices and tenons;

(c) Somebody who can work out the construction and the dimensioning can sketch all the parts; a semi-skilled worker can machine the parts, leaving the assembly work to a skilled cabinet maker;

(d) Apprentices can carry out the cleaning and sanding of finished furniture;

(e) Many standardized parts such as shelves, lipping, drawers, carcass frames, partitions, bases of beds, turned parts, mouldings, legs, etc. can be held in stock.

However, the one major constraint of the one-off system is that volume of operation is limited due to the span of control of the foreman or production manager. Beyond a certain volume, resources cannot be extended indefinitely, as nearly none of the production control techniques is applicable to the one-off system. For example, if an average of fifty orders are flowing in weekly and average delivery is in five weeks, the number of units on the factory floor at any one period would be two hundred and fifty units. If this constraint is ignored, this would lower the quality as well as increase unit cost.

Many furniture manufacturers do start small. Faced with increasing demand, many of these small firms increase their production over the years, but they fail to improve or change their production planning method as they grow larger. The need to change the production method can be demonstrated by referring to Multi-Collection as an example. Multi-Collection, a furniture company started in 1980, with seven workers, is now employing eighty. It started by producing one-off and gradually diversified its production into a product mix in 1982 and, finally, in 1983, it had two separate production units, one for producing on a one-off basis and the other in small batches. On the whole, the one-off system of production still predominates. Here is a profile of Multi-Collection.

Market: Furniture on orders.

Furniture: All household furniture - modern, antique, and upholstered furniture.

Timber used: Teak, Sapele, pine, African walnut, plywood with teak framing.

Labour: Skilled and semi-skilled.

Delivery date: Five to eight weeks.

Production control: Blackboard and job cards.

Scale of production: An average of eighty different pieces at any one time.

Costing: Directly calculated on job cards.

The production system is too complex to be described in this text.

2. Batch production

Once the size of the market justifies batch production, it is certainly most economical to use batch production method. Many problems will be simplified if not solved. Turnover can be forecasted, scheduled, maintained and manipulated right through the production programme. Load and sequence of machines, labour values and the most economic batch size can be predetermined. Different techniques of work measurements can be used. Jigs can be used and quality control can be exercised. Realistic delivery dates can be predetermined and any deviation can be immediately diagnosed and remedied. In short, the batch production method gives the possibility of offering the right product, the right qulaity, at the right price and at the right date.

In spite of the advantages, we must have a critical mind and analyze the implications involved.

(a) Would the price of similar products, produced on a one-off basis be cheaper? If that is the case then either the indirect cost of running the system is too high or the batch size is too small.

(b) If we switch from one-off to batch method, should we and can we maintain the same work force - thus putting all eggs in one basket?

(c) If we switch to batch production while keeping the same range of product mix, this would involve an increasing amount in stock and this results in prohibitive costs.

(d) Do we absorb the cost of stock-keeping by increasing sales or by forced selling with instant delivery or is the risk of obsolescence too high as the life cycle of any design is too short?

(e) Do we retail our products directly or do we become too dependent on independent retailers? In the furniture industry, there are various policy objectives and therefore the planning method should be designed accordingly. Generally, the policies are geared towards achieving large product mix, short delivery date, with minimum capital tied down in parts. However, fluctuations in demand are a major constraint in the furniture industry.

Examples of two companies which both produce a large product mix but nevertheless differ in their policies regarding delivery and stocking of parts are given hereunder. The examples are also meant to illustrate how a production plan can be scheduled, maintained and manipulated.

Example A:

This factory schedules its production every three weeks and advertises its current production on trade media. The designs can be changed rather frequently. Since production is scheduled for a three month period, rather large batches can be produced. The retailer does not have to maintain any excess stock. Delivery is guaranteed even if demand increases suddenly. Production is not so much affected by any unforeseen and unpredictable constraint such as strikes, cyclones. shortage of raw materials, and machine break down, etc. The main problem is that a large stock of parts must be held, extra personnel is needed and these increase costs.

Example B:

This company too has a wide product mix but it keeps the minimum physical stock. Here sales are forecasted every month. The sales budget and turnover are scheduled every three months and the production controller designs his production plan accordingly. To help him finalize his production plan, he refers to previous production plans, he considers actual orders received, and takes into consideration designs to be promoted. The production plan is then broken down into machine time, material costs, labour costs. Though the production of parts is scheduled over a sixteen week period, it gives a specific quantity every week. Adjustments t the plan are made weekly.

As an example, suppose 200 units of product **X** are scheduled weekly but actually only 150 units have been sold for the past four weeks as from week two to five. The next production plan will be based on the prevailing average sales. To reach the average sales figure, the following variables are to be considered: past sales figures, number of units unsold, number assembled, number of outstanding orders. Since production is committed for four weeks, adjustment is possible only as from week 10.

Production of **X** is either curtailed or cancelled. Similarly if product **Y** has a positive sales figure, the quantity produced weekly will be adjusted so that the sales budget is reached.

The advantages here are that the production plan is being reviewed every month in line with the level of sales, the company has a fast turnover, less capital is tied down in stock, the risk of obsolescence is minimized. However, inevitably there are some disadvantages such as uneconomical batch size, design potential is limited because of the tendency to standardize, the system is heavily dependent on human efficiency, unforeseen circumstances such as machine breakdown, material shortage, sudden jumps in demand have immediate effects on the system.

Loading scheduling techniques

Scheduling is the process of actually issuing work to the shop floor giving dates and times of commencement of each section of the order and the anticipated completion dates. The schedules are usually issued daily or weekly in the form of lists to each section concerned.

