A Laboratory Manual for

Computer Aided Manufacturing (3161917)

B.E. Semester 6 (Mechanical)

Directorate of Technical Education, Gandhinagar, Gujarat

Compter Aided Manufacturing
(3161917)

Lab Manuals
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Certificate

This is to certify that Mr./Ms. _____ _____ Enrollment No. _____ of B.E. Semester VI Mechanical Engineering of this Institute (GTU Code: 031) has satisfactorily completed the Practical / Tutorial work for the subject **Computer Aided Manufacturing (3161917)** for the academic year 2023-24.

Place: _____

Date: _____

Name and Sign of Faculty member

Head of the Department

Preface

This lab manual is meticulously crafted to guide you through an exploration of essential components in modern manufacturing, spanning from NC/CNC Machine Tools to Integrated Production Management Systems. The field of Computer-Aided Manufacturing is a testament to the transformative power of technology, with its ability to enhance precision, efficiency, and flexibility in the production environment. As you embark on this educational journey, you will delve into key aspects of CAM, gaining hands-on experience and a profound understanding of the tools and systems that define contemporary manufacturing practices.

Uncover the intricacies of Numerical Control (NC) and Computer Numerical Control (CNC) machine tools. Learn how these technologies have evolved to redefine machining processes, allowing for unparalleled precision and automation. Through practical exercises, you'll grasp the principles behind programming and operating CNC machines, unlocking the potential for intricate and efficient part production.

Explore the world of Programmable Logic Controllers, the backbone of industrial automation. Understand how PLCs facilitate seamless integration and control of various manufacturing processes. Hands-on activities will guide you in programming and troubleshooting PLCs, empowering you to harness their capabilities in real-world scenarios.

Investigate the concept of Group Technology and its role in organizing manufacturing processes. Dive into Computer-Aided Process Planning, a critical component in streamlining production workflows. Through case studies and exercises, grasp the art of efficient process planning that optimizes resources and minimizes production time.

Enter the era of flexibility in manufacturing. Explore how Flexible Manufacturing Systems adapt to varying production requirements, allowing for rapid changes and enhanced productivity. Engage in simulations and practical exercises to understand the intricacies of designing and operating FMS.

Embrace the future with an exploration of Robot Technology in manufacturing. Understand the diverse roles robots play, from material handling to complex assembly tasks. Practical sessions will acquaint you with programming and interfacing robots, unleashing their potential for precision and efficiency.

Gain insights into the holistic approach of an Integrated Production Management System. Learn how information flows seamlessly across various stages of manufacturing, from design to delivery. Through case studies, comprehend the significance of integration in optimizing resources and ensuring a responsive and agile production environment.

Practical – Course Outcome matrix

Course Outcomes (COs):

CO-1   Illustrate Computer Aided Manufacturing with NC, CNC and PLC technology for Industry

CO-2   Describe the Group Technology and Computer Aided Process Planning.

CO-3   Describe Flexible Manufacturing System with tools and equipment's.

CO-4   Describe Robot technology for Computer Aided Manufacturing system.

CO-5   Demonstrate Integrated Production Management system.

Sr. No.	Objective(s) of Experiment	CO 1	CO 2	CO 3	CO 4	CO 5
1.	To study about basics of Computer Aided Manufacturing.	√				
2.	A Study of Numerical Control, Numerical Control Machine Tool and their working.	√				
3.	Study of CNC, VNC, DNC and Adaptive control and Prepare detail specification for CNC Turning Center and CNC Machining Center	√				
4.	Practice CNC Part programme for given Components.	√				
5.	To Study about Programmable Logical Controller. Prepare ladder Logic diagram for given exercises.	√				
6.	Study and Practice about Group-Technology.		√			
7.	Study of Computer Aided Process Planning and prepare process plan for machining component.		√			
8.	Study of Automatic Material Handling Equipment.			√		
9.	To study Role of Robot in Manufacturing and Collect the application of robot in automobile industries.				√	
10.	To Study About Computer Aided Production Planning.				√	

Industry Relevant Skills

Computer-Aided Manufacturing (CAM) is a critical aspect of modern manufacturing processes, where computer software and machinery are used to automate and control manufacturing operations. To thrive in the field of Computer-Aided Manufacturing, it's essential to possess a combination of technical skills, software proficiency, and industry knowledge. Here are some industry-relevant skills for Computer-Aided Manufacturing:

1. **CAD Software Proficiency:**

   Knowledge of Computer-Aided Design (CAD) software is fundamental for creating 3D models of components or products. Familiarity with software like AutoCAD, SolidWorks, or CATIA is valuable.

2. **CAM Software Proficiency:**

   Mastery of CAM software is crucial for generating toolpaths and instructions for CNC (Computer Numerical Control) machines. Examples include Mastercam, Siemens NX CAM, or CAMWorks.

3. **CNC Programming:**

   Understanding and proficiency in CNC programming is essential. This includes knowledge of G-code and M-code programming languages, as well as the ability to optimize toolpaths for efficiency and precision.

4. **Materials and Processes Knowledge:**

   Understanding the properties of different materials and manufacturing processes is vital. This includes knowledge of machining techniques, tool selection, and material behavior during manufacturing.

5. **Mathematics and Geometry:**

   Strong mathematical skills, particularly in geometry and trigonometry, are necessary for creating precise toolpaths and understanding the spatial relationships in a manufacturing environment.

6. **Problem-Solving Skills:**

   CAM professionals often encounter challenges during the manufacturing process. The ability to troubleshoot, identify issues, and implement solutions is crucial.

7. **Automation and Robotics:**

   Knowledge of automation systems and robotic applications in manufacturing is becoming increasingly important. Familiarity with robotic programming and integration is a valuable skill.

8. Quality Control:

Understanding quality control processes and techniques is essential to ensure that manufactured components meet specified tolerances and standards.

9. Computer Skills:

Proficiency in general computer skills, including data management, file organization, and system troubleshooting, is important for efficient CAM operations.

10. Communication Skills:

Effective communication skills are essential for collaborating with design teams, engineers, and other stakeholders. Clear communication helps in understanding manufacturing requirements and ensuring that designs are manufacturable.

11. Industry-specific Knowledge:

Staying updated on industry trends, advancements in manufacturing technologies, and evolving standards is crucial for maintaining relevance in the CAM field.

Guidelines for Faculty members

1. Teacher should provide the guideline with demonstration of practical to the students with all features.
2. Teacher shall explain basic concepts/theory related to the experiment to the students before starting of each practical
3. Involve all the students in performance of each experiment.
4. Teacher is expected to share the skills and competencies to be developed in the students and ensure that the respective skills and competencies are developed in the students after the completion of the experimentation.
5. Teachers should give opportunity to students for hands-on experience after the demonstration.
6. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected from the students by concerned industry.
7. Give practical assignment and assess the performance of students based on task assigned to check whether it is as per the instructions or not.
8. Teacher is expected to refer complete curriculum of the course and follow the guidelines for implementation.

Instructions for Students

1. Students are expected to carefully listen to all the theory classes delivered by the faculty members and understand the COs, content of the course, teaching and examination scheme, skill set to be developed etc.
2. Students shall organize the work in the group and make record of all observations.
3. Students shall develop maintenance skill as expected by industries.
4. Student shall attempt to develop related hand-on skills and build confidence.
5. Student shall develop the habits of evolving more ideas, innovations, skills etc. apart from those included in scope of manual.
6. Student shall refer technical magazines and data books.
7. Student should develop a habit of submitting the experimentation work as per the schedule and s/he should be well prepared for the same.

Common Safety Instructions

Safety is a top priority in any laboratory setting, including Computer-Aided Manufacturing (CAM) laboratories. Here are some common safety instructions that should be followed in a CAM laboratory:

o Always wear appropriate personal protective equipment (PPE) such as safety glasses, ear protection, gloves, and any other necessary gear based on the specific processes and equipment being used.

o Avoid loose clothing, jewelry, or accessories that could get caught in machinery. Wear appropriate clothing that covers the body to provide an additional layer of protection.

o Ensure that all personnel operating CAM equipment are properly trained and have a thorough understanding of the equipment's operation, emergency procedures, and safety features.

o Know the location and proper use of emergency stop buttons on machines. In case of an emergency or unexpected event, be prepared to quickly shut down equipment to prevent accidents.

o Familiarize yourself with the MSDS for all materials used in the CAM processes. This includes information on potential hazards, safe handling procedures, and emergency measures.

o Ensure that all machines have proper guards and barriers in place. Do not remove or bypass safety features on machinery, as they are designed to protect users from potential hazards.

o Adhere to proper electrical safety practices, such as using grounded equipment, avoiding frayed cords, and being cautious around electrical panels. Report any electrical issues immediately.

Index
(Progressive Assessment Sheet)

Sr. No.	Objective(s) of Experiment	Page No.	Date of perform ance	Date of submiss ion	Assessme nt Marks	Sign. of Teacher with date	Remar ks
1	To study about basics of Computer Aided Manufacturing.						
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3	Study of CNC, VNC, DNC and Adaptive control and Prepare detail specification for CNC Turning Center and CNC Machining Center						
4	Practice CNC Part programme for given Components.						
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10	To Study About Computer Aided Production Planning.						
	Total						

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DEPARTMENT OF MECHANICAL ENGINEERING
GOVERNMENT ENGINEERING COLLEGE, PATAN
COMPUTER AIDED MANUFACTURING (3161917)
B. E. VI SEM

EXPERIMENT NO: 1   DATE:

AIM: To study about basics of Computer Aided Manufacturing.

Concepts:

Computer-Aided Manufacturing (CAM) represents the use of computer systems to plan, manage, and control manufacturing operations. It encompasses a broad range of technologies and processes that leverage computer-based systems to enhance efficiency and precision in manufacturing.

Objectives:

- **Automation:** CAM aims to automate various aspects of the manufacturing process, reducing manual intervention and improving accuracy.

- **Precision and Efficiency:** The primary objective is to achieve higher levels of precision in manufacturing processes, leading to improved product quality. Increased efficiency and reduced production time are also key goals.

- **Cost Reduction:** CAM seeks to optimize resource utilization, minimize wastage, and ultimately reduce production costs.

- **Flexibility:** The ability to adapt quickly to changing production requirements is a crucial objective. CAM systems often support flexible manufacturing processes to accommodate varying demands.

- **Integration:** Integration of various stages in the manufacturing process, from design to production and beyond, is a fundamental goal. This ensures seamless data flow and coordination.

Scope:

The scope of CAM is vast and encompasses various facets of manufacturing, including:

- **Computer-Aided Design (CAD):** Integration with CAD systems for efficient product design.
- **Computer-Aided Process Planning (CAPP):** Optimizing the planning phase for manufacturing processes.
- **Numerical Control (NC) and Computer Numerical Control (CNC):** Automation of machine tools for precision manufacturing.
- **Robotics and Automation:** Utilizing robots for tasks such as assembly, material handling, and inspection.
- **Flexible Manufacturing Systems (FMS):** Implementing systems that can adapt to different production requirements.
- **Integrated Production Management Systems:** Coordinating and managing information flow across the entire production cycle.

Nature & Type of Manufacturing System:

- **Nature:**

  CAM systems are inherently dynamic and responsive to the evolving needs of the manufacturing industry. They exhibit the following characteristics:

  - **Digital Integration:** Processes are digitized and interconnected, allowing for seamless data exchange.
  - **Adaptability:** CAM systems are designed to adapt to changes in product design, production volume, and other variables.
  - **Real-time Monitoring:** Real-time data monitoring and analysis contribute to better decision-making.
  - **Interdisciplinary:** CAM involves collaboration between various disciplines, such as engineering, computer science, and management.

- **Types of Manufacturing Systems:**

  - **Mass Production Systems:** Characterized by high-volume, standardized production processes. CAM helps optimize efficiency and reduce costs in mass production.

- **Batch Production Systems:** Involves producing a limited quantity of products in batches. CAM facilitates efficient planning and execution of batch production.
- **Job Shop Production Systems:** Customized production of low-volume, specialized products. CAM aids in adapting to diverse product requirements.
- **Project Manufacturing Systems:** CAM supports project-based manufacturing, where products are unique and produced for specific projects.
- **Flexible Manufacturing Systems (FMS):** Incorporates computer-controlled machines and automation to handle various production tasks, allowing for flexibility in product types and volumes.

Evolution:

The evolution of CAM can be traced from the early stages of manual control to the sophisticated, computer-based systems of today. Key milestones include the development of Numerical Control (NC), the integration of CAD and CAM, the rise of robotics, and the emergence of smart manufacturing concepts. The continuous evolution of CAM is driven by advancements in computing technology, automation, and a growing emphasis on Industry 4.0 principles. As technology continues to progress, CAM will likely play a pivotal role in shaping the future of manufacturing.

Benefits of CAM:

- **Precision and Accuracy:** CAM systems enable high precision and accuracy in manufacturing processes, reducing errors and ensuring consistent product quality.
- **Efficiency and Productivity:** Automation in CAM leads to increased production efficiency, reduced cycle times, and enhanced overall productivity.
- **Cost Reduction:** By optimizing resource utilization, minimizing waste, and streamlining processes, CAM contributes to cost reduction in manufacturing.
- **Flexibility:** CAM allows for quick adaptation to changes in production requirements, supporting flexible manufacturing systems that can handle diverse products and volumes.
- **Integration:** Seamless integration with other systems (such as CAD, CNC, and PLCs) ensures a smooth flow of information across the entire manufacturing process.
- **Time Savings:** CAM reduces lead times by automating tasks and accelerating the production

cycle, enabling faster time-to-market for products.

- **Customization and Complexity Handling:** CAM systems are capable of handling complex designs and enable the efficient production of customized and intricate components.
- **Data-Driven Decision Making:** Real-time monitoring and data analysis provide valuable insights for decision-making, helping in optimizing processes and identifying areas for improvement.

Role of Management in CAM:

- **Strategic Planning:** Management plays a crucial role in developing a strategic plan for the implementation of CAM, aligning it with overall organizational goals.
- **Resource Allocation:** Efficient allocation of resources, including personnel, technology, and finances, is essential for successful CAM implementation.
- **Training and Development:** Management ensures that the workforce receives adequate training and development to operate and maximize the benefits of CAM systems.
- **Change Management:** Implementing CAM often involves significant changes in processes and workflows. Management oversees effective change management strategies to minimize resistance and facilitate smooth transitions.
- **Quality Assurance:** Management is responsible for establishing and maintaining quality standards in CAM processes, ensuring that the final products meet or exceed customer expectations.
- **Risk Management:** Identifying potential risks associated with CAM implementation and developing strategies to mitigate them are critical management responsibilities.

Concepts of Computer Integrated Manufacturing (CIM):

Integration of Systems: CIM involves the seamless integration of various manufacturing systems, such as CAD, CAM, CNC, PLCs, and others, to create a unified and interconnected environment.

- **Data Exchange:** CIM emphasizes the exchange of data and information across different stages of the manufacturing process, promoting a cohesive flow of information.
- **Interdisciplinary Approach:** CIM takes an interdisciplinary approach, involving collaboration between different departments, such as design, engineering, production, and management.
- **Automation:** Automation is a key component of CIM, with the goal of minimizing manual intervention and maximizing efficiency in manufacturing operations.

- **Holistic View:** CIM provides a holistic view of the entire manufacturing process, from product design and planning to production and beyond.

Impact of CIM on Personnel:

- **Skill Enhancement:** The implementation of CIM requires personnel to acquire new skills, especially in areas such as computer programming, automation, and data analysis.
- **Job Redefinition:** CIM may lead to a redefinition of job roles, with a shift towards more supervisory and decision-making responsibilities rather than manual tasks.
- **Increased Productivity:** Personnel may experience increased productivity and job satisfaction as repetitive and mundane tasks are automated, allowing them to focus on more challenging and rewarding aspects of their roles.
- **Continuous Learning:** In a CIM environment, personnel need to embrace a culture of continuous learning to keep up with technological advancements and updates.

Role of Manufacturing Engineers:

- **System Design:** Manufacturing engineers play a key role in designing and implementing integrated manufacturing systems, ensuring they meet production requirements and goals.
- **Process Optimization:** Manufacturing engineers use their expertise to optimize manufacturing processes, leveraging CIM concepts to improve efficiency and quality.
- **Quality Assurance:** Ensuring product quality is a critical responsibility of manufacturing engineers in a CIM environment. They design and implement quality control measures throughout the production cycle.
- **Interdisciplinary Collaboration:** Manufacturing engineers collaborate with professionals from various disciplines, including design, engineering, and management, to ensure a smooth integration of CIM components.
- **Technology Adoption:** Manufacturing engineers are responsible for evaluating and adopting new technologies that align with CIM principles, keeping the manufacturing processes up-to-date and competitive.
- **Continuous Improvement:** Manufacturing engineers drive continuous improvement initiatives, leveraging CIM data and analytics to identify areas for enhancement and innovation in the manufacturing process.

MCQ Exercises:

1. What does CAM stand for?

    A) Computer-Aided Maintenance

    B) Computer-Aided Manufacturing

    C) Computer-Aided Modeling

    D) Computer-Aided Management

2. Which of the following is a key objective of CAM?

    A) Cost Increase

    B) Precision Reduction

    C) Efficiency Improvement

    D) Automation Elimination

3. CAM systems are designed to enhance which of the following in manufacturing processes?

    A) Complexity

    B) Inefficiency

    C) Precision

    D) Manual Intervention

4. What is a primary responsibility of management in CAM implementation?

    A) Minimizing Automation

    B) Increasing Manual Tasks

    C) Ensuring Efficient Allocation of Resources

    D) Avoiding Change Management

5. Quality Assurance in CAM is the responsibility of:

    A) Production Workers

    B) Marketing Team

    C) Management

    D) Maintenance Staff

6. CIM emphasizes the integration of which systems?

      A) Only CAM

      B) Only CAD

      C) Various Manufacturing Systems

      D) Only CNC

7. What is a key characteristic of CIM?

      A) Isolation of Systems

      B) Lack of Data Exchange

      C) Interdisciplinary Approach

      D) Manual Workflow

      Impact of CIM on Personnel

8. In a CIM environment, personnel may experience increased productivity due to:

      A) Increased Manual Tasks

      B) Automation of Mundane Tasks

      C) Decreased Skill Requirements

      D) Reduced Job Satisfaction

9. What does CIM stand for?

      A) Computer-Integrated Maintenance

      B) Computer-Integrated Modeling

      C) Computer-Integrated Manufacturing

      D) Computer-Integrated Management

10. What does the "Integration" sector in the CIM Wheel signify?

      A) Collaboration between Departments

      B) Manual Workflow

      C) Isolation of Systems

      D) Lack of Communication

Rubrics:

1. MCQ Exercises
2. Assignment Completion
3. Attendance
4. Submission
5. Attention in Laboratory

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						

_____

Signature of Subject Teacher

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EXPERIMENT NO: 2   DATE:

AIM: A Study of Numerical Control, Numerical Control Machine Tool and their working.

Introduction

Complexity of a product increases the time to produce a component as more time is consumed by operator in reading the drawing and checking dimension.

Today industry demands faster production in harder and tougher material. Conventional machine tools can not meet these demands.

Numerical control machine are highly flexible and are most economical for producing single or larger number of parts in batches. Numerical control is a form of digital control of machining process. It is a flexible method of automation which can change itself according to the combination of a machine tool and a control system no doubt that these control use characteristic and symbols.

Introduction to NC machine tool

It is the main components of a Numerical Control system, which executes the operations.
It includes different parts / sub assemblies

- work table
- cutting tool
- jigs and fixture
- motors for during spindle and tool
- coolant and lubricating system

Latest development in Numerical Control machine tools is the versatile machining centre. This is a single machine capable of doing a number of operations such as drilling, reaming, tapping, milling and boring. All types of tools are mounted on a drum/chine or egg box type which is put into the spindle by automatic tool changer under the control of tool selection instruction.

Difference between using special purpose machine and numerical control machine

- ▪ **SPECIAL PURPOSE MACHINE**

They have fixed sequence of operations with little or no variations t machine a part.

1) Suitable for mass production having identical parts.
2) The machine requires more time for setting up.
3) The program or sequence of operations is built into hardware.
4) It has less scope of variation as it is too costly.

