LECTURE NOTES

ON

COMPUTER INTEGRATED MANUFACTURING

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UNIT-I

1.1 Introduction To CIM

Computer Integrated Manufacturing (CIM) encompasses the entire range of product development and manufacturing activities with all the functions being carried out with the help of dedicated software packages. The data required for various functions are passedfrom one application software to another in a seamless manner. For example, the productdata is created during design. This data has to be transferred from the modeling softwareto manufacturing software without any loss of data. CIM uses a common databasewherever feasible and communication technologies to integrate design, manufacturingand associated business functions that combine the automated segments of a factory ora manufacturing facility. CIM reduces the human component of manufacturing andthereby relieves the process of its slow, expensive and error-prone component. CIM standsfor a holistic and methodological approach to the activities of the manufacturing enterprise in order to achieve vast improvement in its performance.This methodological approach is applied to all activities from the design of the productto customer support in an integrated way, using various methods, means and techniquesin order to achieve production improvement, cost reduction, fulfillment of scheduleddelivery dates, quality improvement and total flexibility in the manufacturing system.

CIM requires all those associated with a company to involve totally in the process of productdevelopment and manufacture. In such a holistic approach, economic, social and humanaspects have the same importance as technical aspects.

Manufacturing industries strive to reduce the cost of the product continuously to remaincompetitive in the face of global competition. In addition, there is the need to improve thequality and performance levels on a continuing basis. Another important requirement ison time delivery. In the context of global outsourcing and long supply chains cutting acrossseveral international borders, the task of continuously reducing delivery times is really anarduous task. CIM has several software tools to address the above needs.

Manufacturing engineers are required to achieve the following objectives to be competitive in a global context.

• Reduction in inventory

• Lower the cost of the product

- Reduce waste
- Improve quality
- Increase flexibility in manufacturing to achieve immediate and rapid response to:
    - Product changes
    - Production changes
    - Process change
    - Equipment change
    - Change of personnel

CIM technology is an enabling technology to meet the above challenges to the manufacturing.

The advances in automation have enabled industries to develop islands of automation.Examples are flexible manufacturing cells, robotized work cells, flexible inspection cellsetc. One of the objectives of CIM is to achieve the consolidation and integration of theseislands of automation. This requires sharing of information among different applicationsor sections of a factory, accessing incompatible and heterogeneous data and devices. Theultimate objective is to meet the competition by improved customer satisfaction throughreduction in cost, improvement in quality and reduction in product development time.

1.2 Types Of Manufacturing

Manufacturing industries can be grouped into

i. Continuous Process Industries

In this type of industry, the production process generally follows a specificsequence. These industries can be easily automated and computers are widelyused for process monitoring, control and optimization. Oil refineries, chemicalplants, food processing industries, etc are examples of continuous processindustries.

ii. Mass Production Industries

Industries manufacturing fasteners (nuts, bolts etc.), integrated chips, automobiles,entertainment electronic products, bicycles, bearings etc. which are all massproduced can be classified as mass production industries. Production lines arespecially designed and optimized to ensure automatic and cost effective operation.Automation can be either fixed type or flexible.

iii. Batch Production (Discrete Manufacturing)

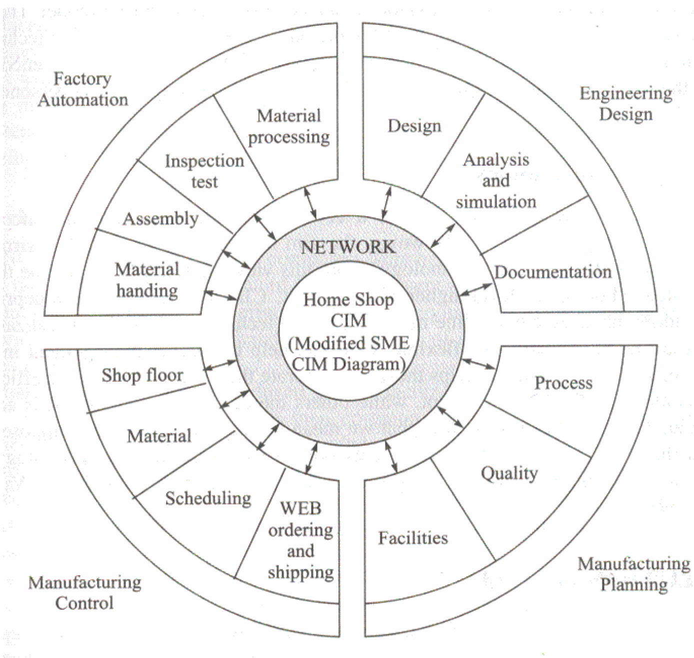
The largest percentage of manufacturing industries can be classified as batchproduction industries. The distinguishing features of this type of manufacture arethe small to medium size of the batch, and varieties of such products to be takenup in a single shop. Due to the variety of components handled, work centersshould have broader specifications. Another important fact is that small batchsize involves loss of production time associated with product changeover.

1.3 Definition of CIM

Jack Conaway, CIM Marketing manager, DEC, defines CIM is nothing but a data managementand networking problem.

The computer and automated systems association of the society of Manufacturing Engineers(CASA/SEM) defines CIM is the integration of total manufacturing enterprise by usingintegrated systems and data communication coupled with new managerial philosophies thatimprove organizational and personnel efficiency.

1.4CIM Wheel



1.5 CIM components

Nine major elements of a CIM system are

- Marketing
- Product Design
- Planning
- Purchase
- Manufacturing Engineering

• Factory Automation Hardware

• Warehousing

• Logistics and Supply Chain Management

• Finance

• Information Management

i. Marketing: The need for a product is identified by the marketing division. The specifications of the product, the projection of manufacturing quantities and the strategy for marketing the product arealso decided by the marketing department. Marketing also works out the manufacturing costs to assess the economic viability of the product.

ii. Product Design: The design department of the company establishes the initial database forproduction of a proposed product. In a CIM system this is accomplished through activities such as geometric modeling and computer aided design while considering the product requirements and concepts generated by the creativity of the design engineer.

Configuration management is an important activity in many designs. Complex designs are usually carried out by several teams working simultaneously, located often in different parts of the world. The design process is constrained by the costs that will be incurred in actual production and by the capabilities of the available production equipment and processes. The design process creates the database required to manufacture the part.

iii. Planning: The planning department takes the database established by the design department and enriches it with production data and information to produce a plan for the production of the product. Planning involves several subsystems dealing with materials, facility, process, tools, manpower, capacity, scheduling, outsourcing, assembly, inspection, logistics etc. In a CIM system, this planning process should be constrained by the production costs and by the production equipment and process capability, in order to generate an optimized plan.

iv. Purchase: The purchase departments is responsible for placing the purchase orders and follow up, ensure quality in the production process of the vendor, receive the items, arrange for inspection and supply the items to the stores or arrange timely delivery depending on the production schedule for eventual supply to manufacture andassembly.

v. Manufacturing Engineering: Manufacturing Engineering is the activity of carrying out the production of the product, involving further enrichment of the database with performance data and information about the production equipment and processes. In CIM, this requires activities like CNC programming, simulation and computer aided scheduling of the production activity. This should include online dynamic scheduling and control based on the real time performance of the equipment and processes to assure continuous production activity. Often, the need to meet fluctuating market demand requires the manufacturing system flexible and agile.

vi. Factory Automation Hardware: Factory automation equipment further enriches the database with equipment and process data, resident either in the operator or the equipment to carry out the production process. In CIM system this consists of computer controlled process machinery such as CNC machine tools, flexible manufacturing systems (FMS), Computer controlled robots, material handling systems, computer controlled assembly systems, flexibly automated inspection systems and so on.

vii. Warehousing: Warehousing is the function involving storage and retrieval of raw materials, components, finished goods as well as shipment of items. In today's complex outsourcing scenario and the need for just-in-time supply of components and subsystems, logistics and supply chain management assume great importance.

viii. Finance: Finance deals with the resources pertaining to money. Planning of investment, working capital, and cash flow control, realization of receipts, accounting and allocation of funds are the major tasks of the finance departments.

ix. Information Management: Information Management is perhaps one of the crucial tasks in CIM. This involves master production scheduling, database management, communication, manufacturing systems integration and management information systems.

1.6 Evolution Of CIM

Computer Integrated Manufacturing (CIM) is considered a natural evolution of thetechnology of CAD/CAM which by itself evolved by the integration of CAD and CAM.Massachusetts Institute of Technology (MIT, USA) is credited with pioneering the development in both CAD and CAM. The need to meet the design and manufacturingrequirements of aerospace industries after the Second World War necessitated thedevelopment these technologies. The manufacturing technology available during late 40'sand early 50's could not meet the design and manufacturing challenges arising out of theneed to develop sophisticated aircraft and satellite launch vehicles. This prompted the USAir Force to approach MIT to develop suitable control systems, drives and programmingtechniques for machine tools using electronic control.

The first major innovation in machine control is the Numerical Control (NC),demonstrated at MIT in 1952. Early Numerical Control Systems were all basically hardwiredsystems, since these were built with discrete systems or with later first generation integratedchips. Early NC machines used paper tape as an input medium. Every NC machine wasfitted with a tape reader to read paper tape and transfer the program to the memory of themachine tool block by block. Mainframe computers were used tocontrol a group of NCmachines by mid 60's. This arrangement was then called Direct Numerical Control (DNC)as the computer bypassed the tape reader to transfer the program data to the machinecontroller. By late 60's mini computers were being commonly used to control NC machines.At this stage NC became truly soft wired with the facilities of mass program storage, offlineediting and software logic control and processing. This development is called ComputerNumerical Control (CNC).

