FlexibleManufacturingSystem

FlexibleManufacturingSystem

- AhighlyautomatedGTmachinecell,consistingof agroupofprocessingstations(usuallyCNCmachinet ools),interconnectedbyanautomatedmaterialhan dlingandstoragesystem,and controlledbyanintegratedcomputersystem
- TheFMSreliesontheprinciplesofGT
- Nomanufacturingsystemcanproducean unlimitedrangeofproducts
- AnFMSis capableofproducinga singlepart familyor alimitedrangeofpartfamilies

FlexibilityTestsinanAutomated ManufacturingSystem

- Automatedmanufacturingcellwithtwomachinetoolsand robot.Isitaflexiblecell?
- Toqualifyasbeingflexible,amanufacturingsystemshould satisfythefollowingcriteria

(“yes”answerforeachquestion):

1. Canitprocessdifferentpartstylesinanon-batchmode?
2. Canitacceptchangesinproductionschedule?
3. Canitrespondgracefullytoequipmentmalfunctionsand breakdowns?
4. Canitaccommodateintroductionofnewpartdesigns?

Iftheautomatedsystemdoesnotmeetthesefourtests,it shouldnotbeclassifiedasaflexiblemanufacturingorcell.

IstheRoboticWorkCellFlexible?

1. Canitmachinedifferentpartconfigurationsinamixratherthanin batches?
2. Canproductionscheduleandpartmixbechanged?
3. Canitoperateif onemachinebreaksdown?

Example:whilerepairsarebeingmadeonthebrokenmachine,canits workbetemporarilyreassignedtotheothermachine?

4.Asnewpartdesigns aredeveloped,canNC partprogramsbewritten off-lineandthendownloadedtothesystemfor execution?

ThisfourthcapabilityalsorequiresthatthetoolingintheCNC machinesaswellastheendeffecterof therobotaresuitedtothe newpartdesign.

FMSComponents

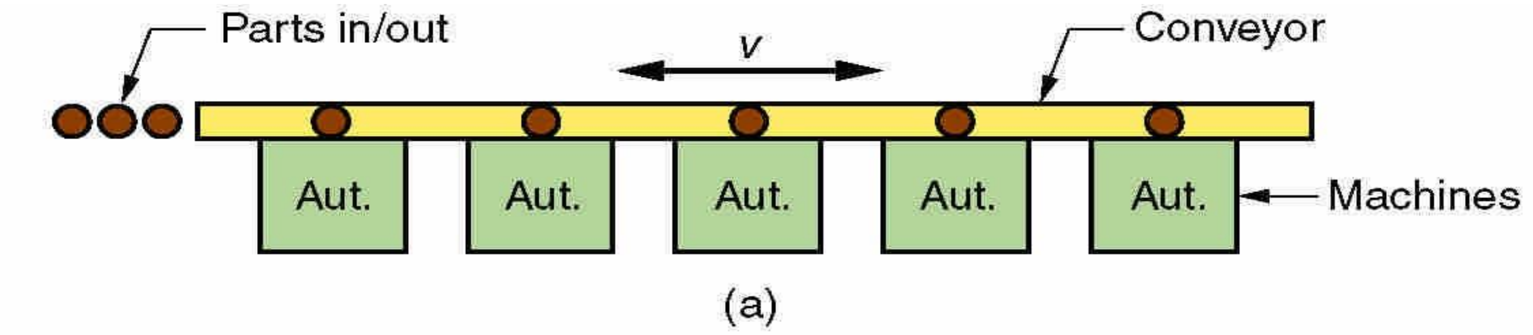
- Hardwarecomponents
- *Workstations-CNCmachinesinamachining typesystem*
- *Materialhandlingsystem-meansbywhich partsaremovedbetweenstations*
- *Centralcontrolcomputer-tocoordinatetheactivitiesofthecomponents soas toachieveas*moothoveralloperationofthesystemSoftwareandcontrolfunctionsHumanlabour

FiveTypesofFMSLayouts

1.In-
line2.Loop3
.Ladder4.O
penfield
5.Robot-centeredcell

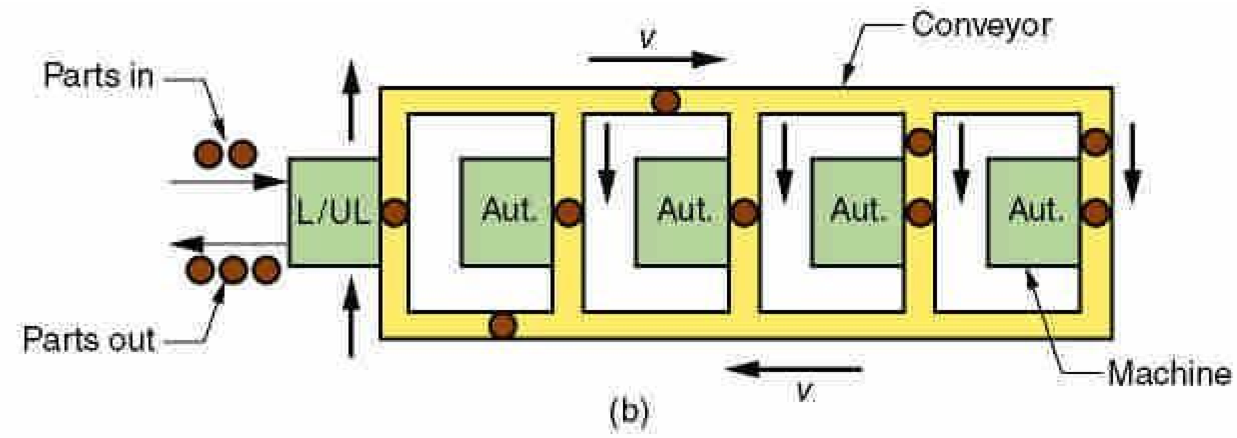
- ThebasiclayoutoftheFMSis establishedbythe materialhandlingsystem
- ThreeofthefiveFMSlayouttypes:

(a)in-line



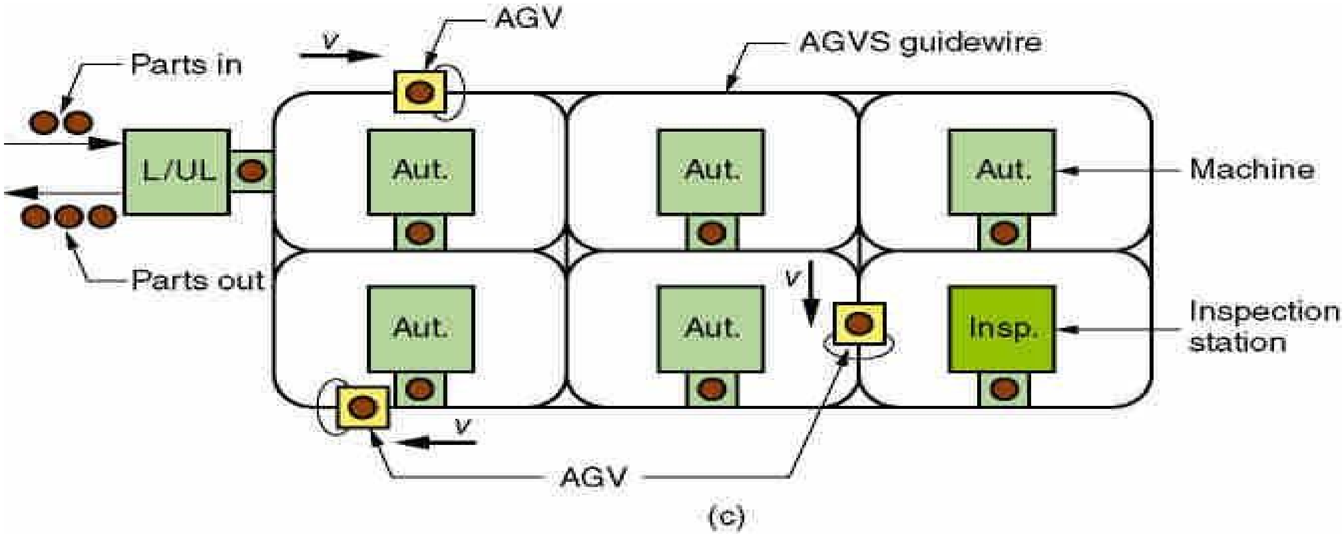
Key:Aut=automatedstation;L/UL=load/unload station;Insp=inspectionstation;AGV= automatedguidedvehicle;AGVS=automatedguidedvehiclesystem

(b) Ladderlayout



Key:Aut=automatedstation;L/UL=load/unload station;Insp=inspectionstation;AGV=automatedguidedvehicle;AGVS=automatedguidedvehiclesystem

(c) openfield



Key:Aut=automatedstation;L/UL=load/unload station;Insp=inspectionstation;AGV=automatedguidedvehicle;AGVS=automatedguidedvehiclesystem

TypicalComputerFunctionsinaFMS

- *NCpartprogramming-developmentofNC programsfornewpartsintroducedintothesys tem*
- *Productioncontrol-productmix,machine scheduling,andotherplanningfunctions*
- *NCprogram download-part programcommands mustbe downloadedtoindividualstations*
- *Machinecontrol- individualworkstationsrequirecontrols,usuallyCN C*

MoreComputerFunctionsinaFMS

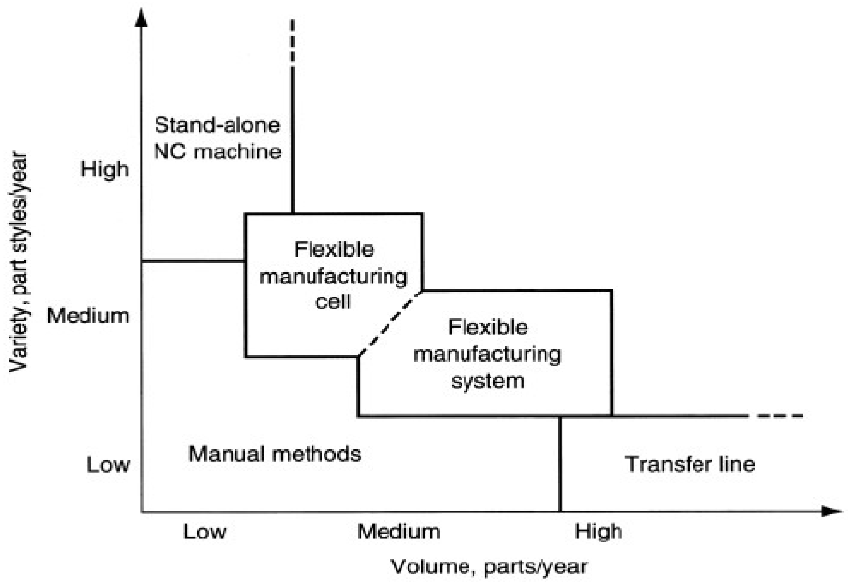
- *Workpartcontrol-monitorstatusofeachworkpartin thesystem,statusofpalletfixtures,orders*on loading/unloadingpalletfixtures
- *Toolmanagement-toolinventorycontrol,toolstatus relativetoexpectedtoollife,toolchanging*and resharpening,andtransporttoandfromtoolgrinding
- *Transportcontrol-schedulingandcontrolofwork handlingsystem*
- *Systemmanagement- compiles managementreports onperformance(utilization,piececounts,*production rates,etc.)

