Single Station Manufacturing Cells

L-15

Contents

1) Single Station Manned Workstations(type IM)

- It is the standard model for which consists of one worker tending one machine, is probably the most widely used production method today. It dominates job shop production and batch production, and it is not uncommon even in high production. The reasons for widespread adoption.

(i) It requires the shortest amount of time to implement. The user company can quickly launch production of a new part or product, while it plans and designs a more automated production method

(ii) It requires the least capital investment of all manufacturing systems

(iii) Technologically, it is the easiest system to install and operate.

(iv) For many situations, particularly for low quantities, it results in the lower cost per unit produced

(v) In general, it is the most flexible manufacturing system with regard to changeovers from one part or product style to the next.

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- Single station manned cell classification includes the case where two or more workers are needed full-time to operate the machine or to accomplish the task at the workplace ($n=1$, $W>1$). Examples include:

(i) Two workers required to manipulate heavy forgings in a forge press

(ii) A welder and fitter working in an arc welding setup

(iii) Multiple workers combining their efforts to assemble one large piece of machinery at a single assembly station

Contd.

- Another variation is there when equipment in station supports the principle machine. The other equipment is clearly subordinate to the main machine. Examples of clearly subordinate equipment include:

(i) Drying equipment used to dry plastic molding powder prior to molding in a manually operated injection molding machine

(ii) A grinder used at an injection molding machine to grind the sprues and runners from plastic moldings for recycling

(iii) Trimming shears used in conjunction with a forge hammer to trim flash from the forgings

2) Single station Automated cell (type I A)

- In this , it is consist of a fully automated machine capable of unattended operation for a time period longer than one machine cycle.

Reasons why this category is important includes the following:

(i) Labor cost is reduced compared with the single manned station

(ii) Among automated manufacturing systems, the single station automated cell is the easiest and least expensive system to implement

(iii) Production rates are generally higher than for a comparable manned machine

(iv) It often represents the first step in implementing an integrated multi-station automated system. The user company can install it individually and subsequently integrate with (a) electronically by means of supervisory computer system (b) physically by means of an automated material handling system.

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--Examples of supporting equipment in automated cell include:

(i) Robot loading and unloading an automated production machine. The production machine is the principal machine in the cell, and the robot plays a supporting role.

(ii) Bowl feeders and other parts-feeding devices used to deliver components in a single robot assembly cell. In this case, the assembly robot is the principal production machine in the cell, and the parts feeders are subordinate.

a) Enablers for unattended Cell Operation

- The key feature of single station automated cell is its ability to operate unattended for extended periods of time. The enablers required for unattended operation in single and batch model production must be distinguished from those required for mixed model production.

Enablers(technical attributes) for Unattended Single Model and Batch Model Production

(i) Programmed cycle

(ii) Parts storage subsystem

(iii) Automatic transfer of workparts

(iv) Periodic attention of a worker

(v) Built- in safeguards

Contd.

Enablers (technical attributes) for mixed model production.

(i) Work identification subsystem
(ii) Program downloading capability
(iii) Quick setup changeover capability

b) Parts storage Subsystem and Automatic Parts Transfer

- The parts storage subsystem and automatic transfer of parts between the storage subsystem and the processing station are necessary conditions for a single station automated cell, that is cell that operates unattended for extended periods of time. The storage subsystem has a designed parts storage capacity n_p , Accordingly, the cell can be theoretically operate unattended for a length of time given by:

$UT = n_p T_c$ where UT = unattended time of operation of the manufacturing cell (min). Np = parts storage capacity of the storage subsystem and Tc is cycle time of the automated workstation (min/pc).

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Typical objectives for designing the storage subsystem with sufficient capacity to satisfy the plant's operational objectives expressed in terms of the time periods of unattended operation.

(i) A fixed time interval that allows a worker to tend multiple machines

(ii) The time between scheduled tool changes, so that tools and parts can be changed during the same machine downtime

(iii) One complete shift

(iv) Overnight operation, sometimes referred to as lights out operation. The objective is to keep the machines running with no workers in the plant during the middle and/or night shifts.

