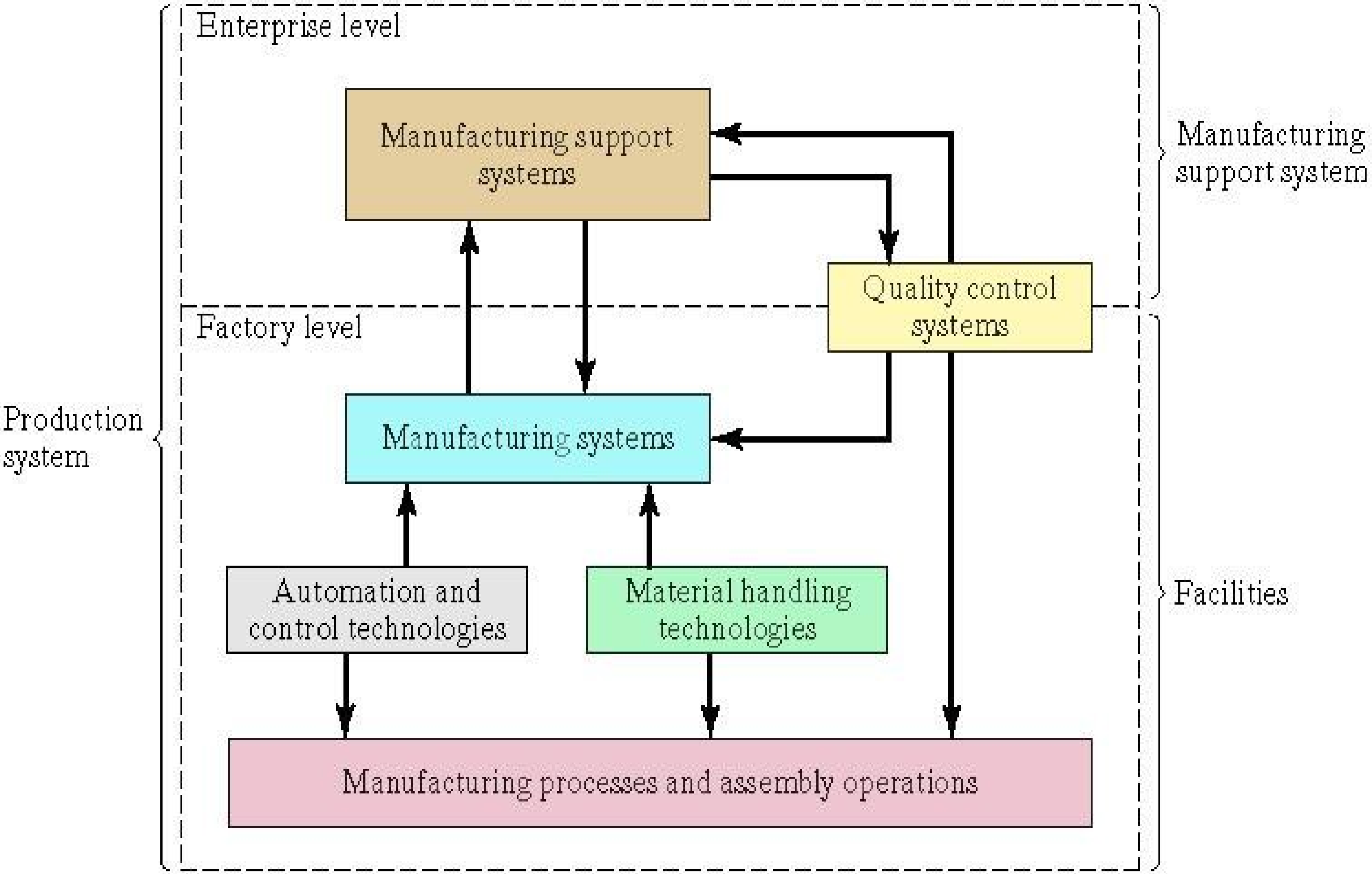
AUTOMATIONANDNUMERICAL CONTROL

INTRODUCTIONTOPRODUCTIONSYSTEM



TYPESOFPRODUCTIONSYSTEMS

1. Continuousflowtypeproductionsystems
2. Massproductionsystems
3. Batchproductionsystems
4. Jobproductionsystems

AUTOMATION

- Automationcanbedefinedasthetechnologyusedfortheapplicationofintegratedmechanical,electronicandcomputerbasedsystemsintheoperationand controlofproduction systems.

Need forautomation:

1. Toincreaseproductivity
2. Toreducecostofproduction
3. Toimproveproductquality
4. Tomitigatetheeffectsoflabourshortages
5. Toreduceproductiontime
6. To avoidhighcostofnotautomating
7. Tohavebettercontrolovermanufacturingactivities
8. Toimproveworkersafety
9. Toreduceoreliminateroutinemanualandclerical tasks

TypesofAutomation

- Fixed(Hard)Automation

- Sequenceofprocessingoperationsisfixedbyproduction equipmentconfiguration

- ProgrammableAutomation

- Productionequipmentsaredesignedwithacapabilityto changethesequenceofoperationssoas toaccommodate differentproductconfigurations.

- FlexibleAutomation

- Automationsystemcapableofproducingproductsofdesign variations.Continuouslywithvirtuallylittleornotimelossforchangeoversfromoneproducttoother.

Comparisonparameters	**FixedAutomation**	**Programmable Automation**	**Flexible Automation**
Initial investment	High initial investmentforcustom-engineered equipment.	High initial investmentforgeneralpurpose equipment.	High initial investmentforcustom-engineered equipment.
Productionrate	high	Lowtomedium	medium
Flexibility	Highlyinflexible	Flexiblein accommodatingchangesinproductvariety.	Flexiblein accommodating productdesign variations
Production systems	Suitablefor continuousflowtype andmass productionsystems	Suitablefor batch productionsystems	Suitablefor continuous productionof variableproducts
Toolsetuptime	Notoolsetuptimeastoolingisfixed.	Toolsetuptimevariesfrombatchto batch.	Minimaltoolsetup time.

AdvantagesofAutomation

- Improvesstandardofliving
- Reducesworkinghours
- Bringssaferworkingenvironment
- Automationinproductionresultsinbetterqualityproductsin lowerprices
- Overallskillofmanufacturinglabourwillbeupgraded

DisadvantagesofAutomation

- Reducedlabourrequirementmayincreaseunemployment
- Unemploymentcanresultinreducedpurchasingpowerand economicslowdown.

NumericalControl

- NumericalControl(NC)- A controlsystemwhichprimarily processesnumericinput.Limitedprogrammingcapabilityatthe machinetool.Limitedlogicbeyonddirectinput.Thesetypesof systemsarereferredtoas “hardwirecontrols”andwerepopular fromthe1950’sto1970’s.