DutiesPerformed byHumanLabour

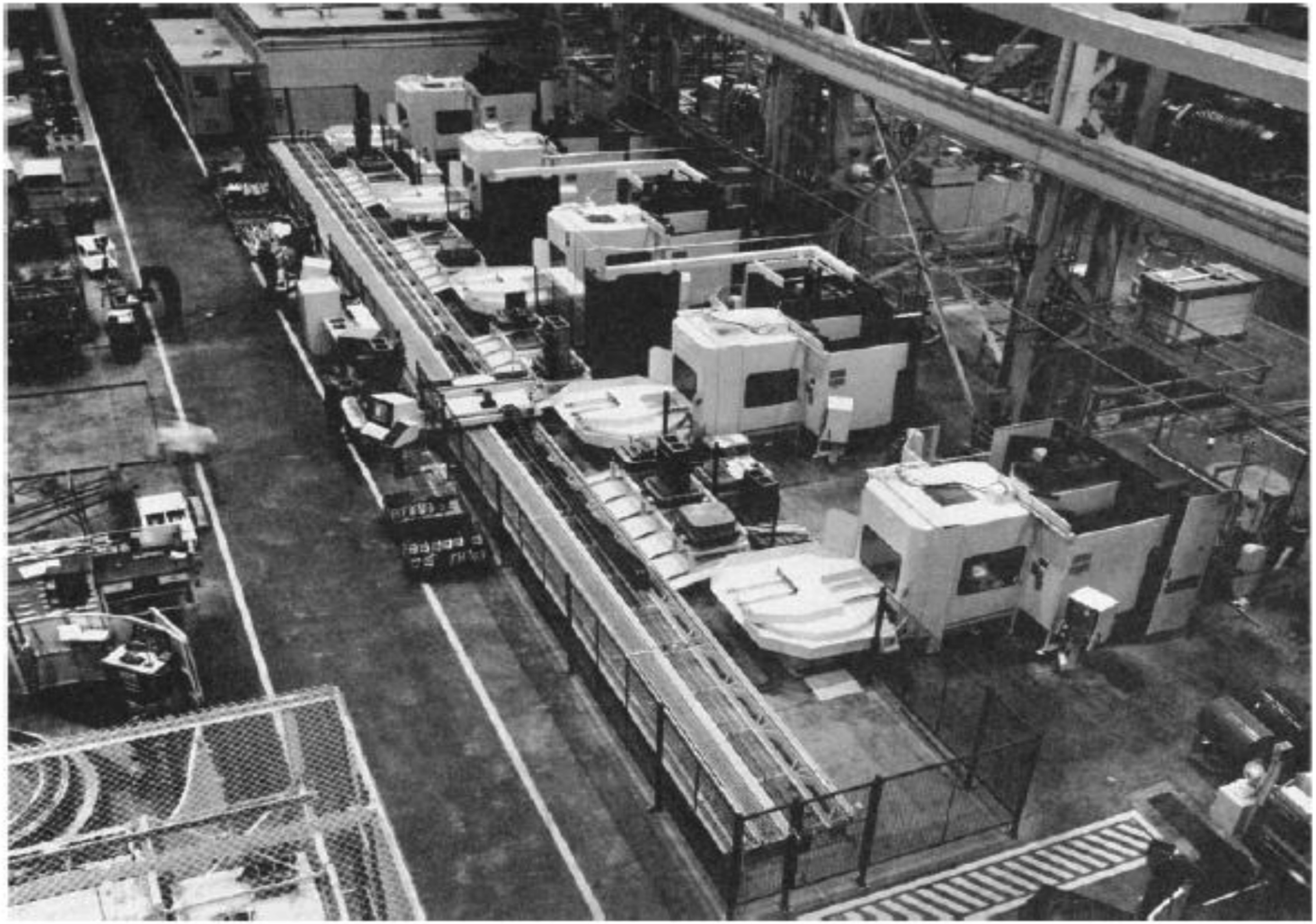
- Loadingandunloadingpartsfromthesystem
- Changingandsettingcuttingtools
- Maintenanceandrepairofequipment
- NCpartprogramming
- Programmingandoperatingthecomputer system
- Overallmanagementofthesystem

FMSApplications

- Machining–mostcommonapplicationofFMStechnology
- Assembly
- Inspection
- Sheetmetalprocessing(punching,shearing,bending,andforming)
- Forging



- **Applicationcharacteristicsofflexiblemanufacturingsystemsandcells relativetoothertypesofproductionsystems**



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TypicalFMSBenefits

- Highermachineutilizationthanaconventional machineshopduetobetterworkhandling, off-linesetups,andimprovedscheduling
- Reducedwork-in-processduetocontinuousproductionrathert hanbatchproduction
- Lowermanufacturingleadtimes
- Greaterflexibilityinproductionscheduling

IntroductiontoComputerAided ProcessPlanning

ComputerIntegratedManufacturing(CIM)

- ComputerAidedDesign(CAD)
  - 2D
  - 3D
  - ConcurrentEngineering
- ComputerAidedProcessPlanning(CAPP)
  - Variant
  - Generative
- ComputerAidedManufacturing(CAM)
  - CNC
  - Robotics
  - MaterialHandling
  - JustinTime(JIT)
  - GroupTechnology
  - FlexibleManufacturingSystems

Whatisprocessplanning?

