Cairo University
Faculty of Engineering
Mech. Power Department

ACC Virtual Labs
Automatic Control Circuits & Virtual Labs for Mechanical Power Systems

دبلوم تطبيقات التحكم الأوتوماتيكى فى نظم القوى الميكانيكية

MEP 599 Diploma Project-Fall 2019-2020

Description and Analysis of Some CNC Systems: Selection of Design Factors and Automatic Control Circuits with Safety Parameters

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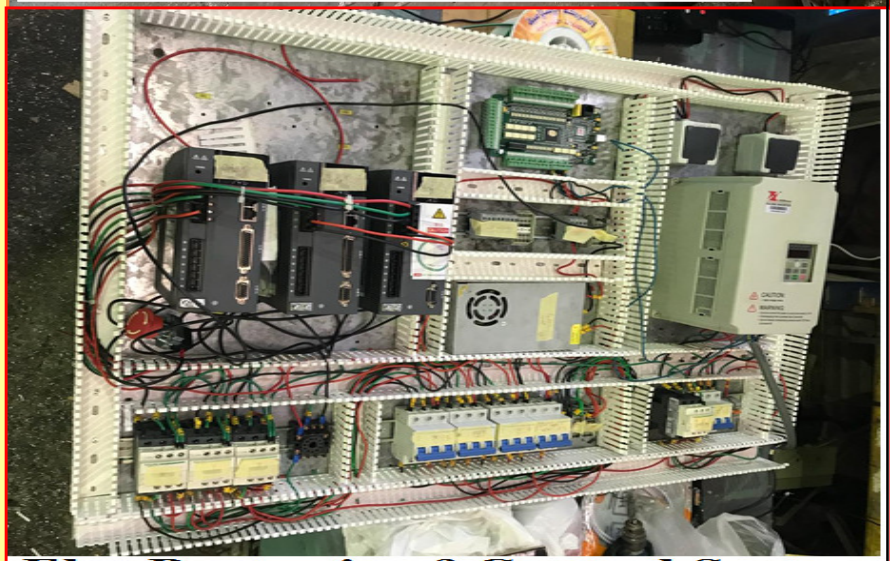
Abstract

It is known that accuracy of parts produced by traditional machines (e.g., Lathe, Milling, Scrapper, .etc) is greatly depends on both type and accuracy of machine components and skills and experience of machine operators who do many hard manual work in fixing, replacing, changing cutting tools in addition to measuring required final tolerances and dimensions of produced parts. Enhancing operator's skills have great effect only on limited quantity products but have less effect on overall productivity and processing time and cost in the case of mass production requirements.

Recently, most traditional production machines are replaced by CNC (Computer Numerical Control) machines in order to increase both the accuracy and productivity and to reduce production cost and time without relying on the skills or experience of the machine operators. CNC machining is a manufacturing process where computer programs control how the machine will manufacture parts with minimum effect from operators. This CNC software can control everything from the motions the machine makes to spindle speed, turning coolant on or off, replacing cutting tools and much more. The computer language used to program CNC machines is called "G-Code". There are many different kinds of CNC machines including 3D Printers, CNC Mills, CNC Lathes, CNC Lasers, Water Jets, Elec. Discharge Machines (EDM's), CNC Routers, and more.