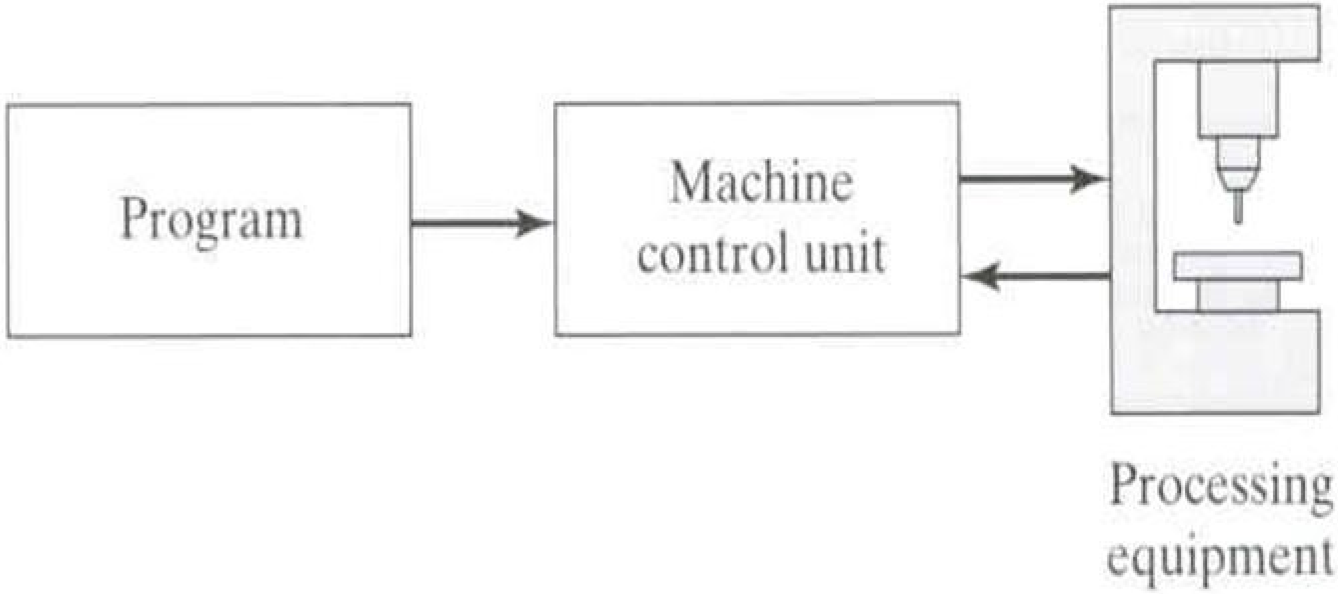
- Numerical controlis amethodofautomaticallyoperatinga manufacturingmachinebasedona codeofletters,numbers, andspecialcharacters.

- Thenumericaldatarequiredto produceapartis providedtoa machineintheformofa program,called*partprogramorCNC program*.

- Theprogramistranslatedintothe appropriateelectrical signalsfor inputtomotorsthatrunthemachine.

- ModernNC machinehas acomputeronboard,Computer NumericalControl(CNC).Theycanrununattendedatover20,000 rpm(spindlerspeed)witha feedrateof over600ipmandan accuracyof 0.0001

BasiccomponentsofNCsystem



Basic components of an NC system.

CNCMachines

MachiningCenters,equippedwithautomatictoolchangers,arecapableof changing90 or moretools. Can performmilling,drilling,tapping,boring…on many faces.

CNCMachines

TurningCentersarecapableof executingmany differenttypesof lathecutting operationssimultaneouslyonarotating part.

ClassificationofNCmachinetoolsystems

- Accordingto controlloopfeedback system

1. Openloopsystem
2. Closedloopsystem

- Accordingto typeof toolmotioncontrol

1. Pointtopoint
2. Straightcut
3. Continuouspath

- Accordingto programmethod

1. Absoluteprogramming
2. IncrementalProgramming

- Accordingto typeof controller

1. NCbasedcontroller
2. CNCbasedcontroller

CNCControllers

TheNCcontrolleristhebrainoftheNCsystem,itcontrolsallfunctionsof themachine.

- Motioncontroldealswiththetoolposition, orientationandspeed.
- Auxiliarycontroldealswithspindlerpm,toolchange,fixtureclampingandcoolant.

Manydifferenttypesofcontrollersareavailableinthemarket(GE, Fanuc,Allen-Bradley,Okuma,Bendix,…).

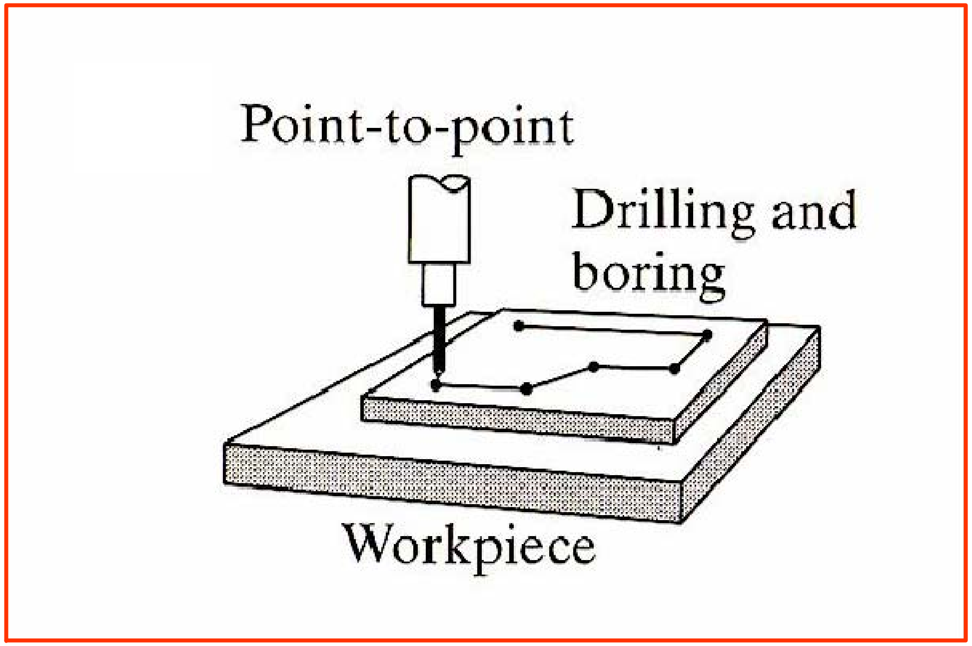
Therearetwobasictypesofcontrolsystems:

point-to-pointand**continuouspath**.

Point-to-PointToolMovements

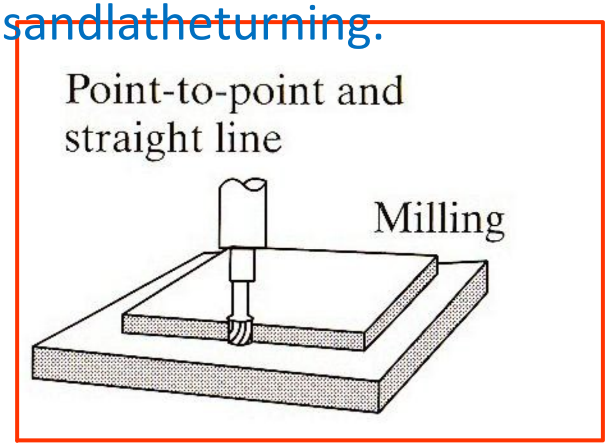
Point-to-pointcontrolsystemscausethetooltomovetoa pointonthepartand executeanoperationatthatpointonly. Thetoolisnotincontinuouscontactwiththepartwhile itis moving.

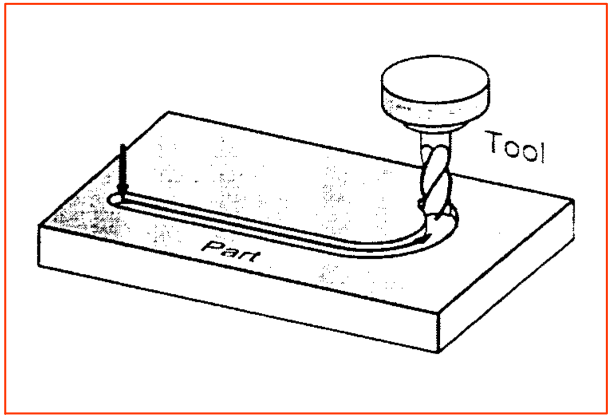
Drilling,reaming,punching,boringandtappingareexamples ofpoint-to-pointoperations.