- Recipe/Algorithm/Step-by-stepinstructions
- FastFoodChain
- SametasteeverywherefromNYtoLA
- Howdotheydoit?
- Customizationinformaldinnerrestaurant

ManufacturingEnvironment

- Roleofthe mastermachinist insmallbatch manufacturing
- Manufacturingis more complex thancookingyetthe planningforitis similar
- Jobshop:groupmachineswhich performsame operationtogether
- Routingof parts throughthe variousdepartments
- Processplan definesthe route
- Reductioninthe necessaryskillofoperatorcanbe achievedbyusingadetailedprocessplan

FormalDefinition

“Processplanningcanbedefinedas anactof preparing processingdocumentationforthemanufacturingof a piece,partoran assembly”

- dependingon the production environmentcanbe
  - Rough
  - Detailed
- Whenprocessplanningis done usingacomputer: “ComputerAidedProcessPlanning”

Step-by-step operationsina samplepart

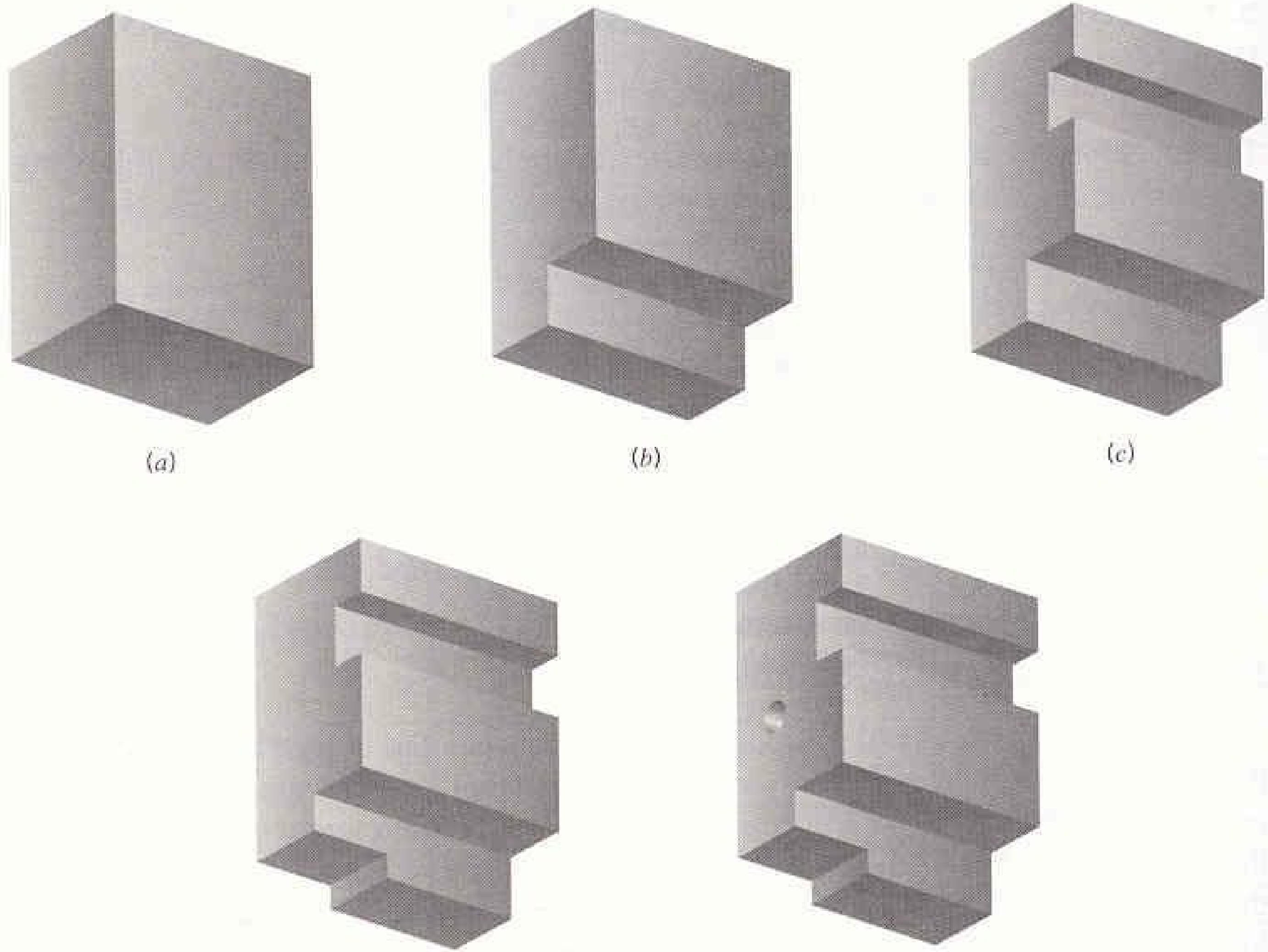


FIGURE 5.7 Successive modification of a part: (*a*) part with plane geometric features; (*b*) step addition; (*c*) slot addition; (*d*) side step addition; (*e*) a blind cylindrical hole addition.

- Manufacturingapartto meetdesignspecs.
  - Selectionofinitialblock
  - Sequenceofoperations
  - Selectionofmachine,process
    - Surfacefinish
    - Quality
    - Tolerance
    - Hardness
    - Life
    - Cost

ARoughProcessPlan

Route Sheet by: T.C. Chang

Part No. S1243
Part Name: Mounting Bracket

workstation	Time(min)
1. Mtl Rm	
2. Mill02	5
3. Drl01	4
4. Insp	1

Figure 1.1 A rough process plan

ADetailedProcessPlan

PROCESS PLAN					ACE Inc.