Once the sales department has already committed itself for the delivery dates for the various designs, in order to be able to meet those delivery dates, we must divide the work content of the order, taking into account the factory's capacity. We have to assess in advance of manufacture (before work commences) the balance of work between departments and sections. Hopefully, some can be altered to divert work to the underloaded sections assuming that cost breakdown remains unchanged. In case this is not possible, the sales department can gear its efforts towards taking orders suiting particularly an underloaded department.of

The bar chart or the Gantt Chart or in a more complex form "the Network Analysis" provides a simple method of manipulating the existing and new work load so as to arrive at a final delivery date before work commences.

An example of short term load (work content in standard hours) is given hereunder:

Department A			Department B		
Period May|July (inclusive)	Process R 50,000	Process S 20,000	Process X 30,000	Process Y 20,000	Process Z 40,000

For example, let us calculate standard capacity for process R over the period May|July. Let us assume the number of standard hours at 100% efficiency for three months (May to July) inclusive (assuming normal hours) is 60,000

Estimated actual efficiency is 80%

Standard capacity (80% x 60,000) is 48,000 standard hours.

Therefore, according to the above table, to carry process R, we need 50,000 standard hours. Consequently 2000 extra hours are required. This may be achieved through overtime.

Bar charts and Gantt charts (see Figs. 1 and 2) are useful forms of graphical represer.tation of production planning and control. They indicate process operation, jobs or activities drawn on a time scale.

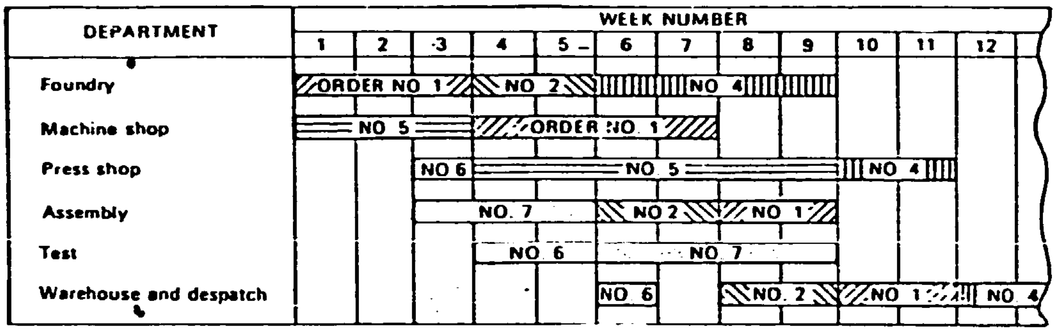

Fig.1: Bar chart showing seven orders loaded

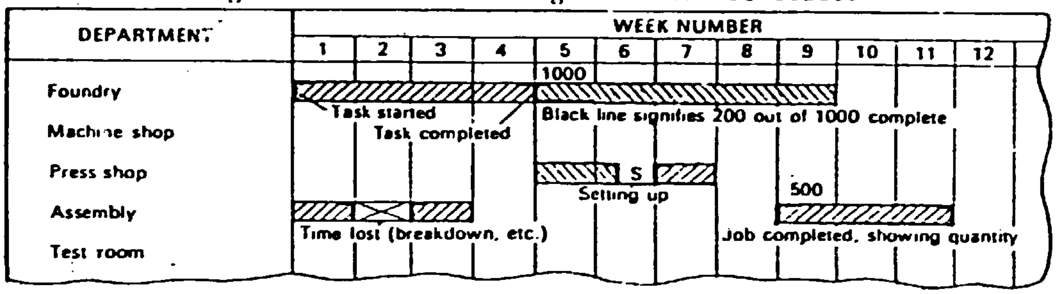

Fig.2: Gantt chart (bar chart beomes Gantt when Gantt symbols are used).

Network analysis

This technique goes beyond the possibilities of Bar Chart and Gantt Chart. It shows very precisely, the interdependence of the various jobs and indicates in events of delays, the realtive importance of the different jobs in terms of delivery or terminal date.

The term 'network analysis' covers several types of network techniques among which are Critical Path Analysis (the most commonly used), PERT (Programme Evaluation and Review Technique) and RAMPS (Resource Allocation with Multi-Project Scheduling).

In all those techniques, a 'network' of activities is drawn which shows the relationship of each activity with all the other remaining activities making up the network, For the furniture industry, the method of network analysis which is mostly used is the **path analysis**.

Our next aspect is method study and work measurement techniques meant to improve productivity and efficiency.

1. Method study

The basic procedure of method study is a method to investigate a problem at six different stages which are "**Select, Record, Examine, Develop, Install** and **Maintain**".

The **Select** stage is to identify the nucleus of the problem - the real root of the problem.

The **Record** stage is to record all the facts in a more understandable form by means of graph charts.

The **Examine** stage is the critical examination stage looking for the best possible solution.

The **Develop** stage is the validation of a solution by testing, measuring, comparing the various alternatives so as to select the best solution.

The **Installing** stage is when modification or alteration is made. It also refers to the retraining or rehearsal that has to be undergone.

The **Maintaining** stage follows the installing stage. It is to ensure the smooth running of the new installed system and a constant review of the situation.

To record facts, it is very difficult to rely on memory. In method study, there are five basic symbols which are used to represent what is happening in terms of men or materials.

Operations: Produces, accomplishes, furthers to process.

Transport: Movement or transport.

Inspection: Checks or verifies for quality or quantity (or both).

Delay: An interference in the process which causes waiting or delay.

Storage: Held in storage. Cannot be removed without authorization.

To record the above activities, there are various methods that can be used - eg. charts, diagrams, films, memo motion.