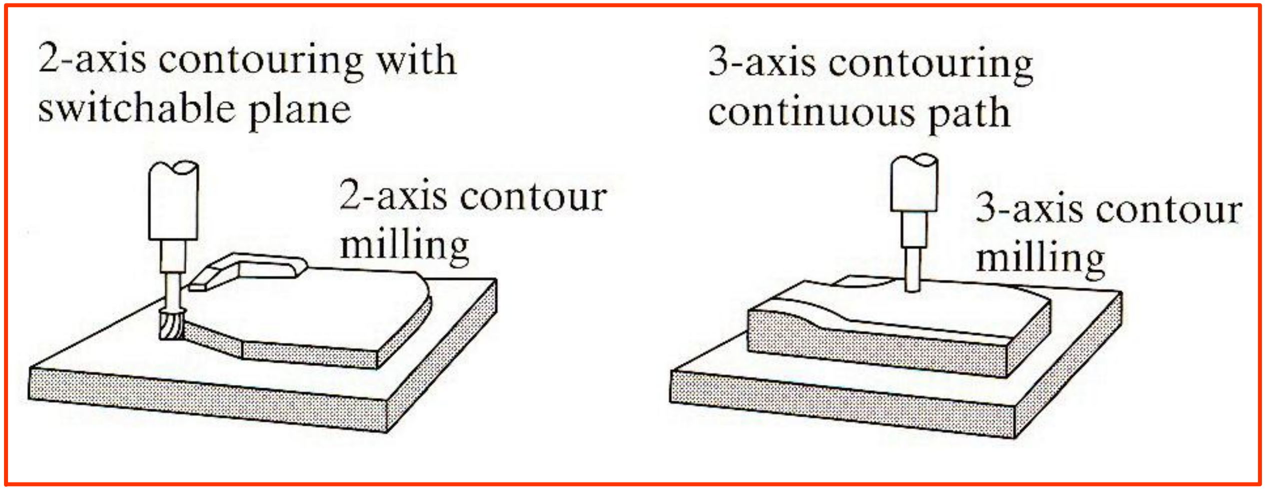


Continuous-PathToolMovements

Continuous-pathcontrollerscausethetooltomaintaincontinuouscontactwiththepartastheetoolcutsa contourshape. Theseoperationsincludemillingalonganylinesatanyangle,milling arcsandlatheturning.

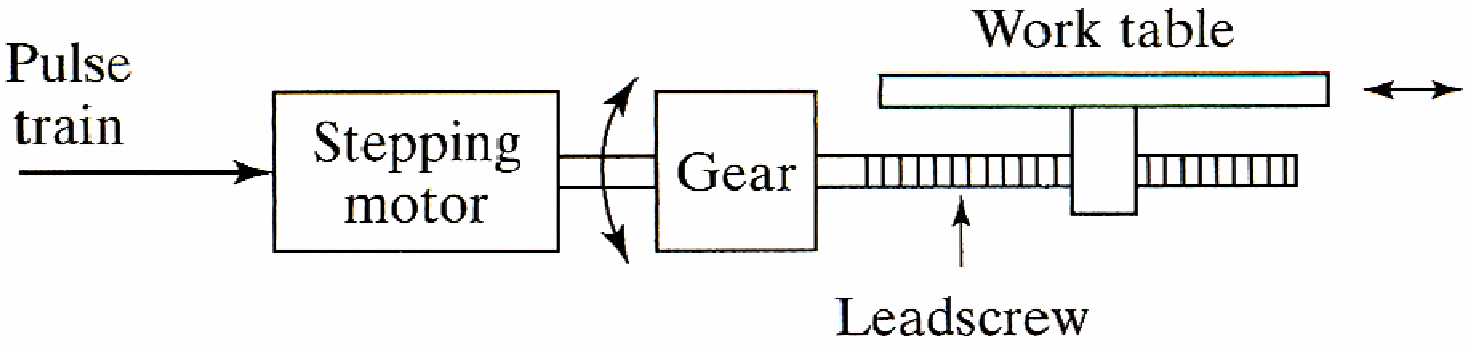






OpenLoopSystemsforControllingToolMovement

Usessteppingmotortocreatemovement.Motorsrotatea fixed amountforeachpulse receivedfromtheMCU. Themotorsendsa signalbackindicatingthatthemovementiscompleted.Nofeedback tocheckhowclosethe actualmachinemovementcomestothe exactmovementprogrammed.



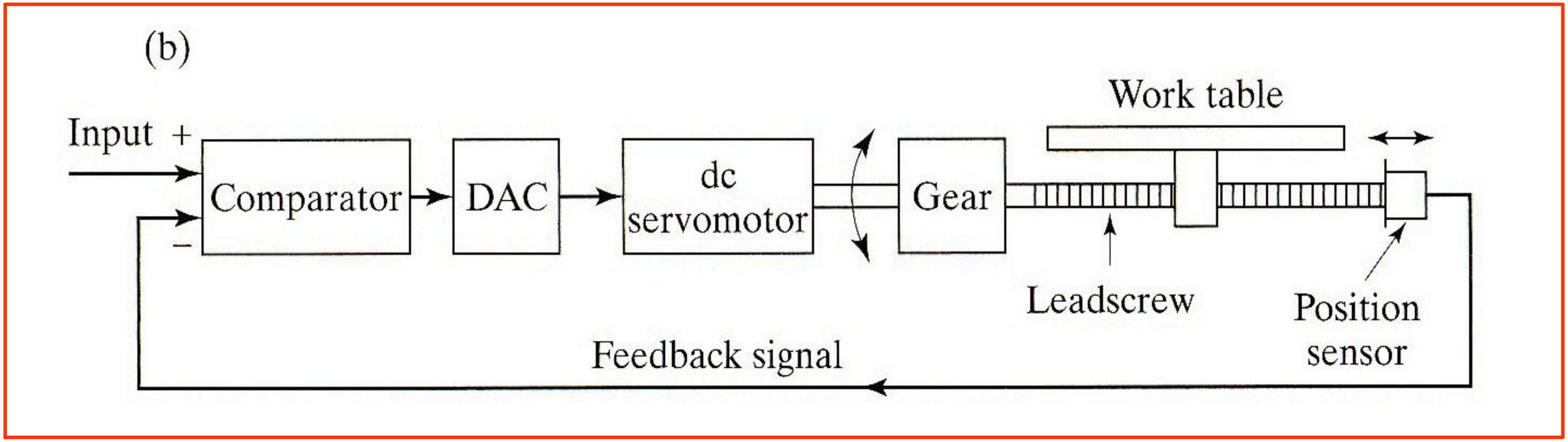
ControlSystems

- Open-LoopControl
  - Steppermotorsystem
  - Currentpulsessentfromcontrolunittomotor
  - Eachpulseresultsinafiniteamountofrevolutionofthe motor

- Open-LoopLimitations
  - Controlunit“assumes”desiredpositionisachieved
  - Nopositioningcompensation
  - Typically,alowertorquemotor
- Open-LoopAdvantages
  - Lesscomplex,Lesscostly,andlowermaintenancecosts

ClosedLoopSystemsforControllingToolMovement

AC,DC,andhydraulicservo-motorsareused.Thespeedof thesemotorsarevariableand controlledbytheamountof currentorfluid.Themotorsareconnectedtothespindleand thetable.ApositionsensorcontinuouslymonitorsthemovementandsendsbackasignaltoComparatortomakeadjustments.