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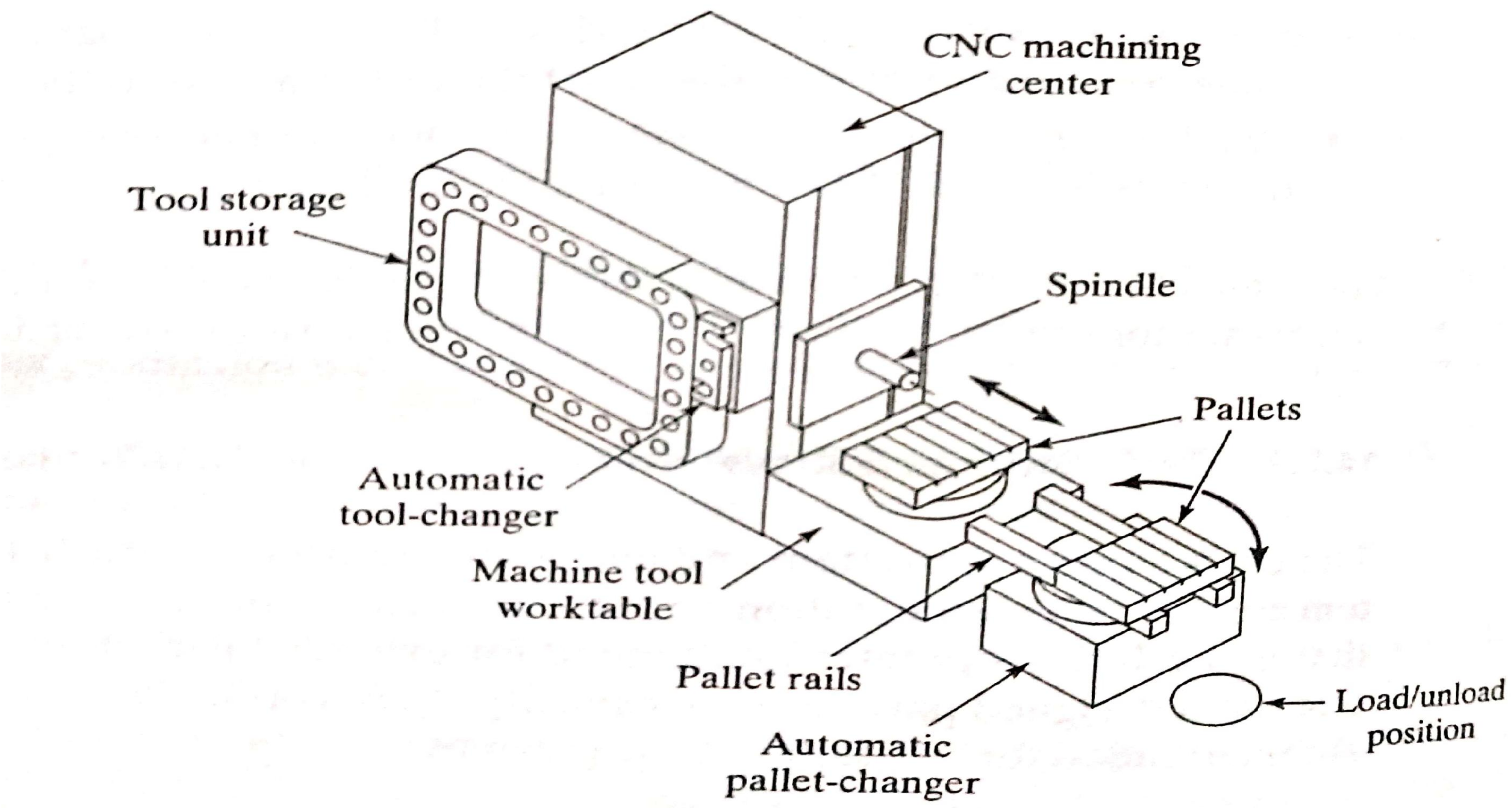
Storage Capacity of One Part:

- The minimum storage capacity of parts storage subsystem is one workpart
- This case is represented by an automatic parts transfer mechanism operating with manual loading/unloading rather than with a parts storage subsystem.
- An Example of this arrangement in machining is a two-position automatic pallet changer, used as the parts input/output interface for a CNC machining center.

