

Practical No. 3

Aim:- Study the constructional details of following components of CNC machine installed in lab for:

- Automatic tool changer and tool setter
- Multiple pallets
- Swarf removal
- Safety devices

Procedure: Automatic tool changer

Theory : The machining center or turning centre in CNC equipment often requires more than one tool to complete the process. These tools are hold in the tool magazine, from where they can be picked, used and are placed back after use in an operation. These tools are changed and are set quite regularly in between the process and hence must be done at a fast speed. The time spent to change these tools (idle time) must be minimized. For this a device known as automatic tool changer (ATC) is used.

(a) CONSTRUCTIONAL DETAIL AND WORKING OF ATC : The CNC machines are designed to perform a number of operations in a single setting of the job. A number of tools may be required for making a complex part. In a manual machine, the tools are changed manually whenever required. In a CNC machine, tools are changed through program instructions. The tool are fitted in a **tool magazine** or drum. When a tool needs to be changed, the drum rotates to an empty position approaches the old tool and pull it. Then it again rotates to position the new tool, fits it and then retracts. This is a typical tool changing sequence of an automatic tool changer (ATC).

ATC take approximately 3 to 7, seconds time during tool change operation. This requires that each tool can be identify by some form of coding device which can be recognised by the tool transfer arm. The general working principle of a ATC employs a **tool transfer arm** which is used to select the desired tool automatically from the magazine and replace it with a new tool which is already exists in the machine spindle. (Fig. P- 3.1 (a) (b)).

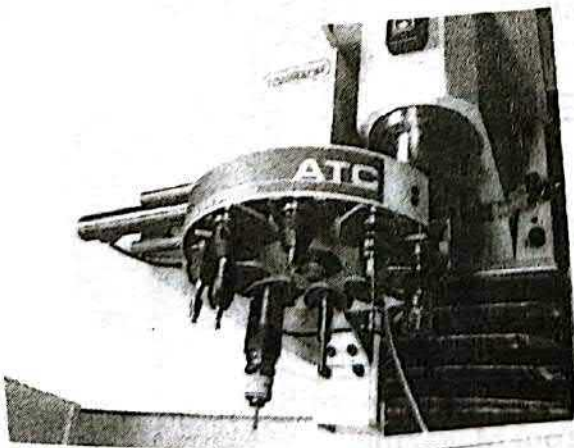


Fig. 3.1(a)

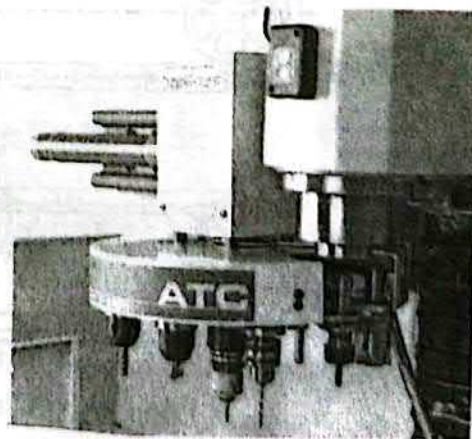
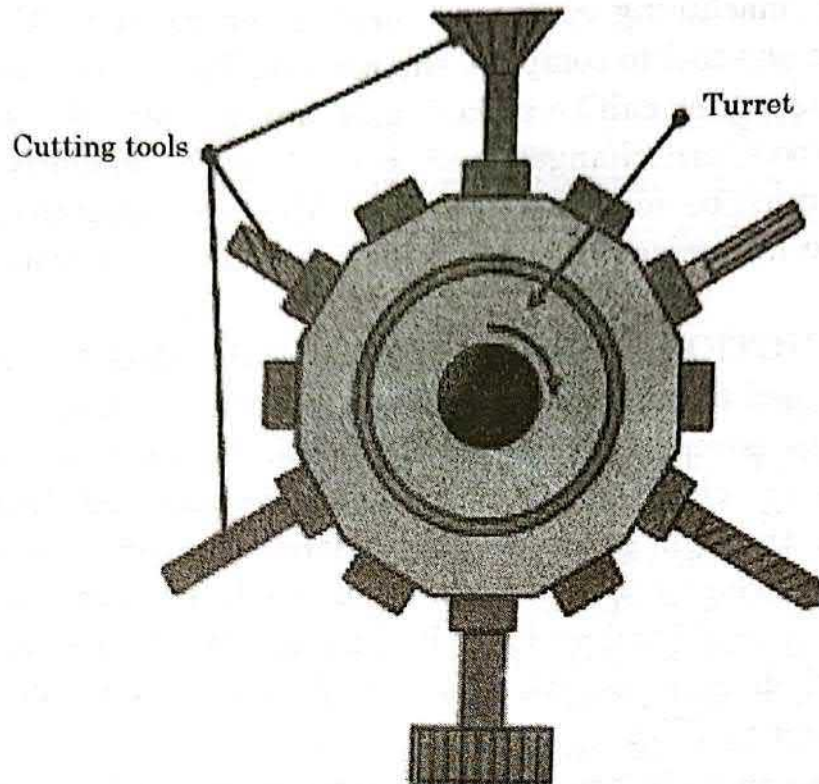


Fig. 3.1(b)

Types of tool Magazines : Tool magazines are classified into three types :

(i) Turret type : This is the simplest type of tool magazine as shown in fig. P-3.2. In this type tool storage and changing produce is combined.