Charts: (a) outline process charts; (b) Flow process charts, subdivided into 'man type' and 'materials type' depicting the activities of operators or materials respectively; (c) two-handed process charts; (d) multiple activity or man machine chart; (e) simultaneous motion cycle (or SIM) charts.

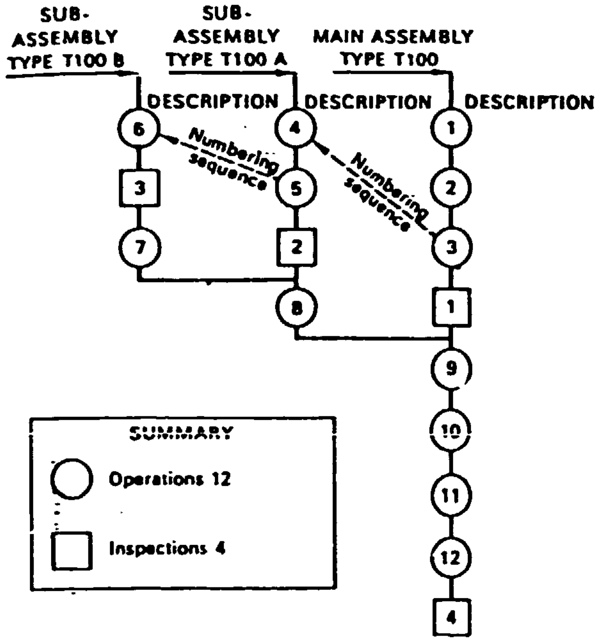

Fig.3: Outline process chart

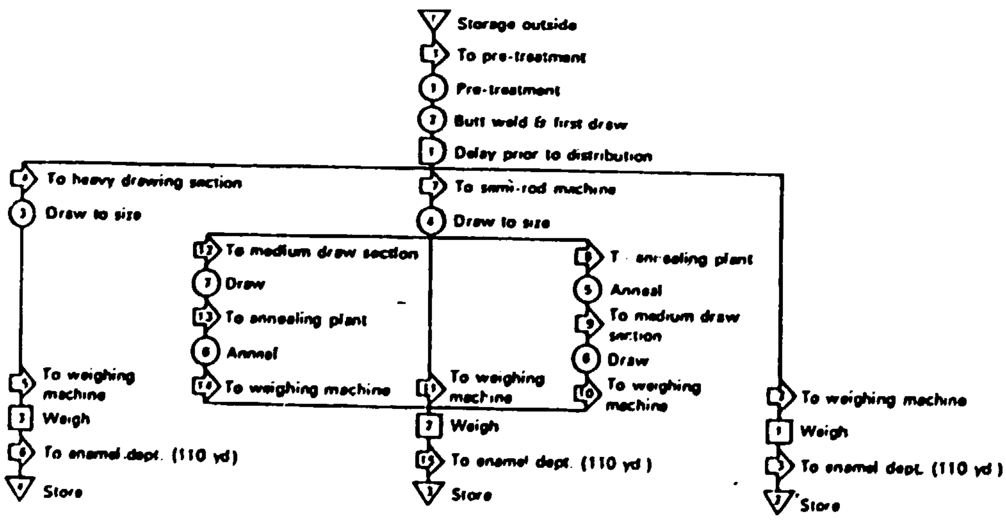

Fig.4: Flow process charts

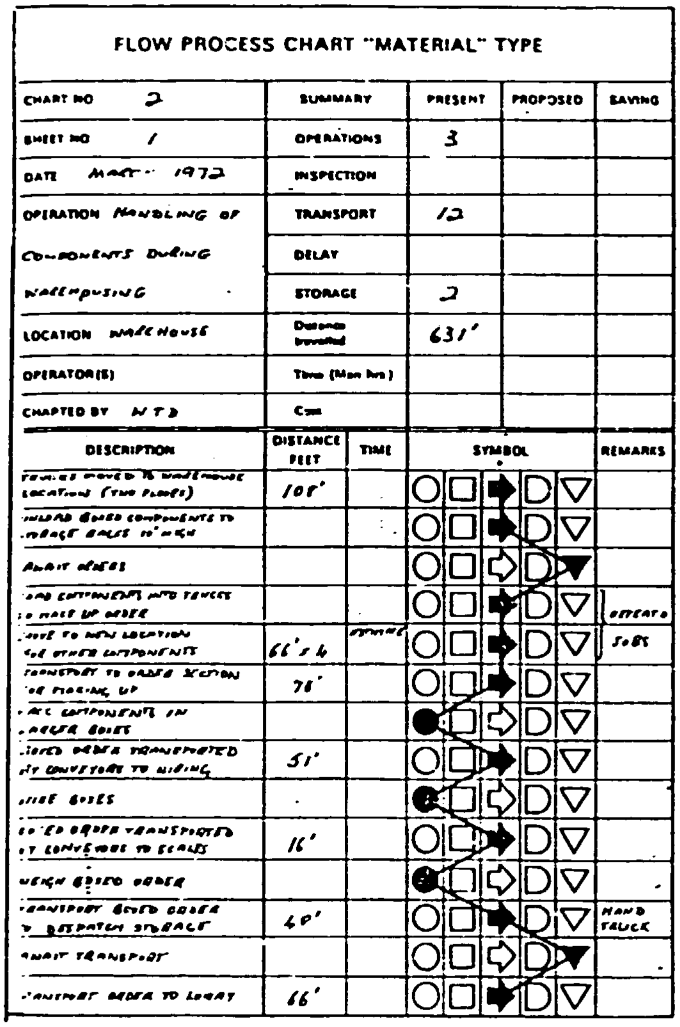

Fig. 5: Material flow chart

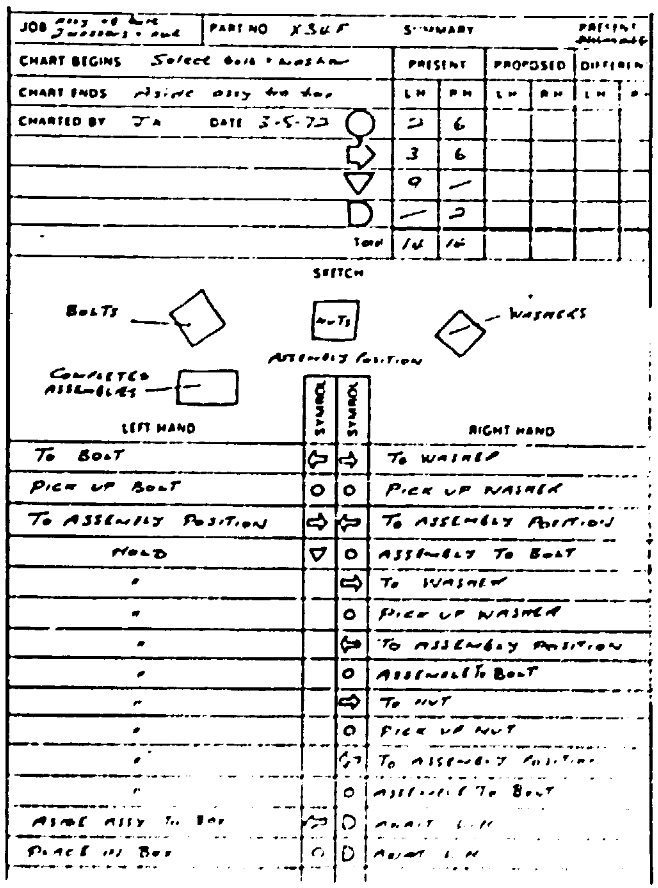