- • **NUMERICAL CONTROL MACHINE**

1) This is a flexible method in which the sequence of operation can be changed to machine a new part.
2) This can be applied to short/batch production runs or even a single part.
3) Complex setting up procedure are almost by passed in this machine programmed is stored as software.
4) These machines have large scope for variation of different products without involvement of high cost.

Basic components of numerical control machine tools

There are Three basic components : -

1) PROGRAM OF INSTRUCTION

It is the detailed step by step set of direction which tells the machine tool what to do. It is coked in numerical or symbolic form of some type of input medium that can be interpreted by the controller unit. The forms of input media are punching card, magnetic tape, even 35mm motion picture film. The program of introduction is prepared by someone called a part programmer.

2) CONTROLLER UNIT

This consists of the electronics and hardware that read and interpretation the program of instruction and convert it into mechanical action of the machine tool. A conventional Numerical Control unit includes the tape reader, a data buffer, signal out put channels to the machine tool, feedback channels from the machine tool and the sequence controls to coordinates the overall

operation of foregoing elements.

The data contained on tape are read into data buffer, the purpose of this device is to store the input instruction in logical blocks of information. A block of information usually represents one complete step in the sequence of processing elements.

The signal output channels are connected to the servomotor and other controls in the machine tool, through these channels the instructions are sent to the machine tool from controller unit.

Sequence controls coordinate the activity the other elements of the controllers unit.

3) MACHINE TOOLS OR OTHER CONTROLLED PROCESS

It is the part of Numerical Control that performs useful work. The machine tool consists of the worktable and spindle as well as the motors and controls necessary to drive then it also includes the cutting tools, work fixtures and other auxiliary equipments needed to machining operation. Machining centre is capable of producing variety of different operations.

Drilling, Tapping, Reaming, Milling, Boring.

It has the capacity to change tool drum of other holding device. The machine tables can ouent the job so that it can be machined on several surfaces.

The NC Procedure

1) PROCESSING PLANNING

The engineering drawing of the work part must be interpreted in terms of manufacturing process to be used. This step is referred to as process planning and it is concerned with the preparation of a route spect route spect is a listing of the sequence of operations which must be performed on the workpart.it also lists the machine through which the part must be routed.

2) PART PROGRAMMING

A part programming plans the process for the portions of the job to the accomplished by NC. These are ways to program for NC.

- Manual part programming
- Computer assisted part programming

In manual part programming, the machining instruction is prepared on a form called a part program monuseight. in complete aided part programming much of tediously computational work require in manual part programming is transferred to the computer. this is especially appropriate

for complex work piece geometry.

3) TAPE PREPARATION

A punched tape is prepared form the part programmers NC process plan. In manual part programming, the part punch tape is prepared directly from the part programmed many slight on a type writer like devices equipped with tape punching capability.

4) TAPE VERIFICATION

After the punched type has been prepared a method its usually provided for checking the accuracy of the tape. Sometimes the tape is checked by running it through a computer program which plots the various tool movements on paper.

5) PRODUCTION

The final step in NC procedure is to use the NC tape in production. This involves ordering the raw work parts, specifying and preparing the fooling and any special fixturing that may be require and setting up the NC machine tool for the job.

Classification of numerical control system

1) ACCORDING TO TYPE OF MACHINE

- POINT TO POINT SYSTEM

Here the work piece is moved with respect to the cutting tool unit arriving at a numerically defined position and then the motion is stopped.The cutting tool performs its job when the axes are without motion and then the work piece moves to the next point and the cycle is repeated. The path of the cutting tool and its feed while traveling from one point to the next one are without any significance. The system would required only position, loops for controlling the final position of the tool when reaching the place to be drilled.

(a)   Point-to-point

Drilling and boring

Workpiece

X·Y Plane of tool movement
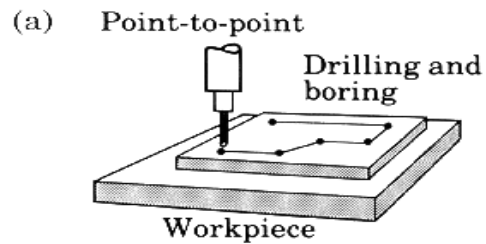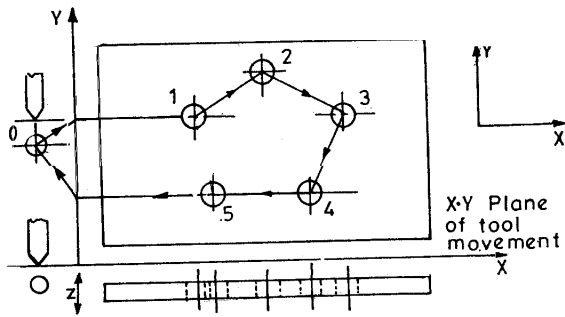
- CONTOURING SYSTEM

    Here control of cutting tool is performed while the axes of motion are moving. all axes of motion might move simultaneously, each one with a different speed, while this speed may be changed even within the path bet – two given points. the path of cutting tool and its feed are establishing the desired contour of part and at some tome the feed also affects the surface finish, system has to contain in addition to position control loops as well.

contouring
continuous path

3-axis contour milling
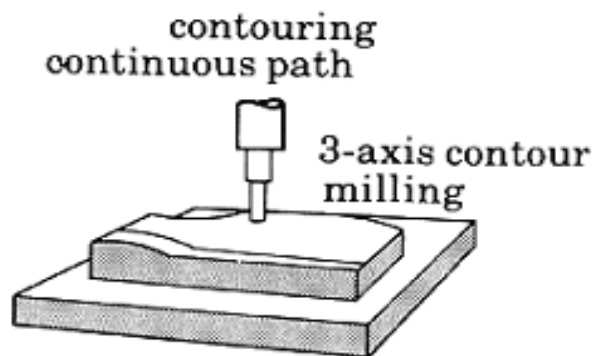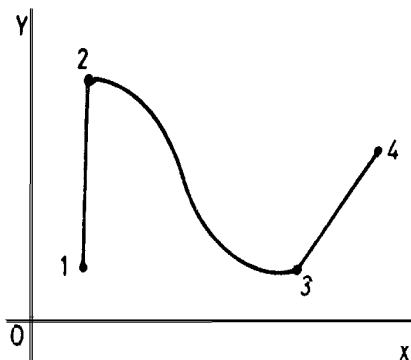
- STRAIGHT CUT SYSTEM

    The cutting tool can move only along straight lines which are parallel to the main axes of motion of ht machine tool. In a straight cut system the feed is programmed on the tape and maybe selected by the programmer.

straight line

Milling
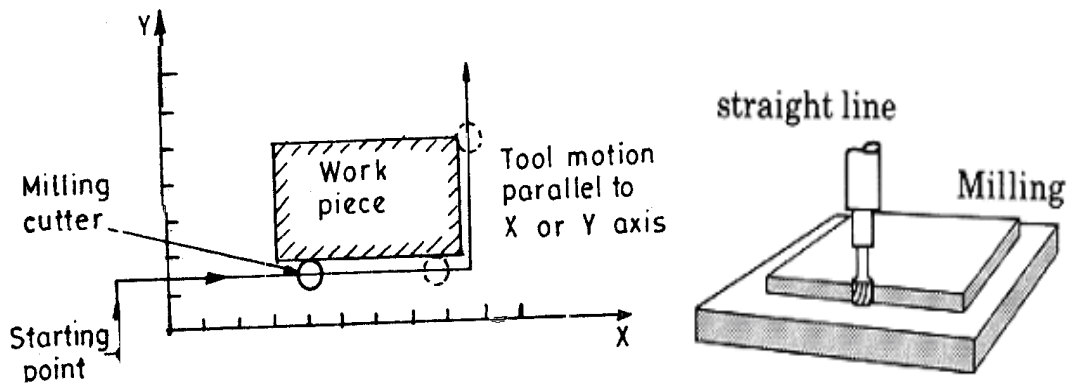
4) ANALOG AND DIGITAL CONTROL

In analog control system the quantities may be varied continuously while in digital system they are varied discreetly such as presented or absence of a quantity. The shortest cycle of presence absence is the resolution of the digital system and establishes its accuracy. Each such cycle of information provides a voltage pulse where each pulse represents a basic length unit which determines the system resolution.

Both digital and analog controls are used in Numerical System of machines tools. The input to Numerical Control systems is always digital, as the dimensions that are taken from the drawling are given in number which is digital form. The output of Numerical Control system is always analog, as the slides of the machine tool are moving in a continuous and smooth form.

ANALOG CONTROL SYSTEM   DIGITAL CONTROL SYSTEM
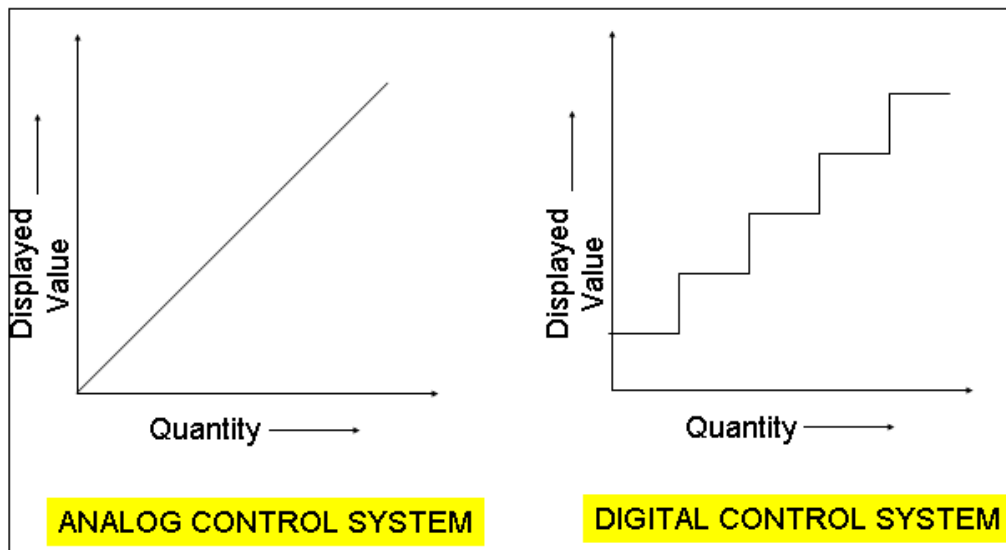
5) OPEN LOOP AND CLOSE LOOP SYSTEM
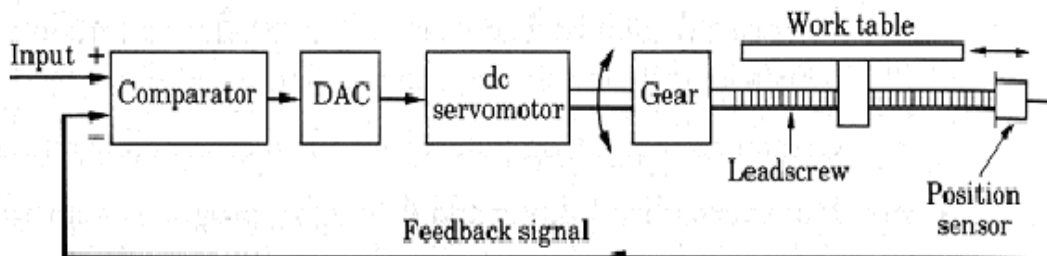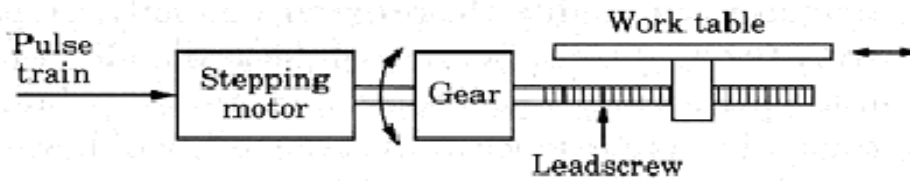
Open loop control has no feed back and the action of controller has no reference to result it produces. Open loop NC systems are always digital types are using stepper motor for driving slides.

The close loop control measures the axis actual position and compares it with the desired reference position. The difference between the actual and desired values is error; the control is designed in such a way as to eliminate or to reduce to a minimum.

Machine control unit (MCU)

Every machine tool has main unit which is known as MCU, consists of some electronics circuitry that reads NC programs. Interpreted it and conversely translate it for r mechanical action of machine tool.

TYPES: -

- HOUSED MCU :

    This MCU may be mounted on machine tool or may be built in casing of machine.

- SWING AROUND MCU :

    MCU is directly mounted on machine which can "swing around" and it can be adjusted as par reference of operations.

- STAND ALONE MCU :

    It is enclosed in separate cabinets which are installed in at some, remote or some

place near to machine.

Input media used by NC machine

The input media used by NC machine can be grouped under following categories.

1) PUNCHED CARDS

Joseph Maria was the first person to use cards with punched holes as an input media on automatic weaving machine for guiding threads through holes.

The two type of punched cards

1) chivac
2) JBM

Have different information codes approximately equal sign to an Indian past card or 7 3/8" * 3 ¼".

It has 80 columns and rows where the data is punched in the form of rectangles holes or no holes. The card are made of first stiff paper and with a careful use, they can be processed through a mechanical card recorder for a number of times. The punching position are marked with a no representing its row which is helpful in easily identifying the position by raked eye. One card is used for punching 72 characters and if an instruction is large, then it may be continued an succeeding cards, punching the last character on each card as '$'.

2) MAGNETIC TAPE

This was first information medium used with the first NC machines. Magnetic tapes are made of plastic material and are coated with brown colored gamma ferric oxide layer which can be magnetized and demagnetized easily. These are usually 25.4mm wide, with a capacity of 2 characters per mm and available in 6mm width. It has usually 7 channels on which the data is recorded in the form of small magnetic spots. The data can be accessed in sequential form

Its advantages are:

- Greater information storage capacity.
- Information can be erased and used again.
- Directly compatible with computer information codes.
- Best suitable for complex contouring system due to large data.

3) FLOPPY DISK

Floppy disks have brought a revolution in computer technology. These are made up of Mylar and again coated with magnetic aside. They are random access media means that data can be accessed from any where on the disk and in any fashion. The data on the disk is organized on tracks and sectors. They are available in variety of signs and capacities. If data recorded is not to be charged again and is only needed reading then the write protector notch is closed with a tape. The precaution while using a floppy are

- Never bend it.
- Never press it inside a load etc.
- Avoid placing in magnetic fields.
- Avoid dust and dirt near it.

Applications of numerical control

The most common applications of NC is for metal cutting machine tool within this category NC equipment performs.

Milling

Drilling and related process

Boring

Turning

Grinding

Sawing

Small lot and batch production jobs represents the idea situates for the application of NC.

If engineering design changes or shifts in the production schedule are likely. The use of tape control provides the flexibility need to adopt to these changes.

If quickly and inspection are important issues. NC would be most suitable, owing to its high accuracy and repeatability.

Advantages of NC:

1) REDUCED NON PRODUTION TIME:

NC machine accomplish this by means of fewer setups, less time in setting up, reduces work piece handling time automatic tool changing on same machine.

2) REDUCED FIXTURING:

NC requires fixtures which are simpler and less costly to fabricate because the positioning is done by NC tape rather than the jig and fixture.

3) REDUCED MANUFACTURING LEAD TIME:

Because jobs can be set up more quickly with NC and fewer setups are generally required with NC the load time to deliver a job to customer is reduced.

4) GREATER MANUFACTURING FLEXIBILITY:

With NC it is less difficult to adopt engineering design changes alteration to production schedule change over in jobs for rush orders and so on.

5) IMPROVED QUALITY CONTROL:

Numerical Control produces parts with greater accuracy reduced scrap and lower inspection requirement.

6) REDUCED INVENTORY:

Owing to fewer setups and shorter load times with NC the amount of inventory carried by the company is reduced.

7) REDUCE FLOOR SPACE REQUIREMENT:

Since one NC machining centre can accomplishs the production of several conventional machines the amount of floor space require in NC shop is usually less.

Disadvantages of NC

1) HIGHER INVESTMENT COST

NC machine tools represents a more sophisticated and complex technology. This technology costs more to buy the higher cost required manufacturing management to use these machines more aggressively than ordinary equipments.

2) HIGHER MAINTANENCE COST

Because NC machine are used harder the maintenance problems becomes more acute.

3) FINDING AND/OF TRAINING NC PERSSONAL:

Certain aspects of NC stop operations require a higher skill level than conventional operations. Part programmers and NC maintenance personnel are two skill areas where available personnel are in short supply.

4) MANAGEMENT INFORMATION

The conventional NC system is not equipped to provide timely information on operational performance to management.

MCQ Exercises:

1. What does NC stand for in the context of manufacturing?

    A) Numerical Computation

    B) Numerical Control

    C) Non-Conventional

    D) Network Control

2. What is the primary purpose of the ball screw in CNC machines?

    A) Transmitting power

    B) Providing linear motion

    C) Controlling temperature

    D) Enhancing tool life

3. What is the role of a CNC controller in a machining process?

    A) Providing power to the machine

    B) Controlling the tool path and movement

C) Measuring temperature

D) Monitoring tool wear

4. Which type of sensor is commonly used for detecting the position of a tool in CNC machines?

A) Pressure Sensor

B) Proximity Sensor

C) Temperature Sensor

D) Light Sensor

6. Which type of motor is commonly used in CNC systems for precise positioning?

A) DC Motor

B) Stepper Motor

C) Induction Motor

D) Hydraulic Motor

7. In CNC machining, what does the "Z" axis typically represent?

A) Vertical Axis

B) Horizontal Axis

C) Radial Axis

D) Tangential Axis

8. What is the purpose of subroutines in CNC part programming?

A) Controlling coolant flow

B) Repeating a sequence of commands

C) Measuring tool temperature

D) Adjusting spindle speed

10 What do parametric subroutines allow in CNC programming?

A) Repeating a sequence with variable parameters

B) Controlling spindle speed

C) Adjusting tool diameter

D) Measuring workpiece temperature

Rubrics:

1. MCQ Exercises
2. Assignment Completion
3. Attendance
4. Submission
5. Attention in Laboratory

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						

_____

Signature of Subject Teacher

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EXPERIMENT NO: 3   DATE:

AIM: **Study of CNC, VNC, DNC and Adaptive control and Prepare detail specification for CNC Turning Center and CNC Machining Center**

Computer Numerical Control

Computer numerical control is a NC system that utilizes a dedicated, stored program computer to perform some or all of the basic numerical control functions. Because of the trend toward downsizing in computers, most of the CNC systems sold today use a microcomputer based controller unit. Over the years, minicomputers have also been used in CNC controls.