Since 70's, numerical controllers are being designed around microprocessors, resultingin compact CNC systems. A further development to this technology is the distributednumerical control (also called DNC) in which processing of NC program is carried out indifferent computers operating at different hierarchical levels - typically from mainframehost computers to plant computers to the machine controller. Today the CNC systems arebuilt around powerful 32 bit and 64 bit microprocessors. PC based systems are alsobecoming increasingly popular.

Manufacturing engineers also started using computers for such tasks like inventorycontrol, demand forecasting, production planning and control etc. CNC technology wasadapted in the development of co-ordinate measuring machine's (CMMs) which automatedinspection. Robots were introduced to automate several tasks like machine loading,materials handling, welding, painting and assembly. All these developments led to theevolution of flexible manufacturing cells and flexible manufacturing systems in late 70’s.

Evolution of Computer Aided Design (CAD), on the other hand was to cater to thegeometric modeling needs of automobile and aeronautical industries. The developmentsin computers, design workstations, graphic cards, display devices and graphic inputand output devices during the last ten years have been phenomenal. This coupled withthe development of operating system with graphic user interfaces and powerful interactive(user friendly) software packages for modeling, drafting, analysis and optimizationprovides the necessary tools to automate the design process.

CAD in fact owes its development to the APT language project at MIT in early 50’s.Several clones of APT were introduced in 80’s to automatically develop NC codes from the geometric model of the component. Now, one can model, draft, analyze, simulate,modify, optimize and create the NC code to manufacture a component and simulate themachining operation sitting at a computer workstation.

1.7Needs of CIM

- Computer Numerical Control (CNC)
- Direct Numerical Control (DNC)
- Computer Process Control
- Computer Integrated Production Management
- Automated Inspection Methods
- Industrial Robots etc.

1.8 CIMS Benefits:

(i) Products quality improvement.

(ii) Shorter time in launching new product in the market.

(iii) Flow time minimized.

(iv) Inventory level reduced.

(v) Competitiveness increases.

(vi) Improved scheduling performance.

(vii) Shorter vendor lead time.

(viii) Improved customer service.

(ix) Increase in flexibility and responsiveness.

(x) Total cost minimized.

(xi) Long term profitability increases.

(xii) Customers lead time minimized.

(xiii) Manufacturing productivity increases.

(xiv) Work in process inventory decreases.

1.9Basic components of NC system

1.Input medium

2.MCU

3.Machine Tool

Basic Components of an NC System And NC system consists of three basic components: (1) Program of instructions: The detailed step-by-step commands that direct the actions of the processing equipment. In machine tool applications, the program of instructions is called a part program, and the person who prepares the program is called a part programmer. In these applications, the individual commands refer to positions of a cutting tool relative to the worktable on which the workpart is fixtured. Additional instructions are usually included, such as spindle speed, feed rate, cutting tool selection, and other functions. The program is coded on a suitable medium for submission to the machine control unit. (2) Machine control unit MCU: Consists of a microcomputer and related control hardware that stores the program of instructions and executes it by converting each command into mechanical actions of the processing equipment, one command at a time. The related hardware of the MCU includes components to interface with processing equipment and feedback control elements. The MCU also includes one or more reading devices for entering part programs into memory. The MCU also includes control system software, calculation algorithms, and translation software to convert the NC part program into a usable format for the MCU.

1.10 NC motion control system

In order to accomplish the machining process, the cutting tool and workpiece must be moved relative to each other. In NC, there are three basic types of motion control system (Point-to-point, Straight cut and Contouring). Point-to-point systems represent the lowest level of motion control between the tool and workpiece. Contouring represents the highest level of control.

1-Point-to-point Positioning Control:

Point-to-point (PTP) is also sometimes called a positioning system. In PTP, the objective of the machine tool control system is to move the cutting tool to a predefined location. The principle function of the PTP is to position the tool form one point to another within coordinate system. The positioning may be linear in the x-y plane or linear and rotary if the machine has a rotary table. Each tool axis is controlled independently, therefore; the programmed motion always in rapid traverse. Once the tool reaches the desired location, the machining operation is performed at that position (machining can only take place after positioning is completed).

NC drill presses are a good example of PTP systems. The spindle must first be positioned at a particular location on the workpiece. This is done under PTP control. Then the drilling of the hole is performed at the location, and so forth. Since no cutting is performed between holes, there is no need for controlling the relative motion of the tool and workpiece between hole locations.

Positioning systems are the simplest machine tool control systems and are therefore the least expensive of the three types. However, for certain processes, such as drilling operations, tapping, riveting and spot welding, PTP is perfectly suited to the task and any higher level of control would be unnecessary. Example bellow illustrate path of three drilled holes.

2-Straight-cut Positioning Control: -

Straight-cut control systems are capable of moving the cutting tool parallel to one of the major axes at a controlled rate suitable for machining. It is therefore appropriate for performing milling operations to fabricate workpieces of rectangular configurations. Most of the straight-cut systems an fitted with manually adjustable feed control, this feed control is shared by all the programmable axes of the NC machine, because of this shared feed control feature; the system can also perform milling operation at 45˚ to the primary axes of the machine. An example of a straight cut operation is shown in Figure (2). An NC machine capable of straight cut movements is also capable of PTP movements.

3-Contouring (continuous) Path CNC System: -

Contouring is the most complex, the most flexible, and the most expensive type of machine tool control. It is capable of performing both PTP and straight-cut operations. In addition, the distinguishing feature of contouring NC systems is their capacity for simultaneous control of more than one axis movement of the machine tool. The path of the cutter is continuously controlled to generate the desired geometry of the workpiece. Contouring system generates a continuously controlled tool path by the capability of computing the points of the path (interpolating). For this reason, contouring systems are also called continuous-path NC systems. All NC contouring system have the ability to perform linear and circular or parabolic interpolation features which recorded in the NC computer under a (G preparatory code).

1.11 Applications of NC

1.Machine tool applications, such as drilling, milling, turning, and other metal working.

2.Non machine tool applications, such as assembly, drafting, and inspection. The common operating feature of NC in all of these applications is control of the work head movement relative to the work part.

Also…

1-Parts are processed frequently and in small to medium lot sizes. 2- Part geometry is complex. 3- Close tolerances must be held on the workpart. 4- Many operations must be performed on the part in its processing. 5- Much metal needs to be removed (for machining applications). 6- Engineering design changes are likely. 7- It is an expensive part where mistakes in processing would be costly. 8- Parts require 100% inspection

1.12 Advantages and Disadvantages of NC

Advantages of NC machine tools:

1. Reduced lead time:

Lead time includes the time needed for planning, design and manufacture ofjigs, etc. This time may amount to several months. Since the need for special jigs andfixtures is often entirely eliminated, the whole time needed for their design andmanufacture is saved.

2. Elimination of operator errors:

The machine is controlled by instructions registered on the tape provided thetape is correct and machine and tool operate correctly, no errors will occur in the job.Fatigue, boredom, or inattention by operator will not affect the quality or duration ofthe machining. Responsibility is transferred from the operator to the tape, machinesettings are achieved without the operator reading the dial.

3. Operator activity:

The operator is relieved of tasks performed by the machine and is free toattend to matters for which his skills and ability are essential. Presetting of tools,setting of components and preparation and planning of future jobs fall into thiscategory. It is possible for two work stations to be prepared on a single machine table,even with small batches. Two setting positions are used, and the operator can besetting one station while machining takes place at the other.

4. Lower labor cost

More time is actually spent on cutting the metal. Machine manipulation timeex.:. Gear changing and often setting time are less with NC machines and help reducethe labor cost per job considerably.

5. Smaller batches

By the use of preset tooling and presetting techniques downtime betweenbatches is kept at a minimum. Large storage facilities for work in progress are notrequired. Machining centers eliminate some of the setups needed for a succession ofoperation on one job; time spent in waiting until each of a succession of machine isfree is also cut. The components circulate round the machine shop in a shorter period,inter department costs are saved and 'program chasing' is reduced.

6. Longer tool life

Tools can be used at optimum speeds and feeds because these functions arecontrolled by the program.

7. Elimination of special jigs and fixtures

Because standard locating fixtures are often sufficient of work on machines. The cost of special jigs and fixture is frequently eliminated. The capital cost of storagefacilities is greatly reduced. The storage of a tape in a simple matter, it may be keptfor many years and manufacturing of spare parts, repeat orders or replacements ismade much more convenient.

8. Flexibility in changes of component design

The modification of component design can be readily accommodated byreprogramming and altering the tape. Savings are affected in time and cost.

9. Reduced inspection.

The time spent on inspection and in waiting for inspection to begin is greatlyreduced. Normally it is necessary to inspect the first component only once the tape isproved; the repetitive accuracy of the machine maintains a consistent product.

10. Reduced scrap

Operator error is eliminated and a proven tape results in accurate component.

11. Accurate costing and scheduling

The time taken in machining is predictable, consistent and results in a greateraccuracy in estimating and more consistency in costing.

1.13 Computer Numerical Control (CNC) Machines

With the availability of microprocessors in mid 70's the controller technology has made atremendous progress. The new control systems are termed as computer numerical control(CNC) which are characterized by the availability of a dedicated computer and enhancedmemory in the controller. These may also be termed "soft wired numerical control".