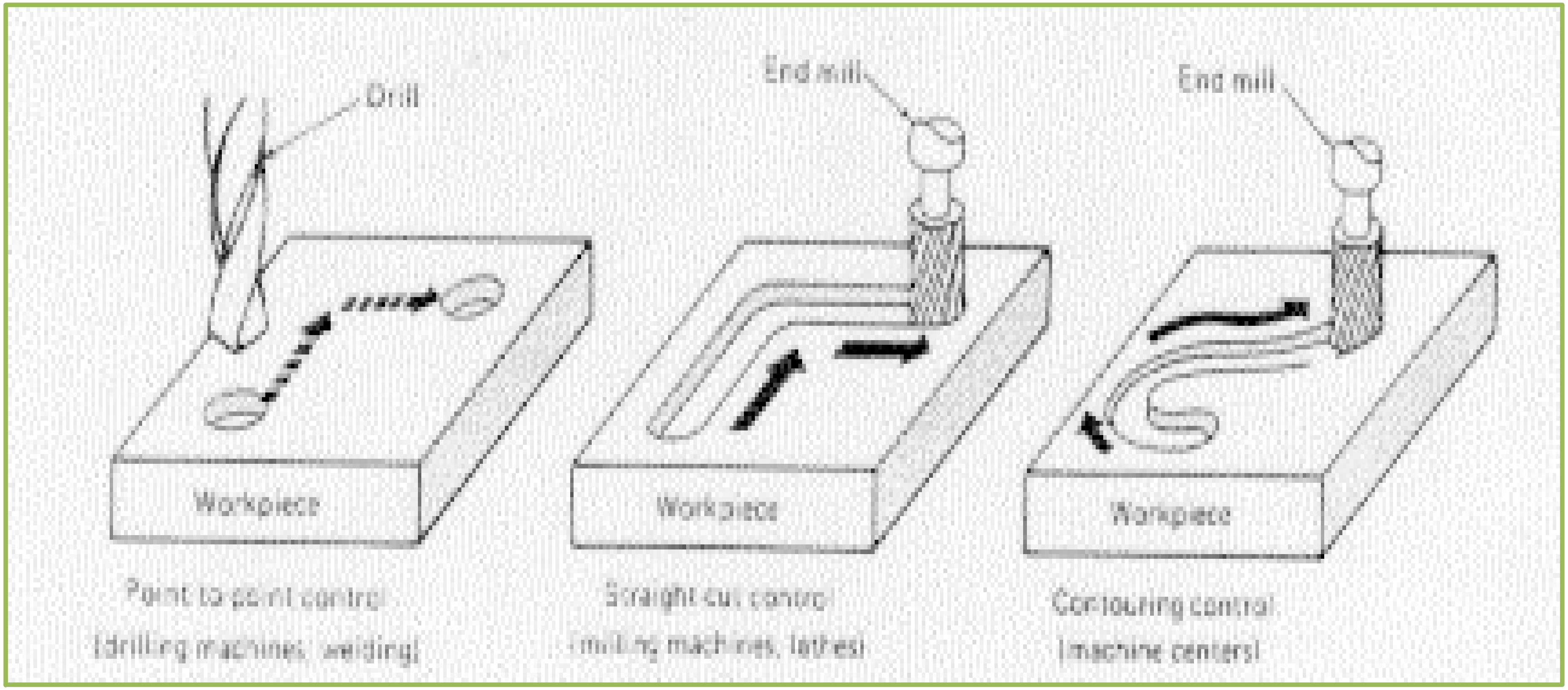
ControlSystems

- Closed-LoopControl
  - VariableDCmotors -Servos
  - Positioningsensors-Resolvers
    - Feedbacktocontrolunit
    - Positioninformationcomparedtotargetlocation
    - Locationerrorscorrected
- Closed-LoopAdvantages
  - DCmotorshavethe abilitytoreverseinstantlytoadjustfor positionerror
  - Errorcompensationallowsforgreaterpositionalaccuracy (.0001”)
  - DCmotorshavehigher torquerangesvs..steppermotors
- Closed-looplimitations
  - Cost

ThreeBasicCategoriesofMotion Systems

- PointtoPoint-Nocontouringcapability
  - Straightcutcontrol-oneaxismotionatatime iscontrolledformachining
- Contouring-multipleaxis’scontrolled simultaneously

ThreeBasicCategoriesofMotion Systems



FlowofComputer-Aided CNCProcessing

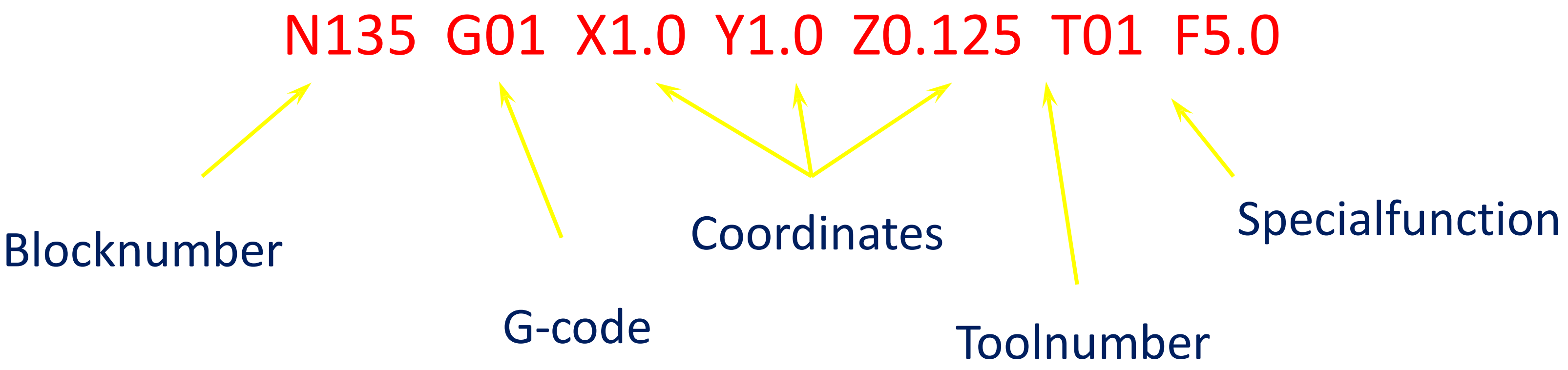
- Developorobtainthe3Dgeometricmodelofthepart, usingCAD.
- Decidewhichmachiningoperationsandcutter-path directionsarerequired(computerassisted).
- Choosethetoolingrequired(computerassisted).
- RunCAMsoftwaretogeneratetheCNCpartprogram.
- Verifyandeditprogram.
- Downloadthepartprogramtotheappropriatemachine.
- Verifytheprogramontheactualmachineandeditif necessary.
- Runtheprogramandproducethepart.

BasicConceptofPartProgramming

Partprogrammingcontainsgeometricdataabouttthepartand motioninformationtomovethecuttingtoolwithrespecttothe workpiece.

Basically,themachinereceivesinstructionsas asequenceof blockscontainingcommandstosetmachineparameters;speed,fee dandotherrelevantinformation.

Ablockis equivalenttoalineofcodesinapartprogram.



N135 G01 X1.0 Y1.0 Z0.125 T01 F5.0

BasicConceptofPartProgramming

TheGcodespreparetheMCUforagivenoperation,typically involvingacuttermotion.

G00	rapidmotion,point-to-pointpositioning
G01	linearinterpolation(generatingaslopedorstraightcut)G06
	parabolicinterpolation(producesasegmentofaparabola)G1
7	XYplaneselection
G20	inputvaluesininches
G28	
	automaticreturntoreferencepointG
33	threadcutting
M00	programstop
M03	

	startspindlerotation(cw)
M06	toolchange
M07	turncoolanton

NCwordsusedinpartprograms

N-

wordsG-

words

X,Y,Zwords

Feedcommands(Fcode)

Usedto specifythe cutterfeedratesin inchperminute.

Speedcommands(Scode)

Usedtospecifythespindlespeedinrpm.

Toolcommands(Tcode)

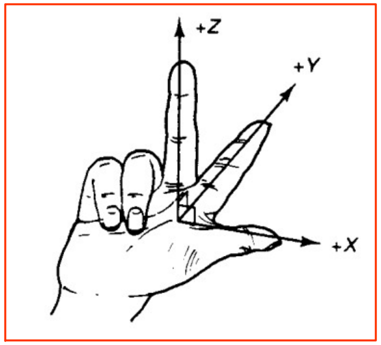
Specifieswhichtoolto beused,machineswithautomatictoolchanger.