Diagram- Automated Pallet Changer integrated with a CNC machining center



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<u>Storage Capacities greater than one:</u>

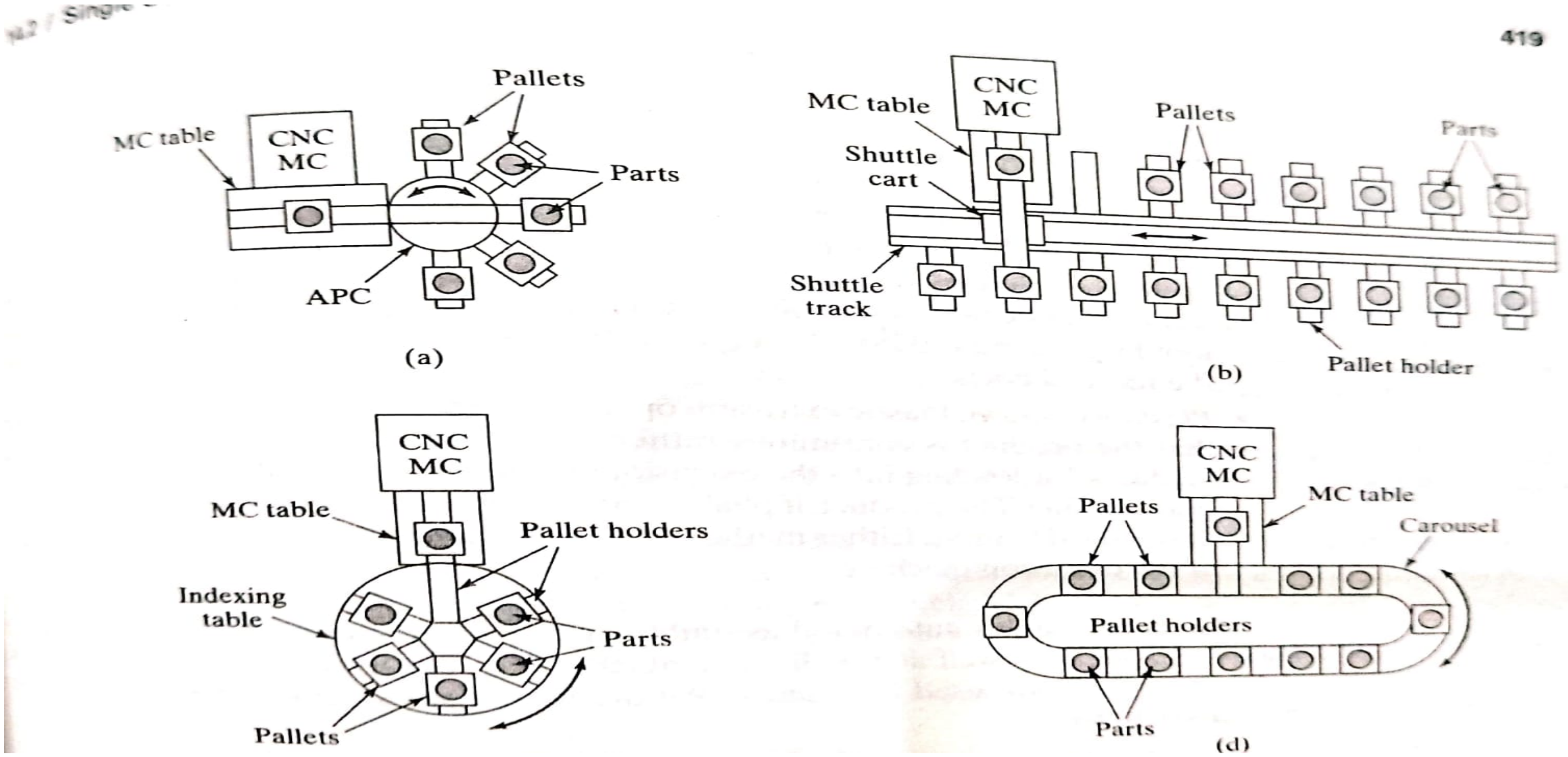
- In place of pallet changer robots are used to load or unload between storage system to machine tool
- In many cases, the starting material is not a discrete workpart. Examples are:

(i) Sheet metal stamping

(ii) Plastic injection molding: Which contains hopper to store the parts

(iii) Plastic extrusion

Diagram- Designs of parts storage subsystem that might be used with CNC machining centers