In CNC, the program is entered once and then stored in the computer memory. Thus unlike NC, tape reader is used only for the original loading of the part program and data. Compared to regular NC, CNC offers additional flexibility and computational capability. New system options can be incorporated into the CNC controller simply by reprogramming the unit. Because of this reprogramming capacity, both in terms of part programs and system control options, CNC is often referred to by the term "soft-wired" NC .
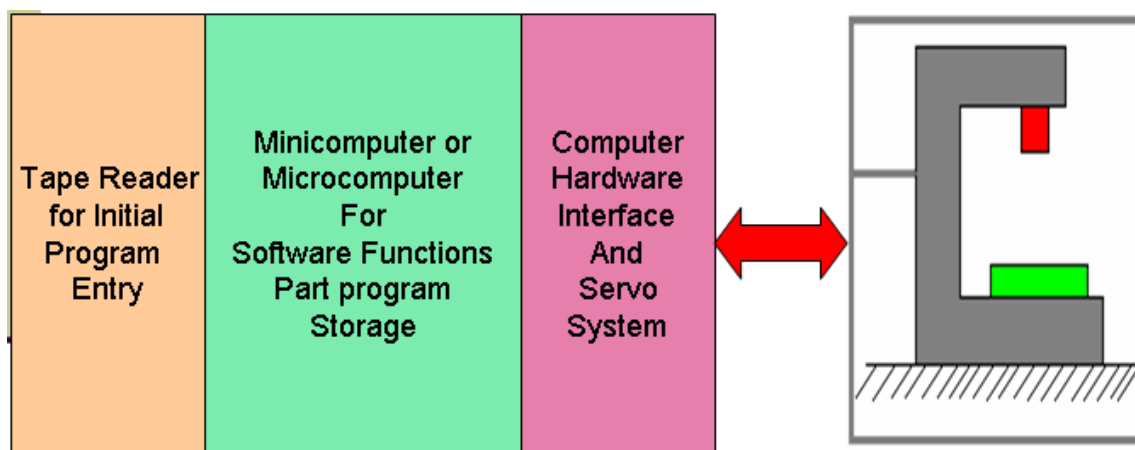
Computer Numerical Control

FUNCTIONS OF CNC

There are a number of functions which CNC is designed to perform. Several of these functions would be either impossible or very difficult to accomplish with conventional NC. The principal functions of CNC are:

1. Machine tool control
2. In-process compensation
3. Improved programming and operating features
4. Diagnostics

MACHINE TOOL CONTROL

The primary function of the CNC system is control of the machine tool. This involves conversion of the part program instructions into machine tool motions through the computer interface and servo system. The capability to conveniently incorporate a variety of control features into the soft wired controller unit is the main advantage of CNC. Some of the control functions, wired circuits than with the computer. This fact has lead to development of two alternative controller designs in CNC:

1. Hybrid CNC
2. Straight CNC

In the hybrid CNC system, the controller consists of the soft wired plus hard wired circuits. The hard wired components perform those functions which they do best, such as feed rate generation and circular interpolation. There are several reasons for the popularity of the hybrid CNC configuration. As mentioned previously, certain NC functions can be performed more efficiently with the hard wired circuits. These are functions which are common to most NC systems. Therefore, the circuits that perform these functions can be produced in large quantities at relatively low cost. Use of these hard wired circuits saves the computer from performing these calculation chores. Hence a less expensive computer is required in the hybrid CNC controller.

The straight CNC system uses a computer to perform all the NC functions. The only hard wired elements are those required to interface the computer with the machine tool and operator's console. Interpolation, tool position feedback, and all the other functions are performed by computer software. It is possible to make changes in the interpolation programs, whereas the logic contained in the hard wired circuits of the hybrid CNC cannot be altered.

IN PROCESS COMPENSATION

A function closely related to machine tool control is in process compensation. This involves the dynamic correction of the machine tool motions for changes or errors which occur during processing. Some of the options included within the category of CNC in process compensation are:

- Adjustments for errors sensed by in process inspection probes and gauges.
- Recomputation of axis positions when an inspection probe is used to locate a datum reference on a work parts.
- Offset adjustments for tool radius and length.
- Adaptive control adjustments to speed and/or feed.
- Computation of predicted tool life and selection of alternative tooling when indicated.

IMPROVED PROGRAMMING AND OPERATING FEATURES

The flexibility of the soft wired control has permitted the introduction of many convenient programming and operating features. Included among these are the following:

- Editing of part programs at the machine. This permits correction or optimization of the program.
- Graphic display of the tool path to verify the tape.
- Various types of interpolation circular, parabolic and cubic interpolation.
- Use of specially written subroutines.
- Local storage of more than one part program.

DIAGNOSTICS

NC machine tools are complex and expensive systems. The complexity increases the risk of components failures which lead to system downtime. It also requires that the maintenance personnel be trained to a higher level of proficiency in order to make repairs. A possible function which goes beyond the normal diagnostics capability is for the CNC systems to contain a certain amount of redundancy of components which are considered unreliable. When one of these components fails, the diagnostics subsystems would automatically disconnect the faulty components and activate the redundant component. Repairs could thus be accomplished without any breaks in normal operations.

ADVANTAGES OF CNC

Computer numerical control possesses a number of inherent advantages over conventional NC. The following list of benefits will serve also as a summary of our preceding discussion:

1. The part program tape and tape reader are used only once to enter the program into computer memory. These results in improved reliability, since the tape reader is commonly considered the least reliable component of a conventional NC system.

2. Tape editing at the machine site. The NC tape can be corrected and even optimized during tape tryout at the site of the machine tool.

3. Metric conversion. CNC can accommodate conversion of tapes prepared in units of inches into the International system of units.

4. Greater flexibility. One of the more significant advantages of the CNC over conventional NC is its flexibility. This flexibility provides the opportunity to introduce new control options with relative ease at low cost. The risk of obsolescence of the CNC system is thereby reduced.

5. User written programs. One of the possibilities not originally anticipated for CNC was the generation of specialized programs by the user. These programs generally take the form of MACRO subroutines stored in the CNC memory which can be called by the part program to execute frequently used cutting sequences.

6. Total manufacturing system. CNC is more compatible with the use of a computerized factory wide manufacturing system. One of the stepping stones toward such a system is the concept of direct numerical control.

Voice NC programming

Voice programming of NC machines involves vocal communication of the machining procedure to a voice input NC tape preparation system. VNC allows the programmer to avoid steps such as writing the program by hand, keypunching or typing, and manual verification. One of the principal companies specializing in voice input systems is Threshold Technology, INC, of Delran, New Jersey.

To perform the part programming process with VNC, the operator speaks into a headband microphone designed to reduce background acoustical noise. Communication of the programming instructions is in shop language with such terms as "turn", "thread", and "mill line", together with numbers to provide dimensional and coordinate data. Before the voice input system can be used, it must be "trained" to recognize and accept the individual programmer's voice pattern. This is accomplished by repeating each word of the vocabulary about five times to provide a reference set which can subsequently be compared to voice commands given during actual programming. The entire vocabulary for the

threshold system contains about 100 words. Most NC programming jobs can be completed by using about 30 of these vocabulary words.

In talking to the system, the programmer must isolate each word by pausing before and after the word. The pause must be only one tenth of a second or longer. This allows the speech recognition system to identify boundaries for the uttered command so that its wave characteristics can be compared with words in the reference set for that programmer. Typical word input rates under this restriction are claimed to be about 70 per minute. As the words are spoken, a CRT terminal in front of the operator verifies each command and prompts the operator for the next command.

Direct Numerical Control

It can be defined as a manufacturing system in which a number of machines are controlled by a computer through direct connections & in real time. The tape reader is omitted in DNC. The part program is transmitted to the machine tool directly from the computer memory. One large computer can be used to control more than 100 separate machines.

Component of DNC system

It has four basic components.

1. Central computer
2. Bulk memory, which stores the NC part program
3. Telecommunication line
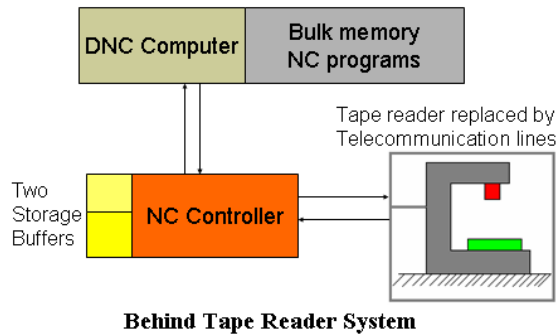4. Machine tools

Direct Numerical Control
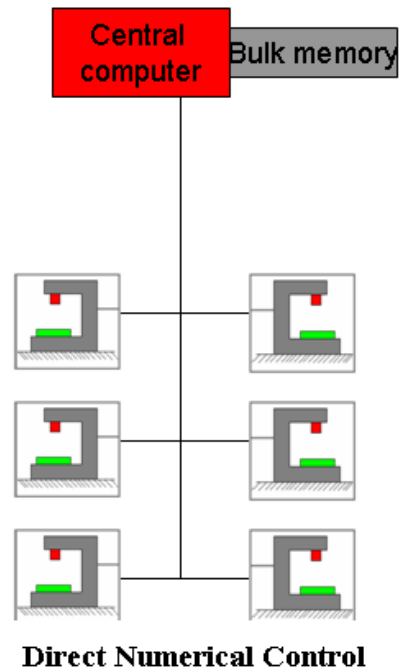
Computer calls the part program instruction from bulk storage and sends them to the individual machine as need arises. It also receives data back from the machines.

Satellites are minicomputers, and they serve to take some of the burden off the central computer. Each satellite controls several machines. Group of part programs inst are received from the central computer & stored in buffers. Feedback data from the machines are also stored in the satellite buffer before being collected at central computer.

Types of DNC

1. **Behind the tape reader (BTR) system.**

   Here the computer is linked directly to the regular NC controller unit. Tape reader is replaced by telecommunication lines to DNC computer. There are 2 temporary storage buffers. One buffer is receiving a block of data; the other is providing control instructions to the machine tool.

Behind Tape Reader System

2. Special machine control unit.

NC controller is replaced by special machine control unit. Special MCU facilitate communication between the machine tool & the computer special machine MCU configuration achieves a superior balance between accuracy of the interpolation & fast metal removal rates.

Special Machine Control Unit
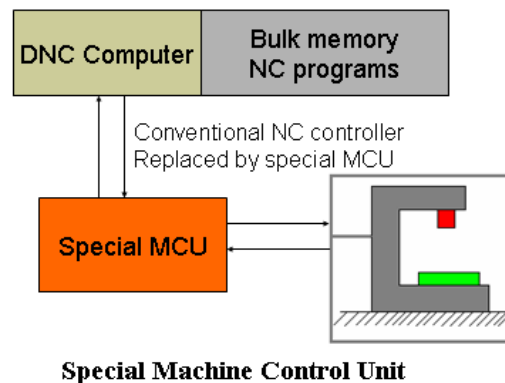
Functions of DNC

1. NC without punched tape

several problems of NC are related to the use of punched tape. There is also the expense associated with the equipment that produces the punched tape.

2. NC part program storage

Purposes of program storage subsystem structuring are:

a) The Programs must be made available for downloading to the NC machine tools.

b) The subsystem must allow for new programs to entered, old programs to be deleted & edited.

c) The DNC software must accomplish the post processing function.

d) The storage subsystem must be structures to perform certain data processing & management function. The storage for NC programs not frequently used.

3. **Data Collection, Processing & Reporting**

　　　　The transfer of data from the machine tools back to the central computer. The basic purpose is to monitor production in the factory. Data must be processed by DNC computer & reports are prepared to provide management with information necessary for running the plant.

4. **Communication**

　　　　Essential communication links in DNC are between the following:
   a) Central computer & machine tools
   b) Central computer & NC part programmer terminal
   c) Central computer & bulk memory

   ❖ Optional communication links may also be established between the DNC system and,
   a) Computer aided design (CAD) system
   b) Shop floor control system
   c) Corporate data processing computer
   d) Remote maintenance diagnostics system

Advantage of DNC

1. Elimination of punched tapes & tape readers.
2. Greater computational capability & flexibility because computation & data processing function are implemented with software rather than hard wired devices.
3. Convenient storage of NC part programs in computer files.
4. Program stored as CLFILE – part program is stored as cutter path data rather than post processed programs for specific machine tools. It provides flexibility of production scheduling.
5. Reporting of shop performance is done easily by DNC system.
6. Establishes the framework for the evolution of the future computer automated factory.

Adaptive Control Machining System

　　　　Adaptive control denotes a control system that measures certain output process variables & use these to control speed &/or feed. Nearly all the metal cutting variables that can be measured have been tried in experimental adaptive control system.

Although NC has signification effect on downtime, it can do relatively little to reduce the in process time compared to a conventional machine tool. NC guides the sequence of tool positions or the path of tool during machine, adaptive control determines proper speeds &/or feeds during machining as a functioning of variations in such factors as material hardness, depth of cut.

Source of variability in machining where adaptive control can be most advantageously applied,

a) Variable geometry of cut in the form of changing depth or width of cut.
b) Variable work piece hardness & variable machinability.
c) Variable work piece rigidity.
d) Tool wear.
e) Air gaps during cutting.

Types of Adaptive control machining system

1. **Adaptive control with optimization (ACO)**

    Here the performance is optimized accuracy to the given prescribed index of performance. The index of performance is usually an economic function. It is most delicate closed loop control system which optimizes the conditions automatically.

    The system attempts to maximize the ratio of work material removal rate to tool wear rate known as index of performance.

    $$IP = MRR/TWR$$

    Where,

    IP = Index of performance

    MRR = Material removal rate

    TWR = Tool wear rate

2. **Adaptive control with constrains (ACC)**

    In this system the machining conditions such as feed rate or/and speed are maximized within given limits of machine & tool constrains.

    The adaptive controls are feed by signals of following two sensors,

    a) Tool vibration sensor measuring vibrations of tool by accelerometer mounted on the machine spindle housing.

b) Spindle torque sensor which measure strain gauges mounted on machine spindle.

❖ **Important constraints for ACC system:**
1. Max. & Min. spindle speed.
2. Max. allowed torque.
3. Max. & Min. allowed chip load.
4. Max. permitted feed rate.
5. Impact chip load.
6. Max. Allowed vibrations.

Advantages of ACM system

1. **Increased production rate:**

   On line adjustments to allow for variations in work geometry, material & tool wear provide the machine with the capacity to achieve highest metal removal rates that are consistent with existing cutting conditions.

2. **Increased tool life:**

   Because adjustments are made in the feed rate to prevent severe loading of the tool, fewer cutters will be broken.

3. **Greater part protection:**

   Instead of setting cutter force constraint limit on the basis of max. Allowable cutter & spindle deflection, the force limit can be established on the basis of work size tolerance.

4. **Less operator invention:**

   Transfer of control over the process into the hands of management via the part programs.

5. **Easier part programming:**

   The selection of feed is left to the controller unit rather that to the part programmer. The programmer can afford to, take less conservative approach. Less time is needed to generate the program for the job & fewer layouts are required.

• **Prepare detail specification for following:**
   1. CNC Turning Center

2. CNC Turn Mill Center

3. CNC Machining Center

MCQ Exercises:

1. What does NC stand for in manufacturing?

    A) Numerical Computation

    B) Numerical Control

    C) Non-Conventional

    D) Network Control

2. In NC machining, what generates the control signals for the machine tool?

    A) Central Processing Unit (CPU)

    B) Numerical Controller

    C) Hydraulic System

    D) Human Operator

3. What is the primary advantage of CNC over conventional NC?

    A) Higher Cost

    B) Lower Precision

    C) Greater Flexibility

    D) Manual Operation

4. Which of the following is a common programming language used in CNC?

    A) Java

    B) G-code

    C) HTML

    D) Python

5. What is the main purpose of DNC in manufacturing?

    A) Centralized Data Processing

    B) Manual Machining

    C) Human Resource Management

D) Component Design

6. In DNC, what is directly connected to the machine tool?

    A) Human Operator

    B) Computer Terminal

    C) Central Processing Unit

    D) Storage Device

7. What does VNC stand for in the context of CNC machining?

    A) Virtual Network Controller

    B) Visualized Numerical Control

    C) Voice Numerical Control

    D) Variable Numerical Code

8. What is a key advantage of VNC in CNC machining?

    A) Increased Machining Speed

    B) Remote Monitoring and Control

    C) Reduction in Tool Wear

    D) Manual Operation

9. What is the primary goal of Adaptive Control in machining?

A) Achieving Consistent Tool Wear

B) Adjusting Machining Parameters in Real Time

C) Minimizing Flexibility

D) Increasing Human Intervention

10. In Adaptive Control, what type of data is used to adjust machining parameters?

    A) Historical Data

    B) Fixed Data

    C) Static Data

    D) Predefined Data

Rubrics:

1. MCQ Exercises
2. Assignment Completion
3. Attendance
4. Submission
5. Attention in Laboratory

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						

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## COMPUTER AIDED MANUFACTURING (3161917)
B. E. VI SEM

EXPERIMENT NO: 4   DATE:

AIM: Practice CNC Part programme for given Components.

• Write a program of CNC Turning Centre for following component as shown in FIG(A):
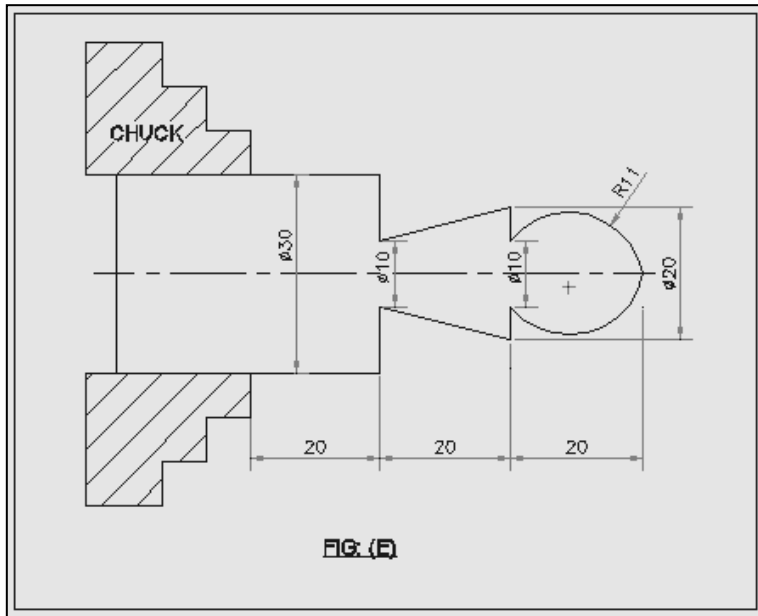
Raw Material Size : 30Ø mm X 80 mm Long

FIG: (A)
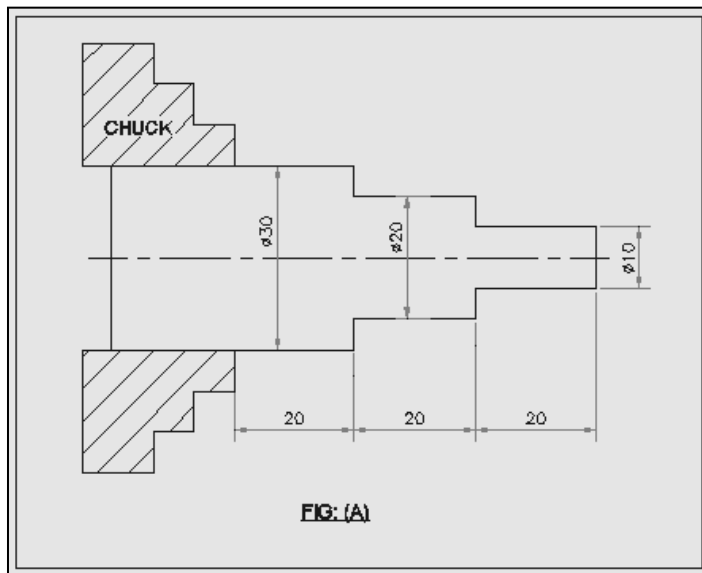
• Write a program of CNC Turning Centre for following component as shown in FIG(B):
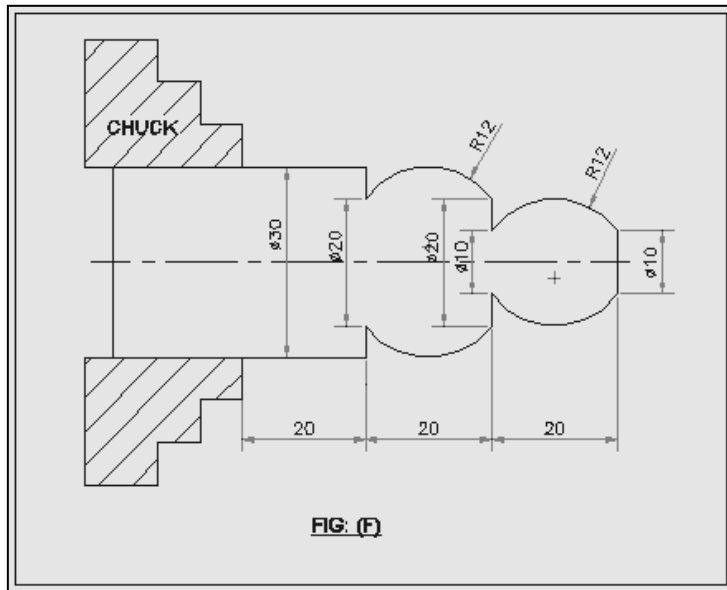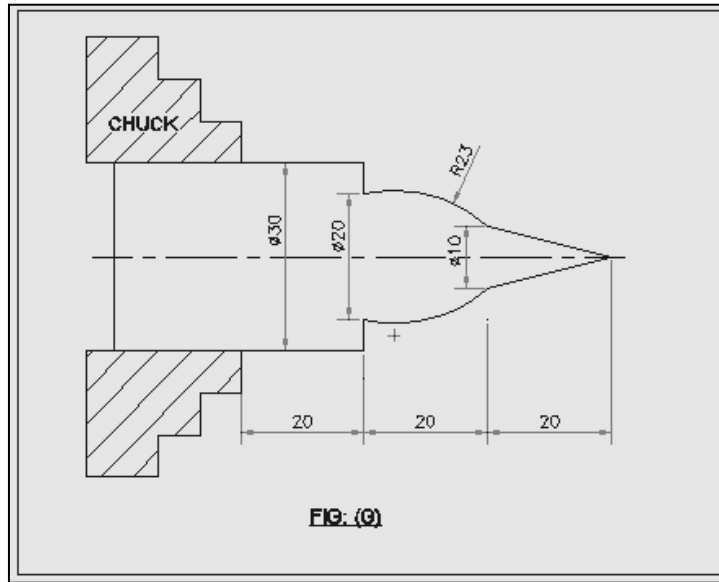
Raw Material Size : 30Ø mm X 80 mm Long