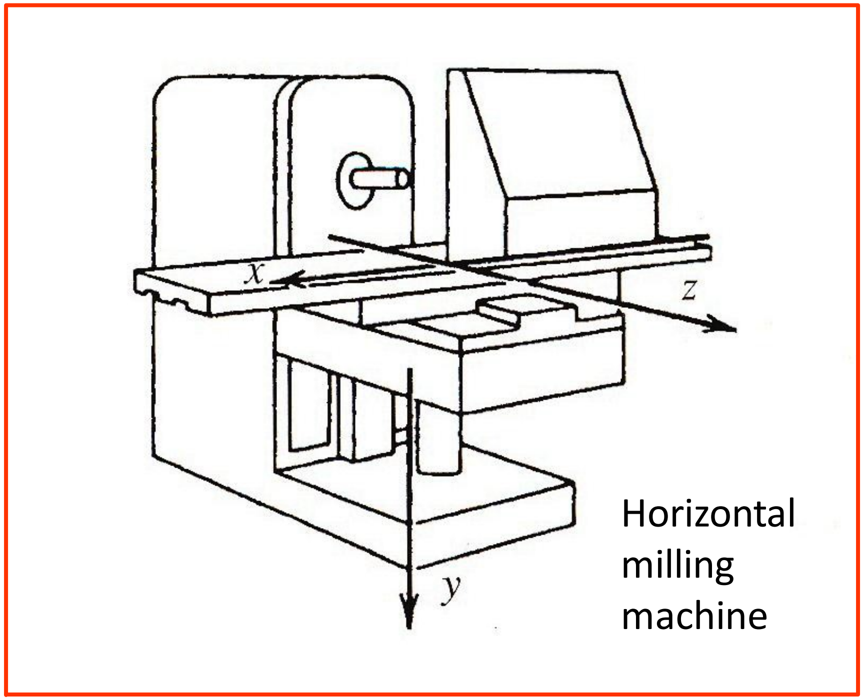
M-words

EOB

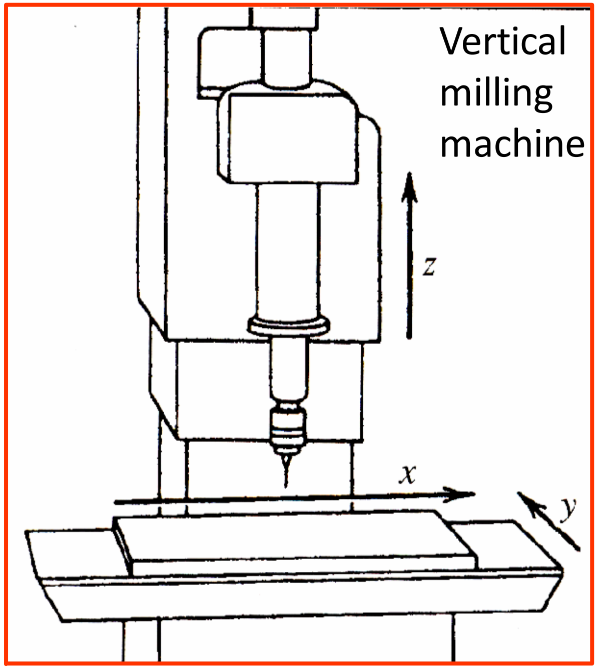
CNCMachineAxesofMotion

Thecoordinatesystemused forthe toolpathmustbeidenticaltothe coordinatesystem usedbythe CNC machine.The standardsfor machine axesareestablishedaccordingtotheindustrystandardreportEIARS-267A.



