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Distributed Numerical Control System: An Advancement in CNC/DNC System

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Abstract: ***In the today's manufacturing environment, every kind of system is integrating with the computerization systems. This computerized system is already involved in the manufacturing environment. This manufacturing system is controlled by numbers, letters & symbols, called Numerical Control System (NC System). This system gets advancement by the role of computers & efficient system created, called Computer Numerical Control System (CNC System) and again improved by central computer system, called Direct Numerical Control System (DNC System). Now, for get a highly efficient numerical control system with precision and accuracy beyond human ability, a new system introduces, called Distributed Numerical Control System, which is the advancement in CNC/ DNC System. Thus, this paper presents the advancements of Distributed Numerical Control System over CNC/DNC System.***

Keywords: Advancement, Manufacturing Systems, NC, CNC, DNC, CAPP, CAD, CAM, CIM

1. Introduction

The systems aspects of manufacturing are more important than ever today. The word manufacturing was originally derived from two Latin words, Manus (hand) and Factus (make), so that the combination means made by hand. In 1567 this type of manufacturing system was used and product verities were very simple to construct. This system is improved and makes efficient with the control of numbers, letters and symbols, called Numerical Control System (NC System). For the manufacturing, a set of programs were used to control the processes.

This NC System is improved by the integration of computers. The microcomputers control the manufacturing processes, by the G codes and M codes, called Computer Numerical Control System (CNC System). Computer Numerical Control (CNC) is one in which the functions and machine tool motions are controlled by means of a prepared program containing coded alphanumeric data (G Codes and M Codes). CNC system can control the motions of the workpiece or tool, the input parameters such as feed, depth of cut, speed, and the functions such as turning spindle on/off, turning coolant on/off.
Direct Numerical Control (DNC) is a system that uses a central computer to control several machines at the same time for the manufacturing.

2. Numerical Control (NC) System and Computer Numerical Control (CNC) System

NC is an acronym for Numerical Control and CNC is an acronym for Computer Numerical Control. The CNC System uses the computers to control the manufacturing process. The difference between NC and CNC is one of age and capability. The earliest NC machines performed limited functions and movements controlled by punched tape or punch cards. As the technology evolved, the machines were equipped with increasingly powerful microprocessors (computers) with the addition of these computers, NC machines become CNC machines.

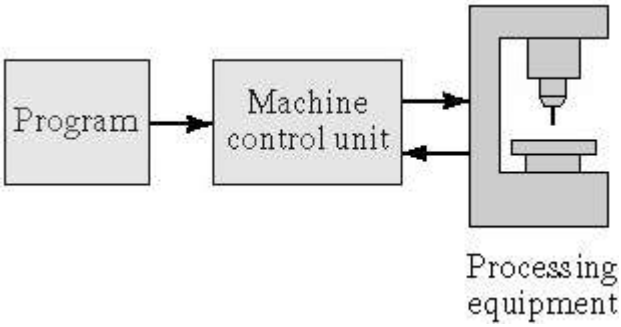

Figure 1: Components of an NC System

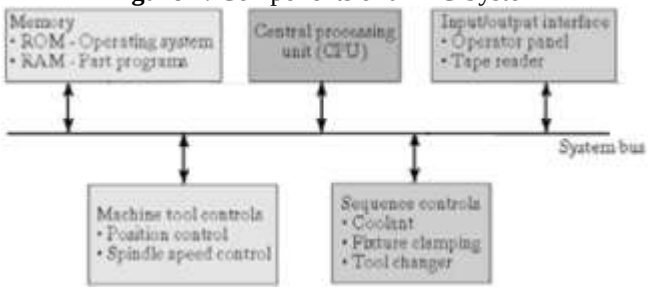

Figure 2: Configuration of CNC Machine Control Unit

CNC machines have far more capability than their predecessor. Some of the enhancements that came along with CNC include: Canned Cycles, Sub Programming, Cutter Compensation, Work coordinates, Coordinate system rotation, automatic corner rounding, chamfering, and B-spline interpolation.

3. Advantages and Disadvantages of Computer Numerical Control (CNC) Systems

A. Advantages

- High Repeatability and Precision e.g. Aircraft parts.
- Volume of production is very high.
- Complex contours/surfaces need to be machined.
- Flexibility in job change, automatic tool settings, less scrap.
- Safer, higher productivity, better quality.
- Less paper work, faster production, reduction in lead times.

B. Disadvantages

- Costly setup, skilled operators.
- Computers, programming knowledge required.
- Maintenance is difficult.

4. Direct Numerical Control (DNC) System

Direct Numerical Control (DNC) is a system that uses a central computer to control several machines at the same time. It's a 1960s technology, which uses two way communication systems.