FIG: (B)

- Write a program of CNC Turning Centre for following component as shown in FIG(C):

  Raw Material Size : 30Ø mm X 80 mm Long

FIG: (C)

- Write a program of CNC Turning Centre for following component as shown in FIG(D):
- Raw Material Size : 30Ø mm X 80 mm Long

FIG: (D)
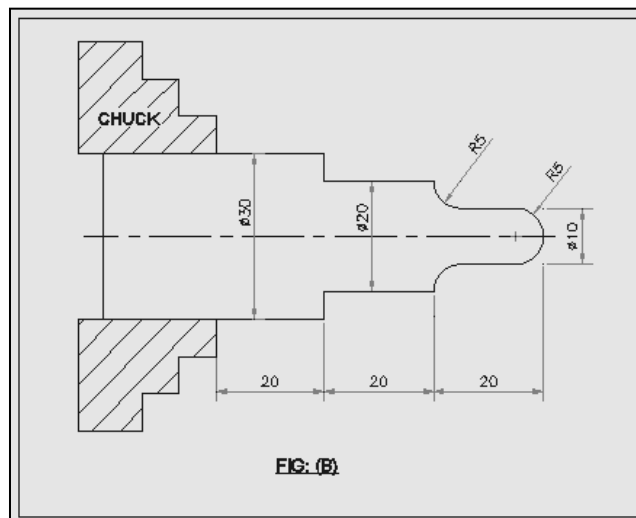
- Write a program of CNC Turning Centre for following component as shown in FIG(E):

  Raw Material Size : 30Ø mm X 80 mm Long

FIG: (E)

- Write a program of CNC Turning Centre for following component as shown in FIG(F):

  Raw Material Size : 30Ø mm X 80 mm Long

FIG: (F)

- Write a program of CNC Turning Centre for following component as shown in FIG(G):

  Raw Material Size : 30Ø mm X 80 mm Long

FIG: (G)

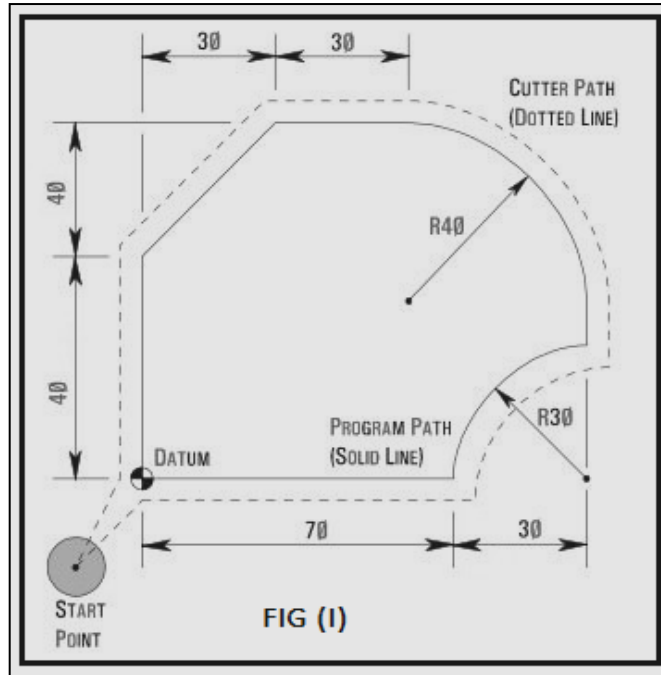- Write a program of CNC Turning Centre for following component as shown in FIG(H):

  Raw Material Size : 30Ø mm X 80 mm Long

FIG: (H)
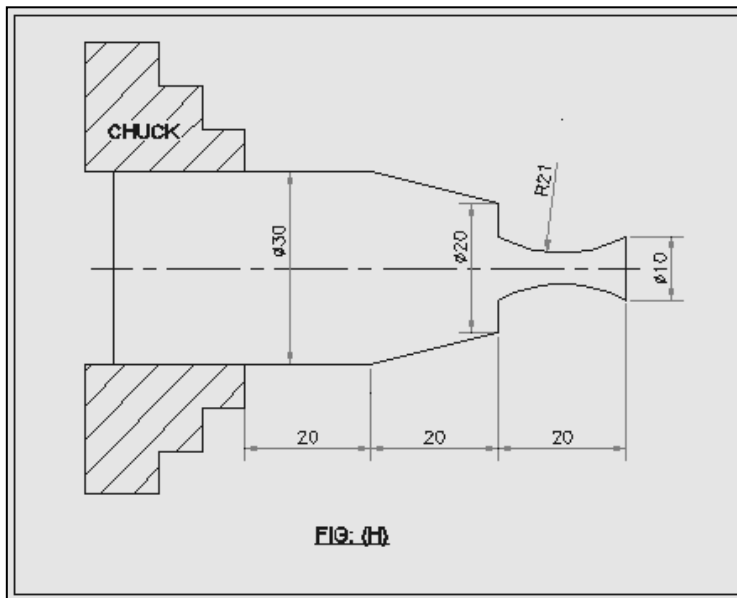
- Write a program of CNC Machining Centre for following component as shown in FIG(I):

FIG (I)

- Write a program of CNC Machining Centre for following component as shown in FIG(J):
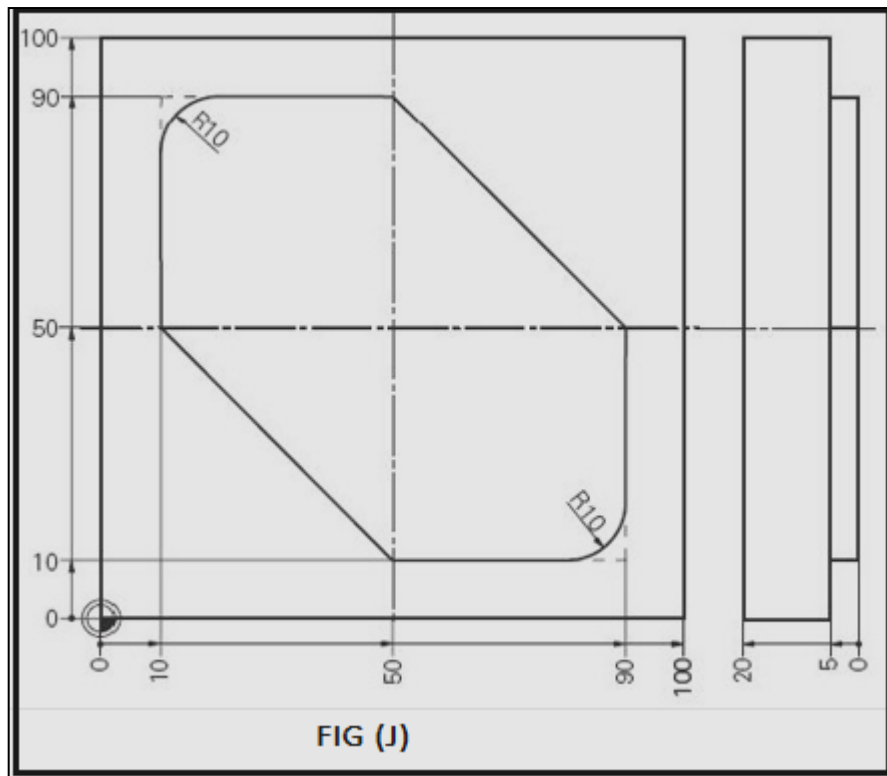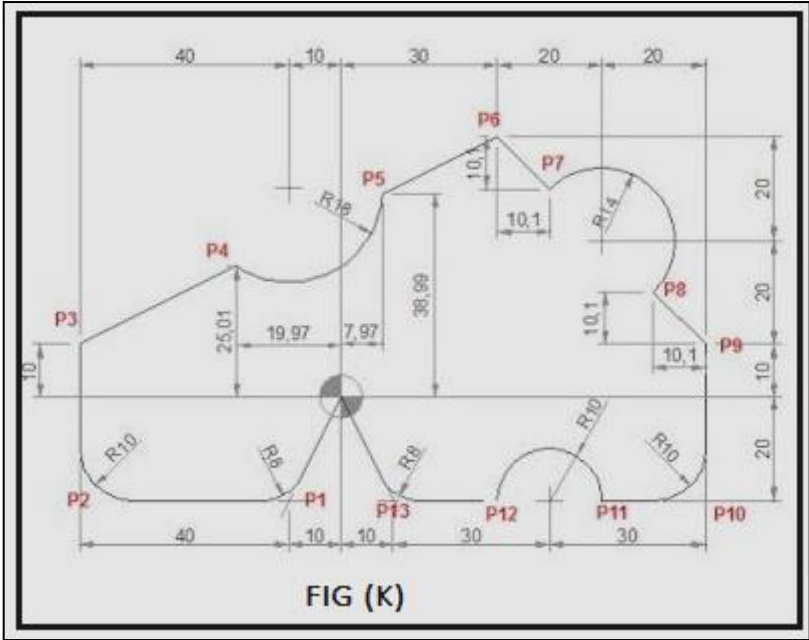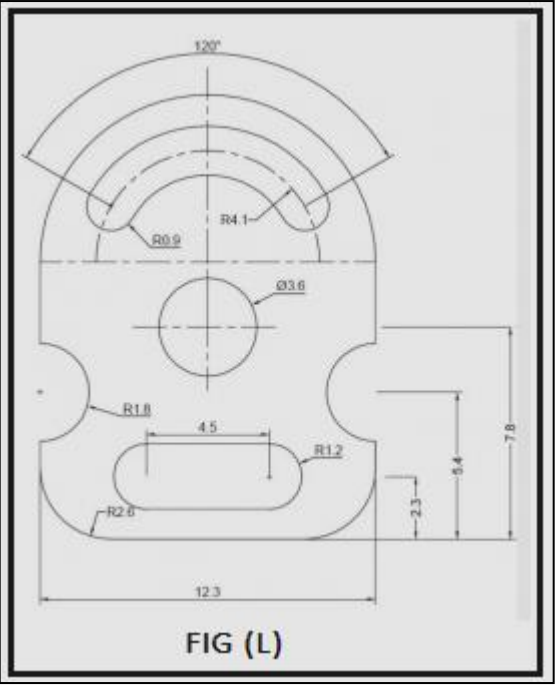

FIG (J)

- Write a program of CNC Machining Centre for following component as shown in FIG(K):

FIG (K)

- Write a program of CNC Machining Centre for following component as shown in FIG(L):

FIG (L)

MCQ Exercises:

1. What does CNC stand for?

      a. Computer Navigation Control

      b. Computer Numerical Control

      c. Centralized Numeric Coding

      d. Control Navigation Center

2. In CNC part programming, G-code is used for:

      a. Graphics rendering

      b. Generating shapes

      c. Controlling machine movements

      d. Generating toolpaths

3. Which code is used for rapid positioning in CNC programming?

      a. G00

      b. G01

      c. G02

      d. G03

4. What is the purpose of M-code in CNC programming?

      a. Tool change

      b. Rapid positioning

      c. Linear interpolation

      d. Circular interpolation

5. G-code G02 is associated with:

      a. Linear interpolation

      b. Circular interpolation (clockwise)

      c. Circular interpolation (counterclockwise)

      d. Rapid positioning

6. In CNC machining, the term "feed rate" refers to:

     a. Speed of spindle rotation

     b. Speed of tool movement

     c. Speed of workpiece rotation

     d. Speed of coolant flow

7. Which code is used to specify the cutting tool's compensation in CNC programming?

     a. G41

     b. G42

     c. G43

     d. G44

8. The CNC coordinate system typically includes:

     a. X and Y axes

     b. X, Y, and Z axes

     c. X, Y, Z, and A axes

     d. X, Y, Z, A, B, and C axes

9. G-code G90 is used for:

     a. Absolute programming

     b. Incremental programming

     c. Circular interpolation

     d. Tool compensation

10. What is the function of a post-processor in CNC part programming?

     a. Converts CAD models to G-code

     b. Converts G-code to machine-specific code

     c. Generates toolpaths

     d. Controls machine movements directly

Rubrics:

1. MCQ Exercises
2. Assignment Completion
3. Attendance
4. Submission
5. Attention in Laboratory

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						

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Signature of Subject Teacher

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EXPERIMENT NO: 5   DATE:

AIM : To Study about Programmable Logical Controller. Prepare ladder Logic diagram for given exercises.

Introduction

A PLC (Programmable Logic Controller) is an industrial computer used for automation of electromechanical processes, such as control of machinery on factory assembly lines, amusement rides, or light fixtures. PLCs are expected to work flawlessly for years in industrial environments that are hazardous to the very microelectronic components that give modern PLCs their excellent flexibility and precision.

Prior to PLCs, many of these control tasks were solved with contactor or relay controls. This is often referred to as hardwired control. Circuit diagrams had to be designed, electrical components specified and installed, and wiring lists created. Electricians would then wire the components necessary to perform a specific task. If an error was made the wires had to be reconnected correctly. A change in function or system expansion required extensive component changes and rewiring.

PLC (Programmable Logic Controller)

Before you start using PLC, it is convenient to know and understand its architecture. See figure As shown in figure, PLC consists of the following parts:

1) POWER SUPPLY: Provides the voltage needed to run the primary PLC components.

2) I/O MODULES: Provides signal conversion and isolation between the internal logic-level signals inside the PLC and the field's high level signal.

3) PROCESSOR SYSTEM: Provides intelligence to command and govern the activities of the entire PLC systems.

4) PROGRAMMING DEVICE: Used to enter the desired program that will determine the

sequence of operation.
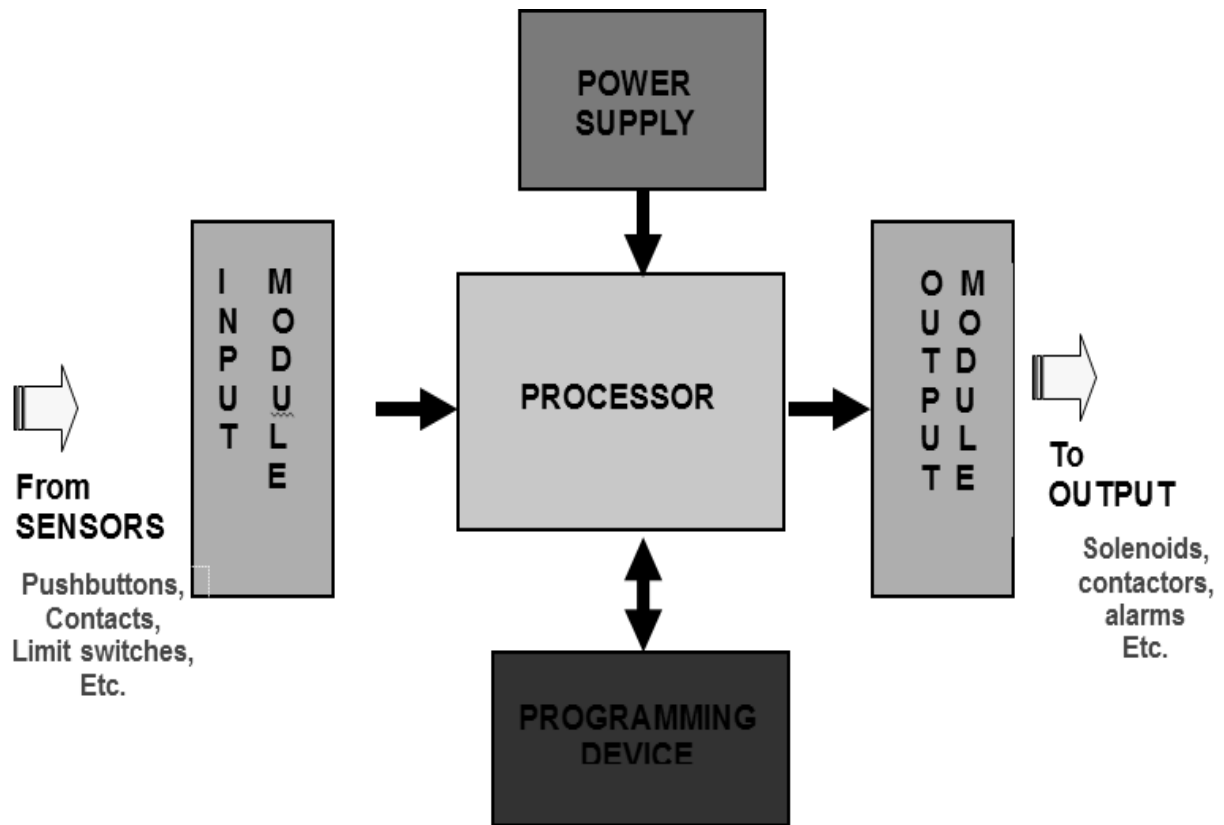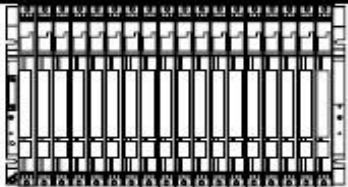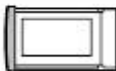
PLC architecture

The following are some advantages of PLC over other microcontrollers:

1) Cost effective for controlling complex systems.

2) Flexible and can be reapplied to control other systems.

3) Computational abilities allow more sophisticated control.

4) Trouble shooting aids making programming easier and reduce downtime.

5) Small physical size, so shorter project time.

In this experiment Siemens S7-400 PLC will be used, table 1 presents the main components of this model.

Siemens S7-400 PLC main components

Components	Function	Illustration
Racks (UR: Universal Rack) (CR: Central Rack) (ER: Expansion Rack)	... provide the mechanical and electrical connections between the S7-400 modules.	
Power Supply Modules (PS = Power Supply) Accessories: Backup battery	... convert the line voltage (120/230 VAC or 24 VDC) to the 5 VDC and 24 VDC operating voltages required to power the S7-400.	
CPUs Central Processing Units (CPUs)	... execute the user program; communicate via the multipoint interface (MPI) with other CPUs or with a programming device (PG).	
Memory cards	... store the user program and parameters.	
IF 964-DP interface module	... used to connect distributed I/Os via PROFIBUS-DP	
Signal Modules (SM = Signal Module) (digital input modules, digital output modules, analog input modules, analog output modules) Accessories: Front connector with three different terminal systems	... match the different process signal levels to the S7-400. ... form the interface between PLC and process.	
Interface modules (IM = Interface Module) Accessories: Connecting cable Terminator	... interconnect the individual racks of an S7-400.	
Cable ducts	...are used for routing cables and as ventilation.	
PROFIBUS bus cables	...connect CPUs to programming devices.	