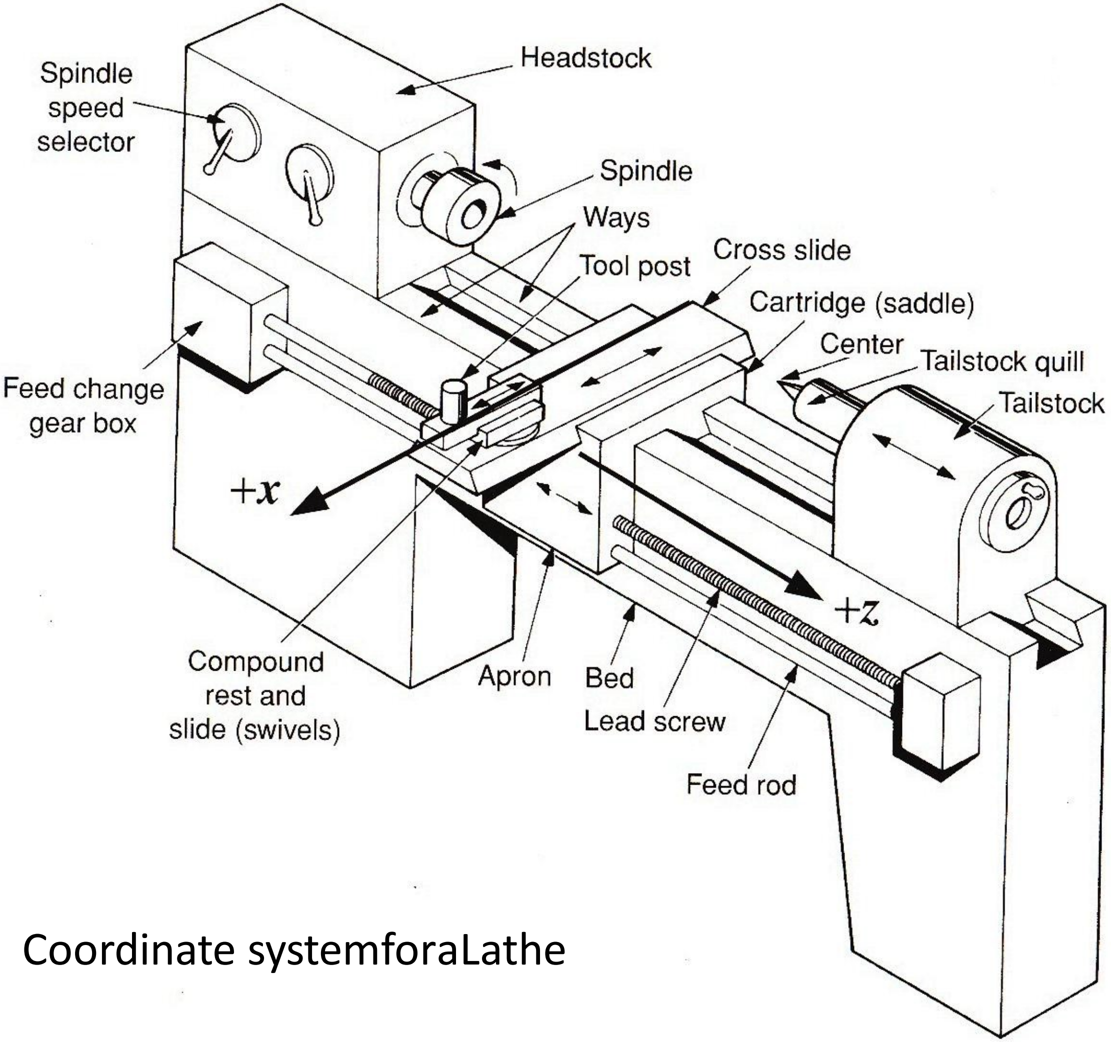


Horizontal milling machine



Vertical milling machine

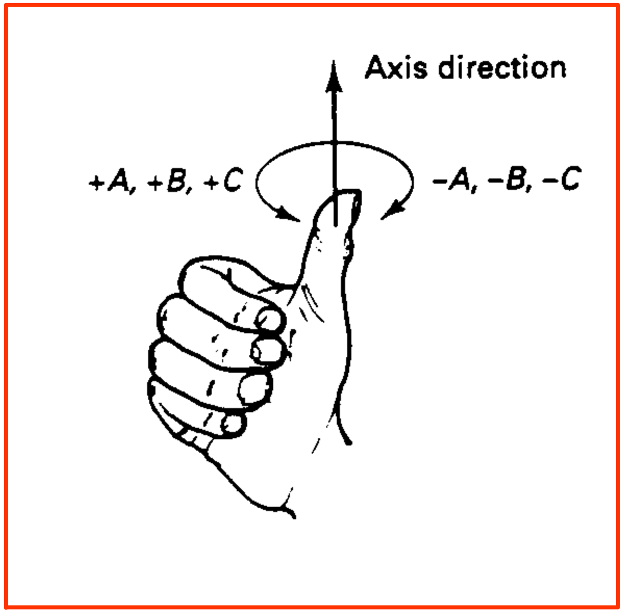
CNCMachineAxesofMotion

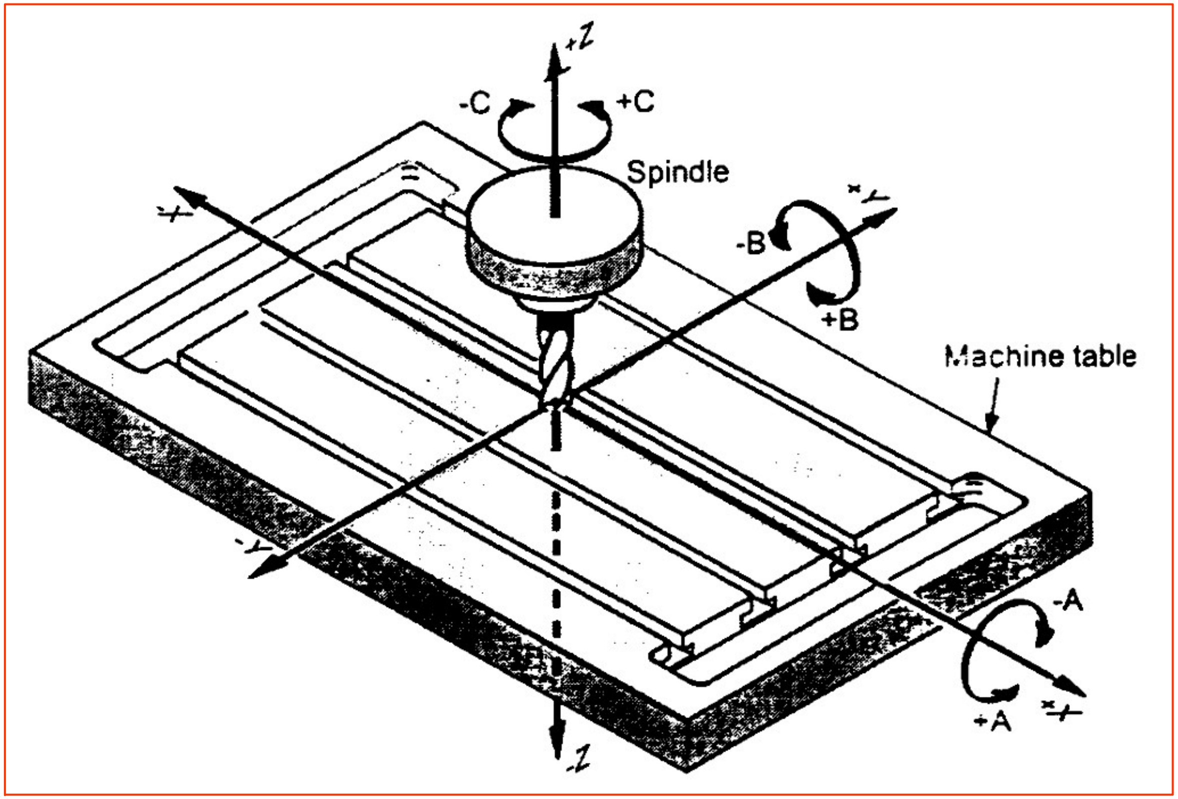


Coordinate systemforaLathe

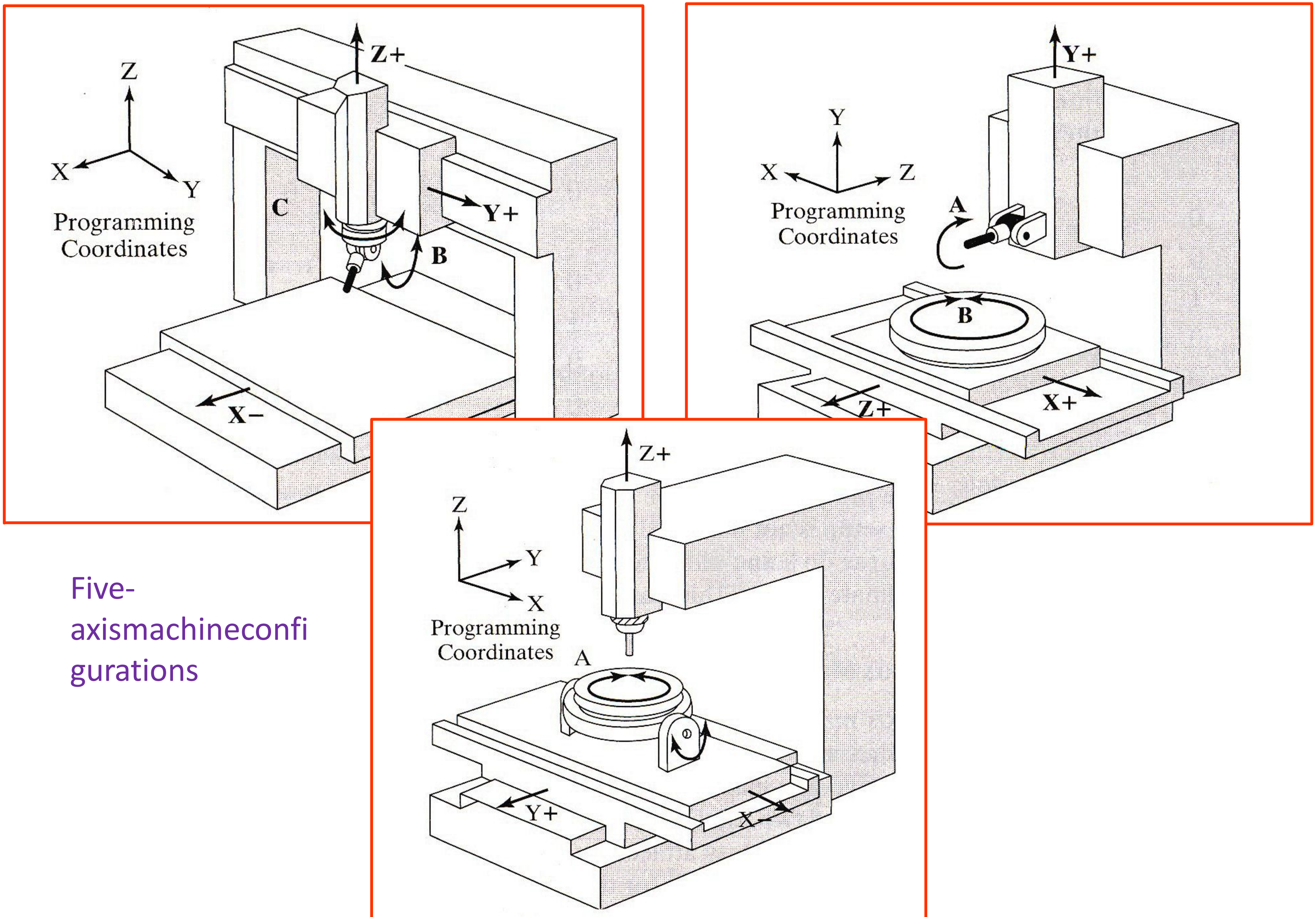
CNCMachineAxesofMotion

MorecomplexCNCmachineshave thecapability ofexecutingadditionalrotarymotions(4thand5thaxes).