A CNC system basically consists of the following: (a) Central processing unit (CPU) (b) Servo control unit (c) Operator control panel (d) Machine control panel (e) Programmable logic controller (f) Other peripheral devices.

1.14 Advantages of CNC

(a) High Repeatability and Precision, e.g. Aircraft parts. (b) Volume of production is very high. (c) Complex contours/surfaces need to be machined, e.g. Turbines. (d) Flexibility in job change, automatic tool settings, less scrap. (e) Safer, higher productivity, better quality. (f) Less paper work, faster prototype production, reduction in lead times. (g) Easier to program. (h) Easy storage of existing programs. (i) Avoids human errors. (j) Usually generates closer tolerances than manual machines. (k) Program editing at the machine tool. (l) Control systems upgrades possible. (m) Option -resident CAM system at machine tool. (n) Tool path verification.

1.15 Functions of CNC

1. Storage of more than one partprogram:

With improvements in computer storagetechnology, newer CNC controllers have sufficient capacity to store multipleprograms. Controller manufacturers generally offer one or more memory expansionsas options to the MCU

2. Various forms of program input:

Whereas conventional (hard-wired) MCUs arelimited to punched tape as the input medium for entering part programs, CNCcontrollers generally possess multiple data entry capabilities, such as punched tape,magnetic tape, floppy diskettes, RS-232 communications with external computers,and manual data input (operator entry of program).

3. Program editing at the machine tool:

CNC permits a part program to be editedwhile it resides in the MCU computer memory. Hence, a part program can be testedand corrected entirely at the machine site, rather than being returned to theprogramming office for corrections. In addition to part program corrections, editing alsopermits cutting conditions in the machining cycle to be optimized. After theprogram has been corrected and optimized, the revised version can be stored onpunched tape or other media for future use.

1.16 Direct numerical control (**DNC**)

It is also known as **distributed numerical control** (**DNC**), is a common manufacturing term for networking CNC machine tools. On some CNC machine controllers, the available memory is too small to contain the machining program (for example machining complex surfaces), so in this case the program is stored in a separate computer and sent *directly* to the machine, one block at a time. If the computer is connected to a number of machines it can *distribute* programs to different machines as required. Usually, the manufacturer of the control provides suitable DNC software. However, if this provision is not possible, some software companies provide DNC applications that fulfill the purpose. DNC networking or DNC communication is always required when CAM programs are to run on some CNC machine control.

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

DNC involved the control of a number of machine tools by a single mainframe computer through direct connection and in real time. The tape reader is omitted in DNC System, thus relieving the system of its least reliable components. Instead of using the tape reader, the part program is transmitted to the machine tool directly from the computer memory. The DNC Computer is designed to provide the instructions to each machine tool on the demand. DNC also involves the data collection and processing from the machine tool back to the computer. Two types of DNC System are used: 1. Behind the Tape Reader (BTR) System, 2. Special Machine Control Unit (SMCU)

1.17 Components of DNC

Input medium: - Part program or instructions needed to drive the machine tool components.

Machine control unit (MCU): - Electronics & control hardware.

Machine tool:

1.18 Functions of DNC

i. Part Program management: Part program stored in the hard disc can be routedto appropriate machines in the network depending upon the schedule.

ii. Shop floor editing: Program can be edited or modified to take into accountdesign changes, tool changes or machine changes.

iii. Shop floor graphics: The tool path simulation can be carried out on the shopfloor.

iv. Data collection: The DNC computer can be used for shop floor data collectionfor scheduling and monitoring.

v. Shop scheduling: Since NC program dispatch is interlinked with the schedule,the DNC computer can be used for scheduling.

vi. Statistical Process Control (SPC): The SPC function can be integrated into theworking of the DNC computer as it can be interfaced with the shop floor datacollection function.

vii. Tool offset management: Tool offset data is sent to appropriate machine by thisfunction.

1.19 Advantages of Direct Numerical Control (DNC) Systems

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

1.20 Advancements of Distributed Numerical Control System.

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

UNIT-II

2.1 Development of computers

Several computer platforms can be used for running the software packages for computer integrated manufacturing. Figure 4.1 shows a typical computer hardware configuration. Usually a powerful server computer and a number of client nodes will be used. The server will be usually a high performance computer, configured to meet the specific operational requirements. The nodes may be a personal computer (PC) or a graphics workstation. The heart of any computer is a microprocessor, which is designed on the basis of the length of the word it can handle. Thus, we have 16 bit, 32 bit and 64 bit microprocessors. The microprocessor carries out arithmetic operations such as addition and subtraction. They also carry out logic operations and alter the sequence in which instructions are carried out depending upon the statements contained in the program. The server stores data and the programs (operating system and application programs) in a part of its primary memory. The remaining part of this memory acts as the working storage and buffer storage for input and output. The contents of this memory are lost when the power is switched off and therefore it is called volatile memory. This memory is called Random Access Memory (RAM) or read-write Memory. Another type of primary memory is the Read Only Memory (ROM) in which some programs stay resident. These programs are permanently stored by

the computer manufacturer. The Basic Input/Output System (BIOS) is usually stored in ROM. The nodes may also have adequate memory and processing capabilities depending on the application requirements.

Super computers take advantage of the most recent advancement in electronic circuit design, processing techniques and memory organization to attain computing speeds many times that of main frames. Typically main frames operate at a few megaflops (one megaflop is a million floating point operations per second) whereas supercomputers can have speeds between 20-400 megaflops.

2.2 CIM Hardware And CIM Software

CIM Hardware comprises the following:

Manufacturing equipment such as CNC machines or computerized work centers, robotic work cells, DNC/FMS systems, work handling and tool handling devices, storage devices, sensors, shop floor data collection devices, inspection machines etc.

Computers, controllers, CAD/CAM systems, workstations / terminals, data entry terminals, bar code readers, RFID tags, printers, plotters and other peripheraldevices, modems, cables, connectors etc.,

CIM software comprises computer programmes to carry out the following functions:

- Management Information System
- Sales
- Marketing
- Finance
- Database Management
- Modeling and Design
- Analysis
- Simulation
- Communications
- Monitoring
- Production Control
- Manufacturing Area Control
- Job Tracking
- Inventory Control
- Shop Floor Data Collection
- Order Entry
- Materials Handling
- Device Drivers
- Process Planning
- Manufacturing Facilities Planning
- Work Flow Automation
- Business Process Engineering
- Network Management
- Quality Management

2.3 Manufacturing data

i. Product Data: Data about parts to be manufactured. It includes text and geometry data.

ii. Manufacturing Data: The information as to how the parts are to be manufactured is available in production data.

iii. Operational Data: Closely related to manufacturing data but describes the things specific to production, such as lot size, schedule, assembly sequence, qualification scheme etc.

2.4 Structure of Database

A data base can be defined as a collection of data in a single location designed to be usedby different programmers for a variety of applications. The term database denotes a commonbase of data collection designed to be used by different programmers. More specifically itis a collection of logically related data stored together in a set of files intended to serve oneor more applications in an optimal fashion. Data are stored such that they are independentof the data. A database must also have a predetermined structure and organization suitablefor access, interpretation, or processing either manually or automatically.

2.5 Database Requirements Of CIM

i. Designing assemblies and performing tolerance analysis on those assemblies.

ii. Preparing production drawings of assemblies, individual parts, tooling, fixtures and other manufacturing facilities.

iii. Creating analytical models of parts for structural, kinematical and thermal analysis (FEM, MeMetc).

iv. Calculating weights, volumes, centres of gravity and other mass properties and costs of manufacturing (cost estimation).

v. Classifying existing parts according to shape, function, and the process by which they are manufactured and retrieving these parts from the parts library on demand (Group technology and coding).

vi. Preparing part lists and bill of materials (BOM).

vii. Preparing process plans for individual part manufacture and assembly (Variant or Generative).

viii. Programming CNC machines for processing complete parts (CAM).

ix. Designing work cells and programming the movement of components in those cells using work handling devices like robots, conveyors, AGV's/ RGV's, etc. (Cellular manufacture).

x. Controlling engineering changes and maintaining associativity between design and manufacturing (PDM, VPDM, concurrent associativity etc).

xi. Preparing programs to handle components or manipulate production equipment (like welding torches or robots).

xii. Preparing inspection programs including programs for CNC co-ordinate measuringmachines [CNC CMM's].The exchange of graphic information has been advanced with increasing acceptanceof Initial Graphics Exchange Specification (IGES) and STEP.

2.6Database Models

2.6.1.Hierarchical Database

Fig shows a typical hierarchical file structure. The nodes in level 2 are the children of node at level 1. The nodes at level 2 in turn become parents of nodes in level 3 and so on.

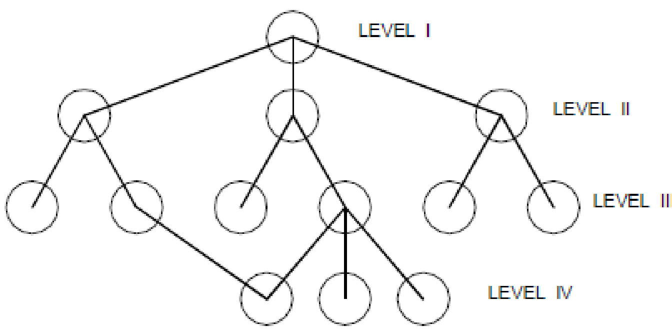


Fig. A Typical Hierarchical File Structure

In a hierarchical model, data files are arranged in a tree like structure which facilitates searches along branch lines; records are subordinated to other records at a higher level. Starting at the root of the tree, each file has a one-to-many relationship to its branches. A parent file can have several children. A good example of such an organization might be a parts list, in which each product is composed of assemblies which are in turn composed of sub assemblies and/or component parts.