You can notice from figure that the common of the digital input module is connected to the ground of the circuit while the common of the digital output module is connected to the powersource.
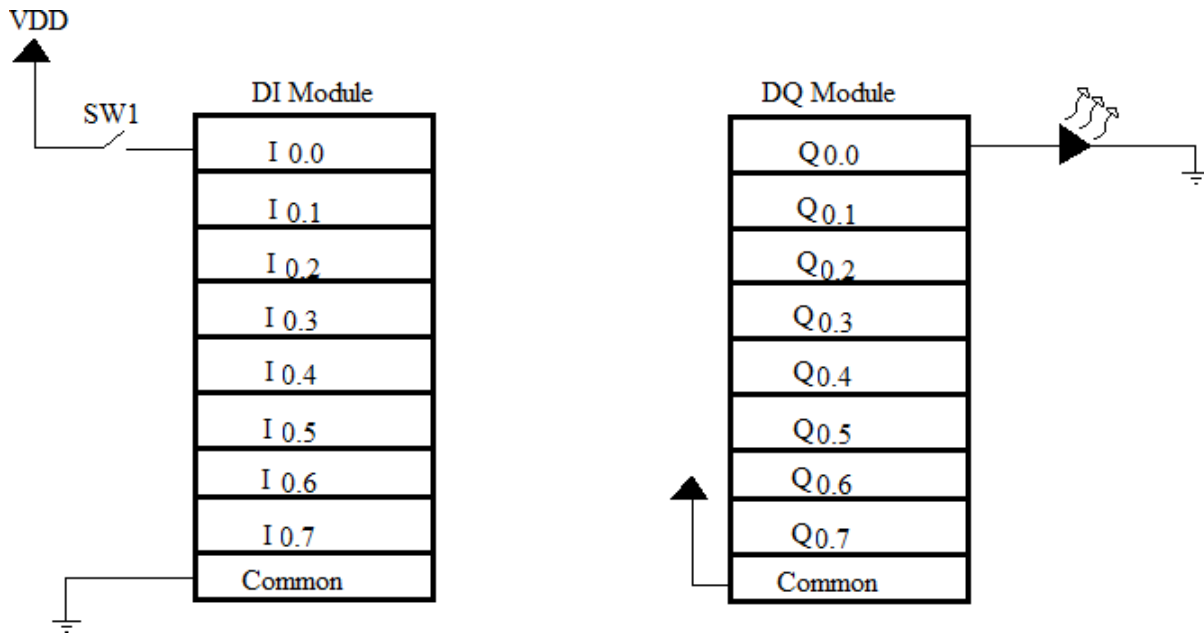
Simple Connection using Siemens S7-400 PLC

The last figure shows a switch connected to the input I0.0 in the digital input module, and an LED connected to the output Q0.0 in the output module.

Ladder Logic Programming

Figure shows electrical continuity, when SW1 is closed, the current will flow from L-1 to L-2 and energize the load.
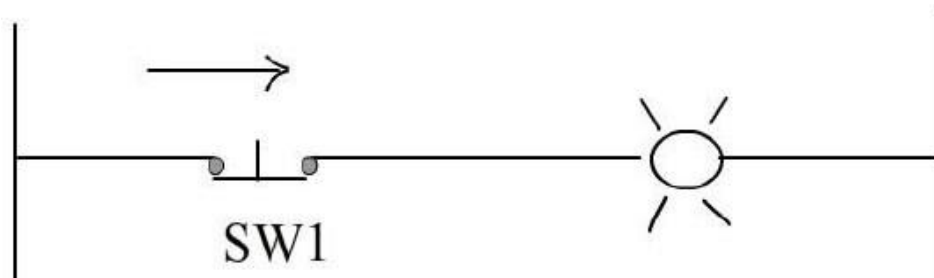
Hardwire switch-lamp circuit

Even though PLC ladder logic was modeled after the conventional relay ladder, there is no electrical continuity in PLC ladder logic. PLC ladder rungs should have logical continuity in order for the output to be energized. PLC ladder program uses familiar terms like "rungs", "normally open" and "normally closed" contacts, as illustrated in table 2.

Fundamental contacts and coils instructions of PLC ladder logic programming

Symble	Name	Description
—| |—	*Examine if closed*	*It works as normally open switch in a ladder program. If it is ON, the contact will close and allow power (logic) to flow from left to right. If the status is OFF (logical 0), the contact is Open, power (logic) will NOT flow from left to right.*
—|/|—	*Examine if open*	*It works as normally closed switch in a ladder program, and it works exactly opposite to that of the examine if closed.*
—( )—	*Normally open coil*	*This can be used to represent any discrete output from the control logic. When "solved" if the logic to the left of the coil is TRUE, the referenced output is ON (logical 1).*

In a ladder logic program, there is no physical conductor that carries the input signal through to the output. Each rung in the ladder diagram is a program statement. This program statement consists of a condition or sometimes conditions, along with some type of action.

Inputs are the conditions, and the action, or output, is the result of the conditions. As in case of physical wiring hardware devices connected in series or parallel, PLC also combines ladder program instructions in series or parallel. However, rather than working in series or parallel, the PLC combines instructions logically using logic operators like: AND, OR, and NOT. These operators are used to combine the instructions on a PLC rung to make the outcome of each rung either true or false.

1. **AND-logic function:**

    A series circuit of two switches can be regarded as AND logic function. In figure 4, both switches (SW1 AND SW2) must be closed to have electrical continuity to energize the output (Light-1). Hence the keyword here is AND.

AND-logic function

The circuit shown in figure 5 represents a schematic ladder logic rung for the circuit shown in
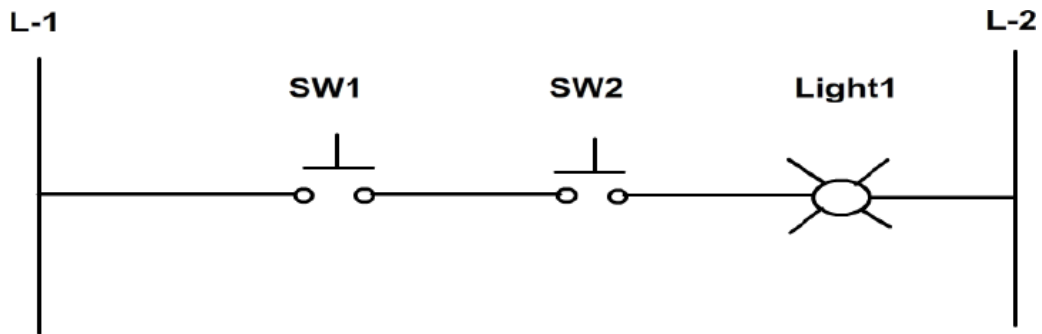
figure

When switch 1 and switch 2 are closed the output coil will beenergized.
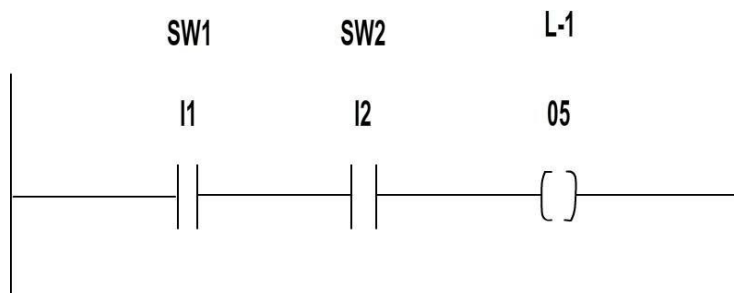
Ladder logic diagram for AND function

2. **OR-logic function:**

A parallel circuit of two switches can be regarded as OR logic function. In figure 6, oneof the switches (SW1 **OR** SW2) must be closed to have electrical continuity to energize the output (Light-1). Hence the keyword here is OR.
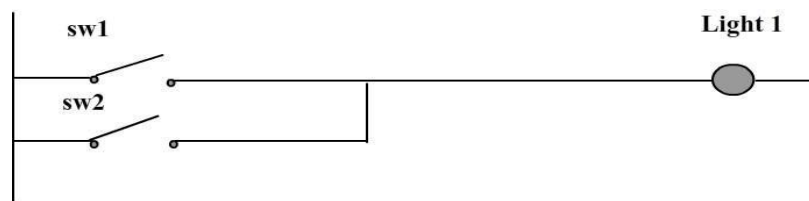
OR-logic function

The circuit shown in figure 7 represents a schematic ladder logic rung for the circuit shown in figure 6. If switch 1 or switch 2 is closed the output coil will be energized.
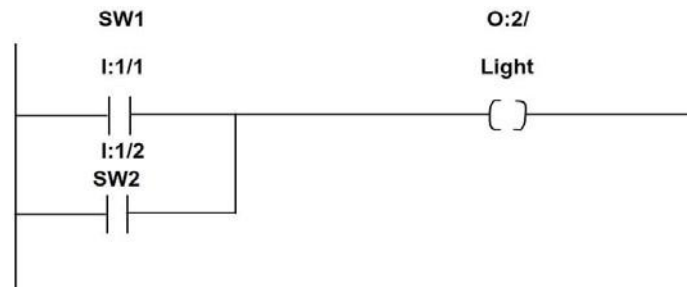
Ladder logic diagram for OR function

3. The PARALLEL NOT logic function:

Figure shows ladder diagram for the parallel NOT logic function and its truth table is illustrated in table.
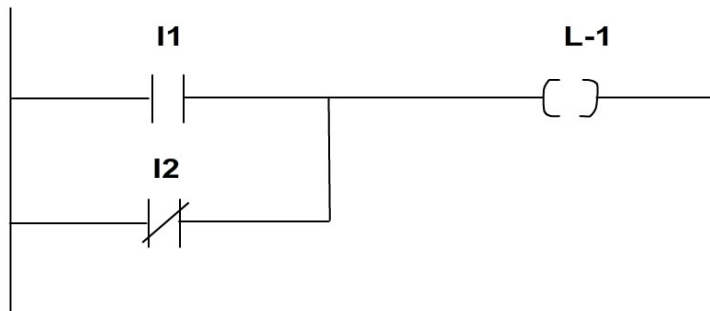
Ladder logic diagram for parallel NOT function Table: Parallel NOT logic function truth

INPUTS		INPUT STATUS FILE		OUTPUTS
I:1	I:2	I:1	I:2	O:0
0	0	0	1	1
0	1	0	0	0
1	0	1	1	1
1	1	1	0	1

Part 1: Logic functions implementation

1- Connect two switches to the

digital input module.2- Connect one

LED to the digital output module.

3- Write down the ladder diagram to implement AND-logic function using SIMATICManager software.

4- Download the program to the PLC.

5- Repeat steps 1 through 4 to implement OR-logic function.

6- Repeat steps 1 through 4 to implement Parallel NOT-logic function.

Part 2: NOR-logic function implementation

1- Write down the Boolean sum-of-product expression for NOR logic function, see table 4.

Table 4: NOR-logic function truth table

Switch 1	Switch 2	Output
0	0	1
1	0	0
0	1	0
1	1	0

2- Connect two switches to the

digital input module.3- Connect one

LED to the digital output module.

4- Write down the ladder diagram to implement NOR-logic function using SIMATICManager software.

5- Download the program to the PLC.

Part 3: Alarm system implementation using 2 LEDs

Assume that we have 3 signals (Inputs) that we get from the field that warn us about some kindof fire danger. The system works as follows:

Any 1 signal, turn the green light on.

Any 2 signals will turn the orange light on.

All 3 signals, will turn the two lights simultaneously.

1- Connect three switches to the digital input module.2- Connect two LEDs to the digital output module.

3- Write down the ladder diagram to implement the previous system using SIMATICManager software.

4- Download the program to the PLC.

Part 4: The sealed in coil pattern implementation

This pattern is the basis for remembering state in a PLC. The pattern consists of a trigger condition and a coil, where a contact from the coil branches around the trigger condition to "seal itself in" once the coil is energized, see figure 11.
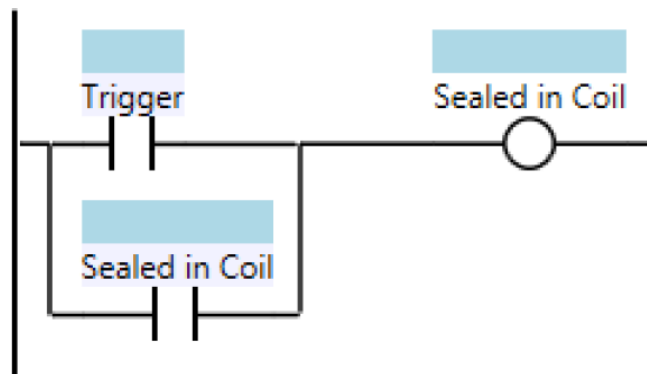
Figure 11: The sealed in coil pattern

1- Connect one switch to the digital input.

2- Connect one LED to the digital output.

3- Write down the ladder diagram to implement this function using SIMATIC Managersoftware.

4- Download the program to the PLC.

Part 5: The state coil pattern implementation

This pattern is an extension to the Sealed in Coil pattern. The pattern consists of a trigger condition, a coil, with a contact from the coil branching around the trigger condition to "seal itself in", and then some other condition to "break the seal", see figure 12.

1- Connect one switch to the digital input.2- Connect one LED to the digital output.

3- Write down the ladder diagram to implement this function using SIMATIC Managersoftware,

4- Download the program to the PLC.
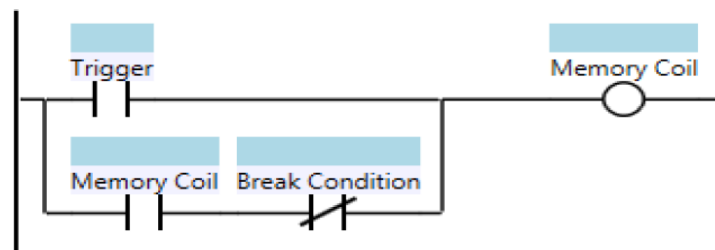
Figure: The state coil pattern

Part 6: The start/stop circuit pattern implementation

A very useful Ladder Logic Programming Pattern is the Start/Stop Circuit. This pattern is an extension to the Sealed in Coil pattern and is similar to the State Coil, see figure.
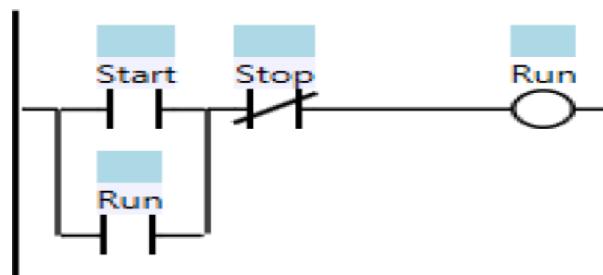
Figure: The start/stop circuit pattern

1- Connect one switch to the digital input.

2- Connect one LED to the digital output.

3- Write down the ladder diagram to implement this function using SIMATIC Managersoftware,

4- Download the program to the PLC.

Part 7: DC motor direction control

1- Connect three switches to the digital input, as follows:

Forward pushbutton, Backward pushbutton, and Overall system switch.

2- Connect forward motor and backward motor connections to the digital output.

3- Write a ladder diagram to control the direction of the motor using the pushbuttons.

Hints:

1) Use the idea of an interlock (electrical and mechanical); to prevent the situation of pressing the backward and forward pushbuttons at the same time, and stop the motor when it reaches its maximum limits.

2) Use the idea of state coil pattern since we are using pushbuttons to control the directionof motion.

- **Prepare ladder logic for following cases:**

Exercise 1: Motor Control

Create a ladder logic diagram for a motor control system with the following specifications:

- A Start button (NO) is used to activate the motor.
- A Stop button (NC) is used to deactivate the motor.
- A normally open overload relay is used to protect the motor.
- The motor is controlled by a normally open contactor.

Exercise 2: Conveyor Belt Control

Design a ladder logic diagram for controlling a conveyor belt with the following conditions:

- A Start button (NO) is used to start the conveyor.

- A Stop button (NC) is used to stop the conveyor.
- A limit switch (NO) is used to detect the presence of a product on the conveyor.
- When the limit switch is activated, a solenoid-operated brake engages to stop the conveyor.

Exercise 3: Traffic Light Control

Create a ladder logic diagram for a simple traffic light control system with the following conditions:

- Three traffic lights: Red, Yellow, and Green.
- A pedestrian crossing button (NO) to request a pedestrian signal.
- The sequence should follow a standard traffic light pattern but should also incorporate pedestrian signals.

Exercise 4: Pump Control

Design a ladder logic diagram for a pump control system with the following features:

- A Start button (NO) to activate the pump.
- A Stop button (NC) to deactivate the pump.
- A float switch (NO) to detect the water level.
- If the water level is low, the pump should activate; otherwise, it should deactivate.

Exercise 5: Batch Processing

Create a ladder logic diagram for a simple batch processing system with the following conditions:

- Three tanks: A, B, and C.
- Two pumps: Pump 1 and Pump 2.
- A start button (NO) to initiate the batch process.
- Each tank has a level sensor (NO) to detect when it is full.
- Pumps should activate to transfer liquid from one tank to another.

MCQ Exercises:

1. What does PLC stand for?

   a. Programmable Logic Computer

   b. Programmable Logic Controller

   c. Programmed Logic Circuit

   d. Personal Logic Console

2. Which of the following is NOT a typical input device for a PLC?

      a. Push Button

      b. Proximity Sensor

      c. Solenoid Valve

      d. Limit Switch

3. What is the primary purpose of a PLC?

      a. To process text-based data

      b. To control industrial processes and machinery

      c. To perform complex mathematical calculations

      d. To manage network communication

4. Which programming language is commonly used for programming PLCs?

      a. Python

      b. Java

      c. Ladder Logic

      d. C++

5. What is the function of a PLC output?

      a. To receive signals from sensors

      b. To execute control actions based on the programmed logic

      c. To store data for future use

      d. To display information on a screen

6. Which of the following statements about ladder logic is true?

      a. It is a physical ladder used in industrial settings.

      b. It is a programming language commonly used in PLCs.

      c. It is a type of sensor used for proximity detection.

      d. It is a mathematical formula for PLC calculations.

7. What is the purpose of a PLC scan cycle?

      a. To scan and eliminate bugs in the PLC program

      b. To execute the programmed logic repeatedly

c. To generate random values for PLC calculations

d. To communicate with external devices

8. Which component of a PLC is responsible for storing the program and data?

    a. Central Processing Unit (CPU)

    b. Input Module

    c. Output Module

    d. Power Supply

9. In ladder logic, what does a normally open (NO) contact represent?

    a. A closed electrical circuit

    b. An open electrical circuit

    c. A sensor input

    d. A relay output

10. What is the role of a PLC in an automated manufacturing process?

    a. To create a comfortable working environment for operators

    b. To control and optimize the production process

    c. To manage administrative tasks

    d. To perform quality inspections on finished products

Rubrics:

1. MCQ Exercises
2. Assignment Completion
3. Attendance
4. Submission
5. Attention in Laboratory

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						

_____

Signature of Subject Teacher

GUJARAT TECHNOLOGICAL UNIVERSITY
DEPARTMENT OF MECHANICAL ENGINEERING
GOVERNMENT ENGINEERING COLLEGE, PATAN
COMPUTER AIDED MANUFACTURING (3161917)
B. E. VI SEM

EXPERIMENT NO: 6   DATE:

AIM: Study and Practice about Group-Technology.

Introduction: -

Group technology (GT) is a manufacturing concept in which similar parts are identified and grouped together in parts groups or families to take advantage of their similarities in manufacturing and design. GT can also improve the productivity of design personnel by decreasing the amount of work and time involved in designing parts by simply modifying the design of the already existing part.

Part familes: -

A part family is a collection of parts which are similar either because of geometrical shape and size or because similar processing steps are required in their manufacture. It possible for parts in the same family to be very similar in design yet radically different in the area of production requirements. The opposite may also be true. The part family concept is central to design-retrieval systems and most computer-aided process planning schemes. The parts, which are similar in their design characteristics, are grouped in a family referred to as a design part family. These part, which are similar in their manufacturing characteristics, are groped in a family referred to as a manufacturing part family. The characteristics used in classifying parts are referred to as "attributes".

Figure illustrates examples of two parts from the same family. These parts are placed in the same family based on design characteristics. They have exactly the same shape and size. However, they differ in the area of production processes. Part 1, after it is drilled will go to a tolerance of painting station foe two coats of primer. Its dimensions must be held to a tolerance of +/- 0.3125 mm. Part 2, after it is drilled will go to a finishing station for sanding and buffing. Its dimensions require more restrictive tolerance of +/-0.075 mm. The parts differ in material: part 1is of cold rolled steel and part 2 is of

aluminum.

