Chapter VIII
CNC Machine Tools

ABSTRACT

The introduction of CNC machines has radically changed the manufacturing industry. Curves are as easy to cut as straight lines, complex 3-D structures are relatively easy to produce, and the number of machining steps that required human action has dramatically reduced. With the increased automation of manufacturing processes with CNC machining, considerable improvements in consistency and quality can be achieved. CNC automation reduced the frequency of errors and provided CNC operators with time to perform additional tasks. CNC automation also allows for more flexibility in the way parts are held in the manufacturing process and the time required to change the machine to produce different components. In a production environment, a series of CNC machines may be combined into one station, commonly called a “cell”, to progressively machine a part requiring several operations.

CNC controller is the “brain” of a CNC machine, whereas the physical configuration of the machine tool is the “skeleton”. A thorough understanding of the physical configuration of a machine tool is always a priority for a CNC programmer as well as the CNC machine tool manufacturers. This chapter starts with a historical perspective of CNC machine tools. Two typical types of CNC machine tools (i.e. vertical and horizontal machining centres) are first discussed. Tooling systems for a CNC machine tool are integral part of a CNC system and are therefore elaborated. Also discussed are the four principal elements of a CNC machine tool. They are machine base, machine spindle, spindle drive, and slide drive. What letter should be assigned to a linear or rotary axis and what if a machine tool has two sets of linear axes? These questions are answered later in the chapter. In order for readers to better comprehend the axis and motion designations, a number of machine tool schematics are given.
A HISTORICAL PERSPECTIVE

Computer numerical control refers specifically to a computer “controller” that reads some sort of machine control (e.g. G-code) instructions and drives the machine tool. The controller does numerically directed interpolation of a cutting tool in the work envelope of a machine. Numerical controllers (NC) were developed in the late 1940s and early 1950s by John T. Parsons in collaboration with the MIT Servomechanisms Laboratory.

The first NC machines, which are frequently referred to as being of the first generation, had been previously designed for manual or fixed cycle operations. These machines had numerical control systems added, but only for numerical control on positioning the work relative to the tool. Considerable time was saved, yet the operator had to select the tools, speeds and feeds.

Second-generation machines are those on which material removal occurs at the same time as control of the work/tool relationship. These NC machines were also termed tape-controlled machines, because the information was stored on either punched tape or magnetic tape. Figure 8.1 illustrates the characteristics of a punched type. It is very cumbersome to edit the information at the machine; the machines had only very limited memory capacity.

The development of computers has created the third-generation machines which are capable of an extended range of machining operations. These machines are commonly referred to as Computer Numerical Control and sometimes Direct Numerical Control (DNC) machines.

PRINCIPLES OF NUMERICAL CONTROL

A CNC system usually contains a machine-control unit (MCU) and the machine tool itself. The MCU is further divided into two elements: the data-processing unit (DPU) and the

Figure 8.1. NC punched tape. ©1969 (or 2003) Industrial Press. Used with permission.
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