Fig. 6: Two-handed process chart

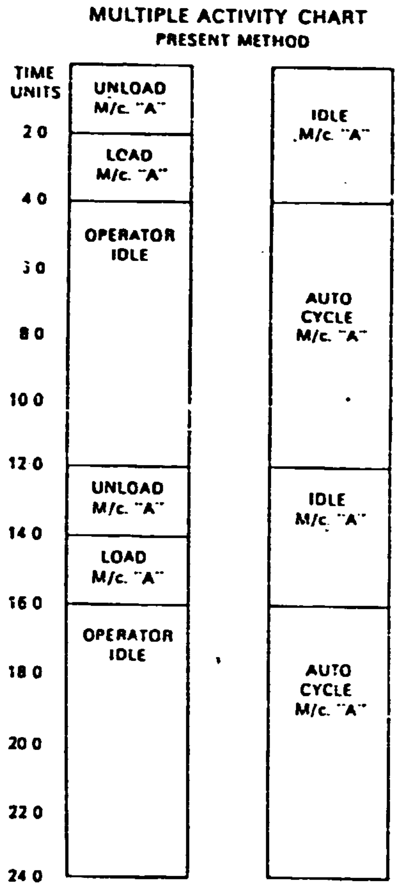

Fig. 7: Multiple activity or man machine chart

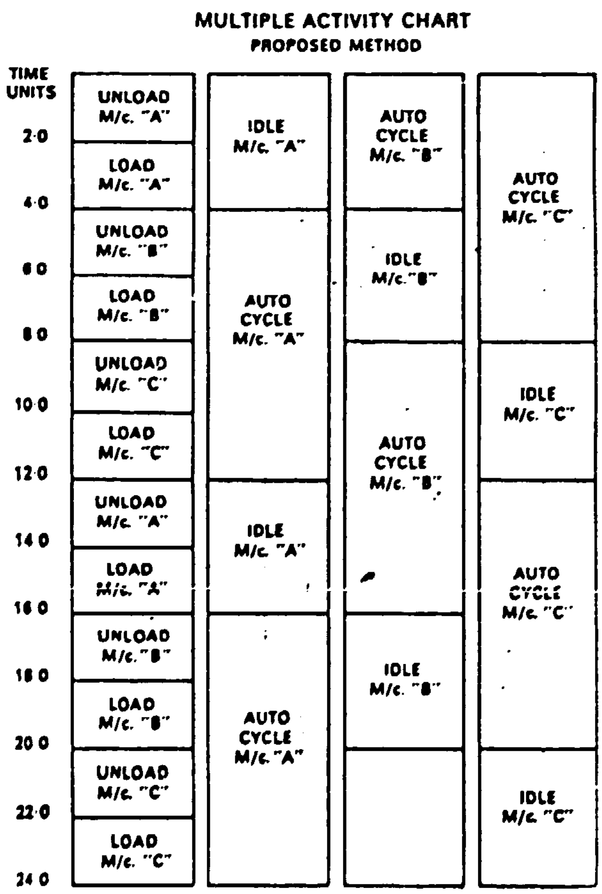

Fig.8: Multiple activity or man-machine chart

SIMO CHART PAGE 1 OF 1

METHOD. PRESENT

OPERATION: River clip and bracket assembly	CHARTED BY: H.S.
DEPARTMENT: T.D	DATE: 23-6-72
OPERATOR: J. KNOWLES	FILM NO: 27

LEFT HAND

DESCRIPTION	TIME	THERBLIG
Carry completed assembly to box	6	TL
Release ass in box	2	RL
Reach for new bracket	4	TE
	3	St G
Carry bracket to fixture	10	TL
Position bracket in fixture	9	P