Fig. contains example of two parts from another family. Although the design characteristics of these two parts are drastically different (i.e. different sizes and shapes),a close examination reveals that are similar in the area of production process. Part 1 is made of stainless steel. Its dimension must be held to a tolerance of +/-0.050mm.and three holes must be drilled through it. Part2, in spite of the differences in its size and shape has exactly the same manufacturing characteristics.   The 13 parts shown in fig.1.3 might constitute a parts family in manufacturing but cannot be grouped as a design part family. By grouping parts into families, manufacturing personnel can cut down significantly on the amount of materials handled and movement wasted in producing them by grouping manufacturing machines into specialized work cells instead of arranging them according to function.

Fig. shows a process-type layout foe batch production in a machine shop. The process machine tools are arranged by function. Fig 1.5 shows a production shop of equivalent capacity, but with the machines arranged into cells. Each cell is organized to specialize in the manufacture of a particular part family. Advantages are gained in the from of reduced work piece handling lower setup times, less in process inventory and shorter lead times.   There are three general methods for grouping parts into families:

1. Visual inspection.
2. Route sheet analysis.
3. Parts classification and coding system.

The visual inspection method is the simplest and least sophisticated method. This is the easiest approach, especeallly for grouping parts by design attributes. In the route sheet inspection method, the route sheets used to route the parts through the various operations to be performed, are inspected. This method sometimes refers to as the production flow analysis (PFA) method. PFA is carried out in three steps.

1. Factory flow analysis.
2. Group analysis
3. Line analysis

The most widely used method for grouping parts is the parts classification and coding method. This is most time consuming and most difficult method.

Production flow analysis- PFA

The production flow analysis is a technique for forming part families and/or machine groups/cells by analysis the operation sequence and the routing of a part through the machines and workstation in the plant. The following steps are involved in PFA:

1. The route sheet of all the components to be manufactured in the shop is examined.

2. A matrix showing the operation numbers and the components number is prepared, showing which component requires which operations.

3. Any particular part is included only in one group. For facility grouping, one machine type should be only in one group.

4. If any operation is required by only one or very few components otherwise if some operation is required by all the components, then these operation should not be taken note of while deciding the groups. Let us consider an example of an assembly requiring 16 parts to be operated on 4 machines as shown in table. To use this method successfully, one should ensure that a reliable data source of routing or operation sheets is available. Part families can be formed with or without a classification and coding system, since production flow analysis requires only operation sheets and production data. A group technology layout is shown in fig the figure shows 324 parts using 22 machine tools before G.T.

Factory Flow Analysis

Factory flow analysis is used in very simple companies with only one processing department and no sub-contracted operations. In a machine shop where a large production of the components have intermediate operations in separately controlled and located departments such as heat treatment, electro-plating, crack detection, or inspection or which used extensive subcontracting facilities.

Parts classification and coding

Parts classification and coding is a method in which the various design and/or manufacturing attributes of a part are identified, listed and assigned a code number. The different classification and coding systems may be grouped as:

1.Design attribute group.

Commonly used design attributes include:

* Dimensions   * Tolerances   * Shape

* Surface finish   * Material   * Function

2. Manufacturing attribute group.

Commonly used manufacturing attributes include:

* Production processes   * Operational sequence

* Tools required   * Production time

* Batch size   * Machine tool

3. Combined attribute group.

Coding system structure

      GT begins with data input, usually through a classification and coding system. A classification and coding system is a means of describing the attributes of parts and grouping them according to those descriptions, as shown in Fig   A part-coding scheme consists of a sequence of symbols that identify the part's design and/or manufacturing attributes. The most common approach recommended is to start classification and coding with only those parts currently being released to the shop. The nature of most manufacturing is such that the number of new component shapes released begin to level out within a short time after a classification and coding system, is implemented, and therefore, an increasingly high percentage of "new" part drawings can be retrieved easily from the existing files.

      Coding systems can be contracted with only numerical symbols, only alphabetical symbols, or a combination of numbers and letters. Numerical codes have certain advantages over alphabetical codes because of a lower risk of reading errors. On the other hand, alphabetical codes can have 26 different values per position while the decimal system only has ten possible values. There are basically three types of code construction used for GT applications.

      1. Hierarchical codes (or monocodes or tree structures).

      2. Attribute codes (or polycodes or chain type structure).

      3. Hybrids, i.e. combination of monocode and polycode structures.

1. Monocode

      A hierarchical code is set up as a tree structure (as shown in fig.) In which each element, or digit, amplifies the information give in the previous digit. A tree structure works well for describing an existing ordered structure but is more difficult to use in

classifying things that have no apparent order.

Although a hierarchical code is said to be difficult to construct, it can provide a very deep analysis of the items classified and can pack an enormous amount of information into a coding system. The resulting code is very compact and yet contains a wealth of information in a rather limited number of digits. Fig. Shows the hierarchical code for a spur gear.

2. Polycodes

Polycodes are based on the total population of different attributes. In such a system, the interpretation of each character in a given digit position is independent of any other digit. One advantage of a polycode over a monocode is that parts with a specific characteristics can be readily identified. This makes the polycodes structures attractive.

3. Hybrid Codes.

Most industrial coding system uses a hybrid construction to combine the best features of monocodes and polycodes. To reduce the length of a strict polycode, the first digit of such System may split the population into appropriate subgroups, as in monocode structure.

Selection of a coding system

Several factors that should be considered in selecting a suitable classification and coding system:

*Objective. What is the major objective of the classification system? Why is a system needed? Is it primarily for design retrieval or part-family manufacturing or both?

*Scope and appliction. What department are involved in using the system? What are the specific and information to be coded? How wide is the range of products and how complex are the parts, process operations, tooling, etc.?

*Costs and time. How much expense will be involved in installation, training, and system maintenance? What is the cost estimate for consultant fees, in-house design, training, etc.? How long will it take to install and staff needed? How long will it take to realize the effects of the system in all areas of application, from design to production?

*Adaptability to other systems. Is the system easily adaptable to the computer system and database being used in the company?

*Management problems. Is there any union problem? Can good cooperation among the involved departments be obtained?

Coding systems

The coding systems widely used are:

1.RNC (Brisch-Birn type developed for General Motors) 6-digit monocode.

2.CODE (Manufacturing data systems) 8-digit hexadecimal semipolycode.

3.MICLASS (TNO) 12-digit decimal semipolycode.

4.DCLASS (Design and classifications information system) 8-digit hybrid code.

5.OPITZ (Dr. H opts, Aachen,West germany) 9-digit decimal semipolycode version.

Benefits of GT

1. In product engineering, GT can help reduce part proliferation, encourage design standardization, provide manufacturing feedback, and help with cost estimating.

2. GT can help manufacturing engineering with process selection, tooling section, machine procurement, facilities planning, materials flow, and materials handling.

3. In production, GT can reduce lead-time, production delays, and setup times and can help with asset utilization, materials handling, communication, product quality, and production supervision.

4. Production control can use group technology for group scheduling, stock accountability, expeding, and reducing WIP inventory. Buy or make decision, as well as establishment of economic order quantities, can also be handled with the application of GT.

Application of GT

1. Product design
2. Tooling and setup
3. Material handling
4. Production and inventory control
5. Process planning procedures.

Advantages of GT

1. Standardization of designs.

2. Forming of part families.

3. Development of machining cells.

4. Production scheduling can be simplified.

5. Management can be more effective because the environment has been simplified.

Disadvantages of GT

1. Installing a coding and classification system requires a large amount of time and effort.

2. Large costs may be incurred in rearranging the plant in to machine cells or groups.

3. GT concepts require changing how people work; employee resistance may be encounter.

4. Without strong support from top management, implementation of GT will be difficult.

CAD/CAM and GT

GT applications provide a common database for effective integration of cad and cam, which leads to successful implementation of CIM. The common database based on the GT concept plays a critical role in the development and implementation of CAD.

- **Using OPTIZ Coding and Classification System table below, Develop the Form code for given component:**
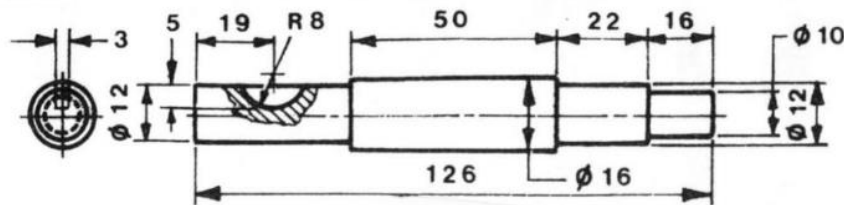
	Digit 1		Digit 2		Digit 3		Digit 4		Digit 5
	Part class		External shape, external shape elements		Internal shape, internal shape elements		Plane surface machining		Auxiliary holes and gear teeth
0	L/D ≤ 0.5	0	Smooth, no shape elements	0	No hole, no breakthrough	0	No surface machining	0	No auxiliary hole
1	0.5 < L/D < 3	1	No shape elements	1	No shape elements	1	Surface plane and/or curved in one direction, external	1	Axial, not on pitch circle diameter
2	L/D > 3	2	Thread	2	Thread	2	External plane surface related by graduation around a circle	2	Axial on pitch circle diameter
3		3	Functional groove	3	Functional groove	3	External groove and/or slot	3	Radial, not on pitch circle diameter
4		4	No shape elements	4	No shape elements	4	External spline (polygon)	4	Axial and/or radial and/or other direction
5		5	Thread	5	Thread	5	External plane surface and/or slot, external spline	5	Axial and/or radial on PCD and/or other directions
6		6	Functional groove	6	Functional groove	6	Internal plane surface and/or slot	6	Spur gear teeth
7		7	Functional cone	7	Functional cone	7	Internal spline (polygon)	7	Bevel gear teeth
8		8	Operating thread	8	Operating thread	8	Internal and external polygon, groove and/or slot	8	Other gear teeth
9		9	All others	9	All others	9	All others	9	All others

MCQ Exercises:

1. What is Group Technology (GT) primarily concerned with in manufacturing?

    a. Employee training

    b. Cost accounting

    c. Part families and production processes

    d. Marketing strategies

2. Which of the following is a key objective of Group Technology?

    a. Increasing product complexity

    b. Reducing the need for automation

    c. Streamlining production processes

    d. Maximizing individual skill sets

3. In Group Technology, what is a "part family"?

    a. A group of employees working together on a project

    b. A set of similar parts that share common characteristics and production processes

    c. A marketing strategy to promote products

    d. A manufacturing facility specializing in a specific product type

4. What is the purpose of the "coding" process in Group Technology?

    a. To create secret messages for employees

    b. To identify unique product features

    c. To assign similar codes to similar parts

    d. To track employee performance

5. Which production layout is commonly associated with Group Technology?

    a. Process Layout

    b. Product Layout

    c. Cellular Layout

    d. Fixed Layout

6. What is the role of a "cell" in Group Technology?

a. A unit of measurement for production efficiency

b. A group of machines and workstations dedicated to producing a specific set of similar parts

c. A type of employee training program

d. A tool used for quality control

7. What benefit does Group Technology bring to inventory management?

    a. Increased inventory levels

    b. Reduced inventory turnover

    c. Improved material handling

    d. Higher carrying costs

8. Which manufacturing philosophy is closely related to Group Technology?

    a. Total Quality Management (TQM)

    b. Just-In-Time (JIT)

    c. Lean Manufacturing

    d. Six Sigma

9. What is the significance of the "dissimilarity matrix" in Group Technology?

    a. It measures the similarity between employees in a workplace.

    b. It identifies differences in product specifications.

    c. It assists in grouping parts based on their dissimilarity.

    d. It evaluates the effectiveness of marketing campaigns.

10. How does Group Technology contribute to lead time reduction in manufacturing?

    a. By increasing the number of process steps

    b. By adding complexity to production processes

    c. By organizing similar parts into cells for efficient processing

    d. By outsourcing production to external suppliers

Rubrics:

1. MCQ Exercises
2. Assignment Completion
3. Attendance
4. Submission
5. Attention in Laboratory

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						

_____

Signature of Subject Teacher

AIM: **Study of Computer Aided Process Planning.**

INTRODUCTION:

Process planning translates design information into the process steps and instructions to efficiently and effectively manufacture products. As the design process is supported by many computer-aided tools, computer-aided process planning (CAPP) has evolved to simplify and improve process planning and achieve more effective use of manufacturing resources.

PROCESS PLANNING:

Process planning encompasses the activities and functions to prepare a detailed set of plans and instructions to produce a part. The planning begins with engineering drawings, specifications, parts or material lists and a forecast of demand. The results of the planning are:

Routings which specify operations, operation sequences, work centers, standards, tooling and fixtures. This routing becomes a major input to the manufacturing resource planning system to define operations for production activity control purposes and define required resources for capacity requirements planning purposes.

Process plans which typically provide more detailed, step-by-step work instructions including dimensions related to individual operations, machining parameters, set-up instructions, and quality assurance checkpoints.

Fabrication and assembly drawings to support manufacture (as opposed to engineering drawings to define the part).

Manual process planning is based on a manufacturing engineer's experience and knowledge of production facilities, equipment, their capabilities, processes, and tooling. Process planning is very time-consuming and the results vary based on the person doing the planning.
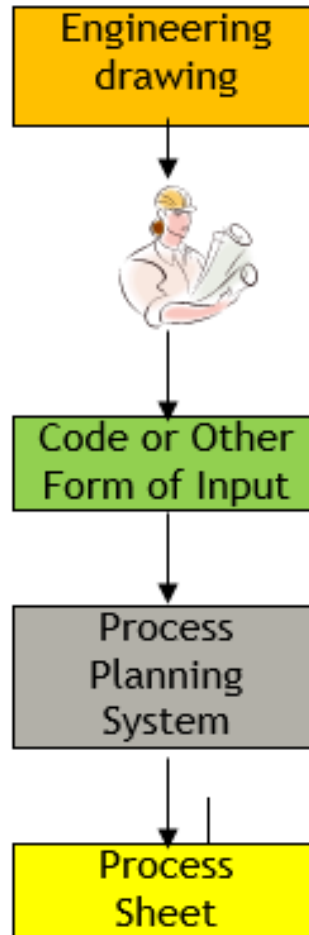
A TYPICAL PROCESS PLANNING SYSTEM

COMPUTER-AIDED PROCESS PLANNING:

Manufacturers have been pursuing an evolutionary path to improve and computerize process planning in the following five stages:

Stage   I   -   Manual classification; standardized process plans

Stage   II   -   Computer   maintained   processplans

Stage   III   -   VariantCAPP

Stage   IV   -   Generative   CAPP

Stage   V   -   Dynamic, generative CAPP

MANUAL CLASSIFICATION:

Prior to CAPP, manufacturers attempted to overcome the problems of manual process planning by basic classification of parts into families and developing somewhat

standardized process plans for parts families (Stage I). When a new part was introduced, the process plan for that family would be manually retrieved, marked-up and retyped. While this improved productivity, it did not improve the quality of the planning of processes and it did not easily take into account the differences between neither parts in a family nor improvements in production processes.

COMPUTER MAINTAINED PROCESS PLAN:

Computer-aided process planning initially evolved as a means to electronically store a process plan once it was created, retrieve it, modify it for a new part and print the plan (Stage II). Other capabilities of this stage are table-driven cost and standard estimating systems.

VARIANT CAPP:

This initial computer-aided approach evolved into what is now known as "variant" CAPP. However, variant CAPP is based on a Group Technology (GT) coding and classification approach to identify a larger number of part attributes or parameters. These attributes allow the system to select a baseline process plan for the part family and accomplish about ninety percent of the planning work. The planner will add the remaining ten percent of the effort modifying or fine-tuning the process plan. The baseline process plans stored in the computer are manually entered using a super planner concept, which is, developing standardized plans based on the accumulated experience and knowledge of multiple planners and manufacturing engineers (Stage III).

GENERATIVE CAPP:

The next stage of evolution is toward generative CAPP (Stage IV). At this stage, process planning decision rules are built into the system. These decision rules will operate based on a part's group technology or features technology coding to produce a process plan that will require minimal manual interaction and modification (e.g., entry of dimensions).

DYNAMIC CAPP:

While CAPP systems are moving more and more towards being generative, a pure generative system that can produce a complete process plan from part classification and other design data is a goal of the future. This type of purely generative system (in Stage

V) will involve the use of artificial intelligence type capabilities to produce process plans as well as be fully integrated in a CIM environment. A further step in this stage is dynamic, generative CAPP which would consider plant and machine capacities, tooling availability, work center and equipment loads, and equipment status (e.g., maintenance downtime) in developing process plans.

The process plan developed with a CAPP system at Stage V would vary over time depending on the resources and workload in the factory. For example, if a primary work center for an operation(s) was overloaded, the generative planning process would evaluate work to be released involving that work center,alternate processes and the related routings. The decision rules would result in process plans that would reduce the overloading on the primary work center by using an alternate routing that would have the least cost impact. Since finite scheduling systems are still in their infancy, this additional dimension to production scheduling is still a long way off.

Dynamic, generative CAPP also implies the need for online display of the process plan on a work order oriented basis to insure that the appropriate process plan was provided to the floor. Tight integration with a manufacturing resource planning system is needed to track shop floor status and load data and assess alternate routings vis-a-vis the schedule. Finally, this stage of CAPP would directly feed shop floor equipment controllers or, in a less automated environment, display assembly drawings online in conjunction with process plans.

A Performing CAPP module has to meet following requirements:
- It must be capable of understanding and analyzing the parts' characteristics;
- It must posses multiple knowledge about machine-tools, cutting tools and their characteristics.
- It must posses the capability of analyzing the interdependencies between part – machining process - quality - cost;
- It must posses multiple calculus possibilities.

STEPS OF PROCESS PLANNING:

Following steps should be taken into consideration while preparing a process planning sheet:-

- Study the overall shape of the part. Use this information to classify the part and determine the type of workstation needed.
- Thoroughly study the drawing. Try to identify all manufacturing features and notes.
- Determine the best raw material shape to use if raw stock is not given.
- Identify datum surfaces. Use information on datum surface to determine the setups.
- Select machines for each setup.
- Determine the rough sequence of operations necessary to create all the features for each setup.
- Sequence the operations determined in the previous step. Check whether there is any interference or dependency between operations. Use this information to modify the sequence of operations.
- Select tools for each operation. Try to use the same tool for several operations if possible. Keep in mind the trade-off on tool-change time and estimated machining time.
- Select or design fixtures for each setup.
- Evaluate the plan generated thus far and make necessary modifications.
- Select cutting parameters for each operation.
- Prepare the final process-plan document.

CAPP PLANNING PROCESS:

The system logic involved in establishing a variant process planning system is relatively straight forward - it is one of matching a code with a pre-established process plan maintained in the system. The initial challenge is in developing the GT classification and coding structure for the part families and in manually developing a standard baseline process plan for each part family.

The first key to implementing a generative system is the development of decision rules appropriate for the items to be processed. These decision rules are specified using decision trees, computer languages involving logical "if-then" type statements, or artificial intelligence approaches with object-oriented programming.

The nature of the parts will affect the complexity of the decision rules for generative planning and ultimately the degree of success in implementing the generative CAPP system. The majority of generative CAPP systems implemented to date have focused on

process planning for fabrication of sheet metal parts and less complex machined parts. In addition, there has been significant recent effort with generative process planning for assembly operations, including PCB assembly.

A second key to generative process planning is the available data related to the part to drive the planning. Simple forms of generative planning systems may be driven by GT codes. Group technology or features technology (FT) type classification without a numeric code may be used to drive CAPP. This approach would involve a user responding to a series of questions about a part that in essence capture the same information as in a GT or FT code. Eventually when features-oriented data is captured in a CAD system during the design process, this data can directly drive CAPP.

CAD/CAM INTEGRATION AND CAPP FEATURES:

A frequently overlooked step in the integration of CAD/CAM is the process planning that must occur. CAD systems generate graphically oriented data and may go so far as graphically identifying metal, etc. to be removed during processing. In order to produce such things as NC instructions for CAM equipment, basic decisions regarding equipment to be used, tooling and operation sequence need to be made. This is the function of CAPP. Without some element of CAPP, there would not be such a thing as CAD/CAM integration. Thus CAD/CAM systems that generate tool paths and NC programs include limited CAPP capabilities or imply a certain approach to processing.