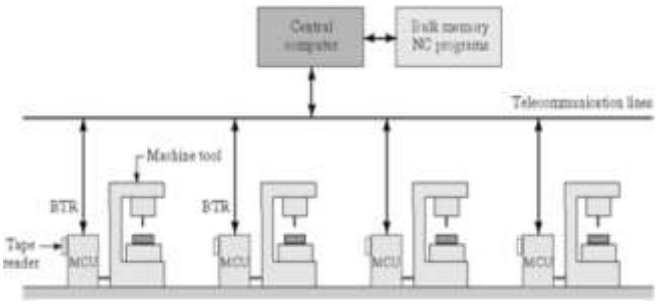

Figure 3: Configuration of DNC Machine Control Unit

DNC involved the control of a number of machine tools by a single mainframe computer through direct connection and in real time. The tape reader is omitted in DNC System, thus relieving the system of its least reliable components. Instead of using the tape reader, the part program is transmitted to the machine tool directly from the computer memory. The DNC Computer is designed to provide the instructions to each machine tool on the demand. DNC also involves the data collection and processing from the machine tool back to the computer. Two types of DNC System are used:

1. Behind the Tape Reader (BTR) System,
2. Special Machine Control Unit (SMCU).

5. Advantages of Direct Numerical Control (DNC) Systems

There are various advantages provided by DNC system. These are as follows:

1) Easy and Effective programming using DNC Software.
2) Higher level of decision making.
3) Real time control of various machine tools.
4) First step which gives hands on experience for future expansion.
5) Elimination of Punched Tape and Tape Reader.
6) CLFILE- A Convent and more general way of program storage.
7) Elimination of hardwired controller unit on some system.
8) Greater Productivity.
9) Convenient Storage of NC Part Program.
10) Greater Computational ability.
11) Location of central computer in remote and clean environment.
12) Effective support to management information system.
13) Effective data collection and reporting.
14) Enhanced manufacturing flexibility by real time rescheduling.

6. Part Programming Languages

The Part Programming Languages are used to define the Manufacturing operation processes and sequence to the computer. The following part programming languages are used:

1) Automatically Programmed Tools (APT): The APT language consists of many different types of statements made up of the following valid letters, numerals and punctuation marks.
2) Adaptation APT (ADAPT) was the first attempt to adapt APT programming system for smaller computers.
3) Automatic System for Positioning Tools (AUTOSPOT) was developed by IBM and first introduced in 1962.
4) Extended subset of APT (EXAPT) was developed jointly in German in about 1964 by several universities to adapt APT for European use. It is compatible with APT and thus can use the same processor as APT.
5) COMPACT was developed by Manufacturing Data Systems, Inc. (MDSI).
6) Sundstrand Processing Language Internally Translated (SPLIT) was developed by Sundstrand Corporation, intended for its own machine tools.
7) Micro-APT (MAPT) is a subset of APT, to be run on the microcomputers.

7. Distributed Numerical Control System

Distributed Numerical Control is a technology that allows a single computer to be networked with one or more machines that use computer numerical control (CNC). In the Distributed Numerical Control (DNC), the central computer downloads complete programs to the CNC machines, which can be workstations or PCs, and can get the information for the machine operations. The speed of the system is increased, large files can be handled and the number of machine tools used is expanded.

Using the Distributed Numerical Control System, an operator can speedily load CNC programs into several machines. It is also feasible to eliminate programs and substitute them with efficient programs. CNC system allows machines, such as drill presses or lathes, to perform multifaceted and repetitive tasks automatically. In this perspective, DNC System facilitates the remote control of multiple programmable robots.

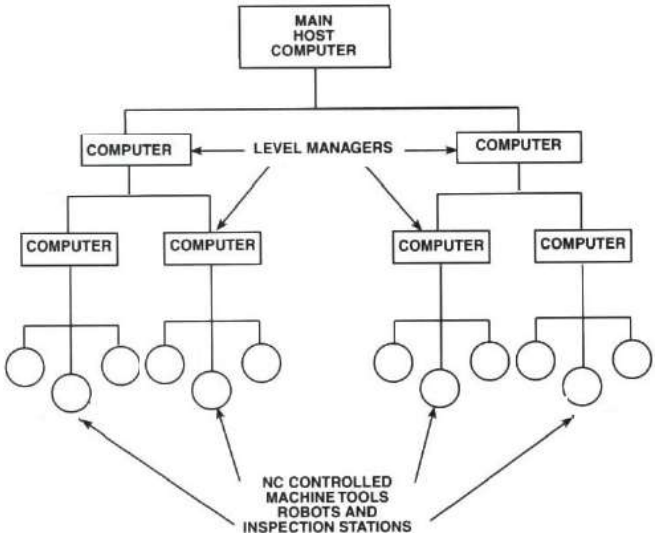

Figure 4: Distributed Numerical Control Network

The Distributed Numerical Control System controls the other computers which are connected in series and those entire computers control the machine control unit, which are configured to the machine tools.