Turret Type

(ii) Chain type : When the number of tools stored in magazine are more than chain type tool magazine and used. A chain type tool magazine is shown in fig.P-3.3.

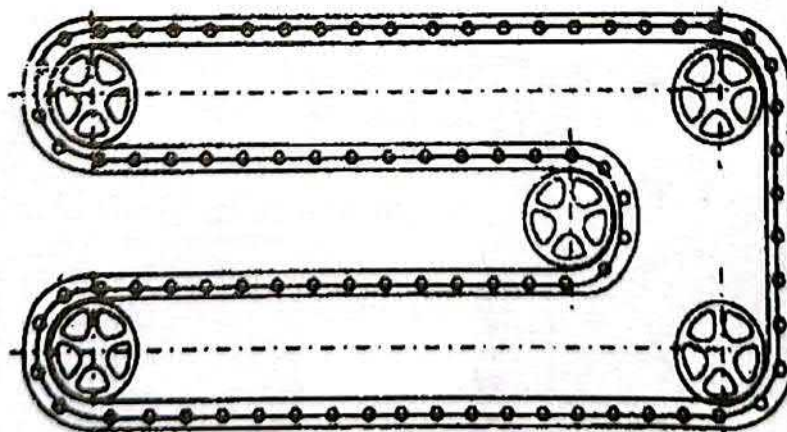
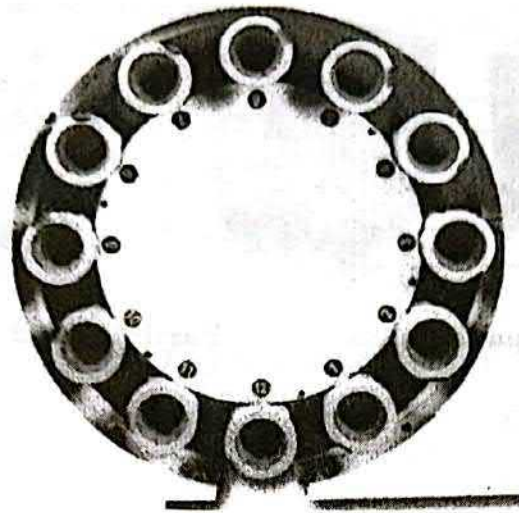


Fig. P-3.3 : Chain Type Tool Magazine

(iii) Drum type : This type of tool magazine found in most of CNC machine tools. In this a typical drum rotates for the purpose of tool change. (Fig. P-3.4).



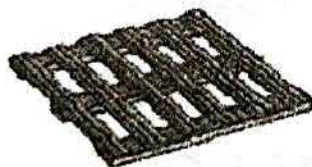
Drum Type

(b) MULTIPLE PALLETS : Multiple pallets are work holders, that are designed for transported by the material handling system. The parts are hold on upper face of pallet and lower face of pallet is designed to be moved, located and clamped in position at work table of the machine. The designed of the multiple pallet is depend on the geometry of the workpiece and nature of the operations. Some common type of multiple pallets are shown in fig. P-3.5.

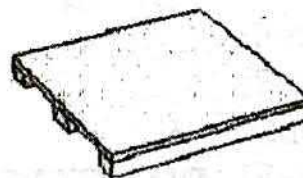
Supports Rich Pallet Types :



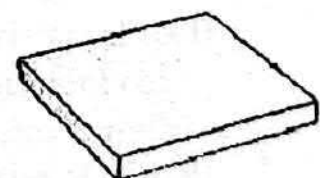
Wood



Steel



Paper

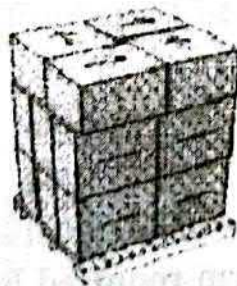


Plain

Single and Mixed Pallet Loads :