Part No. S0125-F
Part Name: Housing
Original: S.D. Smart Date: 1/1/89
Checked: C.S. Good Date: 2/1/89

Material: steel 4340Si

Changes: ____________ Date: _______
Approved: T.C. Chang Date: 2/14/89

No.	Operation Description	Workstation	Setup	Tool	Time (Min)
10	Mill bottom surface1	MILL01	see attach#1 for illustration	Face mill 6 teeth/4" dia	3 setup 5 machining
20	Mill top surface	MILL01	see attach#1	Face mill 6 teeth/4" dia	2 setup 6 machining
30	Drill 4 holes	DRL02	set on surface1	twist drill 1/2" dia 2" long	2 setup 3 machining

ComponentsofProcessPlanning

- Selectionofmachiningoperations
- Sequencingofmachiningoperations
- Selectionofcuttingtools
- Determiningthesetuprequirements
- Calculationofcuttingparameters
- ToolpathplanningandgenerationofNC/CNC programs
- DesignofJigs/Fixtures

ProcessPlanningindifferentenvironments

- Intool-roomtypemanufacturing
  - “makepartasperdrawing”issufficient
- Inmetal-formingtype operations
  - Theprocessplanningrequirementsareembeddeddirectly intothedie.
  - Processplanningis fairlytrivial
- Job-shoptypemanufacturing requires most detailed processplanning
  - Designoftools,jigs,fixturesandmanufacturingsequence aredictateddirectlybytheprocessplan.

Requirementsfor processplanner

- Mustbeabletoanalyzeandunderstandpartrequirements
- Haveextensiveknowledgeofmachinetools,cuttingtoolsandtheircapabilities
- Understandtheinteractionsbetweenthepart,manufacturing,qualityandcost

Traditionalprocessplanning

- Experiencedbasedand performedmanually
- Variabilityinplanner’sjudgmentand experiencecan leadto differencesinthe of whatconstitutesbest quality
- Problemfacingmodernindustryis the currentlackof skilledlaborforceto produce machinedparts aswas doneinthe past
- HenceComputerIntegratedManufacturingand ComputerAidedProcessPlanning

AdvantagesofCAPP

- Reducesthedemandontheskilledplanner
- Reducestheprocessplanningtime
- Reducesbothprocessplanningandm anufacturingcost
- Createsconsistentplans
- Itproducesaccurateplans
- Itincreasesproductivity

ApproachestoCAPP

- Variant
- Generative
- Automatic

VariantProcessPlanning

“basedonthevalidconjecturethatsimilarpartswill havesimilarprocessplans”

Preparatorystage

- GT-basedpartcoding
  - Familiesof similarpartsarecreated
  - Familymatrix
- Aprocessplanistomanufacturetheentirefamilyiscreated