2.6.2 Network Database

The network database is a combination of several hierarchies in which child files can have more than one parent file, thereby establishing a many-to- many relationship among data. A hierarchical model is actually a subset of a network model. Examples of network database languages are TOTAL and IDMS.

2.7 RDBMS (Relational Database Management System)

The relational database eliminates the need to follow predefined access paths to reach target data, and makes data access more flexible. The database user gains quicker access to information since the database provides direct access to all data. The access is independent of the way it is stored. The RDBMS is also flexible. Hence relational database facilitates unanticipated queries and makes it well suited to the manufacturing environment. Several vendors now offer relational database management systems, suitable for CIM applications.

Features of RDBMS include:

- Adhoc or unanticipated queries. This is typical in a manufacturing environment.
- Relational database is dynamic. The relationships change and are extended frequently in a manufacturing database.
- Suitable where enterprise information has to be available to a large number of users for decision making.
- Desirable where application specifications, development and maintenance costs are to be kept at the minimum level.
- Compatible with distributed databases.

2.8Structured Query Language [SQL]

The advent and successful implementation of relational databases has brought with it need for a data base language that is user friendly enough for the common user while being convenient and comfortable for the programmer and applications builder. The structured query language now called SQL [pronounced “sequel”], has emerged to fill this need. The user can easily learn and understand SQL. It can be embedded in a procedural language such as C, COBOL, or PL/l. SQL helps user and programmer to understand the requirements of each other. This fact is very important in making the transition from paperfiles to computerized database systems smooth.

2.9 Benefits of CAD

- Reduced storage space
- Corrections can be made easily
- Repetitive parts of the drawing can be saved and imported as part of a “CAD library”

• CAD systems can be linked with CAM machines to produce objects straight from the drawings • 3D CAD designs can be made to look realistic by using the material library for clients to see

• CAD designs can be easily shared between companies or department using email

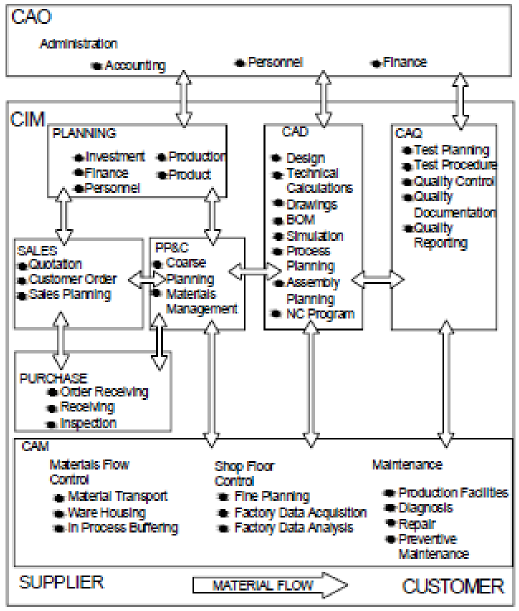
• CAD can be used to create simulated environments to show the client

2.10 Standards For Graphics Programming

1. A Graphic Standards Planning Committee (GSPC) was formed in 1974 by ACM-IGGRAPH (Association of Computing Machinery's Special Interest Group on Graphics and Interactive Techniques).
2. A committee for the development of computer graphics standard was formed by DIN in 1975.
3. IFIP organized a workshop on Methodology in Computer Graphics in 1976.
4. A significant development in CAD standards is the publication of Graphical Kernel System (GKS) in 1982.
5. The Graphics Standards Planning Committee (GSPC) of ACM-SIGGRAPH proposed the CORE system in 1977 and revised it in 1979. Though the development of GKS has been influenced by the CORE system, there are a number of significant differences between the two. However, the core graphics have a number of problems at the level of program portability. From a technological point of view, the GSPC CORE has been eclipsed by the development in GKS.

2.11 Interfaces between CAD and CAM

In order to be able to process the data in a comprehensive manufacturing system, a hierarchical model of an enterprise is used. Each hierarchical level has its own data processing requirements



and there exists a steady flow of instructions from the upper levels to the lower ones. In order to control and synchronize parallel activities on each level, an intensive horizontal data flow takes place. Siemens model also incorporates a Computer Aided Organization (CAO), which comprises accounting, personnel and finance.The Siemens CIM concept is shown in Fig. with structured details of every major module. For each module, its sub modules are defined and their interconnections are explained. A description is given on the required interfaces for the data exchange and the contents of the data, giving special considerations to batch and mass production. Various layouts of production systems and assembly stations are also considered.

2.12 CAD software

The present CAD softwares are AutoCAD (Autodesk) mainly for PC, Pro Engineer (PTC) or Creo, SolidWorks (Dassault Systems) ,CATIA (IBM/Dassault Systems) ,Unigraphics (UGS), Inventor, Fusion 360

2.13 Integration of CAD/CAM/CIM.

Computer Integrated Manufacturing (CIM) is considered a natural evolution of the technology of CAD/CAM which by itself evolved by the integration of CAD and CAM. Massachusetts Institute of Technology (MIT, USA) is credited with pioneering the development in both CAD and CAM. The need to meet the design and manufacturing requirements of aerospace industries after the Second World War necessitated the development these technologies. The manufacturing technology available during late 40'sand early 50's could not meet the design and manufacturing challenges arising out of the need to develop sophisticated aircraft and satellite launch vehicles.

This prompted the US Air Force to approach MIT to develop suitable control systems, drives and programming techniques for machine tools using electronic control.

UNIT-III

3.1 Flexible Manufacturing System-Overview

- A highly automated GT machine cell, consisting of a group of processing stations (usually CNC machine tools), interconnected by an automated material handling and storagesystem, and controlled by an integrated computer system
- The FMSrelies on the principles of GT
- No manufacturing system can produce an unlimited range of products
- An FMS is capable of producing a single part family or a limited range of part families

3.2 Components of FMS

- Hardware components

  Workstations - CNC machines in a machining type system *Material handling system* - means by which parts are moved between stations *Central control computer* - to coordinate the activities of the components so as to achieve a smooth overall operation of the system

- Software and control functions
- Human labor

3.3 FMS Layouts

Five Types of FMS Layouts

1. In-line

2. Loop

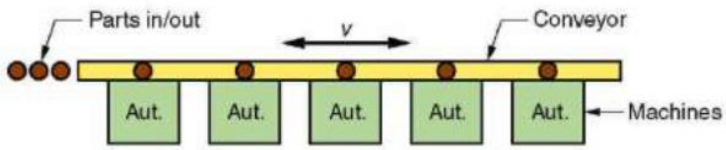
3. Ladder

4. Open field

5. Robot-centered cell

□ □ The basic layout of the FMS is established by the material handling system

Three of the five FMS layout types: (a) in-line

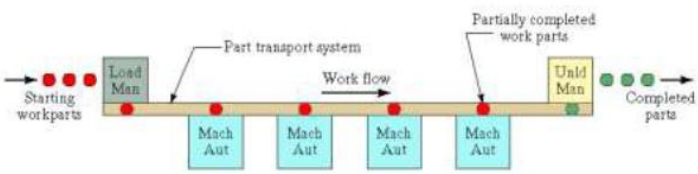


(a)

Key: Aut = automated station; L/UL = load/unload station;

Insp = inspection station; AGV = automated guided vehicle;

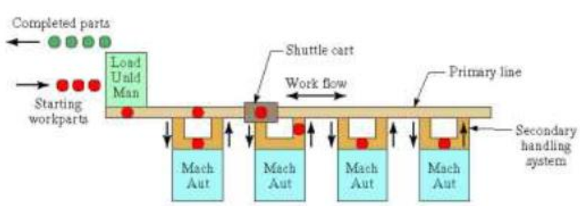
AGVS = automated guided vehicle system



Straight line flow, well-defined processing sequence similar for all work units

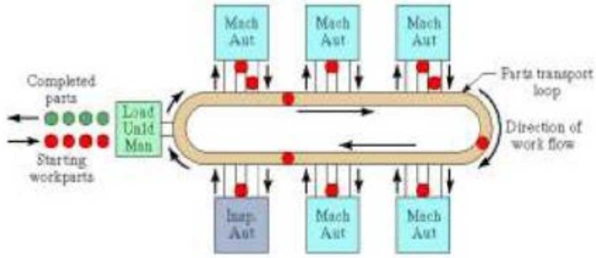
□ □ Work flow is from left to right through the same workstations

□ □ No secondary handling system



□ □ Linear transfer system with secondary parts handling system at each workstation to facilitate flow in two directions

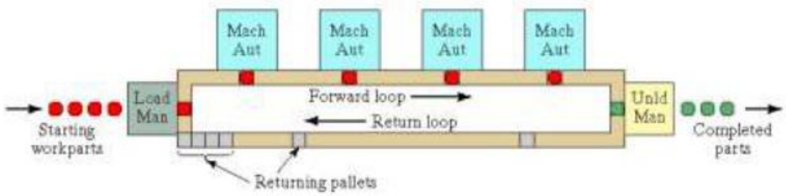
Loop Layout



□ □ One direction flow, but variations in processing sequence possible for different part types