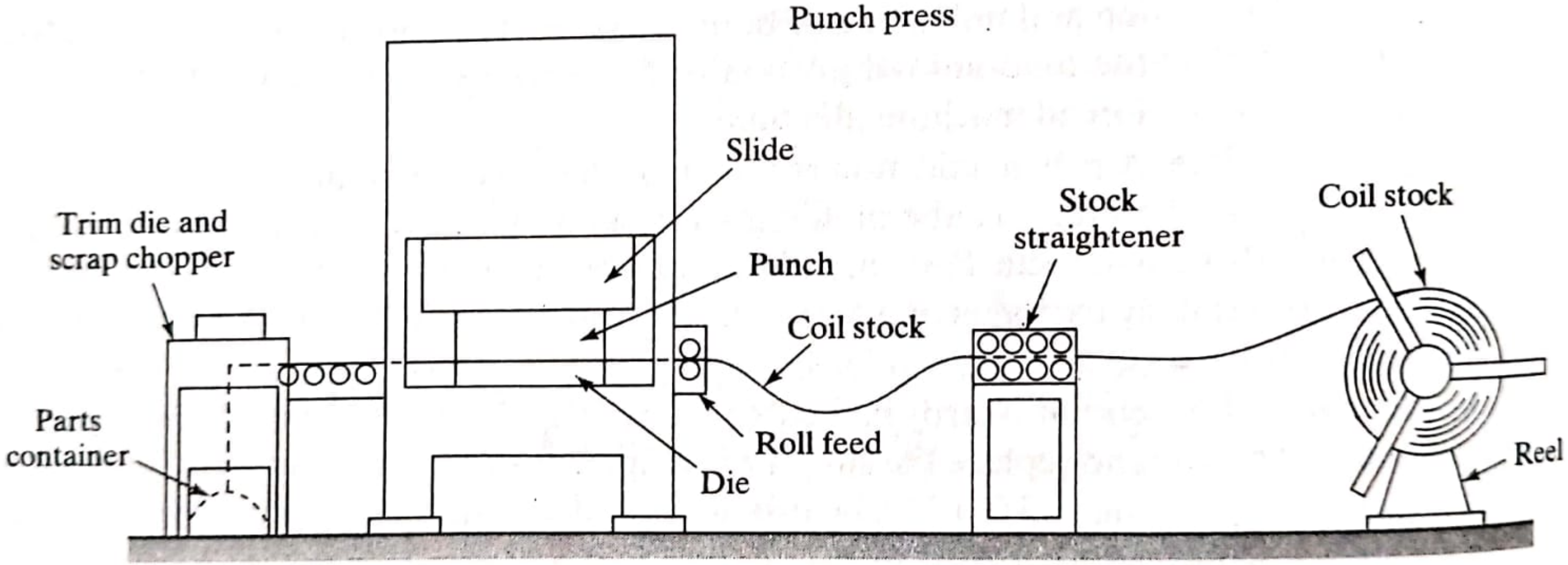
Applications of Single Station Manned Cells

(i) A CNC machining center
(ii) A CNC turning center
(iii) Same as the preceding except the parts are not identical
(iv) A cluster of two CNC turning centers, each producing the same part but operating independently from its own machine control unit
(v) A plastic injection molding machine on semi-automatic cycle, with a worker present to remove the molding, sprue and runner system when the mold opens each molding cycle
(vi) A worker at an electronics assembly workstation placing components into printed circuit boards in a batch operation
(vii) A worker at an assembly workstation performing mechanical assembly of a simple product from components located in tote bins at the station.
(viii) A stamping press that punches and forms sheet metal parts from flat blanks in a stack near the press.

Applications of Single Station Automated Cells

- A CNC machining center with parts carousel and automatic pallet changer, as in the layout. The parts are identical and the machining cycle is controlled by a part program
- A CNC turning center with parts storage tray and robot
- Same as the preceding except the parts are not identical
- A cluster of ten CNC turning centers, each producing a different part. Each workstation has its own parts carousel and robotic arm for loading and unloading between the machine and the carousel.
- A plastic injection molding machine on automatic cycle, with mechanical arm to ensure removal of the molding, sprue and runner system each molding cycle
- An automated insertion machine assembling electronic components onto printed circuit boards in a batch operation
- A robotic assembly cell consisting of one robot that assembles a simple product from components presented by several parts delivery systems
- A stamping press that punches and forms small sheet metal parts from a long coil.