VariantProcessPlanning

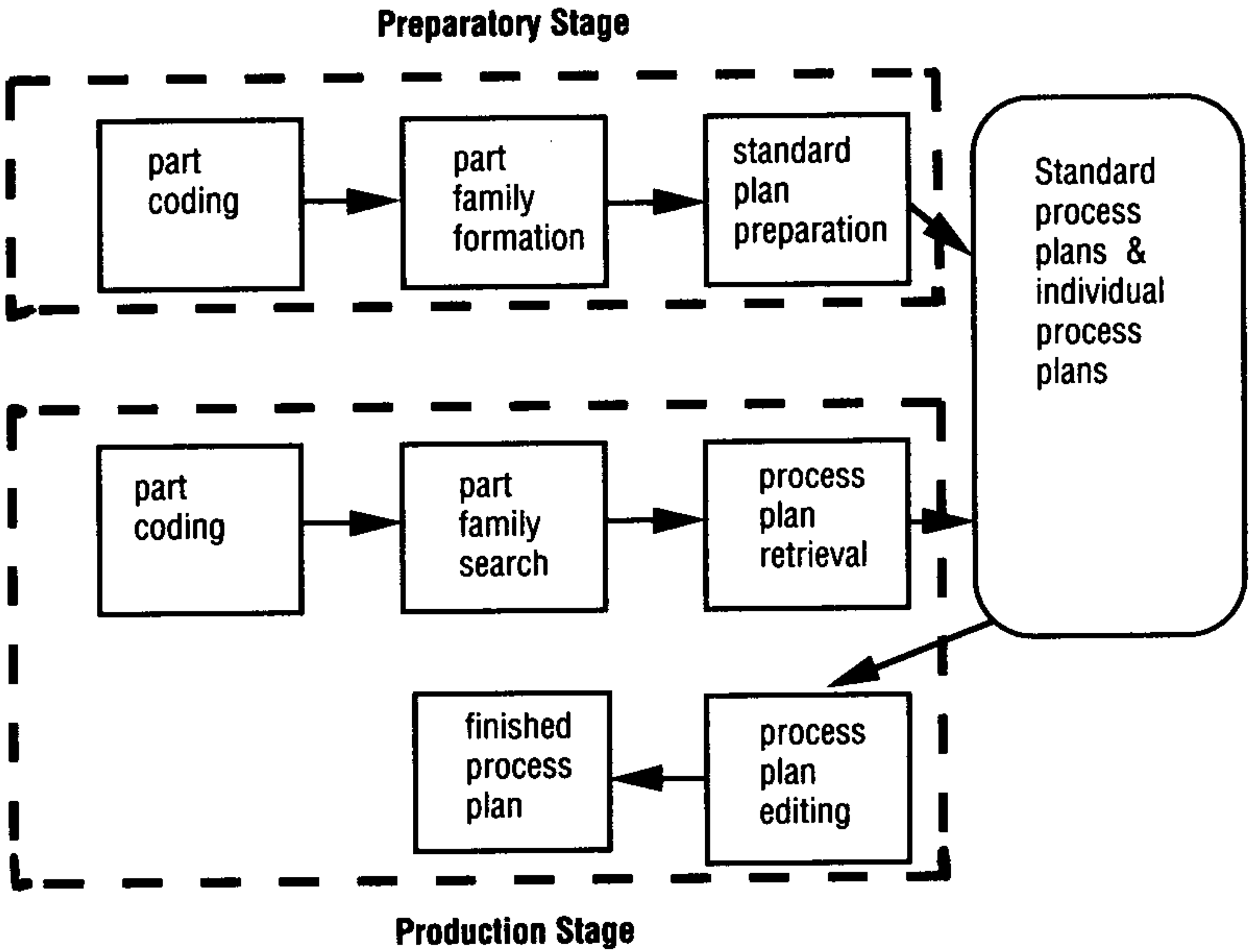
ProductionStage

- Incomingpartiscoded
- Partfamilyisidentified
- Processplaniseditedtoaccountforthedifferentneedsofthe part

Salientpointsofvariantprocessplanning

- Easytobuild,learnanduse
- Experiencedprocess plannersarestillrequiredtoeditthe processplan
- Cannotbeusedinanentirelyautomated manufacturing systemwithoutadditionalprocessplanning

VariantProcessPlanning



GenerativeProcessPlanning

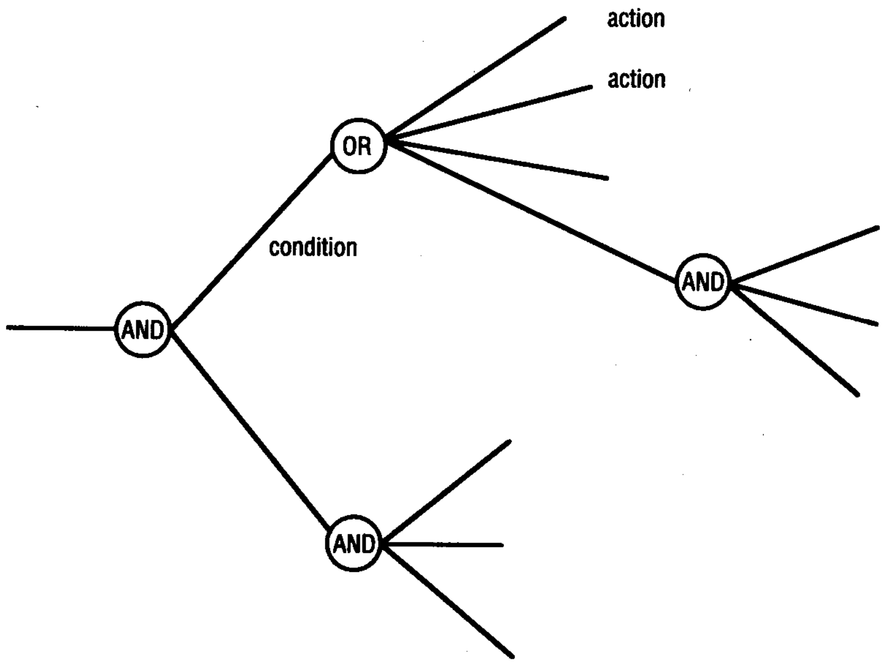
“asystemwhichautomaticallysynthesizesa process planforanew component”

Requires

- Partdescription
  - Parttobeproducedmustbeclearlyandpreciselydefinedinac omputercompatibleformat(OPITZ,AUTAP)
- Manufacturingdatabases
  - Logicofmanufacturingmustbeidentifiedandcaptured
  - Thecapturedlogicmustbeincorporatedinaunified manufacturingdatabase

GenerativeProcessPlanning

- Decisionmaking logicand algorithms
  - Decisiontrees
  - ExpertSystems:
  - AIbased approaches



AutomaticProcessPlanning

“generateacompleteprocessplan directlyfroma CAD drawing”

Requires:

- AutomatedCAD interface
  - TakeageneralCADmodel(3Dforunambiguousdata)and developaninterfacetodevelopamanufacturinginterfacefort hismodel: FeatureRecognitionofCAD
  - Designthepartswithavailablemanufacturingfeatures: FeaturebasedCAD
  - Dual:usefulfeaturesofbothapproaches
- Intelligent(computerbased) processplanner