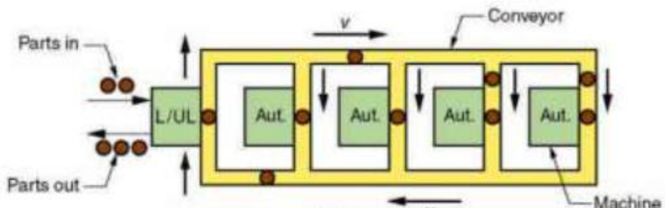
□ □ Secondary handling system at each workstation

Rectangular Layout



Rectangular layout allows recirculation of pallets back to the first station in the sequence after unloading at the final station

Ladder layout

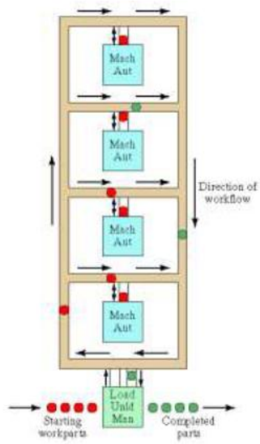


(b)

Key: Aut = automated station; L/UL = load/unload station;

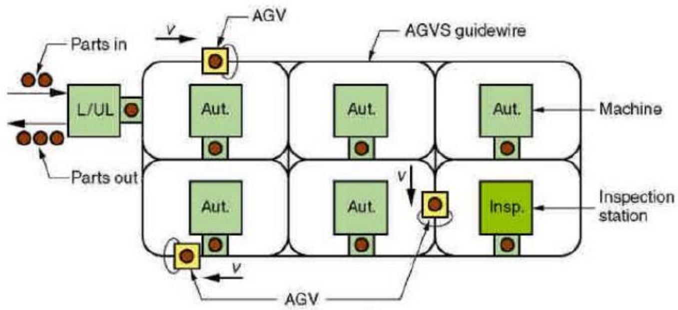
Insp = inspection station; AGV = automated guided vehicle;

AGVS = automated guided vehicle system



Loop with rungs to allow greater variation in processing sequence

Open field



•Key: Aut = automated station; L/UL = load/unload station;

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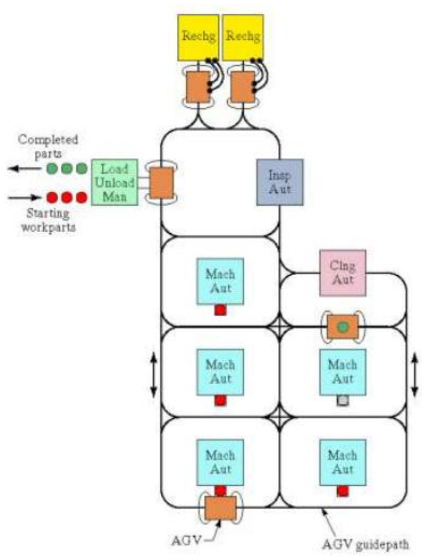
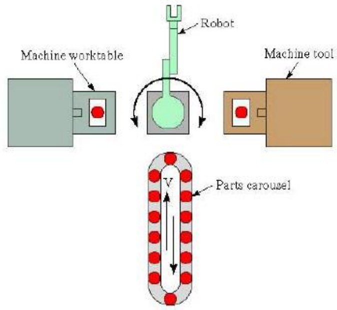


Multiple loops and ladders, suitable for large part families

Robot centered layout



Suited to the handling of rotational parts and turning operations

3.4 FMS Planning and Design Issues

- Part family considerations
    - Defining the part family of families to be processed
        - Based on part similarity
        - Based on product commonality
- Processing requirements
    - Determine types of processing equipment required
- Physical characteristics of workparts
        - Size and weight determine size of processing equipment and material handling equipment
- Production volume
    - Annual quantities determined number of machines required
- Types of workstations
- Variations in process routings
- Workin-process and storage capacity
- Tooling
- Pallet fixtures

FMS Operational Issues

- Scheduling and dispatching
    - Launching parts into the system at appropriate times

- Machine loading
    - Deciding what operations and associated tooling at each workstation
- Part routing
    - Selecting routes to be followed by each part
- Part grouping
    - Which parts should be on the system at one time
- Tool management
    - When to change tools
- Pallet and fixture allocation
    - Limits on fixture types may limit part types that can be processed

3.5 Tool management systems

Tool inventory control, tool status relative to expected tool life, tool changing and resharpening, and transport to and from tool grinding

Transport control - scheduling and control of work handling system *System management* - compiles management reports on performance (utilization, piece counts, production rates, etc.)

3.6 Tool monitoring

Completely automated machining calls for continuous monitoringof tool to sense end of tool life due to gradual wear, breakage of tool due to chipping orcollision in order to avoid further damage. Tool monitoring systems help in sensing aboveevents and in avoiding damage to tool and reducing down time of machine.

A tool monitoring system consists of three individual components for sensing collision,breakage and wear.

All these systems work according to simple and reliable principle of measurement.During machining, cutting forces are continuously sensed through a strain transducermounted on the machine. Any variation during the process of machining leads to a changein the cutting force which is sensed by the strain transducer. If the previously set value iscrossed, then the device gives within a few milliseconds an impulse for the feed to stop.

The system consists essentially of the strain transducer, signal conditioning andprocessing electronics and the machine interface. The piezo-electric strain transducer ismounted on that part of the machine which is subject to maximum deformation. This isusually the turret housing. The signals picked up during machining operation are evaluatedcontinuously by the microprocessors in the system.

3.7Modular Fixturing

Standardization not only reducesdesign effort but also cost. Let us take the example of modular fixtures. Beforethe advent of modular fixtures aircraft industry had to make several thousandnew fixtures for each aircraft project. Once the model is scrapped, most of thefixtures also may be scrapped. Further, it is necessary to have a large storage areaand an efficient system to retrieve the fixtures. With modular fixturing, the needto maintain such large inventory is eliminated. Once the use is over, the fixturecan be dismantled and the fixture components can be used for another fixture.The design is also easy as all the suppliers of modular fixtures supply also amatching CAD library. Thus both the design and tool realization time aresubstantially reduced with modular fixtures.

3.8 Flexibility, Quantitative Analysis of Flexibility

Failure mode and effect analysis gives a design team with an organized approach toevaluate the causes and effects of various modes of failure of a product. The objective ofthis exercise is to improve the quality of the product by anticipating failures andredesigning the part to eliminate such failures.

3.9 Application and benefits of FMS

- Reduced cycle times
- Lower work-in-process (WIP) inventory
- Low direct labour costs
- Ability to change over to different parts quickly
- Improved quality of product (due to consistency)
- Higher utilization of equipment and resources (Utilization better than standalone CNC machines)
- Quicker response to market changes
- Reduced space requirements
- Ability to optimize loading and throughput of machines
- Expandability for additional processes or added capacity
- Reduced number of tools and machines required
- Motivation for designers to add variations and features to meet customer requirements.

• Compatible with CIM

3.10 Material Handling System

***A**. The primary work handling system* - used to move parts between machine tools in the CIMS. It should meet the following requirements.

i). Compatibility with computer control

ii). Provide random, independent movement of palletized work parts between machine tools.

iii). Permit temporary storage or banking of work parts.

iv). Allow access to the machine tools for maintenance tool changing & so on.

v). Interface with the secondary work handling system

***B**. The secondary work handling system* - used to present parts to the individual machine tools in the CIMS.

i). Same as A (i).

ii). Same as A (iii)

iii). Interface with the primary work handling system

iv). Provide for parts orientation & location at each workstation for processing.

3.11 AGVs

AGV is one of the widely used types of material handling device in an FMS. These are battery-owered vehicles that can move and transfer materials by following prescribed paths around the shop floor. They are neither physically tied to the production line nor driven by an operator like forklift. Such vehicles have on-board controllers that can be programmed for complicated andvarying routes as well as load and unload operations. The computer for the materials handling system or the central computer provides overall control functions, such as dispatching, routing and traffic control and collision avoidance. AGV’s usually complementing an automated production line consisting of conveyor or transfer systems by providing the flexibility of complex and programmable movement around the manufacturing shop.

AGV's allow for driverless forklifts and automated storage and retrieval systems. As JIT becomes more imbedded in future manufacturing disciplines, the role of computerized material-bundling equipment will become more vital. Many automated machine tools have built-in systems to monitor tool wear and detect tool breakage. They may use probes or non-contact techniques such as acoustic emission for this purpose. When a tool needs replacement, the machine can signal the tool room for the delivery of a replacement. This may be performed by an

AGV or gantry set up or RGV. Elaborate tool management support is an integral part of FMS software. With this software, operating personnel can have effective centralized control of a large tool inventory. Automated machining operations also need to have the chips cleaned off the workstation and the workpiece. This may be performed by robots or special washing stations. Cleaning may involve turning the workpiece over, vacuuming and washing.

3.12 Advantages of using AGV systems in FMS

(i) Flexibility: The route of the AGV's can be easily altered, expanded and modified, simply by changing the guide path of the vehicles. This is more cost effective than modifying fixed conveyor lines or rail guided vehicles. It provides direct access materials handling system for loading and unloading FMS cells and accessing the automated storage and retrieval system.