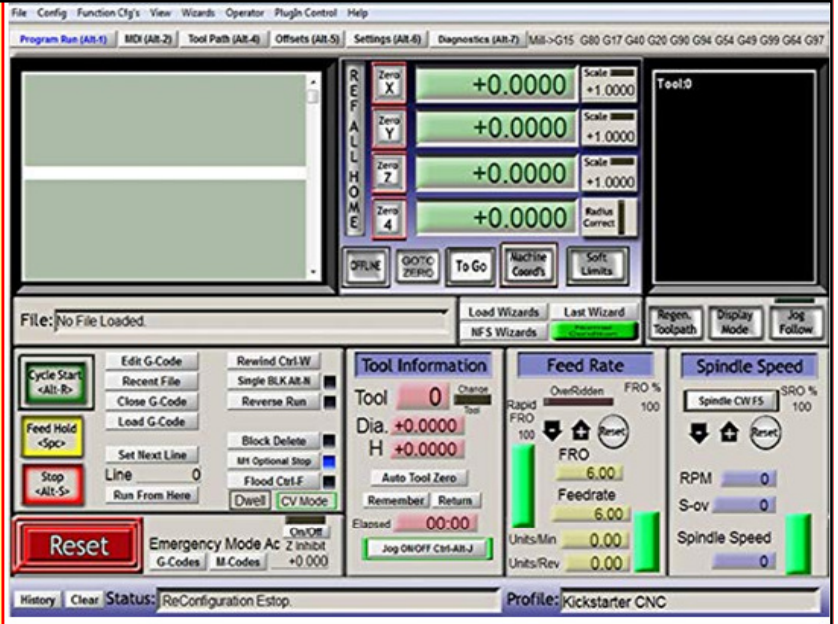
Upgrading of Tekna CNC Machine



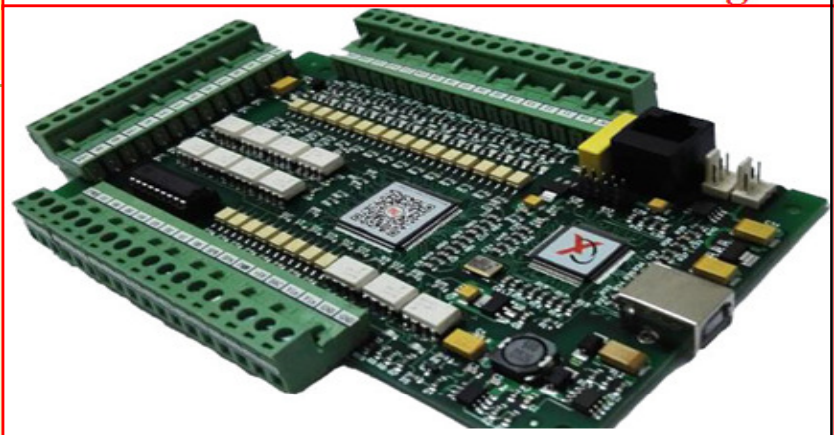
Elec.Protection&Control System

Abstract (continue): It should be noted that the higher accuracy of CNC machines can, however, be affected by some combinations of error sources such as tool deflection, geometrical deviations of moving axis, type of motors and thermal distortions of machine tool structures. Some of these errors can be decreased by controlling the machining process and environmental parameters. However errors such as tool deflection and geometrical errors (which represent significant portions of the total error) need more sophisticated solutions. Removing those later types of errors requires good selection of the machine and accurate testing of its components. Conventional error reduction methods are considered as inefficient and human dependent methods. Most of recently developed solutions cannot fulfill workshop needs& are limited to research papers.

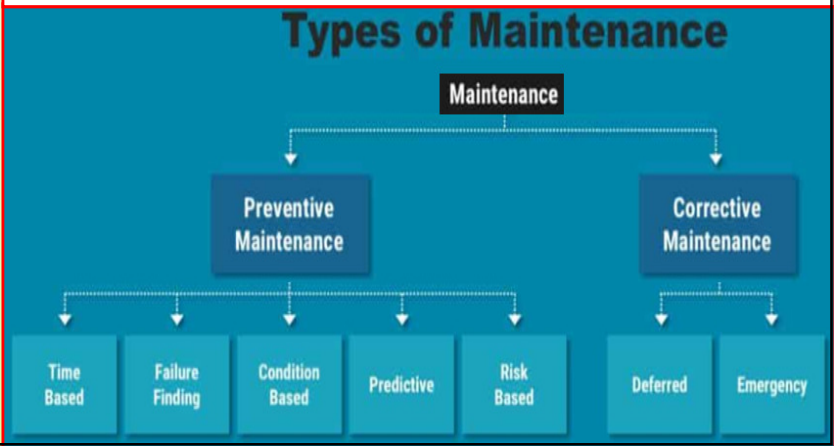
In the present study, we describe, discuss and perform some analysis for some of the error sources and parameters that can affect the accuracy of operation of some CNC machines.



Automatic Control & Protection Program



Automatic Control Board



The main objectives of this study are as follows:

1- Identifying how to select CNC machine parts for manufacturing or buying full CNC machine according to user need.(e.g.: Vee model application, CNC as an automatic control system).

2- Doing an analysis for mechanical design and system selection (Machine frame, power transmission and linear guides).

3- Investigating electric and control systems, using of direct control modules. (Open and closed loop control systems).

4- Investigating control of motors motion for 3-axis & for the spindle using PC for integration. (Selection of suitable motors &control systems).