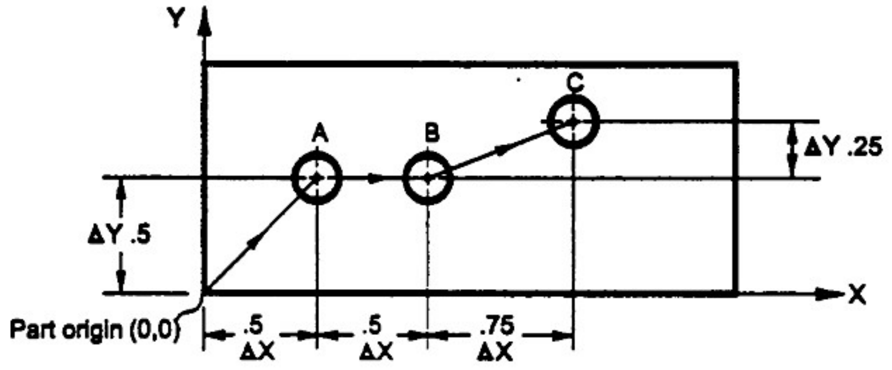
CNC Machine Axes of Motion



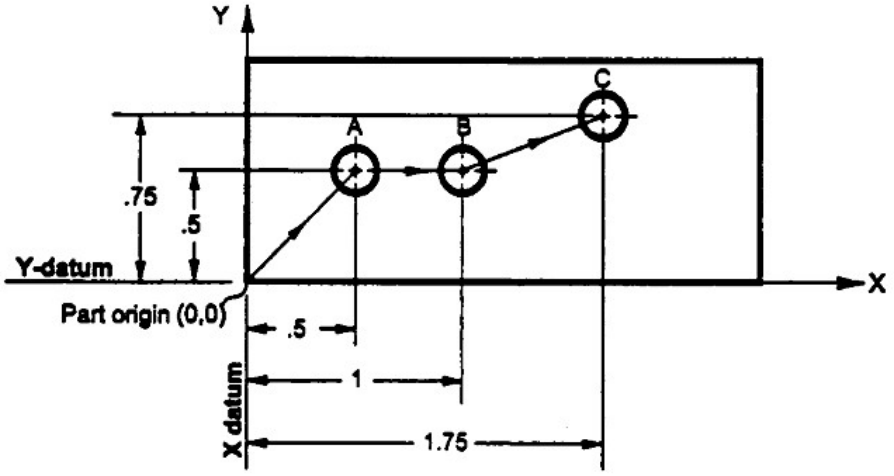
Five-axis machine configurations

CNC Machine Tool Positioning Modes

Within a given machine axes coordinate system, CNC can be programmed to locate tool positions in the following modes; incremental, absolute, or mixed.



Tool position	Location	
	ΔX	ΔY
A	.5	.5
B	.5	0
C	.75	.25

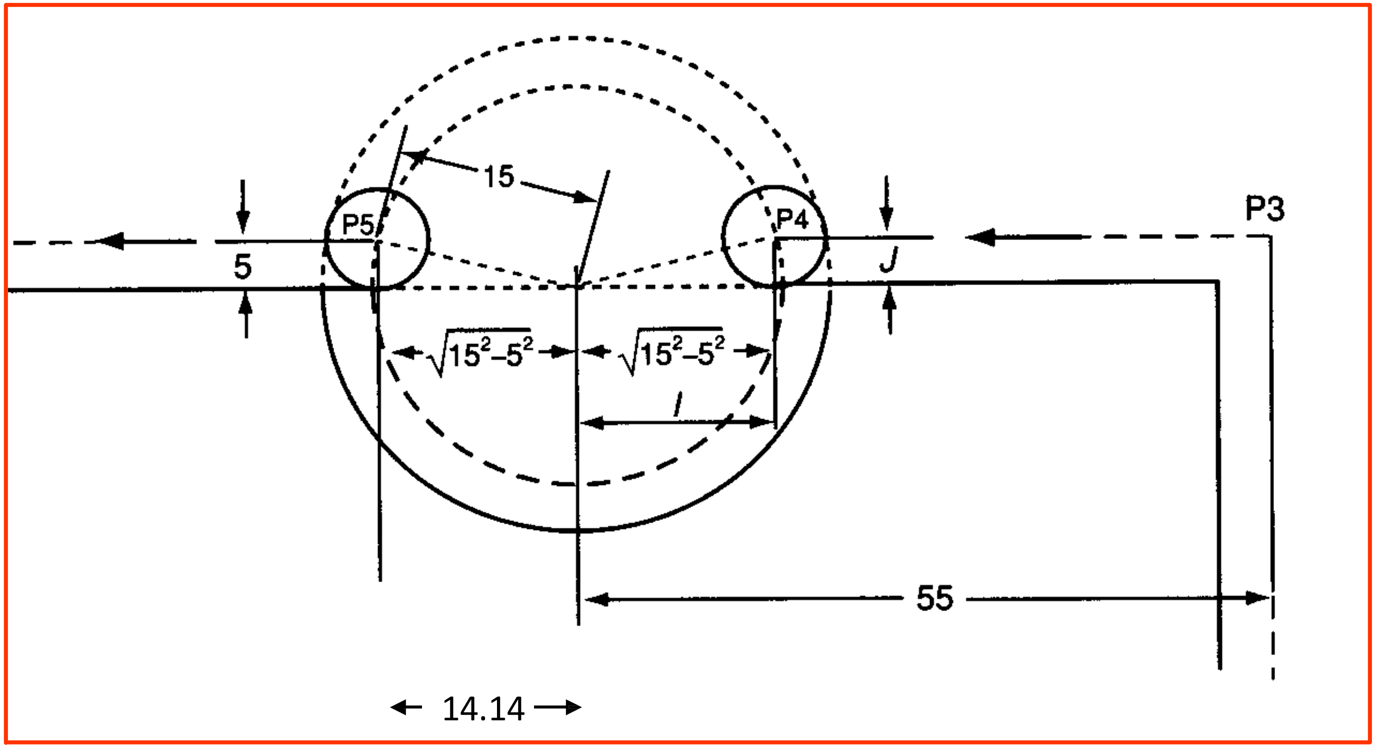


Tool position	Location	
	ΔX	ΔY
A	.5	.5
B	1	.5
C	1.75	.75

Exampleofa partprogram

XandYspecifythe endpoint ofthe arc(P5)withrespecttothe startpoint (P4).

IandJ specifythecenterof thearc withrespecttothestart point.



```
N008G02X-28.28Y0.0I-14.14J-5.0
```

Computer-AssistedPartProgramming

- Identifythepartgeometry,cuttermotions,speeds, feeds,andcutterparameter.
- CodetheaboveinformationusingATP.
- Compiletoproducethelistofcuttermovementsandmachinecontrolinformation(CutterLocationdatafile,CL).
- Usepost-processortogeneratemachinecontroldatafor aparticularmachine.ThisisthesameasNCblocks.

PartProgrammingfromCADDatabase “IntegratedCAD/CAMSystems”

- InanintegratedCAD/CAMsystem,the geometryand toolmotions are derivedautomaticallyfromtheCAD database bythe NCprogram(Pro/E,Unigraphics,….)
- Noneed formanualprogrammingorusingAPT language.

IntegratedCAD/CAMSystem

- CADandCam(ComputerAidedManufacturing)together createalinkbetweenproductdesignandmanufacturing.
- TheCADsystemisusedtodevelopageometricmodelof thepartwhichisthenusedbytheCAMsystemtogeneratepartprogramsforCNCmachinetools.
- BothCADandCAMfunctionsmaybeperformedeitherbythesamesystemorseparatesystemsindifferentroomsorevencountries.
- ExtendingtheconnectionbetweenCADandCAMtoits logicallimitswithinacompanyyieldstheconceptofthecomputer-integratedenterprise(CIE).In CIE allaspectsof theenterpriseiscomputeraided,frommanagementand salestoproductdesignandmanufacturing.