FRAME No. (1000/MIN): 10, 20, 30, 40

RIGHT HAND

THERBLIG	TIME	DESCRIPTION
	25	Idle
TE	8	Reach for clip
St G	6	Select and grasp clip

Fig.9a: Simultaneous motion cycle

LEFT HAND

DESCRIPTION	TIME	THERBLIG
Hold bracket	25	H
Release bracket	2	RL
Reach for rivet	4	TE
Select and grasp rivet	2	St G
Carry rivet to fixture	8	TL
Assemble rivet to bracket	13	A
Idle	32	
Reach for completed assembly	6	TE
Select and grasp assembly	2	St G
Carry assembly to box	6	TL
Release ass. in box	2	RL

FRAME No. (1000/MIN): 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160

RIGHT HAND

THERBLIG	TIME	DESCRIPTION
TL	8	Carry clip to fixture
A	12	Assemble clip to bracket
H	30	Hold clip
TE G	3	Release clip / Reach and grasp M/c lever
V-	16	Form rivet on machine
TL RL	9	Return M/c lever and release
	17	Idle

Fig.9b: Simultaneous motion cycle

2. Work measurement

As explained above, method study is meant to improve the method of production. Similarly, work measurement is the application of techniques designed to establish the time for a qualified worker to carry out a specified task at a defined level of performance.

Techniques: There are several techniques of work measurement, each one applicable to specific situations.

(a) **Time study:** Time study is the most commonly used of all the work measurement techniques (it is, in fact, the basic technique) and consists mainly in measuring work with the aid of a stopwatch, supplemented by a process of rating, or assessing, the performance of the person being studied. The main essentials for carrying out a time study are as follows:

(i) A specification of the job, giving a precise prescription of the method and stating exactly where the job begins and where it ends.

(ii) A consistent system of recording the actual time taken by the operators doing the job under observation;

(iii) A clear understanding of motion (i.e. assessing the speed and effort of work) and, in particular, standard rating, to enable an operator's performance to be taken into account in determining the time for the task or job.

(iv) A scale of assessment with regard to the degree of rest which is required in the performance of the job.

(b) **Synthesis from element times:** When a substantial number of time studies have been made it is possible to build up a 'library' of element times which can be used on a number of different types of jobs. This collection is particularly useful where a range of different 'one-off' type jobs are manufactured which do not warrant a lengthly time study. While each job is different from the other, there are nevertheless many work elements which remain standard or common to all jobs. By selecting the appropriate elements and using their corresponding standard times, much of the need for time study is eliminated. A job time thus compiled is said to be a synthetic time.

(c) **Predetermined motion-time system:** 'Predetermined motion time systems' (PMTS) is the term used to describe systems based on time standards established for basic human notions, such as 'reach' - 'grasp' 'move', 'turn', etc. These time standards, which cover both the nature of the motion and the conditions under which it is carried out, have been compiled from literally thousands of studies using cine cameras and sophisticated timing equipment. Coupled also with expert rating assessments, the resulting time standards consequently are extremely accurate.

(d) **Analytical estimating:** Analytical estimating, in common with the other work measurement techniques thus far described, consists of determining the basic time for a job, firstly by breaking the job down into its various elements, and secondly by summating the basic times appropriate to the elements. The exception in this case is that some of the elements have time values derived from time study, while the remaining elements require estimation preferably by experienced estimators.

Analytical estimating requires trained estimators, preferably craftsmen, who thoroughly understand the jobs for which they are compiling times. For example, in maintenance work, the electrical jobs would be estimated by skilled electricians, fitting jobs by skilled fitters, etc., who in turn have been trained in the skills of estimating. Not only does this ensure that the estimates have bee based on practical experience and are therefore more likely to be rational and as accurate as possible, but also it means that they are more likely to be accepted by the skilled craftsmen to whom they apply.

The elements usually consist of time-studied values and purely estimated values. Synthetic times also play a large part in this technique. As more and more synthetic times are collected, so the estimating becomes reduced and compilation made easier, Where possible, values should be compiled in advance of the work to be done, so that the correct method will have been devised and agreed with supervision beforehand. When the job is actually being carried out, there will naturally be occasions where difficulties will be encountered and adjustments to the times will have to be made. The adjustments would cater for such contingencies as the following:

- nuts or bolts difficult to remove owing to rust, neglect or misuse;
- excessively dirty machinery or plant;
- extra walking for special tools, etc;
- seeking special instructions;
- bad weather.

Times should not be adjusted, however, unless authorized by supervision on an appropriate document. This reduces the tendency in some cases to claim for ficticious occurrences in an effort to increase the authorized time for the job.

Activity sampling: With some jobs, it is either impractical or uneconomic to measure the work content by time study or other means because of the following factors:

(a) a wide variety of work being carried out;

(b) the number of people involved in doing the work (i.e. in the case of large teams of workers);

(c) an excessive amount of time requried to study the work (i.e. long-cycle work);

(d) the infrequent nature of the work.

In such cases, it is more convenient to use the technique of 'activity sampling', which consists of taking a number of observations of the work situation at predetermined intervals of time.

The technique of activity sampling is based on a principle similar to statistical quality control, in which random samples of work are taken and analyzed to find the number of defectives in the batch. The number of defectives thus found are representative of what is happening over the whole of the production cycle. In a similar way, by taking a number of observations of people working, or plant operating, a representative picture of the activity of the whole section, department or factory can be built up. The number of observations to be made can be ascertained statistically so that the degree of accuracy of the results is known. In this way, activity, or work, can be measured to a reasonable degree of accuracy without the necessity of standing at the work-place for long periods of time, taking observations.