5-Studying using simple pneumatic system method for fixing work piece.

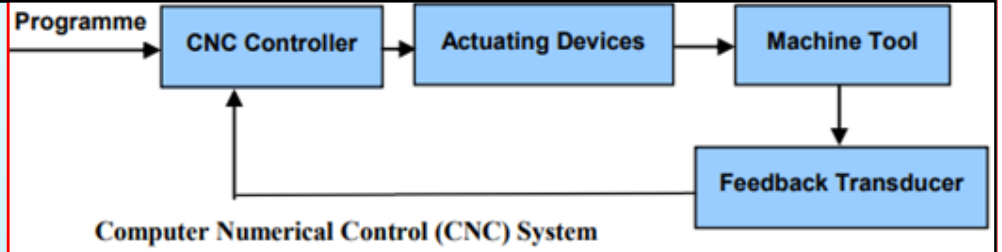
6- Studying the automatic tool changer system during working in the same work piece.

7- Searching on measuring methods of products using both CNC machines and traditional machines.

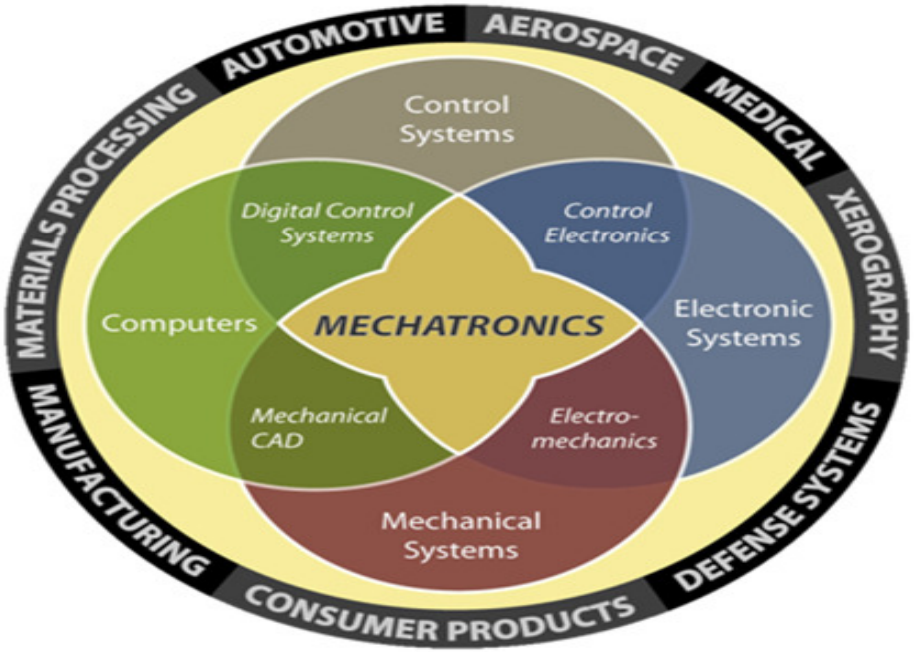
8- Investigating safety considerations of some CNC machines for selection of the most suitable design.

Overview of this document:

✓In Chapter one, we discuss the Mechatronics system and show how that it has good effect in
✓analyzing the CNC systems.
✓In Chapter two, we make an analysis for mechanical design system selection. Machining code modification strategy has been considered as an applicable& effective solution to enhance
✓precise machined components.
✓In Chapter three, we discuss the use of direct control modules according to the product.
✓In Chapter four, we discuss the importance of pneumatic systems and relation with CNC systems and method of fixation and their role to decrease the errors.
✓In Chapter five we discuss design safety considerations which have to be found in addition to general safety precautions.
✓In Chapter six, we show briefly some of the real work in upgrading of a CNC mill machine in one of the great companies in Egypt taking into consideration the previous analysis for reducing error sources and increasing accuracy and efficiency as discussed in the above chapters.