Diagram- stamping press



CNC Machining and Turning Centers

Numerical control machining centers are usually designed with features to reduce nonproductive time. These features include:

(i) Automatic tool changing

(ii) Automatic workpart positioning

(iii) Automatic pallet changer

In addition to this most sophisticated turning centers can accomplish

(i) Workpart gaging: checking key dimensions after machining

(ii) Tool monitoring: sensing when the tools are worn

(iii) Automatic tool changing when tool become worn

(iv) Automatic workpart changing at the completion of the work cycle.

Diagram-NC turning center

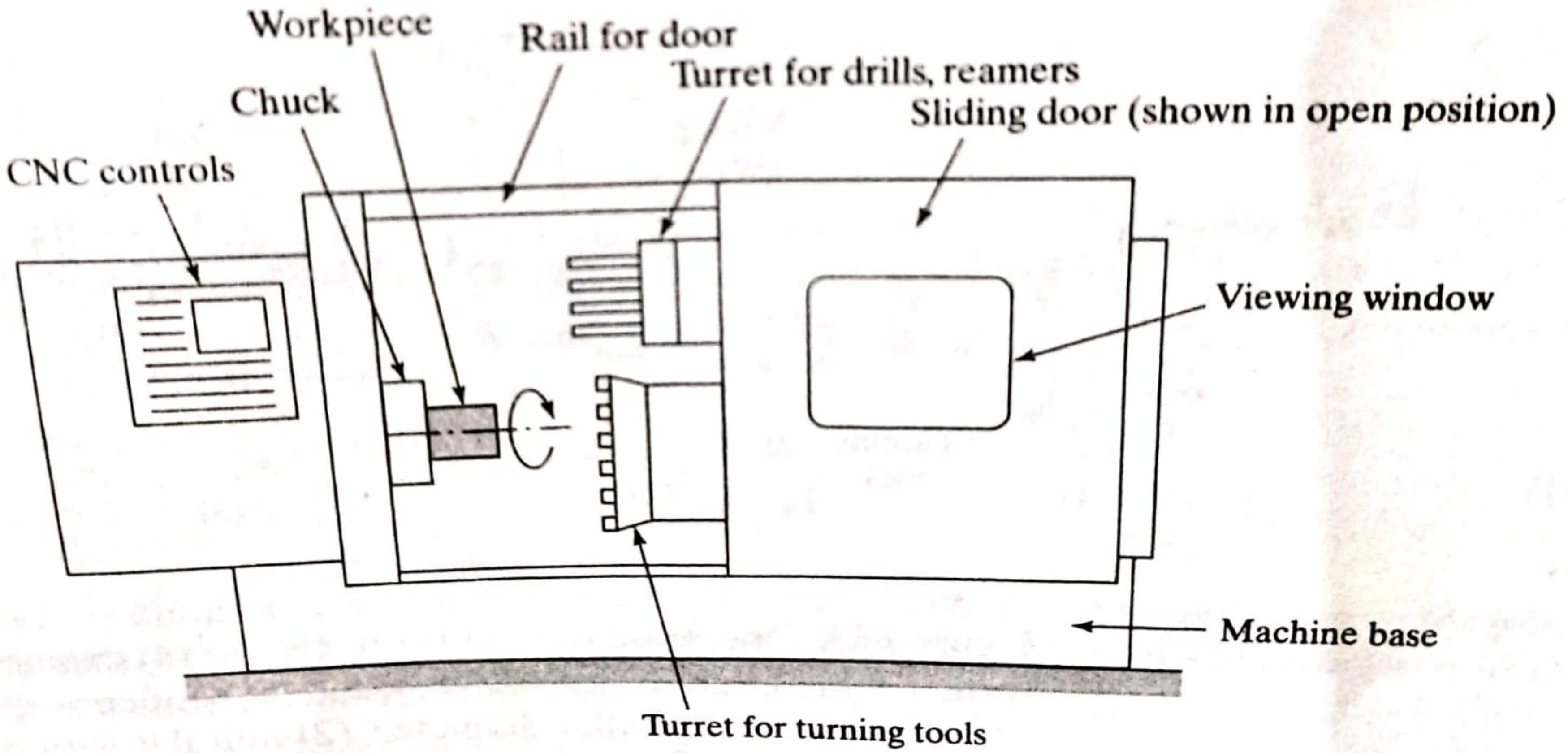
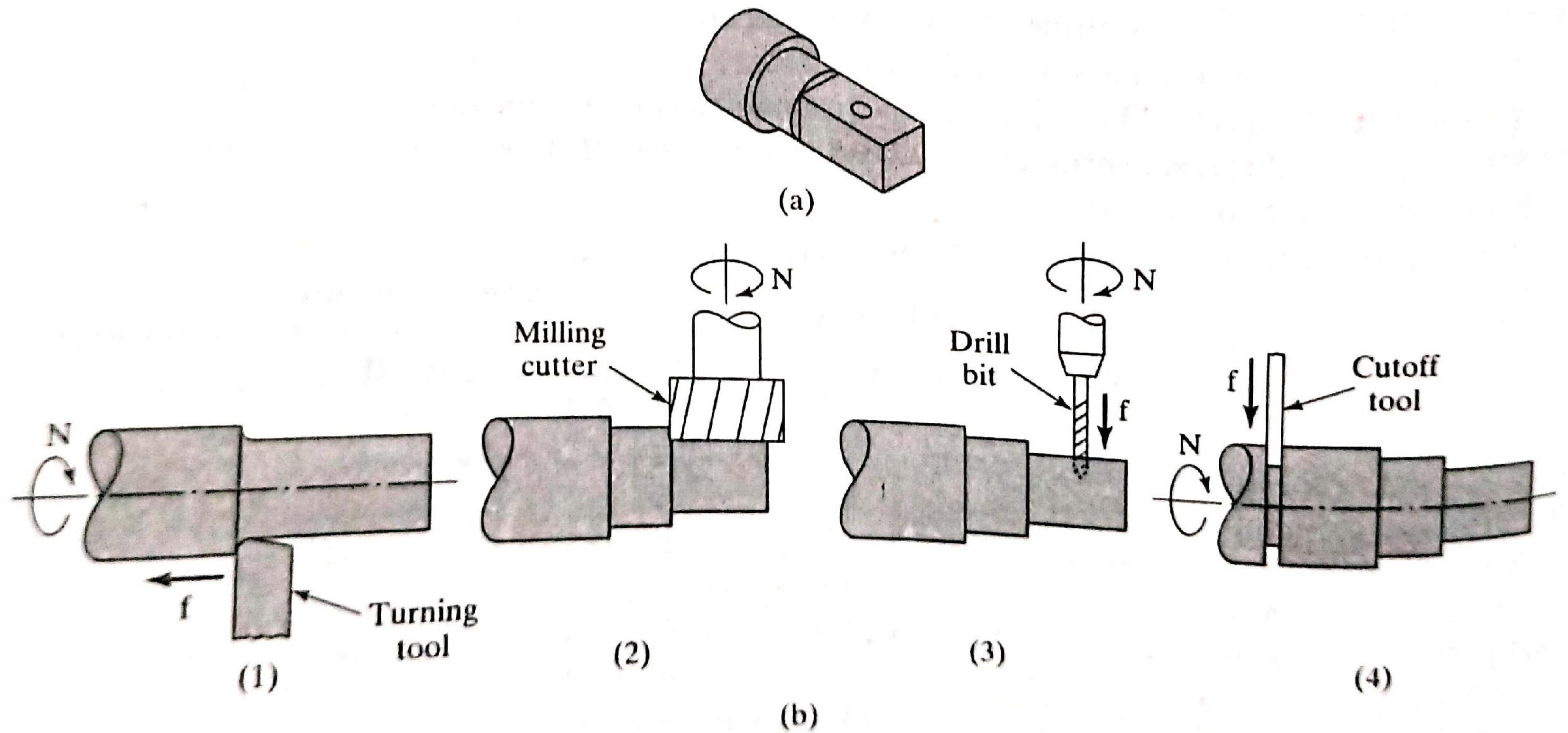


Diagram- operation of mill-turn center



14.4 ANALYSIS OF SINGLE STATION SYSTEMS

Two analysis issues related to single station manufacturing systems are the determination of: (1) the number of single stations required to satisfy specified production requirements, and (2) the number of machines to assign to a worker in a machine cluster.