A further advantage is that activity sampling can be carried out by observers who need not necessarily be trained in work study. Hence the technique is a useful one for supervisory and higher management themselves to utilize, in order to assess the effectiveness of their section or department.

Comparative estimating: is a work measurement technique whereby the time for the job is evaluated by comparing that job with a series of similar jobs whose work content has been measured. When a similar job has been found, the same time value is assigned to the job under consideration.

The technique of comparative estimating is used on 'one-off' type jobs where the cost of time study in its entirety would be uneconomical, owing to the nature of the work. The main use of comparative estimating is on the maintenance work, for which purpose it is ideally suited, since it cuts down the time which would otherwise be spent in compiling time values.

A complete explanation of the steps involved in making a time study is given in annex 1. Since we are dealing with a medium-sized factory, it is assumed that production planning (including production control) will most probably form part of the daily duties of our production manager. Before ending this paper, I would suggest that our production manager familiarize himself with other techniques closely linked to his own discipline, for instance:

(1) rating;

(2) value analysis;

(3) variety reduction;

(4) quality control.

Annex 1

Time Study Methodology

Steps in making a time study

1. Recording all relevant information about the job, i.e. correct workplace layout - temperature - environment (method study) critical analysis on the job itself.
2. Recording a complete description of the correct method under which the study is to be taken.
3. Measure with whatever timing equipment is required, i.e. stopwatch, camera, chronocyclegraph, tape, etc.
4. Simultaneously with (3) rate for speed and effort.
5. Extend the demonstrated times if using cumulative reading method, normalize by the correct method.
6. According to the method of normalizing and incentive or not - add all allowances.
7. Express the answer as the 'time allowed' for the task performed.

Provision should be made on the time study sheet to record all the above. The information obtained above will include:

Time study number and number of sheets - name of observer.

Date of study - name and description of product - drawing number - part number - material - quality - department - description of operation - method used - M/C number - tools, jigs, fixtures and gauges used - machine speed, etc. - sketch of part, operators name and clock number - time study was started and time finished - grade of labour.

Breaking job into elements

"An element is a distinct part of a specified job, selected for convenience of observation, measurement and analysis."

"A work cycle is the sequence of elements which are required to perform a job or yield a unit of production, the sequence may sometimes include occasional elements."

It is necessary to break job into elements.

1. To ensure that productive and non-productive elements can be segregated.
2. To allow the rate of working to be assessed currectly, the operator does not work on every element at the same speed.
3. To enable each element to be easily identified.

4. To allow elements with high fatigue rate to be eliminated.
5. To be able to check the method of production at a later date.
6. To enable a detailed build-up to be produced.
7. To enable synthetic times to be built up for future use on the shop floor and in the cost office.

There are eight types of elements (only two are used in practice: productive and non-productive):

1. A repetitive element - which occurs in every cycle
2. An occasional element - may occur at regular or irregular intervals.
3. A constant element - basic time remains constant on all occasions.
4. A variable element in which basic time varies according to weights, etc.
5. A manual element - performed by the worker.
6. A machine element - automatically performed by the machine.
7. A governing element - occupying more time than any other element.
8. A foreign element - an unnecessary or a non-productive element.

Break points and the layout of the study sheet must be explained before taking the study - where to stand - the approach to the operator.

The advantage of cumulative time to the time study measure (TSM) - easier to get used to - must be explained. It does not matter if an odd element is missed. One cannot cheat on rating.

The number of cycles to be taken on any study will depend upon many factors. It is a sample and as such means the more cycles observed, the more accurate the study - the length of the cycle - number of people involved - the repetitiveness of the job - fatigue - odd elements, etc. are more correct in larger samples.

The study must be continued until the Time Study Measurer is satisfied that accurate results from data collected can be obtained.

Air conditions in the working environment

Often air is laden with dust or polish. This, plus a closed atmosphere, induces fatigue. A good exhausting system is necessary.

Noise

Machinery very noisy, especially saws, planers and moulders. Little done to deaden the noise creating additional fatigue.

Illumination

Glare causes eye-strain and should be avoided, the position of lights is important. Appreciation of light intensity, similar to that laid down in the Factory Acts is also important.

Loading, warehouse and washrooms	10 - 20 foot candles
Rough woodworking	15 - 35 foot candles
Spraying and assembling	35 - 70 foot candles
General machining and inspection	70 - 150 foot candles
Colour inspection	150 - 300 foot candles
Colour identification	300 - 750 foot candles

Duration of working period

Not such a problem today, except for nightwork where too much of the day is spent in activity rather than rest.

Monotony

It is advisable to arrange change of jobs on highly repetitive work; operators become bored and leave the workplace for any or no reason. The provision of tea breaks is excellent to relieve boredom.

Nervous demands

Caused through bad environmental conditions or bad tools, materials, faulty machinery, bad relationships with fellow workers or supervision. All add up to fatigue.

Accident hazards

Excessive overtime, introspective assessment, long hours, all cause fatigue, hence accident hazards.