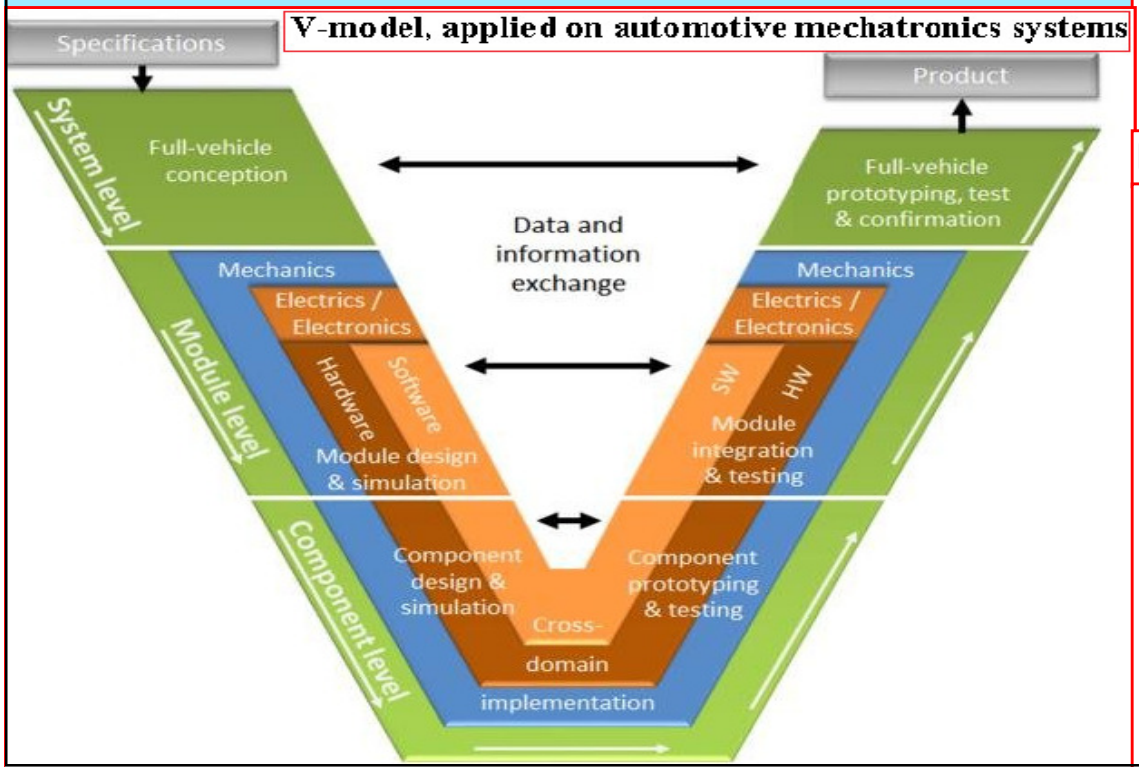


Computer Numerical Control (CNC) System

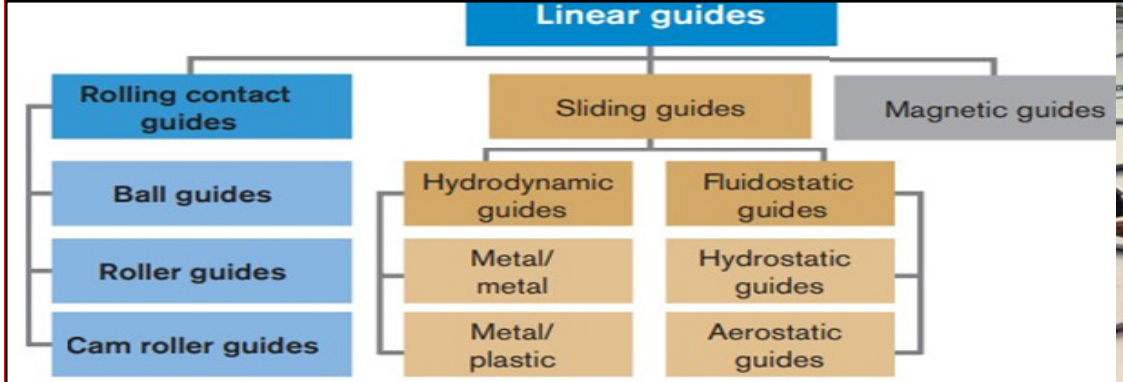


Integration between engineering systems results to Mechatronics

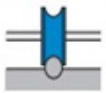
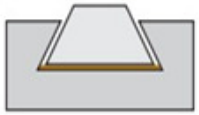
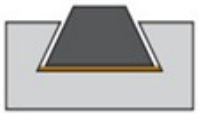
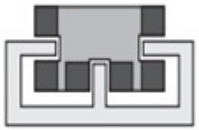
V-model, applied on automotive mechatronics systems