(ii) Real time monitoring and control: Because of computer control, AGV's can be monitored in real time. If the FMS control system decides to change the schedule, the vehicles can be re-routed and urgent requests can be served. AGV's are usually controlled through wires implanted on the factory floor. The control is effected using a variable frequency approach. Radio control, an alternative to in-floor mounted communication lines, permits two way communications between the on-board computer and a remote computer, independent of where the vehicle is i.e. whether it is in the parking place or whether it is in motion. To issue a command to a vehicle, the central computer sends a bit stream via its transmitter using frequency shift keying methods to address a specific vehicle. The signal transmitted from the base station is, therefore, read by the appropriate vehicle only. The vehicle is also capable of sending signals back to the remote controller, to report the status of the vehicle, vehicle malfunction, battery status, and so on.

(iii) Safety: AGV's can travel at a slow speed but typically operate in the range 10 to 70 m/min. They have on-board microprocessor control to communicate with local zone controllers which direct the traffic and prevent collisions between vehicles as well as the vehicle and other objects. A bumper is attached to some designs of AGV's to prevent collision. AGV's may also incorporate warning lights, fire safety interlocks and controls for safety in shops. During design, the use of simulation can help detect whether there are enough vehicles to perform the necessary load, unload and transportation tasks and thus optimize the utilization of the AGV system. Because these vehicles have to work in a tandem with highly organized FMS cells as well as with automated warehouses under computer control, their level of performance will affect the entire efficiency of the FMS.

3.13 Categories of AS/RS

The automatic storage and retrieval system can be classified into several types. Some of them are:

- Unit load AS/RS
- Mini load AS/RS
- Man-on-board AS/RS
- Automated item retrieval system
- Deep lane AS/RS

Basic Components of AS/RS

An AS/RS normally consists of:

- Storage structure
- Storage and retrieval machine
- Storage modules
- Pick-up and deposit stations

Special Features of AS/RS

Some of the special features of AS/RS are:

- Aisle transfer cars
- Full/empty bin detectors
- Sizing stations
- Load identification stations

UNIT-IV

4.1 Group Technology

Group technology is an operations management philosophy based on the recognition thatsimilarities occur in the design and manufacture of discrete parts. Similar parts can thenbe arranged into part families. To implement such a system, some form of classification ofparts and coding is required.Part classification and coding is concerned with identifying the similarities and usingthese similarities to evolve a classification code. Similarities are of two types: designattributes (such as geometric shape and size), and manufacturing attributes (the sequenceof processing steps required to make the part).In companies which employ several design engineers and manufacturing a diverserange of products, such classifications and coding has a number of other uses. One of themajor benefits is avoiding the duplication of similar components. This can result inconsiderable savings in terms of design cost, processing cost and tooling cost. One primenecessity to realize this is to have a good design retrieval system.The parts classification and coding is required in a design retrieval system, and incomputer aided process planning the process routing is developed by recognizing thespecific attributes of the part and relating these attributes to the correspondingmanufacturing operations.

4.2 Part Families

A part family is a collection of parts which are similar either because of geometry and sizeor because similar processing steps are required in their manufacture. The parts within afamily are different, but their similarities are close enough to merit their identification asmembers of the part family. The major obstacle in changing over to group technologyfrom a traditional production shop is the problem of grouping parts into families. Thereare three general methods for solving this problem.

i. Visual inspection

ii. Production flow analysis

iii. Parts classification and coding system

4.3 Parts Classification And Coding Systems

Parts classification and coding systems can be grouped into three general types:

i. Systems based on design attributes

ii. Systems based on part manufacturing attributes

iii. Systems based on both design and manufacturing attributes

Systems in the first category are useful for design retrieval and to promote designstandardization. Systems in the second category are used for computer-aided processplanning, tool design, and other production related functions. The third category representsan attempt to combine the functions and advantages of the other two systems into a singleclassification scheme. The types of design and manufacturing attributes typically includedin classification schemes are listed below:

Part Design Attributes

Basic (External/Internal) shape

Axisymmetric/Prismatic/sheet metal

Length/diameter ratio

Material

Major dimensions

Minor dimensions

Tolerances

Surface finish

Part Manufacturing Attributes

Major process of manufacture

Surface treatments/coatings

Machine tool/processing equipment

Cutting tools

Operation sequence

Production time

Batch quantity

Production rate

Fixtures needed

4.4 Applications and Benefits of Group Technology

Before	**After**
Discontinuous, Random Flow of Through the Shop	Parts Structured Flow of Parts
Reinvent New Parts	Retrieve Parts Already in Production
Multitude of Process Plans for Some Parts	Consistent, Single, Best Process Plans
Continuous Purchase of due to Lack of Total Visibility	Components Regulated Purchase of Components
Inflexible, Rigid, Unable to Respond to Changing Environment	Flexible

4.5 Structure Of A Process Planning Software

Fig represents the structure of a computer aided process planning system. In Fig the modules are not necessarily arranged in the proper sequence but can be based onimportance or decision sequence. Each module may require execution several times inorder to obtain the optimum process plan. The input to the system will most probably bea solid model from a CAD data base or a 2-D modeland validation can then be routed directly to the production planning system andproduction control system.

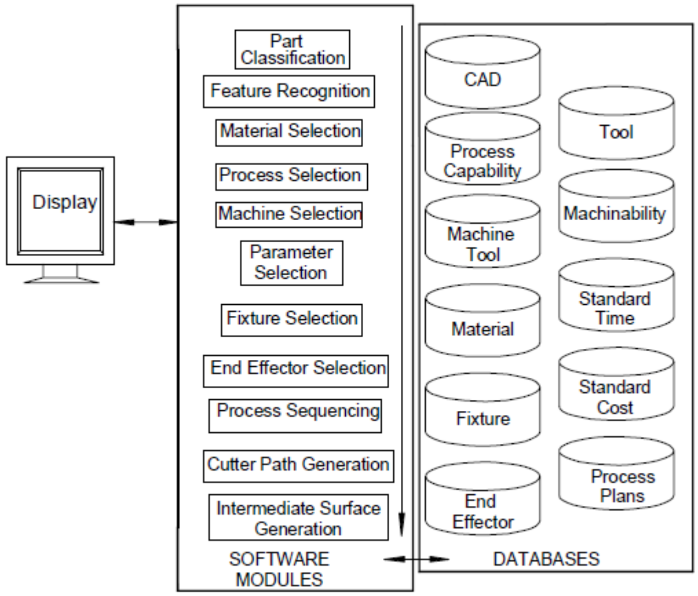


Fig. 9.2 Structure of a Computer Aided Process Planning System

4.6 Process Planning Function

The process planning function is manufacturing system dependent. This implies that noone single process planning system can satisfy all of the different manufacturing systemsneeds. There are several factors that must be considered when one attempts to implementa process planning system. These include:

i. Manufacturing system components

ii. Production volume/batch size

iii. Number of different production families

4.7 CAPP - Methods of CAPP

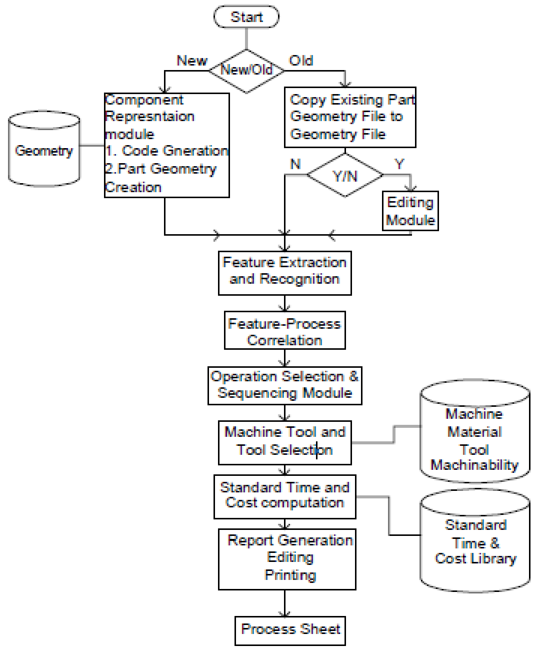
CPPP:

(computerized production process planning) was designed for planning cylindricalparts. CPPP is capable of generating a summary of operations and the detailed operationsheets required for production. The principle behind CPPP is a composite componentconcept. A composite component can be thought of as an imaginary component whichcontains all the features of components in one part family. CPPP incorporates a speciallanguage, COPPL, to describe the process model. CPPP allows an interactive mode wherebythe planner can interact with the system at several fixed interaction points.

Generative process planning is a system that synthesizes process information in orderto create a process plan for a new component automatically. In a generative planningsystem, process plans are created from information available in manufacturing data basewithout human intervention. Upon receiving the design model, the system can generatethe required operations and operation sequences for the component. Knowledge ofmanufacturing must be captured and encoded into efficient software. By applying
decision logic, a process planner's decision making can be imitated. Other planningfunctions, such as machine selection, tool selection, process optimization, and so on, canalso be automated using generative planning techniques. The generative planning hasthe following advantages:
i. It can generate consistent process plans rapidly.
ii. New process plans can be created as easily as retrieving the plans of existingcomponents.
iii. It can be interfaced with an automated manufacturing facility to provide detailedand up-to-date control information.