14.4.1 Number of Workstations Required

Any manufacturing system must be designed to produce a specified quantity of parts or products at a specified production rate. In the case of single station manufacturing systems, this may mean that more than one single station cell is required to achieve the specifications. The problem we address here is to determine the number of workstations required to achieve a given production rate or produce a given quantity of work units. The basic approach is: (1) determine the total workload that must be accomplished in a certain period (hour, week, month, year), where *workload* is defined as the total hours required to complete a given amount of work or to produce a given number of work units scheduled during the period; and (2) then divide the workload by the hours available on one workstation in the same period.

Workload is figured as the quantity of work units to be produced during the period of interest multiplied by the time (hours) required for each work unit. The time required for each work unit is the cycle time on the machine, in most cases, so that workload is given by the following:

$$WL = Q\,T_c \tag{14.4}$$

where WL = workload scheduled for a given period (hr of work/hr or hr of work/wk), Q = quantity to be produced during the period (pc/hr or pc/wk, etc.), and T_c = cycle time required per piece (hr/pc). If the workload includes multiple part or product styles that can all be produced on the same type of workstation, then the following summation can be used:

$$WL = \sum_j Q_j T_{cj} \tag{14.5}$$

where Q_j = quantity of part or product style j produced during the period (pc), T_{cj} = cycle time of part or product style j (hr/pc), and the summation includes all of the parts or products to be made during the period. In step (2) the workload is divided by hours available on one station; that is,

$$n = \frac{WL}{AT} \tag{14.6}$$

where n = number of workstations, and AT = available time on one station in the period (hr/period). Let us illustrate the use of these equations with a simple example and then consider some of the complications.

EXAMPLE 14.1 Determining the Number of Workstations

A total of 800 shafts must be produced in the lathe section of the machine shop during a particular week. Each shaft is identical and requires a machine cycle time T_c = 11.5 min. All of the lathes in the department are equivalent in terms of their capability to produce the shaft in the specified cycle time. How many lathes must be devoted to shaft production during the given week, if there are 40 hr of available time on each lathe?

Solution: The workload consists of 800 shafts at 11.5 min/shaft.

$$WL = 800(11.5 \text{ min}) = 9200 \text{ min} = 153.33 \text{ hr}.$$

Time available per lathe during the week $AT = 40$ hr.

$$n = \frac{153.33}{40} = 3.83 \text{ lathes}$$

This calculated value would probably be rounded up to four lathes that are assigned to the production of shafts during the given week.

There are several factors present in most real life manufacturing systems that complicate the computation of the number of workstations. These factors include:

- *Setup time in batch production*. During setup, the workstation is not producing.
- *Availability*. This is a reliability factor that reduces the available production time.
- *Utilization*. Workstations may not be fully utilized due to scheduling problems, lack of work for a given machine type, workload imbalance among workstations, and other reasons.
- *Worker efficiency*. This occurs when the work is highly manual, and the worker performs either above- or below-standard performance for the given task.
- *Defect rate*. The output of the manufacturing system may not be 100% good quality. Defective units are produced at a certain fraction defect rate. This must be accounted for by increasing the total number of units processed.

These factors affect how many workstations or workers are required to accomplish a given workload. They influence either the workload or the amount of time available at the workstation during the period of interest. In addition, the workload may also be affected by the learning curve phenomenon, as discussed in Section 13.4.

Setup time in batch production occurs between batches because the tooling and fixturing must be changed over from the current part style to the next part style, and the equipment controller must be reprogrammed. Time is lost when no parts are produced (except perhaps trial parts to check out the new setup and program). Yet it consumes available time at a workstation. The following two examples illustrate two possible ways of dealing with the issue, depending on the information given.

EXAMPLE 14.2 Including Setup Time in Workstation Calculations: Case 1

In previous Example 14.1, suppose that a setup will be required for each lathe that is used to satisfy the production requirements. The lathe setup for this type of part takes 3.5 hr. How many lathes are required during the week?

Solution: In this problem formulation, the number of hours available on any lathe used for the shaft order is reduced by the setup time. Hence $AT = 40 - 3.5 = 36.5$ hr.