Determination of relaxation allowances

	Males	Females
personal needs	5 %	7 %
basic fatigue allowance	4 %	4 %

Variable additions

standing	2 %	4 %
Abnormal position allowance		
Slightly awkward	-	1 %
Awkward	2 %	3 %
Very awkward	7 %	7 %

Use of force Lifting, pulling or pushing

Weight lifted or force exerted in kilogrammes

kgs	Males	Females
2.5	0 %	1 %
5.0	1 %	2 %
7.5	2 %	3 %
12.5	4 %	6 %
17.5	8 %	12 %
20.0	10 %	15 %
22.5	12 %	18 %
25.0	14 %	-
30.0	19 %	-
40.0	33 %	-
50.0	58 %	-

Light conditions		
Well below recommended values	2 %	2 %
Quite adequate	5 %	5 %
Air conditions		
Badly ventilated but no toxic fumes	5 %	5 %
Work close to furnace	5 %	15 %
Eye strain		
Fairly fine work	0 %	0 %
Fine or exacting	2 %	2 %
Very fine or exacting	5 %	5 %
Aural strain		
Intermittant loud	0 %	0 %
Intermittant, very loud or high pitched and loud	5 %	5 %
Mental		
Fairly complex process	1 %	1 %
Complex or wide span of apprehension	4 %	4 %
Very complex	8 %	8 %

Monotary (mental)		
Low	0 %	0 %
Medium	1 %	1 %
High	4 %	4 %
Monotary (physical)		
Tedious	2 %	1 %
Very tedious	5 %	2 %

Annex 2

Variety reduction

Successful business in this second half of the twentieth century is dependent not only on the manufacture of products to meet the needs of the world's markets but also on the use of efficient production and management techniques. The flourishing firm is the one which can sell products of a determined quality at a lower cost than its competitors.

One way in which a factory can lower its production costs is to discontinue the manufacture of products that are marginal, unpopular or uneconomic.

An objective analysis of costing records may well reveal a wide range of product and obtaining only 20 percent gross profits from 80 percent of those products. It would be in the best interests of the firm, its employees and its customers to withdraw the least profitable of them from its catalogue.

Inevitably, a compromise has to be reached between the sales and production staff. The eager salesman usually wants his firm to produce to a specified quality and, because of maximum machine utilization, could probably produce that article at a lower cost than the firm's competitors.

Quite clearly, however, no firm can afford to stagnate and rely on one product of unchanging design. New products, and new designs of existing products, must be encouraged. But these developments should be concerned with items which show a distinct promise of customer acceptance. It is this type of progressive managerial thinking that leads to a firm increasing its productivity - and it is an attitude which many companies are now coming to adopt.

Probably the most effective way of promoting this outlook is to bring all sections of an organization together in order to examine in detail, from every point of view, each suspect product. Good costing records will indicate these items. Additional information will need to be obtained about past sales and prospective sales as well as about the gross profit realized on each product. If a product continues to show up unfavourably it would probably be worth while investigating whether it could be produced at a lower cost or sold at a higher profit margin. If it is in no way possible to improve the position then it will be in everybody's interest for the firm to abandon its manufacture.

Some of the benefits resulting from this policy of variety reduction are the following:

Longer runs on the production line;
Less time wasted on changing machine tools;
Easier servicing and maintenance;
Opportunity to use special plant more effectively;
More opportunity to mechanize;
Easier training of operatives;
Simpler inspection;
Simpler office control;
Less paper work;
Less scrap;
Research and development concentrated where they pay the highest dividends;
Saving in capital by eliminating idle plant, tools, space, materials, components and spares.

From the customer's point of view, this adds up to better goods, quicker delivery and, ultimately, a reduction in prices.

To the suggestion that **Methodology** is synonymous with drab repetition, it should be emphasized that what the individual firm using this technique is concerned with is eliminating only economic lines. In any event, it may still be possible to produce a special product - provided the customer is made to realize that he will have to pay a special price for it.

Methodology calls for a completely objective analysis by management, and often raises sentimental arguments, especially when a product of many years' standing is under fire. Applied wisely, however, it can lead to higher productivity, to better labour, machine, material and capital utilization and, in the long term, to lower prices.

Methodology

List products, with percentage contribution to turnover;

Rearrange sequence in descending order of percentage turnover;

Analyse results or plot graph to obtain a pictorial representation of the true picture.

Investigate these models giving the smallest contribution to turnover.

If sales are declining - **OUT**.

If sales are stationary - investigate increase in **price** to obtain greater profit margin.

If sales are increasing - retain for further trail period.

The surplus capacity of the plant now available due to the elimination of the less profitable lines can be utilized by increasing the volume of prdouction of the more popular lines.

Sales might be boosted by a reduction in price now possible through lower costs as a result of **Methodology.**

Annex 3

Quality control

Object

The object of quality control is to satisfy the customer with regard to quality, price and delivery. The quality will be a predetermined one, not necessarily the best, but at a level at which the producer can be relied upon to achieve and which the consumer is prepared to accept. Example of a commodity which is in excess of customer requirements causes a rise in price and a longer waiting time. Quality control will always basically assist:

1. Functional design to prototype: purpose of the object to value analysis, first form of quality control.
2. From the above, the specification is set: materials, size, type of finish, etc. 'Part sheets, jigs, tools are determined.
3. Laying down the necessary tools to do the work: machines that work within the given specifications.
4. Producing the merchandise from the predetermined date to the requirements and limits required.
5. Correct our mistakes, customers complaints, etc.

The point of achievement is to be right first time around and in order to do this, it may be necessary to inspect at certain points throughout manufacture and it is primarily at this point that the art and science of quality control really begin. As probably no two successive pieces through a machine will be identical we will want to know at what point to stop production and reset and for what reason (bad material, faulty tools, bad setting).

Standards set at pre-production stage include defining exactly: materials tools, finish; ways must be found of informing the operator and the inspection of the standards and tolerances required (through part sheets).

It must be understood that any excessive cost in correcting faults (scrap, bad workmanship) is a direct charge against profit. Bad relationships cannot be measured.

Failure costs (Products and services that 'fail' to comply)

Goods that fail inspection, etc. scrap, reworks.

Other cost may include: loss of capacity in excessive resetting and rerunning which could interfere with production schedules: service engineers to repair, extra loss replacing spares.