The Generative part consists of:

• Component representation module
• Feature extraction module
• Feature process correlation module
• Operation selection and sequencing module
• Machine tool selection module
• Standard time / cost computation module
• Report generation module



Modular Structure of a Generative CAPP System

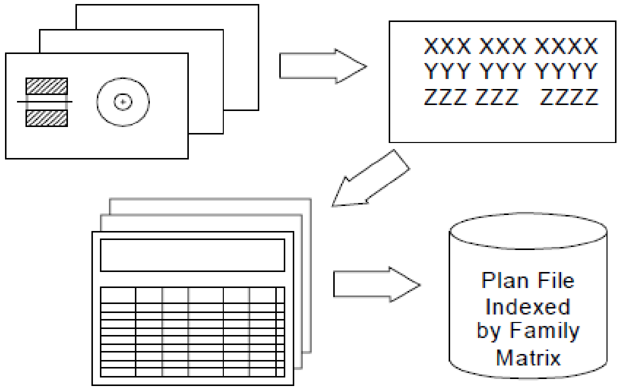
Variant Process Planning

A variant process planning system uses the similarity among components to retrieve theexisting process plans. A process plan that can be used by a family of components is calleda standard plan. A standard plan is stored permanently with a family number as its key.A family is represented by a family matrix which includes all possible members. Thevariant process planning system has two operational stages:

• A preparatory stage and

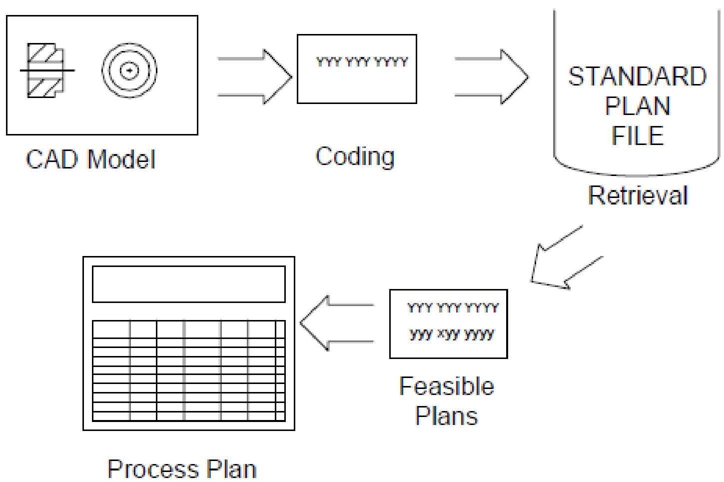
• A production stage

During the preparatory stage, existing components are coded, classified, andsubsequently grouped into families. The process begins by summarizing process plansalready prepared for components in the family. Standard plans are then stored in a database and indexed by family matrices



Process Family Matrix

The operation stage occurs when the system is ready for production. An incoming partis first coded. The code is then input to a part family search routine to find the family towhich the component belongs. The family number is then used to retrieve a standardplan. Some other functions, such as parameter selection and standard time calculations,can also be added to make the system more complete. This system is used in amachine shop that produces a variety of small components



Part Search and Retrieval

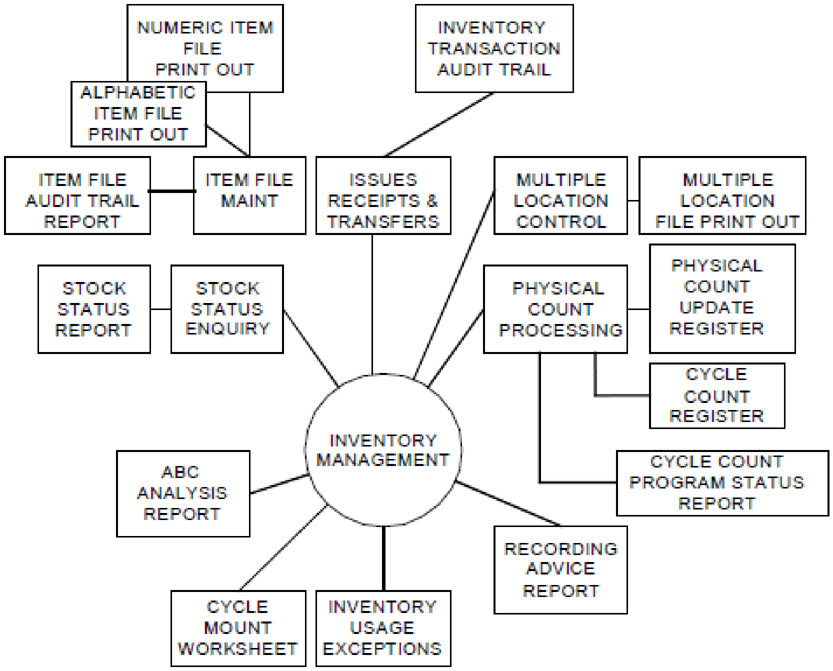
4.8 CAD based Process Planning

The input format of a process planning system affects the ease with which a system can beused, and the capability of the system. The transitional form from the original design(either engineering drawing or CAD model) to a specific input format may be tedious anddifficult to automate. However, such input can provide more complete information abouta component, and more planning functions can beaccomplished using the input.

Using a CAD model as input to a process planning system can eliminate the humaneffort of translating a design into code and other descriptive form. A CAD model contains all the details about a design.However, an algorithm is necessary to identify a generalmachined surface in a CAD model. Additional code is needed to convert the machinedsurface shape from raw material shape. CAD/CAM system uses a CAD model as its input.Several other systems such as GENPLAN, AUTOPLAN, etc., also use a CAD databaseinteractively for tool and fixture selection

4.9 Inventory Management

Inventory is crucial element in any manufacturing environment, and its efficient controlis an essential element for an MRP environment. Inventory systems integrate withnearly all components of the MRP system and must manage the balance betweenrequired inventory and available inventory. The inventory control (IC) component mustcontrol the issue and transfer of material and adjust inventory levels. In a repetitivemanufacturing environment, the IC module is responsible for monitoring the number ofinventory turns per year, with the objectives of increasing the number of turns to maximizeprofit margins. Some MRP packages offer features such as theoretical consumption andback flushing for the process industry.



Modules of Inventory Management

4.10 Materials Requirements Planning

The master production schedule becomes a direct input to the material requirementsplanning (MRP) function, which determines the material needed at each work centrelocation in order to meet the master production schedule. MRP is the heart of anymanufacturing control system. It uses information from the bills of material, inventory,shop and purchase orders, and the master schedule to draw a detailed material requirementsplan. MRP accesses the data from the master production to determine what products willbe built during the planning period.Bills of material and routings define the raw materials required to produce the product,the instructions and routing(s) through the shop the shop floor for producing the product.MRP determines the total gross requirements and compares against current inventory andscheduled receipts (any replenishment orders due).If MRP determines that material will not be available when it is required, it canregenerate planned orders for that material. The important submodulesof MRP.The MRP modules carry out the following:

• Computes when and in what quantities component parts and raw materialsare required.

• Supports minimum, maximum, and multiple order quantity modifications.

• Allows creation and modification of a shop calendar and a variety of reportingcalendars.

• Reports exceptions and recommends changes to order quantities and dates.

• Supports changes in product structures.

• Uses actual components planned for shop orders as a firm planned bill of material

UNIT-V

5.1 Types of production monitoring system

To ensure complete reliability in performing all control functions the tool breakagemonitoring and control system employs three monitoring strategies.

The first involves a safety limit. The high force signal caused by collision exceeds this limit and the feed motoris shut down immediately. Collision is thus detected effectively and automatically.

The second strategy involves the system's microprocessor monitoring every cut andcomparing it with a predetermined force value. If this value is exceeded the feed monitoris stopped instantaneously.

In a third strategy the system looks out for specific events which are typical of toolbreakage. When a tool breaks sudden high-frequency peaks occur in the components ofthe cutting force in radial and feed directions. These peaks, which do not occur in normaloperation, are due to particles of the shattered tool becoming jammed between workpieceand cutting edge. As they break free the cutting forces drop briefly to zero. The breakagemonitoring system, working with preset upper and lower tolerance limits, responds immediately when either of these limits is transgressed and within 2 milliseconds emits asignal to stop the feed. By means of a special stop module the feed drive is shut downwithin 20 milliseconds.

5.2 Process Control

A controlled production process is one in which only random causes influence qualityvariation. It means that the process parameters which affect the variability of the processis well under control and the process monitoring mechanism can detect any significantchange in the process. Statistical process control (SPC) is widely employed in CIM to exerciseprocess control. SPC uses X charts, R charts and SIGMA charts to monitor process variability.Measuring instruments are directly linked to microprocessor-based equipment to processthe data and display results.

5.3 Objectives Of CAQC

i. Improve product quality

ii. Increase productivity in the inspection process

iii. Increase productivity

iv. Reduce lead-time

v. Reduce wastage due to scrap/rework

5.4 Benefits of CAQC

i. With Computer aided inspection and computer aided testing inspection andtesting will typically be done on a 100% basis rather by the sampling procedures normally used in traditional QC. This eliminates any problem in assembly laterand therefore is important in CIM.

ii. Inspection is integrated into the manufacturing process. This will help to reducethe lead-time to complete the parts.

iii. The use of non-contact sensors is recommended for computer aided inspectionand CIM. With contact inspection devices, the part must be stopped and oftenrepositioned to allow the inspection device to be applied properly. These activitiestake time. With non-contact sensing devices the parts can be inspected while inoperation. The inspection can thus be completed in a fraction of a second.

iv. The on-line non-contact sensors are useful as the feedback element of adaptivecontrol systems. These systems will be capable of making adjustments to theprocess variables based on analysis of the data including trend analysis. Anexample of the application of trend analysis can be found in the compensationof gradual wear of cutting tool in a machining operation. This would not only

help to identify out-of-tolerance conditions but also to take corrective action. Byregulating the process in this manner, parts will be made much closer to thedesired nominal dimension rather than merely within tolerance. This will helpto reduce scrap losses and improve product quality.

v. Sensor technology will not be the only manifestation of automation in CAQC.Intelligent robots fitted with computer vision and other sensors, as an integralpart of completely automated test cells is also a feature of CIM.

vi. An important feature of QC in a CIM environment is that the CAD/CAM databasewill be used to develop inspection plan.As mentioned earlier inspection can be either contact or non-contact type. The contactmethod usually involves the use of coordinate measuring machines (CMM).