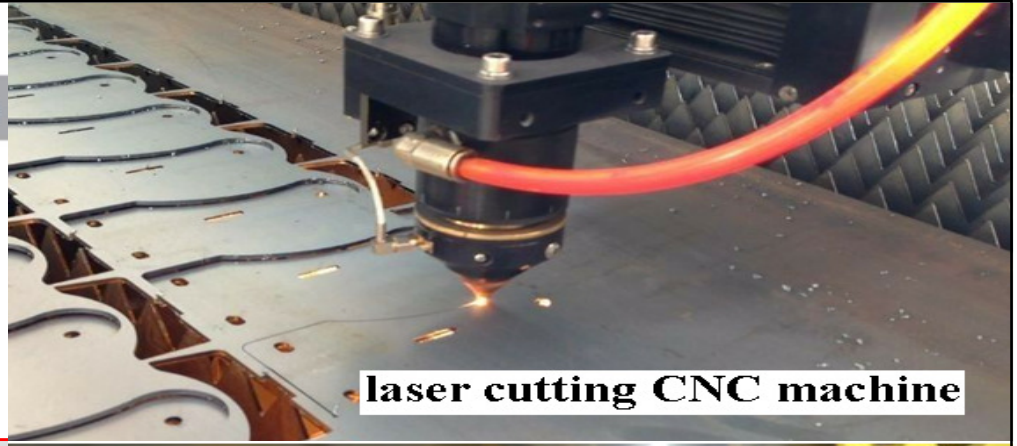


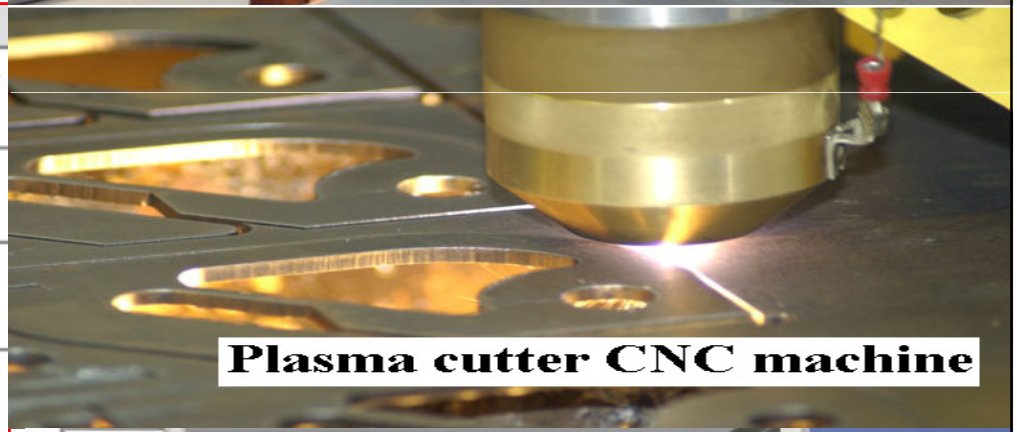

AVIA X-5 machining centre and its Solid-Works model.