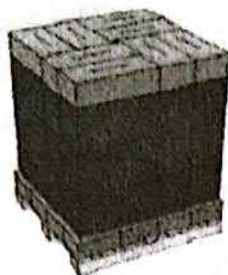


Single load

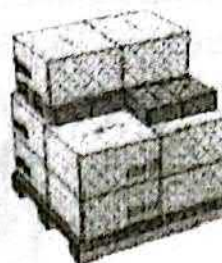
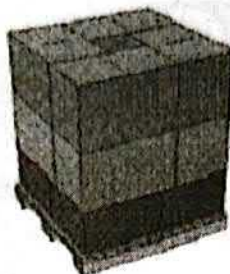


Single load with packaging materials



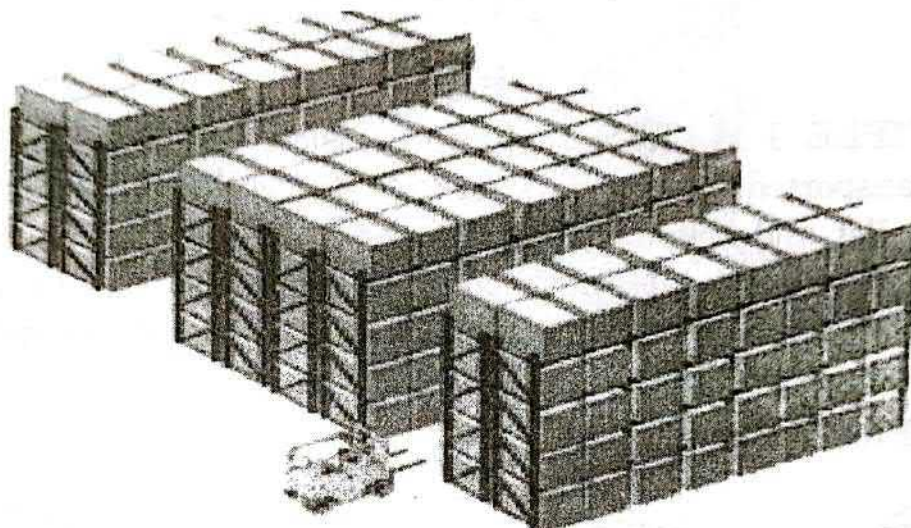


Mixed pallet loads



Partial mixed pallet loads

Fig. P-3.5



Procedure : Swarf removal :

CNC machines are designed to work at cutting conditions with the improved cutting tools on a continuous operation basis. Since the cutting time is much more in CNC machines, the volume of swarf generated is also more. Unless the swarf is quickly and efficiently removed from the cutting zone, it can affect the cutting process and the quality of the finished product. Also the swarf cannot be allowed to accumulate at the machine tool because it may disturb the access to the machine tool. Some auxiliary functions like automatic component loading or automatic tool change may also be affected by accumulation of swarf. To avoid these problems, an efficient swarf control system must be provided with the CNC machine tools with some mechanism to remove the swarf from the cutter and cutting zone and for the disposal of swarf from the machine tool area itself.

1. Swarf removal from cutting zone : The swarf removal from the cutting zone is taken care of by the design configuration of the machine. Slant bed and vertical bed turning centres

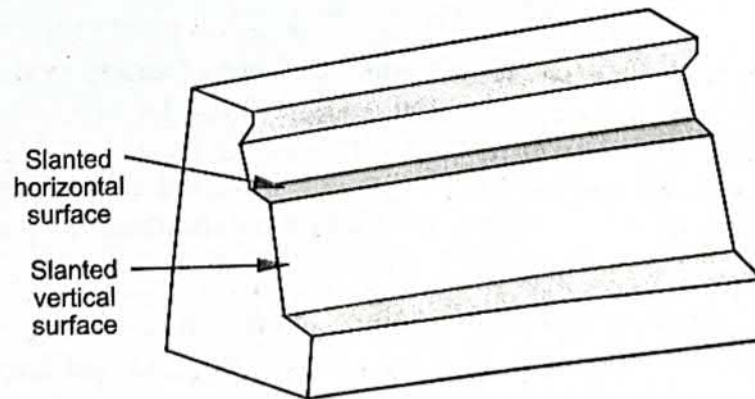


Fig. 4.1. Slanting bed for machine.

have the advantages over flat bed or horizontal bed configuration in that the swarf does not accumulate on the guideways. The machine bed is made slant, generally 20° to the vertical as per the latest trend. The main advantages of this geometry are face flow of swarf, chip and coolant as shown in Fig. 4.1.

Similarly horizontal machining centres are advantageous to vertical machining centres. But swarf removal by gravity is not adequate in CNC machines. To supplement the gravity system, multiple coolant jets are arranged around the cutting tool and the coolant under pressure, takes away the accumulated swarf from the cutting area. It is also possible to programme 'Coolant wash' stage in the part programme, where the cutting area is flooded with pressured coolant and the swarf from the cutting tool and the workpiece is washed away. Compressed air jets are also used for swarf clearance from the cutting zone.