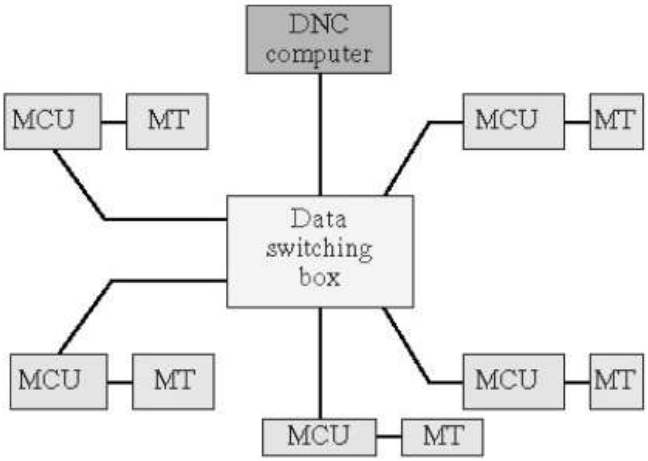

Figure 5: Distributed Numerical Control Configurations - Switching Network

The Distributed Numerical Control System controls the flow of data and information between central computer and machine tools. It download the data and information from the central computer and transfer it to the Machine Tools and Shop Floor, Then collect the data and information from the Machine Tools and Shop Floor and transfer it to the central computer.

The DNC System collects NC Part Programs, List of tools needed for the job, Machine Tool setup instructions, Machine operator instructions, Machine cycle time for part program, Data about the past information of the program, Production schedule information from the central computer, and transfer it to the machine tools and shop floor. After that, DNC System collect data and information of Piece counts, Actual machining cycle times, Tool life statistics, Machine uptime and downtime statistics, Machine utilization, Reliability, Product Quality Data from the Machine Tool and Shop Floor and transfer it to the Central Computer.

The switching network is the simplest DNC system to Configure. It uses a data switching box to make a connection from the central computer to the attached CNC Machine for downloading and uploading the data and information.

8. Advancements of Distributed Numerical Control System

The Distributed Numerical Control System has much of advancements over CNC/DNC System. The following are the major advancements:

1) Capability to connect and maintain entire computers properly in a sequence.
2) Level Managing.
3) Reduced Machine Tools Inspection Requirements.
4) Feedback System is stronger.
5) Data Storage.
6) Backup System for Data & Information.
7) Reduced Non-Productive time.
8) Greater Accuracy and Repeatability.
9) Lower scrap rates.
10) More complex part geometries are possible.
11) Engineering changes can be accommodated more gracefully.
12) Simpler fixtures are needed.
13) Shorter manufacturing lead times.
14) Reduced parts inventory.
15) Less floor space required.
16) Operator skill-level requirements are reduced.

9. Applications of Distributed Numerical Control System

The Distributed Numerical Control System has many applications in the manufacturing field. The flexible manufacturing system also based on distributed numerical control system. In the modern manufacturing the distributed numerical control system plays a vital role. It has many applications such as:

1) Electrical wire wraps machines.
2) Components insertion machines.
3) Drafting machines.
4) Coordinate measuring machines.
5) Tape laying machines for polymer composites.
6) Filament winding machines for polymer composites.
7) Cutting, Knitting and Riveting machines.
8) Continuous and Flexible Production.
9) Complex part geometry operations.
10) Many separate machining operations on the part.
11) Thermal cutting machines.
12) Sheet metal and highly curvature based machines etc.

10. Comparison Chart of CNC, DNC and Distributed Numerical Control System

The chart is showing the comparison among the Computer Numerical Control, Direct Numerical Control and Distributed Numerical Control on the basis of various methodologies:

Description	Computer Numerical Control System	Direct Numerical Control System	Distributed Numerical Control System
Production System used	Batch Production	Mass Production	Very Heavy Mass Production
Computerization System	Single Computer used to control Machine	One computer control more than one machine	A centralized computer controls all computers that control a no. of machines
Programming	Manual/ Automatic Programming	Automatic Programming	Efficient Automatic Programming
Flexibility	Good	Better	Best
Memory Storage Capacity	Normal Memory Storage	Bulk Memory Storage	Very Heavy Memory Storage
Communication Lines	Normal Communication Lines	Telecommunication Lines	Super-Telecommunication Lines
Product Quality and Quantity	Ordinary	Enhanced	Tremendous
Machine Control Technology	General Control	Modern Control	Smart Control
Reliability	Good	Better	Superior
Feedback System	Normal	Better	Efficient & High-tech
Performance	Standard	Greater	Superior
Data Collection and Reporting	Poor	Good	Greater
Technology Used	CAM	CAD/CAM	CAD/CAM/CAPP/CAE
Type of Systems	Hybrid and Straight	BTR and SMCU	Distributed
Backup System	Normal	Better	Stronger

11. Conclusion

The Modern Manufacturing System is based on computerization (CAD/CAM/CIM/CAPP). So, it is required to design a system, which is highly efficient, take lower production time with higher precision and accuracy.

Since, Computer Controlled Machining has evolved over the course of several decades; its current iteration is more sophisticated in terms of precision, automation and production speed than any of its previous forms, including NC programming.

The Distributed Numerical Control System fulfill all above requirement. This system has much advancement over NC/CNC/DNC System, which are already discussed in this paper. Thus, a parametric study of NC/CNC/DNC System shows the advancements of higher efficient and accurate Distributed Numerical Control System.

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