5.5 Coordinate Measuring Machine (Contact Inspection)

The coordinate measuring machine (CMM) is the most prominent example of theequipment used for contact inspection of parts. When used for CIM these machines arecontrolled by CNC. A typical three-dimensional measuring machine consists of a table,which holds the part in a fixed, position, and movable head, which holds a sensing,probe. The probe can be moved in three directions corresponding to the X, Y and ZCoordinates. For manual operation, the control unit is provided with joysticks, or otherdevices which drive X, Y and Z servo motors (AC/DC).During operation, the probe is brought into contact with the part surface to bemeasured and the three co-ordinate positions are indicated to a high level of accuracy.Typical accuracies of these machines are in the neighborhood of + 0.004 mm with aresolution of 0.001 mm. The measuring accuracy of a typical CMM is quoted 2.6 +L/300 micrometers, where L is the measured length in mm.

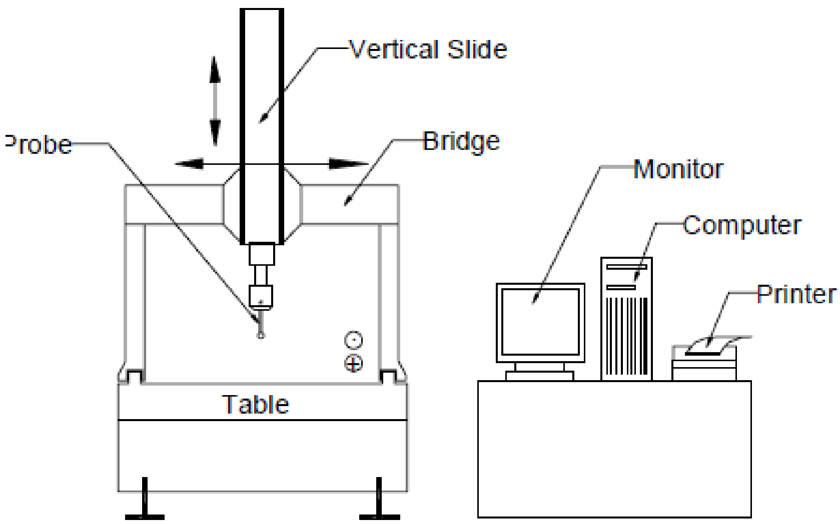


Fig. 14.1 CNC CMM

The major features of a CMM are:

(i) Stationary granite measuring table: Granite table provides a stable referenceplane for locating parts to be measured. It is provided with a grid of threadedholes defining clamping locations and facilitating part mounting. As the table hasa high load carrying capacity and is accessible from three sides, it can be easilyintegrated into the material flow system of CIM.

(ii) Length measuring system: A 3-axis CMM is provided with digital incrementallength measuring system for each axis.

(iii) Air bearings: The bridge, cross beam and spindle of the CMM are supportedon air bearings with high rigidity. They are designed insensitive to vibrations.

(iv) Control unit: The control unit allows manual measurement and self teachprogramming in addition to CNC operation. The control unit is microprocessorcontrolled. Usually a joystick is provided to activate the drive for manualmeasurement.CNC Measuring Centres are provided with dynamic probe heads and a probe changingsystem, which can be operated manually or automatically.

(v) Software: The CMM, the computer and the software together represent onesystem whose efficiency and cost effectiveness depend to a large extent on thesoftware

5.6 Non-Contact Inspection Methods

The field of non-contact inspection, in particular optical inspection is composed of thefollowing basic areas:

i. Inspection of part dimensions.

ii. Inspection of surface defects.

iii. Inspection of completed or semi-completed parts.

The main advantages of non-contact inspection are:

i. It eliminates the need to reposition the work piece.

ii. Non-contact inspection is faster than contact inspection.

iii. There is no mechanical wear encountered in the contact inspection probe.

iv. The possibility of damage to the surface of a part due to measuring pressure is eliminated.

Some of the examples of non-contact inspection are laser interferometer measuringsystem, laser telemetric measuring system, machine vision system and optical gauging.

5.7 Vision System

A vision system can be defined as a system for automatic acquisition and analysis ofimages to obtain desired data for interpreting or controlling an activity. In a broadersense, the term is applied to a wide range of non-contact electro-optical sensing techniquesfrom simple triangulation and profiling to a 3D object recognition technique. These arebased on sophisticated computerized image analysis routines. The applications rangefrom relatively simple detection and measuring tasks to full-blown robot control, whichinclude quality assurance, sorting, material handling and process control, robot guidance,calibration and testing, machine monitoring and safety.The schematic diagram of a typical vision system is shown in Fig 14.2. This systeminvolves image acquisition, image processing or image analysis and interpretation.Acquisition requires appropriate lighting, the use of electronic camera and means ofstoring a digital representation of the image. Processing involves manipulating the digitalimage to simplify and reduce number of data points that must be handled by subsequentanalytical routines used to interpret the data. Computers with suitable softwares areused for this purpose.

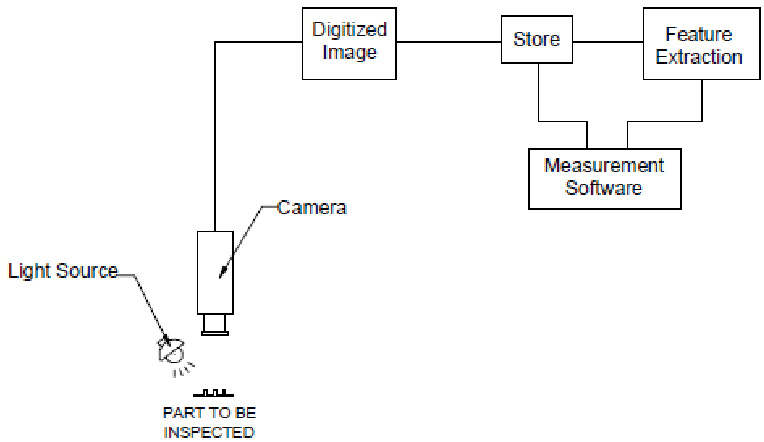


Fig. 14.2 Typical Vision System

By using the vision systems measurements can be carried out at any angle along allthe three reference axes X, Y and Z without contacting the part. The measured values ofthe component parameters are then compared with the specified tolerances, which arestored in the memory of the computer.The measured values, the specified values with the deviation and an indicating onwhether the part is passed or not passed are displayed on the VDU. Using a sortingsystem it is also possible to sort the parts based on these results.Computer vision systems offer several advantages like reduction of tooling and fixturecosts, elimination of need for precise part location for handling by robots and integratedautomation of dimensional verification and defect detection.

5.8 Integration Of CAD/CAM With Inspection System

CAD/CAM systems are seen as a natural adjunct to automatic gauging wherein aproduct is designed, manufactured and inspected in one automatic process. There is astrong trend in the direction of a closed loop, fully adaptive manufacturing system.One of the critical factors in manufacturing quality assurance is to ensure thatevery part coming off the production line is within design tolerance. The successfulfactory constantly monitors quality at each step of design and manufacturing process.In the shop, the coordinate measuring machine assists in this quality assurancefunction. The productivity of the coordinate measuring machine can be improved byinterfacing with a CAD/CAM system. Interfacing with the CAD/CAM database, theoperator can use the off-line programming capabilities of the CMM interface to processthe input values for the part geometry being measured. This eliminates the laboriousmanual data entry techniques and reduces preparation time and increases availabilityof CMM for inspection.

5.9 Flexible Inspection System

Thissystem has been developed with the intention of the integration of the inspection done atseveral places in a factory.FIS also helps to close the loop between the design intent and product performance and toimprove inspection technology and thereby increasing the productivity. A powerful computerserves as a real time processor to handle part dimensional data and as a multi-programmingsystem to perform such tasks as manufacturing process control. The terminal providesinteractive communication with personal computers where the programmes are stored. Thetypical digital input devices used with this system are CMM's, microprocessor based gaugesand other inspection devices. The data from CMM's and other terminals are fed into the maincomputer for analysis and feed back control. The quality control data and inspection data fromeach station are fed through the terminals to the main computer. This type of communicationcould be from more than one factory location, in which case the data will be communicatedthrough telephone lines. Even data from acceptance tests on new machine tool building plantare fed to this computer for analysis. Machine capability studies are also carried out by takinglarge samples (30-50 pieces) from a particular machine. Final product audit and inspection arealso carried out with the help of CMM's and other suitable inspection aids with the capabilityof directly feeding the data to the computer. TESA, CARL JOHANSSON and othermanufacturers of metrology equipment supply such integrated systems.Flexible inspection system involves more than one inspection station. The objective ofthe flexible inspection system is to have an off-line multi-station automated dimensionalverification system to increase the production rate, lessen the inspection time and to maintain
the inspection accuracy and data processing integrity. The important features of FIS includedynamic statistical sampling programs, which provide automatic adjustment to modify thenumber of parts, and part features to be inspected based on the inspection history.