CAD systems also provide graphically-oriented data to CAPP systems to use to produce assembly drawings, etc. Further, this graphically-oriented data can then be provided to manufacturing in the form of hardcopy drawings or work instruction displays. This type of system uses work instruction displays at factory workstations to display process plans graphically and guide employees through assembly step by step. The assembly is shown on the screen and as a employee steps through the assembly process with a footswitch, the components to be inserted or assembled are shown on the CRT graphically along with text instructions and warnings for each step.

If NC machining processes are involved, CAPP software exists which will select tools, feeds, and speeds, and prepare NC programs.

Interfacing the CAPP module with other modules of the CIM system:

The structure of the expert system comprises following main modules:

- Knowledge acquiring module;

- Consulting module for the analyze of the CAD models' shapes;

- Elaboration of the technological process;

- Module for analyzing and optimizing the technological process.

CAPP BENEFITS:

Significant benefits can result from the implementation of CAPP. In a detailed survey of twenty-two large and small companies using generative-type CAPP systems, the following estimated cost savings were achieved:

- 58% reduction in process planning effort

- 10% saving in direct labor

- 4% saving in material

- 10% saving in scrap

- 12% saving in tooling

- 6% reduction in work-in-process

- In addition, there are intangible benefits as follows:

  - Reduced process planning and production lead time; faster response to engineering changes

  - Greater process plan consistency; access to up-to-date information in a central database

  - Improved cost estimating procedures and fewer calculation errors

  - More complete and detailed process plans

  - Improved production scheduling and capacity utilization

  - Improved ability to introduce new manufacturing technology and rapidly update process plans to utilize the improved technology

MCQ Exercises:

1. What is the primary objective of Computer-Aided Process Planning (CAPP)?

    a. Designing products

    b. Optimizing manufacturing processes

    c. Managing inventory

    d. Quality control

2. Which of the following is a key advantage of using CAPP in manufacturing?

    a. Increased manual workload

    b. Reduced lead times

    c. Higher production costs

    d. Limited process flexibility

3. What role does CAPP play in the product life cycle?

    a. Only in the design phase

    b. Only in the production phase

    c. Across the entire product life cycle

    d. None of the above

4. Which type of information is NOT typically included in a process plan generated by CAPP?

    a. Machining operations

    b. Tooling requirements

    c. Employee schedules

    d. Material specifications

5. What is the purpose of a Variant CAPP system?

    a. Customizing products for specific customers

    b. Optimizing manufacturing processes for mass production

    c. Managing inventory levels

    d. Monitoring product quality

6. Which programming language is commonly used for implementing CAPP systems?

    a. Java

    b. C++

    c. Python

    d. All of the above

7. What is the role of a process planner in a Computer-Aided Process Planning system?

    a. Manual execution of all manufacturing processes

    b. Selection and configuration of appropriate manufacturing processes

    c. Monitoring product distribution

d. Quality assurance testing

8. Which of the following is a challenge associated with implementing CAPP in a manufacturing environment?

      a. Increased process efficiency

      b. Lack of skilled personnel

      c. Enhanced flexibility in production

      d. Reduced lead times

9. What does the acronym CAPP stand for?

      a. Computer-Aided Product Packaging

      b. Computer-Aided Process Programming

      c. Computer-Aided Process Planning

      d. Computer-Aided Product Prototyping

10. In CAPP, what does the term "Routing" refer to?

      a. Determining the best travel path in a factory

      b. Programming the movements of a robot

      c. Sequencing and detailing the steps in a manufacturing process

      d. None of the above

Rubrics:

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Signature of Subject Teacher

AIM: Study of Automatic Material Handling Equipment

Introduction:

The flow of material through the processes is an important element in the manufacturing system. some type of automation is essential for handling of material inter-shop & inter –shop in order to reduce labor cost & fulfils many other functions. It is also required to carry row materials from stores to various works cells & the finished product to the warehouse. The material handling element needs to be synchronized with work stations & different operations under a hieratical computer control system .capable of applying decision logic to the movement of materials.

Material handling:

Material handling may be defined as the functions & system associated with the transportation ,storage & physical control to work –in-process material in manufacturing. Also it can be defined as "using the right method to provide Safely the right amount of the right material at the right time , in the right sequence , in the right position , in the right condition , & the right cost". The purpose of material handling in a factory is to move row materials, work in processes, finished parts, tools & supplies from one location to another to facilities the overall operation of manufacturing.

The material control function is concerned with the identification of the various materials in the handling system, their mountings, & the scheduling of their moves.

Material handling system:

The material handling equipment may be categorized in many ways. One of the methods is the source of the motive force & the synchronization of the load movements.

In path motive handling equipment, the force applied to move the loads is provided by the transport path it self, e.g. an escalator & cable car system. In vehicle motive equipment, the force applied to motive the loads is provided by a vehicle or loads platform, e.g. trucks, trains, buses & automobiles.

In synchronous transport system, all loads moving on the transport network or a self – contained segment of the network move simultaneously at the same speed, & with a constant space between loads. In a non-synchronous transport system, the loads can move independently of one another, up to the physical limits cars, & axis.

Material handling equipment:

The material handling equipment can be divided as:

(a)   Manually operated devices hand trucks, overtricks, cranes, monorails & hoists.

(b)   Automated systems –conveyors, AGV's.

(c)   Miscellaneous system–industrial robots, transfer mechanisms, elevators, pipelines, containers, dial indexing tables, etc.

(i) HAND TRUCKS:

These are platforms with wheels for manual movements of items, unit loads, & bulk materials, e.g. wheelbarrows, two & four wheeled trucks, hand lift or manually operated fork – lift trucks.

(ii)POWER TRUCKS:

These are powered vehicles with platform for mechanized movement of items, unit's loads, & bulk materials.

(iii)CRANES, MONORAILS & HOIST:

These handling devices are usually manually operated, designed for lifting, lowering, & transporting heavy objects; e.g. bridge cranes, gantry cranes, jib cranes, overhead monorails, hand & powered hoists.

(iv)CONVEYRS:

It is a large family of handling devices, often mechanized, some times automated, designed to move materials between specific locations over a fixed path, generally in large quantities or volumes, examples include gravity conveyers (chutes, rollers) &

powered conveyors.

(v)AUTOMATED GUIDED VEHICLES (AGV'S) SYSTEM:

These are battery – powered, automatically steered vehicles designed to follow defined pathways. Some are capable of automatically loading & unloading unit loads. They are usually interfaced with other automated system to achieve full benefits of integrated automation. Examples include deriverless trains, pallet trucks & unit load carries.

Principle of material handling:
The principles of material handling are:

(i) UNIT LOAD PRINCIPLE:

Material to be moved should be aggregated in to a larger unit size, & the unit size should be the same for all materials.the materials are typically placed on a pallet or other standard sized containers for the convenience in handling.

(ii)AVOID PARTIAL LOADS:

Transport the full unit loads whenever possible rather than partial loads. Load the material handling equipment to its maximum safe limit.

(iii)SHORTEST DISTANCE PRINCIPLE:

Movements of materials should be over the shortest distances possible. This depends on the plant layout design.

(iv)STRAIGHT – LINE FLOW RULE:

The material handling path should be in a straight line from the point of origination to point of destination. This rule is consistence with the shortestdistane principle.

(v)MINIMUM TERMINALTIME PRINCIPLE:

Movements of a unit load consists of the moves time plus the time required for loading, unloading, & other activities that do not involve actual transport of the materials. Minimize these nonmoving times.

(vi)GRAVITY PRINCIPLE:

Use gravity to assist the movement of materials to the extent possible, at the same time giving consideration to safety & risk of product damage.

(vii)CARRY LOADS BOTH WAYS:

The handling system designed & scheduled, to the extent possible to carry loads in both direction are wasteful.

(viii)MECHANISATION PRINCIPLE;

Manual handling of materials should be avoided. The Handling process should be mechanized where possible to increase efficiency & economy.

(ix)SYSTEM PRINCIPLES:

Integrate the materials handling system. With other System in the facility, including, receiving inspection, Storage, production & assembly, packaging, ware Housing, shipping, & transportation.

(x) SYSTEM FLOW PRINCIPLE:

Integrate the flow of materials with the flow of information in handling & storage system. The information for each items moved should include identification, origination (pick up) point, & destination point.

(xi)PART ORIENTATION PRINCIPLE:

In automated production systems, the orientation of the work part should be established & maintained throughout the material handling processes.

SELECTION OF MATERIAL HANDLING EQUIPMENT:

MHE are given in following order.

i)   Low malignance cost .
ii)   Compliance with safety standards.
iii)   Operational environment.
iv)   Buffer storage.

v) Effective use of operating time.

MATERIAL STORAGE:

Material storage is incapable in the manufacturing systems. Storage is required for work in presses, part and delivery of material taken in excess of our immediate needs.

The storage may be classified as:

a) Static storage systems.

b) Live storage systems.

c) Automated storage systems. (Retrieval   systems)

AUTOMATION EQUATION:

For the modern factory we need programmable   equations. The easiest challenge is to make equations to transport the same part to same place fore ever. To satisfy the requisites for different configurations and options, it is necessary to build versatility and flexibility in to the systems for this purpose, we relay on the computers to do much of the jobs. The equations must be versatile, programmable and must be able to fit in the computers network.

AUTOMATED GUDED VEHICALS- AGVS:

AN AGV   is a computer controlled, drive less vehicle used for transporting materials from point to point in a Manufacturing setting.

The key terms in AGV is:

   i)   Guide path:

The guide path refers to actual path the AGV follows in making its rounds through manufacturing plant the guide path may be of the embedded wire type or optical device.

  ii) Routing:

It is ability of AGV to make designs that allow it to select the appropriate route as it moves across shop floor.

 iii) Traffic management:

This is the method to prevent collisions and to optimize traffic flow and traffic pattern of the Age. The devices used for this purpose are: Shop signs; yield signs, cautions light and stoplight.

1) TYPES OF AGV'S;

   The AGV'S types are:

       i) Towing vehicle

       ii) Unit load vehicles

       iii) Pallet trucks

       iv) Fork trucks

       v) Light load vehicle

       vi) Assembly line vehicles

2) GUIDANCE OF AGV'S:

The guidance of Agv's is following types:

       i) Manual guidance

       ii) Computer or optical guidance

       iii) Self guidance

There are two approach used for steering Age's:

       a) Differential speed steer control

       b) Streed –wheel steer controal

3) AGV SYSTEM MANAGE MENT:

     Fig illustrates an AGV system. There are three key uses in AGV system manage ment   these are: Traffic controal, Vehicle dispatch, and system monitoring.

(i)Traffic Control:

There are three methods for traffic control

(ii)Zone control:

     It is widely used in guide path areas of the Shop floor which are divided in to zones.

(iii)Forward sensing control:

     The traffic control system that works well when most of guide path are straight.
-There are specified ranges that must maintained between AGV'S.

- The sensing device consciously looks forward to since any object that falls within specified range.

(iv)Combined control:

It is used when Guide path system contains long stretches of straight guide path but still has intermittent curves and interaction.

(v) Vehicle Dispatch:

There are five methods:

a) Onboard dispatch:

In this approach each AGV has a Control panel mounted on it.

b) Off board call system:

These are used in situation of process transferring Materials from Agv to stop location is automated.

c) Remote terminal:

In this method, Human operator moves the Agv's around shop floor by the computer.

d)Central terminal:

Computer vehicle dispatch is called Central -Terminal.

e)Combition Dispatch:

In this Method Two or More method described are combined to dispatch.

i)System Monitoring:

The ideal monitoring gives Human operator instant, real time, feed back, That is following:

1) Location of all vehicles with thins the system.
2) Location of Manufacturing.
3) Move ments of vehicles.
4) Amount of time which spend by vehicles.
5) Status of all vehicles.
6) Status of batteries of all vehicles .(Charged , Charging, or weet.)

7) Distination of all vehicals.

There are three system widely used:

    a) Local panel Monitoring.

    b) Computer Display Monitoring.

    c) Performance Report.

COMPONENTS OF AGV'S:

The essential Component of an Agv's are:

1) Mechanical structure.
2) Driving and steering mechanism.
3) Servo control.
4) On board computing facilities.
5) Servo amplifier.
6) Feed back component.
7) On board power system.

APPLICATIONS OF AGV'S:

- Drive less trains operations: For move ment of large quantities of materials over relatively large distance.
- Storage and distribution system:

  -Unit load carries & pallet trucks are used,

  -Also applicable to Light manufacturing & assembly operations.
- Assembly lives operations:

  -Between workstations, Components are kitted & placed on the vehicles for the assembly.
- Flexible Manufacturing system:

  -The Agv's are used as materials handling system in the FMS.
- Miscellaneous applications:

  -Such as small delivery, in office handling, Hospital material handling etc.

ADVANTAGES OF AGV'S:

1) Agv 's represent a flexible approach to material handling, as they controlled by the computer.

2) They decrease Labor cost by decreasing the amount of Human involve ment in material handling.

3) They can operate in Hazardous environment.

4) They can handle & transport Hazardous material safely.

5) Reduction in down time of machines due to timely availability of material.

6) Improvement in productivity & profit.

7) Continuous work without interruptions.

MCQ Exercises:

1. What is the primary purpose of Automatic Material Handling Equipment (AMHE)?

    a. Product design

    b. Material storage

    c. Manufacturing process planning

    d. Employee training

2. Which of the following is NOT a common type of AMHE?

    a. Conveyor systems

    b. Forklifts

    c. Typewriters

    d. Automated guided vehicles (AGVs)

3. What is the advantage of using Automated Storage and Retrieval Systems (AS/RS) in a warehouse?

    a. Increased manual labor

    b. Higher storage capacity

    c. Slower retrieval times

    d. Limited accessibility

4. Which technology is often used for real-time tracking and control of Automated Guided Vehicles (AGVs)?

a. Barcodes

b. Morse code

c. Smoke signals

d. Carrier pigeons

5. What is the role of a Programmable Logic Controller (PLC) in AMHE systems?

a. Human resource management

b. Controlling and coordinating equipment movements

c. Financial accounting

d. Product design

6. Which factor is critical for the successful implementation of AMHE in a facility?

a. Low initial cost

b. Limited scalability

c. Compatibility with existing systems

d. Dependence on manual labor

7. What is the function of a sorting system in an AMHE setup?

a. Identifying defects in products

b. Arranging products in a specific order

c. Staff performance evaluations

d. Monitoring energy consumption

8. Which type of material handling equipment is suitable for moving heavy and bulky items within a factory or warehouse?

a. Conveyor systems

b. Automated guided vehicles (AGVs)

c. Pick and place robots

d. Manual carts

9. What does the term "Goods-to-Person" refer to in the context of AMHE?

a. A manual picking system

b. A person retrieving goods from storage

c. An automated process of delivering goods to a specific location

d. None of the above

10. Which safety feature is commonly incorporated into AMHE systems to prevent collisions?

     a. Rearview mirrors

     b. Horns

     c. Proximity sensors

     d. Traffic lights

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Signature of Subject Teacher

GUJARAT TECHNOLOGICAL UNIVERSITY
DEPARTMENT OF MECHANICAL ENGINEERING
GOVERNMENT ENGINEERING COLLEGE, PATAN
COMPUTER AIDED MANUFACTURING (3161917)
B. E. VI SEM

EXPERIMENT NO: 9   DATE:

AIM: To study Role of Robot in Manufacturing.

Introduction:

       An industrial robot is a general purpose, programmable machine possessing certain anthropomorphic characteristics. The most typical anthropomorphic, or human like, characteristic of a robot is its arm. This arm, together with the robot's capacity to be programmed, makes it ideally suited to a variety of production tasks, including machine loading, spot welding, spray-painting, and assembly. The robot can be programmed to perform a sequence of mechanical motions, and it can repeat that motion sequence over and over until reprogrammed to perform some other job.

   General application characteristics

       There are certain general characteristics of an industrial situation, which tend to make the installation of a robot economical and practical. These general characteristics include:

1) Hazardous or uncomfortable working condition :- In job situations where there are potential dangers to health due to radiation, heat, or toxicity, robot should be considered as a substitute for the human worker.Ex.hot forging, die casting, spray painting, and foundry operations.

2) Repetitive task :- if the work cycle consists of a sequence of elements which do not vary from cycle to cycle, it is possible that a robot could be programmed to perform the task.

3) Difficult handling :- If the work part or tool involved in the operation is awkward

heavy, it might be possible for a robot to perform the task.

4) Multishift operation :- if the initial investment cost of the robot can be spread over 2 or 3 shifts, the labour savings will result in a quicker payback.

Selecting the right applications

Not all robot installations have been successful. There are enough case histories of misapplications, poorly selected equipments, and non-acceptance by factory personnel to make a prospective user very careful, especially in an initial application. The GE Company uses the following criteria in performing a plant survey in search of practical and economical robot applications:

- Simple operations are needed.
- Cycle time is greater than 5s
- Parts can be delivered in proper location.
- Part weight is suitable.
- No inspection is required.
- Setups are not frequent.

Application areas for industrial robots

Indutrial robots have been applied to a great variety of production situations. Applications are divided in following seven categories:

1. Material Transfer
2. Machine Loading
3. Welding
4. Spray Coating
5. Processing Operation
6. Assembly
7. Inspection

Material transfer :

Robot is used to move work parts from one location to another. Examples of material transfer robot operations include

- Pick and place operations
- Palletizing operations
- Depalletizing operation
- Loading parts from conveyor to cartons.

Machine loading:

Robot is required to supply a production machine with raw work parts or to unload finished parts from the machine. Some machine loading applications consist of several part processing machines in a manufacturing cell, with the robot tending two , three, or even four separate machines. Application include:

- Die casting
- Injection molding
- Transfer molding
- Hot forging
- Upsetting
- Stamping press operation
- Machining operations

Welding:

The application is divided into two basic categories, spot welding and arc welding.

Spot welding:

The robot accomplishes spot weld by means of following sequence

1. Position the welding gun in the desired location against the two pieces.
2. Squeezing the electrodes
3. Weld and hold whenthe current is applied
4. Release and cool

This is a sequence which has become an ideal task for a point to point robot.

Arc welding:

Industrial robots capable of continuous path operation can accomplish several types of continuous arc welding processes. These processes include gas metal arc welding

and gas tungsten arc welding.

Application Industeries:

- Automotive industry
- Motorcycle and bicycle frames
- Truck cabins

Spray coating

Spray painting process possess certain health hazards to the human operator like:

1. fumes and mist from spraying operation
2. noise from the spray nozzle
3. fire hazard
4. possible cancer dangers

For these reasons specialized robots are used to perform spray painting.

Advantages

- safety
- coating consistency
- lower materialusage
- less energyused
- greater productivity

Inspection

Robots equipped with mechanical probes ,optical sensing capabilities,ort other measuring devices can be programmed to perform dimensionalchecking and other forms of inspection operation.

EXAMPLE:

At Ford Motor Companies, Michigan, assembly plant four Cincinnati Milacron T3 robots are used in an Automatic Body Checking (ABC) system.

The system performs dimensional inspection on automobile bodies. The robots use electronic probes as their end effectors. With these probes, approximately 150 dimensional checks are made around the windshield, door, and back window openings. These checks are important because the openings receive mating parts the windshield,

doors, etc.) which must fit within fairly close tolerances.