Someprocess planning approaches

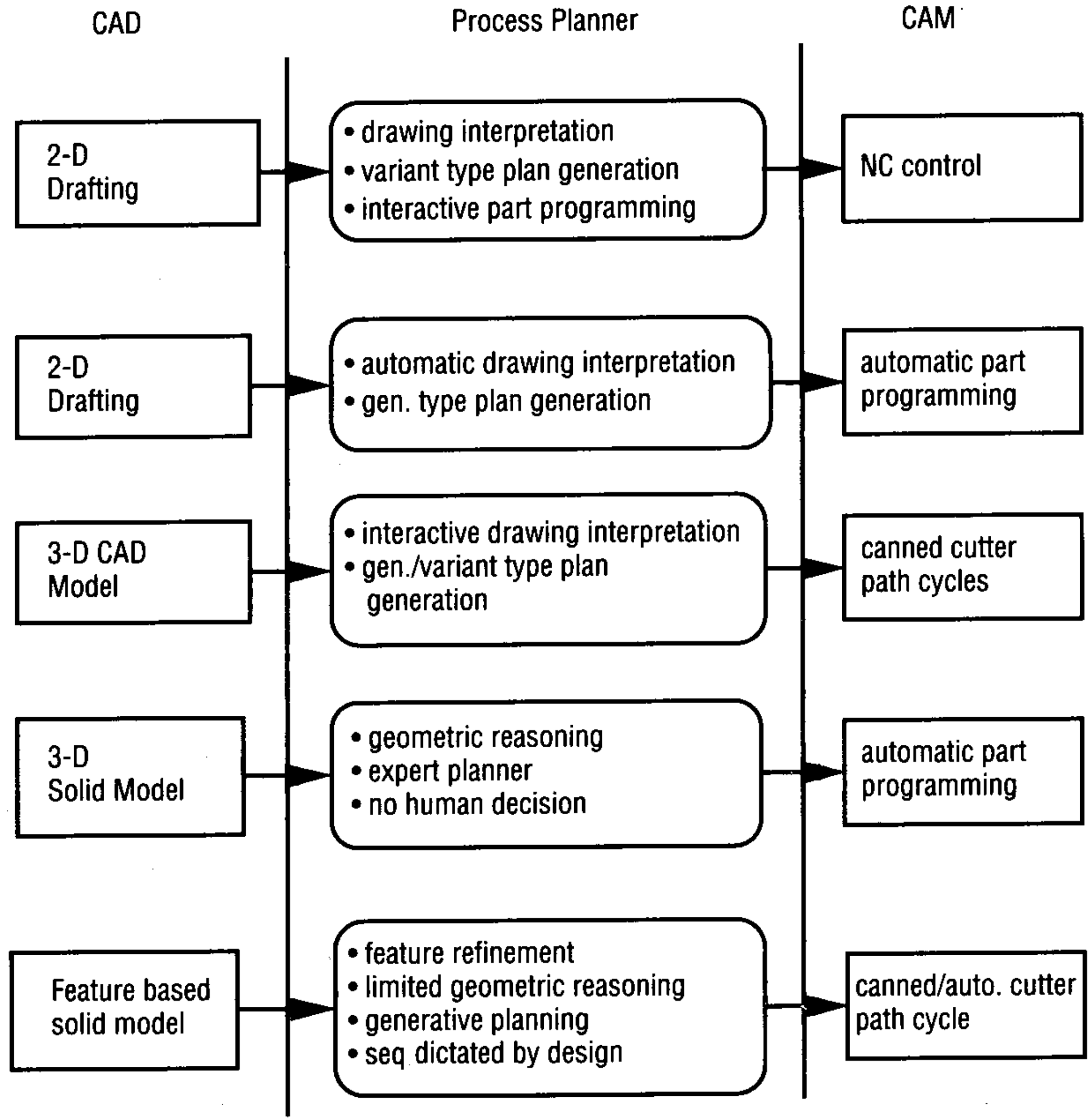


Figure 1.14 Some process planning approaches

FINITEELEMENTANALYSIS

-Introduction

-Coordinatereferencesystems

-Typesof finiteelements

-BasicstepsinFEM

-Advantages

-Limitations

-Applications

-FEApackages

Introduction

- FEMisa methodformathematicalsolutionofwide rangeofengineeringproblems
- InFEMbodyorstructureisdividedintofinitenumber ofsmallerunits knownaselements.
- Theprocessof dividingstructureintofinitenumberof elementsisknownasdiscretization.
- Theelementsareconsideredinterconnectedatjoints whicharenownasnodesornodalpoints
- InFEM,amountofdatahandledisdependentupon numberofelementsintowhichtheoriginalbodyis divided.
- Accuracyincreaseswithnumberofelementstaken.

Coordinatereferencesystems

- GlobalCoordinateSystem

Itis theframeofreferencefortheentirecontinuumorstructure.

Thereis onlyoneglobalcoordinatesystem.

Represented by (X,Y,Z).

- LocalCoordinateSystem

Itis theframeofreferenceforindividual element.

Thereis a localcoordinatesystemforeachelementinthecontinuum.

Representedby(x,y,z)