Appraisal costs: Include the cost of inspection up to and including inspection of the finished article.

Prevention cost: the cost incurred in making sure the work is primarily correct and includes some production inspection (running) operator and inspector training, methods, maintenance.

In America 'Zero Defects' is the rage at the moment aiming all the time for perfection, but as we have seen this is not always practicable and the relationship between the cost and the quality standard should be noted.

Quality of design and quality of conformance

Design is the quality specified by the customer.

Quote quality of part and fittings.

Conformance is how closely the quality of designs or customer is carried out in practice.

Good design will fulfil:

- customer satisfaction,
- capability of the organization to produce,
- getting right thing at right time and place.

Inspection by attribute: That which cannot be measured i.e. appearance, colour and finish, taste, feel and noise.

Inspection by variable: That which can be measured and plotted.

Accuracy and precision of measurement

Do not ask for tighter tolerances than those actually required. Machines may not be accurate enough.

Routine checking of inspection equipment

Sampling incoming batches

Usually 5 to 10 % or a fixed number of pieces say, 10 or 20 nuts and bolts for 100,000 pieces/batch; the sample 10% is 10,000 (too many). For ' small batch of 50 pieces, take a sample of 5. If we did find a bad one in five we would probably assume 20 % are bad. When taking a fixed sample, say 10, per batch, then assume that if 10% is bad expect 1 in 100 - the chances of finding 1 in 10 is remote therefore the sample is probably too small.

Sampling from inspection tables

Defence specification DEF - 131a provides complete range of acceptable quality levels (A.Q.L.)

Up to half a million batch.

How to select the correct A.G.L.

Size of batch = N = 150

Cost of inspecting one piece = i = 1d

Cost of one piece = a = 3d

Cost of repairs if one defective piece is used in production = r = 7d

therefoer (r+a) = 10d

A Available A.Q.Ls	B Sample size	C Cost of Inspection (d)	D Number not inspected	E Cost of repairs (d)	Total cost (d)
All	150	150	0	0	150
0.065%	150	150	0	0	150
0.10 %	125	125	25	0.25	125.25
0.15 %	80	80	70	1.0	81.0
0.25 %	50	50	100	2.5	52.5
0.40 %	32	32	118	4.7	36.7
0.65 %	20	20	130	8.4	28.4
1.00 %	13	13	137	13.7	26.7
1.50 %	32	32	118	17.7	49.7
2.58 %	20	20	130	32.0	52.0
4.00 %	13	13	137	55.0	68.0
6.50 %	8	8	142	92	100.0

B. Sample size

C. Multiply sample size by cost of inspection.

D. Total batch less no. inspected.

E. Cost of repairs = $\frac{(AQL)}{(100)}$ x (No. not inspected) x (r+a)

F. Cost of inspection + cost of repairs.

The inspector

His job is to inspect good work.

The inspector's job is to keep production running so he must assess on patrol whether machine will need resetting before his return, and also final inspection if necessary.

The operator

To produce good work, he must have good tools, jigs, fixtures, gauges and templates and cutters, as well as correct instructions (part sheet) and he must be aware of the quality required. It may then be possible to train the operator to do his own running inspection providing it does not interfere with production. (Hopper fed machine, etc.) First-offs must always be inspected together with occasional patrols.

The training of the operator to do this type of inspection follows the set procedure on any type of work. A skilled man does not necessarily mean skilled in the job he is asked to do. Training within industry by industrial training boards is often available and should be used whenever appropriate.

Teaching the job

1. **Preparation:** Get into the mind of the learner exactly what he has to do, explain key points.
2. **Presentation:** To demonstrate and explain what he is going to learn.
3. **Application:** To let the learner try it out to correct methods.
4. **Practice repetition by constant:** To fix correct method.
5. **Testing:** Put him on his own and see if he has learned.

Note: Key points are divided into two sections:

1. Standard key points which will apply to every job the operator does.
2. Special key points which could apply to one or a limited group of jobs.

Standard

Example of key points: A notice should be placed, possibly above every machine. At the start of every run:

1. Check condition of cutter blocks.
2. Check that jigs, gauges, and other equipment are undamaged.
3. Check correct speed for type of timber.

Work is checked by the patrol inspector at regular intervals.

When operators are checking their own work, the following must be regarded:

1. The check must be quick and simple.
2. Make sure that no production is lost while it is being done.
3. Appreciate this fact when setting rates.
4. Make sure he knows how to use the equipment.
5. Inspection control must be explained.

Control charts for variables

Suppose we take a number of samples from a production line at intervals: say, 20 samples of 4 pieces.

The standard deviation = 99,7 % of the parts will be within the range ± 3 of these units from the average value.

We can say with confidence that the chance of one piece being more than 0/002" too large or too small is 1 in 40 and being more than 0/003" will be 1/1000.

There is always a likelihood of picking any one piece towards the tail, i.e. 1/1000 so it is best to take a group of 4 or 5 pieces. This has a tendency to reduce the range or spread.

Standard deviation

1. Take a sample of say 10 pieces

   = 21 - 20 - 20 - 19 - 21 - 22 - 20 - 18 - 19 - 20 = average 20
2. Subtract this average from each observation

   = +1, 0, 0 - 1 + 1 + 2, 0, -2, - 1, 0
3. Square each one, and remove all plus signs

   + 1, 0, 0, 1, 1, 4, 0, 4, 1, 0
4. Add all squares = 12
5. Divide this by the number of observations less one.

   $\frac{12}{9} = 1.33$
6. Take the square root of 1.33 = 1.15 and this is the standard deviation.