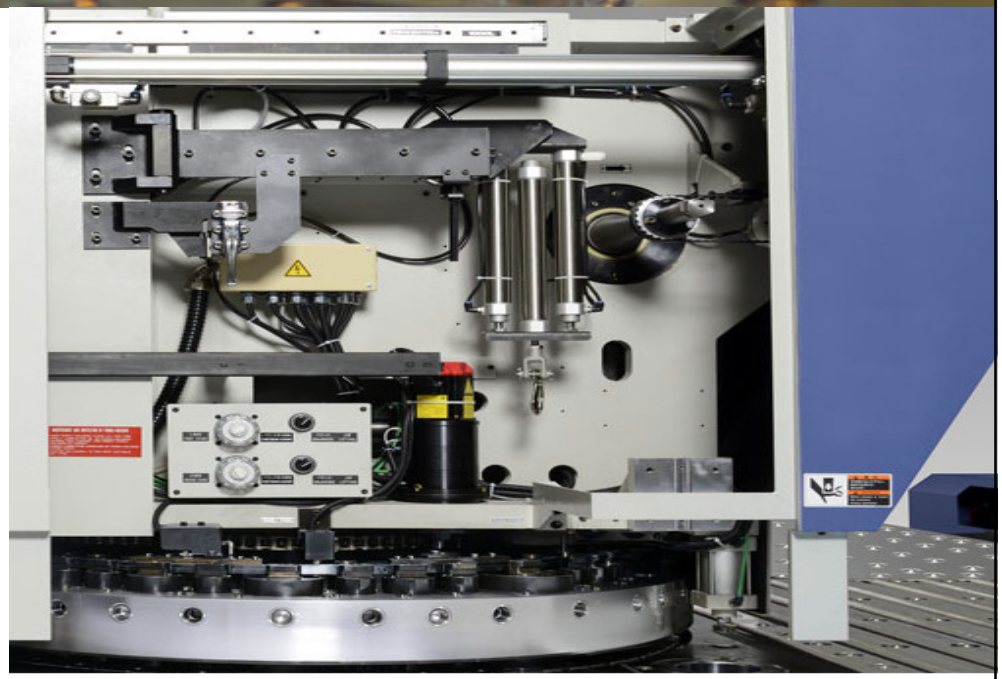


Operating principle of linear guides

Linear guides			Operating principle
Rolling contact guides	Ball guide		There are balls between the moving and fixed machine parts.
	Roller guide		There are rollers between the moving and fixed machine parts.
	Cam roller guide		There are cam rollers supported on ball bearings between the moving and fixed machine parts.
Hydrodynamic sliding guides	Metal/metal		Both machine parts are in contact during standstill. When movement starts, a lubricating film gradually forms between the moving and the fixed machine element. The lubricating film only separates the moving and the fixed element of the machine completely at higher sliding speeds.
	Metal/plastic		The operational principle is the same as for metal/metal. The metal/plastic material combination reduces friction when movement starts, until a complete lubricating film forms.
Fluidostatic sliding guides	Hydrostatic guide		A pump supplies liquid lubricant to the guide. The moving part rises. Between the moving and the fixed element there is a film of lubricant under pressure.
	Aerostatic guide		A compressor supplies compressed air to the guide. The moving and the fixed machine element are separated by the compressed air.
Magnetic guides			The moving and fixed machine elements are separated by magnetic force. The moving part "floats." The guide is therefore non-contacting.