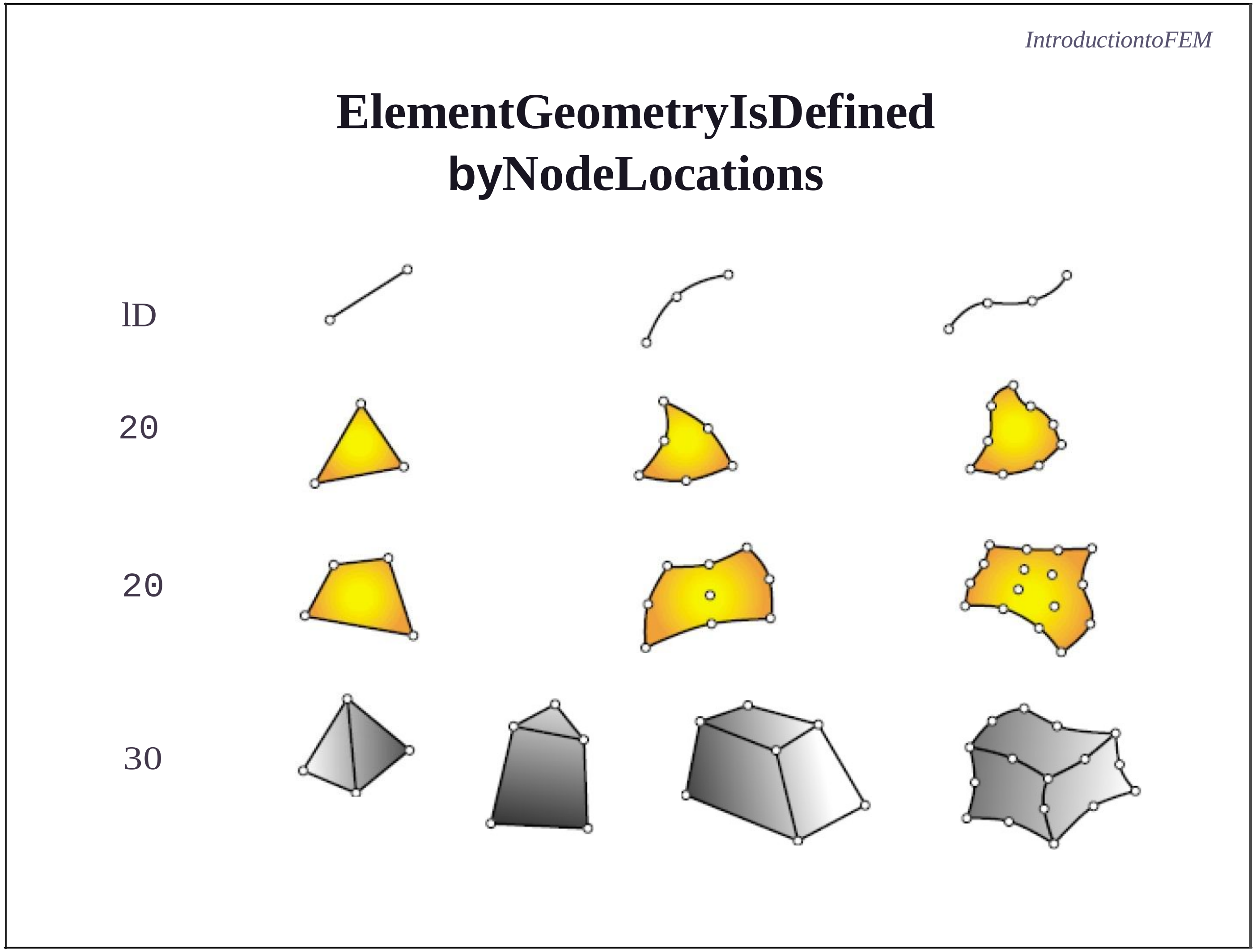
- NaturalCoordinateSystem

Itis theframeofreferencefor the individualelementinwhicha pointwithintheelementis expressedby aset ofdimensionlaessnumbers whosemagnitudes are between-1 and +1.

Itis definedsuchthat at primary external nodalpointssomeofthecoordinateshave unit or zeromagnitude.

Represented by (ξ,η,ζ)

Typesof finiteelements



Basic steps in FEM

- Discretizationofcontinuum
- FormationofelementstiffnessMatrices
- Formationofglobalstiffnessmatrix
- Formationofgloballoadvector
- Formationofglobalnodaldisplacementvector
- Assemblyofglobalstiffness-nodaldisplacement-loadequations
- Incorporationofspecifiedboundaryconditions
- Solutionofsimultaneousequations
- Computationofelementstrainand stresses.

StagesinFEApachages

- Preprocessing
  - Modelingofbodyorstructure
  - Selectionofelementtype
  - Discretizationormeshingofbody
  - Inputtingmaterialinformation
  - Applyingboundarycondition
  - Applyingload
- Processingorsolution
  - Generationofelementstiffnessmatrix&global stiffnessmatrix.
  - Solutionof simultaneousequation.
  - Determinationofnodaldisplacement
  - Determinationofotherparametersuchas strain,stressetc
- Postprocessing
  - Presentationofresultingraphicalas wellas textualformat.

Advantages

- Thephysicalproblemswhichweresofar intractableandcomplexforanyclosed-bound solutionscanbeanalyzed by usingthismethod
- Thismethodcanbe efficientlyappliedtobodies (orstructure)withirregulargeometry.
- Thismethodcantakecareofanytypeofcomplex loading.
- Itcandealwithanytypeofboundarycondition.
- Thismethodcanhandle,withoutdifficulty .Materialnon-homogeneity.

Limitations

- Theaccuracyofresultshighlydependondegree ofdiscretization(ormeshing)
- Manualjudgmentisessentialindiscretization process.
- FEArequireslargecomputermemoryandtime, andhencecostinvolvedis high
- Inthismethod,theerrorininputdatamaygo undetectedanderroneousresultobtained thereformmayappearacceptable.
- Methodiscomplicated&hencenotviablefor simpleproblem.

Applications

FEAwas developedforstructuralanalysis&it furtherappliedforsolutionofprobleminotherfieldlikemechanicaldesign,Mechanical vibration,AeronauticalEngineering,Heat transfer,Fluidflow,soil&rockmechanic,bio-engineeringetc

- Static-linearanalysis
- Staticnon-linearanalysis
- Dynamic-linearanalysis
- Dynamicnon-linearanalysis
- Thermalanalysis
- Fluidflowanalysis

FEApackages

WidelyusedFEApackagesare–

- ANSYS
- NASTRAN
- HYPERMESH
- NISA
- IDEAS
- ADINA
- PATRAN
- COSMOS
- INERTIA
- PRO-E