MCQ Exercises:

1. What is the primary purpose of robots in manufacturing?

      a. Product design

      b. Quality control

      c. Employee training

      d. Office administration

2. Which type of robot is designed to work alongside human workers on the factory floor?

      a. Industrial robot

      b. Collaborative robot (Cobot)

      c. Service robot

      d. Autonomous robot

3. What is the advantage of using robots in repetitive and labor-intensive tasks in manufacturing?

      a. Increased manual labor

      b. Higher production costs

      c. Improved efficiency and consistency

      d. Limited scalability

4. Which programming language is commonly used to program industrial robots?

      a. Python

      b. C++

      c. RobotScript

      d. Java

5. What is the role of a Vision System in robotic manufacturing?

      a. Controlling robot movements

      b. Providing human-like dexterity to robots

      c. Enhancing the robot's ability to perceive and react to its environment

      d. Performing financial calculations

6. Which factor is a limitation of industrial robots in terms of flexibility and adaptability to changing tasks?

      a. High initial cost

      b. Lack of precision

      c. Programming complexity

      d. Small workspace

7. What is the primary function of a Pick and Place robot in a manufacturing setting?

      a. Designing products

      b. Assembling components

      c. Sorting and moving objects

      d. Managing inventory

8. Which application area is NOT commonly associated with the use of robots in manufacturing?

      a. Welding

      b. Painting

      c. Writing code

      d. Assembly

9. What is the purpose of Force/Torque sensors in robotic systems?

      a. Enhancing visual perception

      b. Improving mobility

      c. Providing feedback on applied forces during tasks

      d. Managing energy consumption

10. Which safety feature is crucial for collaborative robots working alongside human operators?

      a. Invisibility cloak

      b. Emergency stop button

      c. Self-destruct mechanism

      d. Loud alarms

Rubrics:

1. MCQ Exercises

2. Assignment Completion

3. Attendance

4. Submission

5. Attention in Laboratory

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						

_____

Signature of Subject Teacher

GUJARAT TECHNOLOGICAL UNIVERSITY
DEPARTMENT OF MECHANICAL ENGINEERING
GOVERNMENT ENGINEERING COLLEGE, PATAN
COMPUTER AIDED MANUFACTURING (3161917)
B. E. VI SEM

EXPERIMENT NO: 10   DATE:

AIM: To Study About Computer Aided Production Planning

Introduction:-

Manufacturing planning and control deals with developing plans for producing products, implementing these plans , monitoring progress toward achieving these plans, and developing and implementing corrective actions when the original plans need modification. Manufacturing operations is directly responsible for manufacturing the product. This includes scheduling and manning the manufacturing equipment, capacity planning, shop-floor control, maintenance, cost management and quality management.

TRADITIONAL PRODUCTION PLANNING AND CONTROL

At least a dozen separate function can be identified as constructing the cycle of activities in traditional production planning and control. Organizationally, some of these functions are performed by departments In the firm other than the production control department. The functions are described in the following sections.

Forecasting:-

Forecasting may be defined as to calculate or predict some future event or condition, usually as a result of rational study and analysis of available pertinent data. It is a procedure which enabled a company to predict future events upon which decision controlling the allocation and use of use of resources can be based.

There are three basic types of forecasting techniques: qualitative , quantitative and casual. The first uses qualitative data (e.g. expert opinion)and information about special events. It may or may not take the past into consideration. The second focuses entirely on pattern changes, and thus relies entirely on historical data. The third uses highly refined and specific information about relationship between system elements and is sufficiently

powerful to take special events into account. Quantitative forecasting techniques are frequently used in master scheduling analysis and decisions. The two most important groups of forecasting methods in this context are those defined in the **time-series** and **explanatory** categories.

Production planning

This is sometimes called aggregate production planning and its objective is to establish general production levels for product groups over the next year or so. It is based on the sales forecast and is used to raise or lower inventories, stabilize, stabilize production over the planning horizon, and allow for the launching of new products into the company's product. Aggregate production planning is a function that precedes the detailed master production schedule.

Process planning

At we described in Chapter 13, process planning involves determining the sequence of manufacturing operations required to produce a certain product and/or its components. Process planning has traditionally been carried out by manufacturing engineers as a very manual and clerical procedure. The resulting document prepared by hand, is called a route sheet and is a listing of the operations and machine tools through which the part or product must be routed. The term "routing" is sometimes applied to describe the process planning function.

Estimating

For purposes of determining prices, predicting costs, and preparing schedules, the firm will determine estimates of the manufacturing lead times and production costs for its products. The manufacturing lead time is the total time required to process a work part through the factory. The production costs are the sum of the material costs, labor, and applicable overhead costs needed to produce the part. These estimates of lead times and costs are based on date contained in the route sheets, purchasing files, and accounting records.

Requirements planning

Based on the master schedule, the individual components and subassemblies that make up each product must be planned. Raw materials must be ordered to make the

various components. Purchased parts must be ordered. And all of these items must be planned so that the components and assemblies are available when needed. This whole task is called requirements planning or material requirements planning.

Purchasing

The firm will elect to manufacturer some components its products in its own plants. Other components will be purchased. Deciding between these alternative is the familiar "make-or-buy" decision. For the components made in-house, raw materials have to be acquired. Ordering the raw materials and purchased components is the function of the purchasing department. Materials will be ordered and the receipt of these items will be scheduled according to the timetable defined during the requirements planning procedure.

Machine loading and scheduling

``It involves the assignment of start dares and due dates for the components to be processed through the factory. Several factors make scheduling complex.
The total number of jobs to be processed through the factory will typically exceed the number of machines by a substantial margin. Accordingly, each machine, or work center, will 'have aqueous of jobs waiting to be processed. Allocating the jobs to work centers is referred to as machine loading. Allocating the jobs to the entire shop is called shop loading.

Dispatching

Based on the production schedule, the dispatching function is concerned with issuing the individual orders to the machine operators. This involves giving out order tickets, route sheets, part drawing, and job instructions. The dispatching function in some shops is performed by the shop foremen, in other shops by a person called a dispatcher.

Expediting

Even with the best plans and schedules, things go wrong. It is the expediter's job to compare the actual progress of the order against the production schedule. For orders that fall schedule, the expedite, the expediter recommends corrective action. This may involve rearranging the sequence in which orders are to be done on a certain machine, coaxing the foreman to tear done one setup so that another order can be run, or hand-carrying parts from one department to the next just to keep production going. There are many reasons why things go wrong in production parts-in process have not yet arrived from the

previous department, machine breakdowns, proper tooling not available, quality problems, and so forth.

Quality control

The quality control department is responsible for assuring that the quality of the product and its components meets the standards specified by the designer. This function must be accomplished at various points throughout the manufacturing cycle. Materials and parts purchased from outside suppliers must be inspected when they are received. The inventory control function applies not only to the company's final products. It also applies to raw materials, purchased components, and work-in-process within the factory.

Master Scheduling

A MPS is generally defined as an anticipated build schedule for manufacturing and items or product options. It is a key decision making activity. The demands coming from business or planning are translated at the MPS level into demands on the manufacturing system. The MPS is driven by a combination of actual customer orders and forecasts of likely orders. The MPS has several important uses.

1. Marketing, engineering, manufacturing and finance use it to coordinate their activities.

2. Management uses it to plan and control workforce levels , plant facilities, equipment materials vendors and costs.

3. Management uses it to specify what should be made.

4. Management uses it as a planning device to balance customer needs with plant capacities.

The MPS is not a demand or sales forecast. It is also not a fabrication or assembly schedules, because inventories have not been considered.

FIGURE 14.1 Cycle of activities in a traditional production planning and control system.

PROBLEMS WITH TRADITIONAL PRODUCTION PLANNING AND CONTROL

There are many problems that occur during the cycle of activities in the traditional approach to production and control. Many of these problems result directly from imitational approach to deal with the complex and ever-changing nature of manufacturing. The types of problems commonly encountered in the planning and control of production are the following:

1.   **plant capacity problems.** Production Jails behind schedule due to a lack of and equipment. This results in excessive overtime, delays in meeting delivery schedules, customer complaints, backordering, and other similar problems.

2.   Suboptimal production. The wrong jobs are scheduled because of a lack of clear order priorities, inefficient scheduling ruls, and the ever-changing status of jobs in the ship. As a consequence, production runs are interrupted by jobs whose priorities have suddenly increased, machine setups are increased, and jobs that are on schedule fall behind.

3.   Long manufacturing lead times.   In an attempt to compensate for problems 1 and 2, production planners allow extra time to produce an order. The shop becomes overloaded, order priorities become confused, and the result is excessively long manufacturing lead times.

4.   Inefficient inventory control control.   At the same time that total inventories are too high for raw materials, work-in-progress, and finished products, there are stock outs that occur on individual items needed for production. High total inventories mean high carrying costs, -while raw material stock outs mean delays in meeting production schedules.   -

5.   Low work center utilization.   This problem results in part from poor scheduling {excessive product changeovers and job interruptions), and form other factors over which plant management has limited control (e.g. equipment breakdowns, strikes. reduced demand for products.)

6.   Process planning not followed. This is the situation in which the regular planned routing is superseded by an ad hoc process sequence. It occurs, for instance, because of bottlenecks at work centers in the planned sequence. The consequences are longer setups, improper tooling, and less efficient processes.

7.   Errors in engineering and manufacturing.   Bills of materials are nit current, route sheets are not up to date with respect to the latest engineering changes, inventory records are inaccurate, and production piece counts are incorrect.

8.   Quality problems. Quality defects are encountered in manufactured components and assembled products, resulting in rework or scrapped parts, thus causing delays in the shipping schedule.

Material Requirements Planning

Material requirements planning is a computerized method for managing inventories and issuing orders for parts and materials. It converts the master schedule for end products into a detailed schedule for a raw materials and components used in the end products. The detailed schedule identifies the quantities of each raw material and

component item. It also tells when each item must be ordered and delivered so as to meet the master schedule for the final products. It is an effective tool for minimizing unnecessary inventory investment and is also useful in production scheduling and purchasing of materials.

Basic MRP Concepts:-

   The basic MRP concepts are:-

1.Independent vs dependent demand.

2.Lumpy Demand.

3.Lead times

4.Common use items.

Independent Demand:-

   Means that demand for a product is unrelated to demand for other items, e.g. end products and space parts. Independent demand patterns must usually be forecasted.

Dependant Demand:-

   Means that demand for the item is related directly to the demand for some other products, e.g. raw materials, component parts and sub assemblies. MRP is the appropriate technique for determining quantities of dependent demand items.

Lumpy Demand:-

   Occurs in large increments. MRP is the appropriate approach for dealing with inventory situations characterized by lumpy demand.

Lead Time:-

   For a job is the time that must be allowed to complete the job from start to finish. In MRP lead times are used to determine starting dates for assembling final products and subassemblies, for producing component parts and for ordering raw materials.

Common use items:-

   In manufacturing the basic raw materials are often used to produce more than one component type. Also a given component may be used on more than one final product. MRP collects these common use items from different products to affect economics in

ordering the raw materials and manufacturing the components.

Structure of a MRP system:-

MRP requires the following data:

1.Master production plan.

2.On-hand inventories.

3.Product structure (bill of material)

4.Purchased or manufactured order status by item.

5.Purchased or manufactured order status by item.

6.Replenishment rules by item:

(a) Lead time   (b) Order quality

(c) Scrap allowance   (d) Safety stock

(e) Etc.

Fig. represents a diagram showing the flow of data into the MRP processor and its conversion into useful output reports. Because so much data is required a major MRP implementation problem is data accuracy.

The master production schedule represents everything the firm plans to ship: finished items, spares, etc. Manufacturing and procurement lead time must be considered; otherwise the product can not be shipped on time. The master production schedule represents the independent demand because it is the combination of orders on the books and forecasts. However end items are usually composed of several components; consequently, end-item demand creates a demand for these components, called dependent demand.

Working of MRP:-

MRP logic tapes the master production schedule and breaks it down into dependent demands using the boil of materials. Some components may be used in different products or subassemblies ; consequently these demands must be consolidated. These consolidated demands are called **gross requirements.**

In the next step inventory on hand is subtracted from gross requirements. At this time any allowances for scrap and safety stock can be applied. Next any purchased or manufacturing orders outstanding are subtracted giving the **net requirements.**

Using the order quantity rules the order quantities are computed and then offset from the requirements date to allow for procurement and manufacturing lead times.

Variations from previous plans must be considered before the current MRP cycle is completed. Because of these changes, orders may have to be expedited, delayed increased and/or decreased.

MRP Output reports:-

The MRP program generates a variety of outputs that can be used in the planning and management of plant operations. These outputs include:

(a) Primary outputs:-

1. Order release notice, to place orders that have been planned by the MRP system.
2. Reports showing planned orders to be released in future periods.
3. Rescheduling notices, indicating changes in due dates for open orders.
4. Cancellation notices, in directing cancellation of open orders because of changes in the master schedule.
5. Reports on inventory status.

(b) Secondary Output:-

1. Performance reports of various types, indicating costs, item usage, actual v's planned lead times, and other measures of performance.
2. Exception reports, showing deviation from schedule, orders that are overdue, scrap, and so on.
3. Inventory forecasts, indicating projected inventory levels in future periods.

Benefits of MRP:-

The benefits of MRP system are:

1. Improved level of customer service.
2. Better production scheduling.
3. Reduced inventory levels.
4. Reduced component shortages.
5. Reduced production lead times.
6. Reduced manufacturing costs.
7. Higher product quality.
8. Less scrap and rework.
9. Higher morale in production.

10. Improved communication.

11. Improved plant efficiency.

12. Improved competitive position.

13. Improved coordination with marketing and finance.

The statistics touted for a well managed MRP system are impressive: productivity up 5-30%,WIP inventories down 30-50% late orders slashed 90%, labor requirements reduced 10%.

Manufacturing-Resource planning-MRP II:-

Manufacturing resource planning: II is an attempt to tie material requirements planning to the financial system of a company and thereby, achieve a "company operating system" and "a total business plan".

MRP-II promises that such a tie-up between MRP and financial system can provide an effective planning tool for a manufacturing company, including a computer model of the business for simulation and what-if planning. Realization of MRP II is based on the assumption that an appropriate and complete computerized business system exists and that a proper simulation model can be created. Moreover, it assumes that all the information system are compatible, permitting exchange and interaction of information.Fig. illustrates a typical management information system.

MRP II is concerned with all facets of the business, including sales, production, engineering, inventories, and cash flows. In all cases, the operations of the individual departments are reduced to the same common denominator; financial data. this common based provides the company management with the information needed to manage it successfully. In essence, MRP II is quite similar to CIPMS.

Structure of MRP II:-

The structure of MRP II is illustrated in fig.. the implementation of MRP II depends largely on an effective management-information system, including timely and accurate status reporting.

The MRP II adopts a modular approach and generally include the following main planning and control modules;

- Resources requirement planning (RRP)
- Production planning (PP)
- Master production schedules (MPS)

- Materials requirement planning (MRP)
- Capacity requirement planning (CRP)
- Shop follow control (SFC)
- Inventory control (IC.)

A typical framework for MRP II for repetitive manufacture is given in fig.18.7.

Capacity Planning:-

`   Capacity planning is concerned with determining what labor and equipment capacity is require to meet the current master production schedule as well as the long term future production needs of the firm. Capacity planning is typically performed in terms of labor and/or machine hours available. The master schedule is transformed into material and component requirements using MRP. Then these requirements are compared with available plant capacity over the planning horizon. If the schedule is incompatible with capacity, adjustments must be made either in the master schedule or in plant capacity. Capacity adjustments can be accomplished in either the short term or the long-term. For short-term adjustments decisions on the following factors are needed.

- Employment level.
- Number of work shifts.
- Labor overtime hours and reduced workweek.
- Inventory stockpit.
- Order backlogs.
- Subcontracting.

Long-term capacity requirements would include the following types of decisions:

- New more productive modern machines.
- New plant construction.
- Purchase of existing plants from other companies.
- Closing down or selling off existing facilities which will not be needed
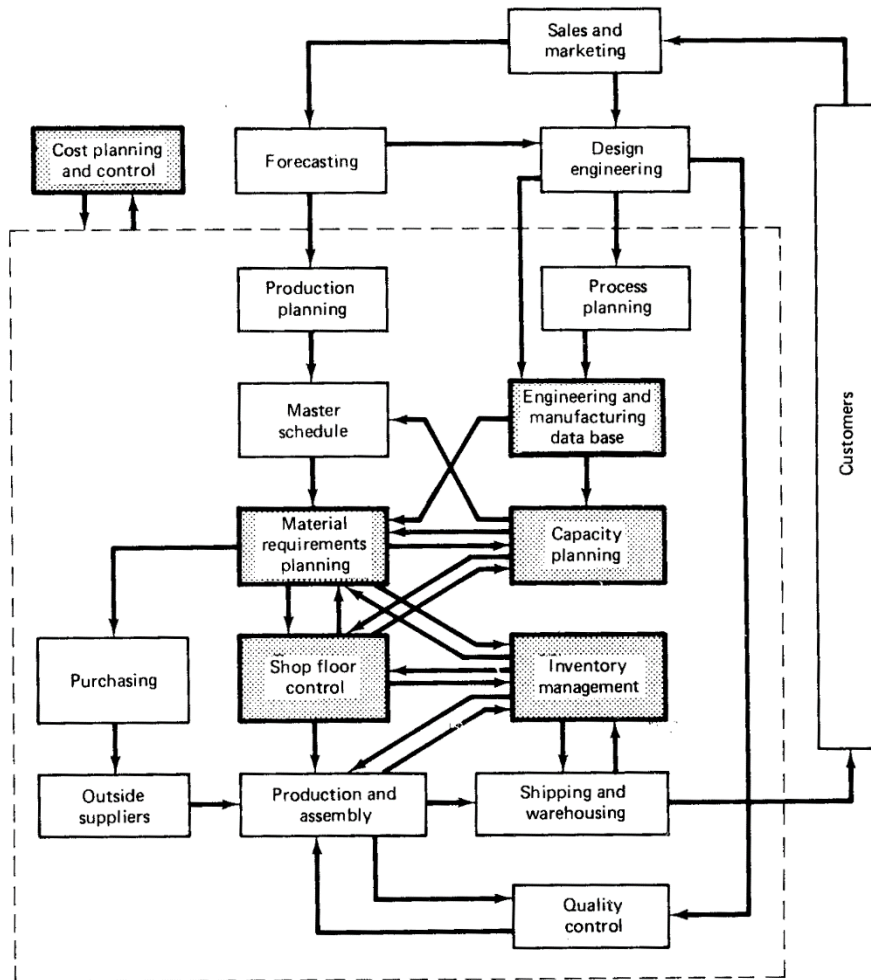- In the future.

FIGURE 14.2 Cycle of activities in a computer-integrated production management system.

MCQ Exercises:

1. What is the main purpose of Material Requirements Planning (MRP)?

    a. Machine maintenance

    b. Inventory control

    c. Quality control

    d. Employee scheduling

2. Which phase of production planning involves defining the sequence of operations and scheduling tasks?

    a. Master Production Scheduling (MPS)

    b. Detailed Planning and Scheduling

    c. Material Requirements Planning (MRP)

    d. Capacity Planning

3. How does MRP assist in managing inventory?

    a. Minimizing safety stock levels

    b. Maximizing order quantities

    c. Identifying excess raw materials

    d. Reducing supplier lead times

4. Which type of production system does Computer-Aided Production Planning often target for optimization?

    a. Batch production

    b. Continuous production

    c. Job shop production

    d. Mass production

5. What is the purpose of a Bill of Materials (BOM) in Computer-Aided Production Planning?

    a. Employee scheduling

    b. Resource allocation

    c. Material identification and requirements

    d. Quality assurance

6. Which component of Computer-Aided Production Planning deals with ensuring that the necessary resources are available to meet production requirements?

    a. Material Requirements Planning (MRP)

    b. Capacity Planning

    c. Master Production Scheduling (MPS)

    d. Detailed Planning and Scheduling

7. What is the significance of a Routing Sheet in production planning?

    a. Employee training

    b. Process documentation

    c. Cost accounting

    d. Supplier negotiations

8. In Computer-Aided Process Planning, what is the purpose of variant process planning?

    a. Optimizing machine utilization

    b. Handling multiple product configurations

    c. Reducing energy consumption

    d. Minimizing lead times

9. What is the main benefit of integrating Computer-Aided Design (CAD) with Computer-Aided Process Planning (CAPP)?

    a. Increased employee morale

    b. Faster internet connectivity

    c. Improved product design consistency

    d. Enhanced communication with suppliers

10. Which production planning approach focuses on adjusting production schedules in real-time based on actual demand and capacity?

    a. Just-in-Time (JIT)

    b. Lean Manufacturing

    c. Agile Manufacturing

    d. Six Sigma

Rubrics:

1. MCQ Exercises
2. Assignment Completion
3. Attendance
4. Submission
5. **Attention in Laboratory**

Rubric wise marks obtained:

Rubrics	1	2	3	4	5	Total
Marks						

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Signature of Subject Teacher