laser cutting CNC machine

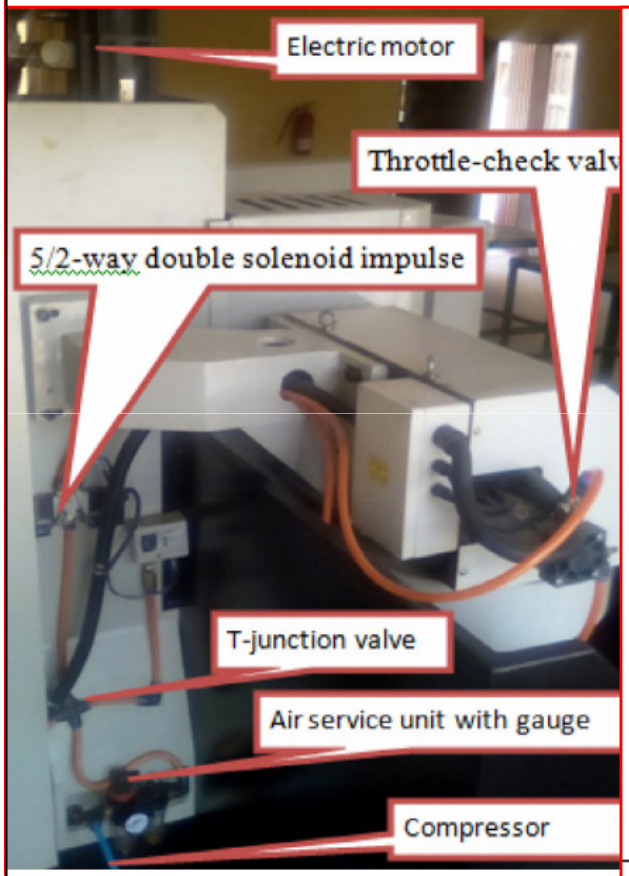

Plasma cutter CNC machine


Mechanical Punching CNC machine

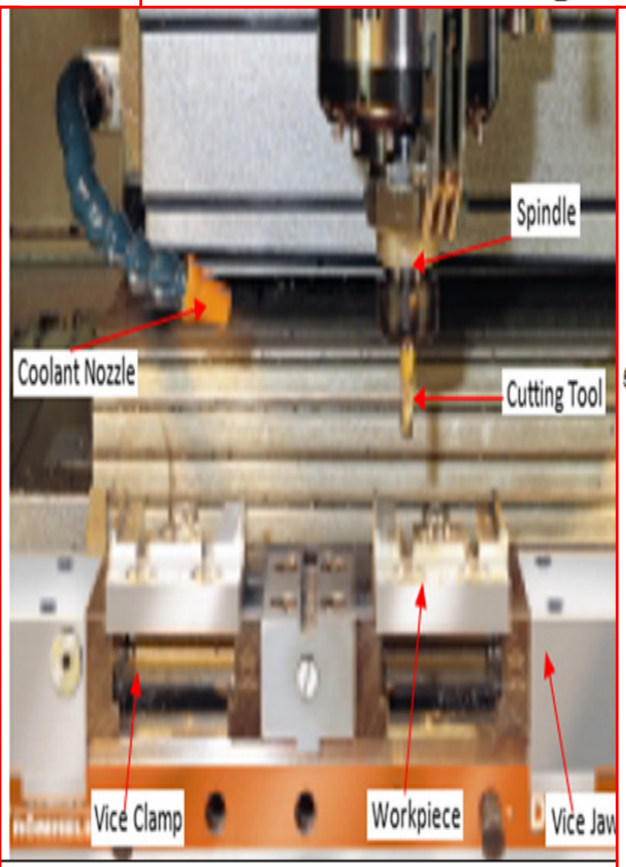
Bridgeport Milling Machine

CNC Multi-Tasking Turn-Mill Mach.

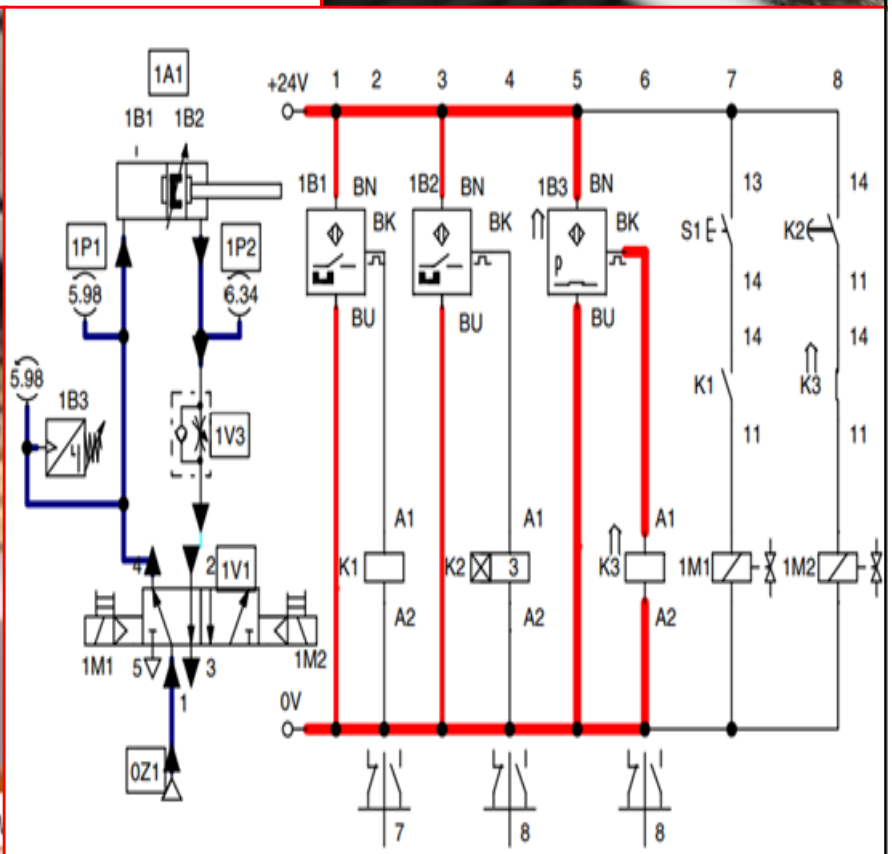
Water-jet CNC cutting machine



Electro-pneumatic assembly of CNC milling mac



Flexible double clamping system (SCFC): an ideal clamping system.



Schematic diagram of SCFC System.