2. Swarf disposal from machine tool : Continuously operating linear or rotary conveyors are used for removing the swarf from the machine tool. The system is such that the swarf from the cutting zone falls directly on the conveyor and is immediately taken away. The swarf from the conveyor is taken to disposal bin, which can then be collected and removed from the machine area.

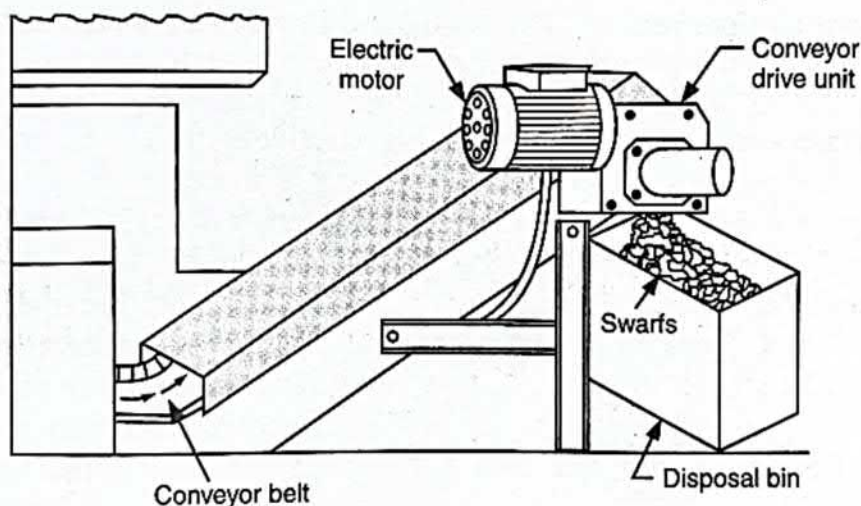


Fig. 4.2. Chip conveyor.

Procedure : Guarding and safety.

The machine tool, tool and work along with operator should be protected against damage or breakage during the cutting operator as CNC machines are continuously operated for long periods at higher speeds.

1. Safety of machine element and workpiece : Protection of machine guideways, drive screws and transducers etc. is very important for efficient working and long life of the machine. Various types of collapsible guards and covers are used to protect all those elements. All the sliding elements are fitted with wipers and the drive screws are normally protected by using

telescopic covers. The protecting devices are designed according to the shape and size of the machine elements. The swarfs are removed by using a high velocity jet of cutting fluid, from the tool and work.

- (i) *Overload protection* : The sensors are fitted to main motors to stop the machine immediately in case of overload.
- (ii) *Clamping sensor* : These sensors are fitted in clamps signalling MCU to close clamps before starting the cutting process.
- (iii) *Work-handling sensors* : These monitor the operational condition and position of work table or spindle drive. Therefore, the work tables are automatically slowed down when the limits are reached.
- (iv) *Measuring device guards* : These are positioned to protect measuring devices from swarfs etc.

2. Safety of the operator : Safety of the operator is an important aspect which cannot be overlooked at the time of designing of CNC machines. Therefore, for the safety of the operator, metallic or plastic transparent guards are given. In case where it is not possible to use these guards, then proximity protection system is provided. The following devices are also used for the complete protection and safety.

(i) **Perimeter guards** : The perimeter guards serve as an enclosure for the machine tool. They protect the operator against flying swarf and from any accident by hitting against the moving components when the machine is working. For the proper visibility of the various elements of the machine to the operator, the transparent windows are used during working of the machines. The access to the machine is provided through large sliding doors for setting up the machines and loading or unloading of the workpiece. The doors have various types of inter-lock switches fitted on them. If the door is opened when the machine is working, the control unit will flash a warning signal or activate a loud sound signal like a buzzer. Few machines also have the facility to cut-off the power if the doors are kept open beyond a given period time.

(ii) **Pressure mats** : In milling, grinding and drilling CNC machines, the pressure mats are used as safety device where the machine table moves in the direction of X and Y axes. Because the working speed of table is high, it may cause some accident if the operator is standing too near to the machine. These mats are placed around the CNC machines and a warning signal is generated if anybody crosses these mats.

(iii) **Light barrier** : Light barriers are also provided on milling, drilling and grinding CNC machines. The light barrier consists of a light source, sending a beam of infra-red light to light sensitive cell. If anything obstructs the light beam, a warning signal is generated which causes to alert the operator. The light barriers are placed around the machine. They can be made inactive, if required.

(iv) **Safety clutches** : These are usually friction clutches, when the transmitted torque exceeds a certain limiting value, they get damaged automatically. They have the advantage of not destroying themselves in case of an overload condition and the system always remains in safe limits.