CAD/CAM

- CAD/CAMsystemsallowfor rapiddevelopmentand modifyingofdesignsanddocumentation.
- The3Dgeometricmodelproducedbecomesacommon elementforengineeringanalysis(FEA),machiningprocess planning(includingCNCpartprogramming,documentation(includingengineeringdrawings),qualitycontrol,andsoon.
- ThecouplingofCADandCAMconsiderablyshortensthetimeneededtobringanewproducttomarket.
- IncreasedproductivityisgenerallythejustificationforusingCAD/CAMsystem.

ManualNCprogramming

Partprogram:Acomputerprogramtospecify

- Whichtoolshouldbeloadedonthemachinespindle;

- Whatarethecuttingconditions(speed, feed,coolantON/OFFetc)

- Thestartpointandendpointofamotionsegment

- howtomove thetoolwithrespecttothemachine.

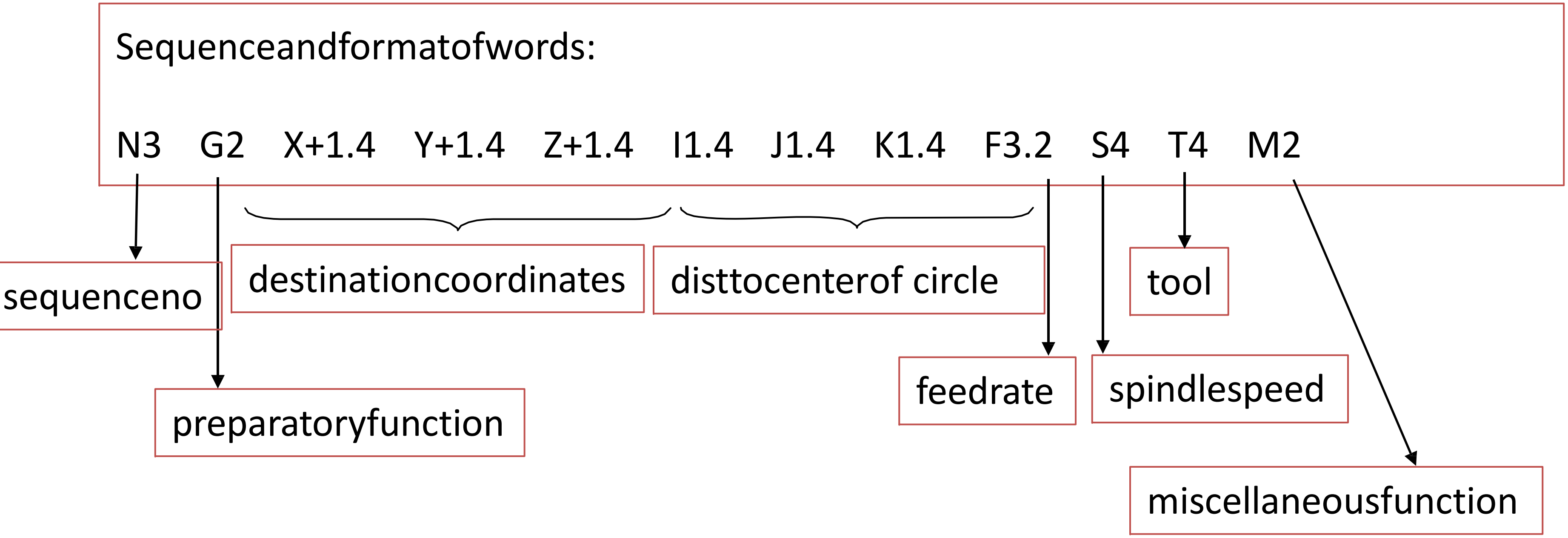
StandardPartprogramminglanguage:RS274-D(Gerber,GN-code)

Output:NCCode

- NumericalControl(NC)Language
  - Aseriesof commandswhich “direct”the cutter motionand supportsystemsofthe machine tool.

Output:NC Code

- G-Codes(G00,G1,G02,G81)
- Coordinatedata(X,Y,Z)
- FeedFunction(F)
- Miscellaneousfunctions(M13)
- N-Programsequencenumber
- T-Toolcall
- S-Spindle command



Sequenceandformatofwords:

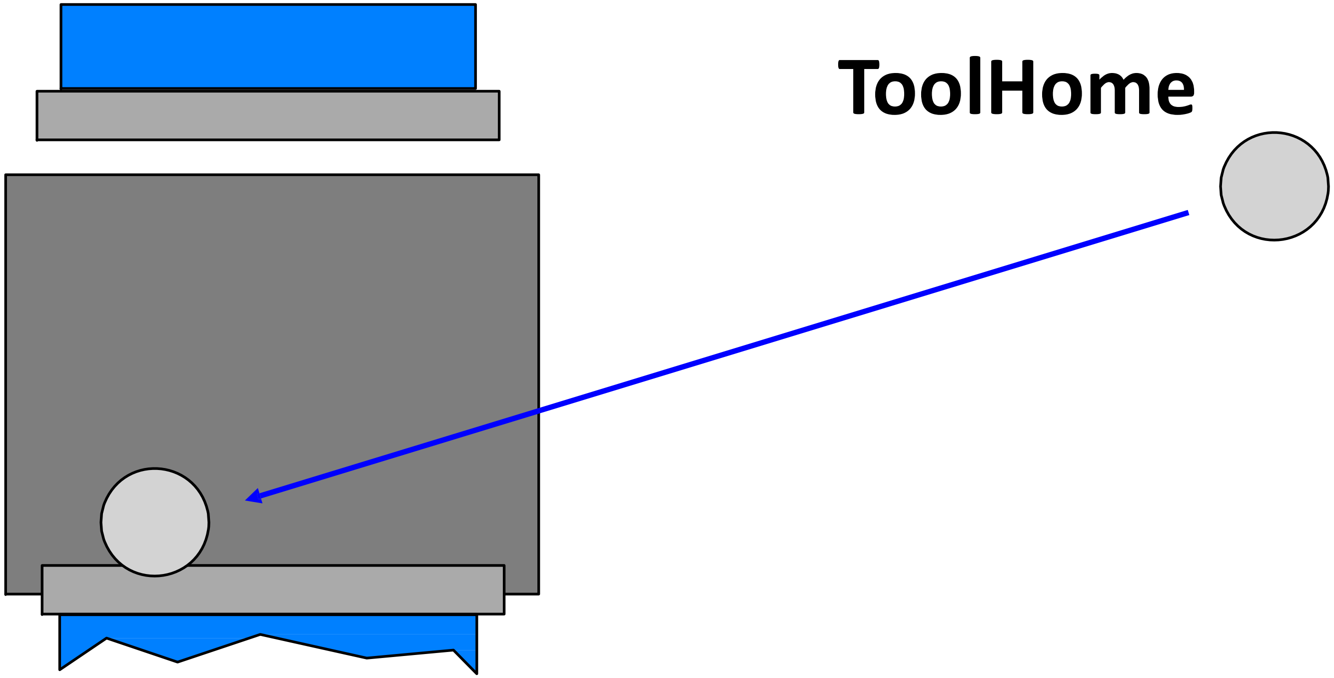
N3 G2 X+1.4 Y+1.4 Z+1.4 I1.4 J1.4 K1.4 F3.2 S4 T4 M2

Output:NCCode

- NCProgramExample
    - N01G90G80
    - N03GOOT12M06
    - N05 GOOX0 Y0 Z.1F10S2500 M13
    - N07G1Z-.5
    - N09 G02 X-10. I0J0F20
    - N13X0Y10
    - N17 X10Y0
    - N19X0Y-10
    - N21 X-10Y0
    - N23M2

Example ofCNC Programming

- *WhatMustBeDoneToDrillAHoleOnACNC VerticalMillingMachine*

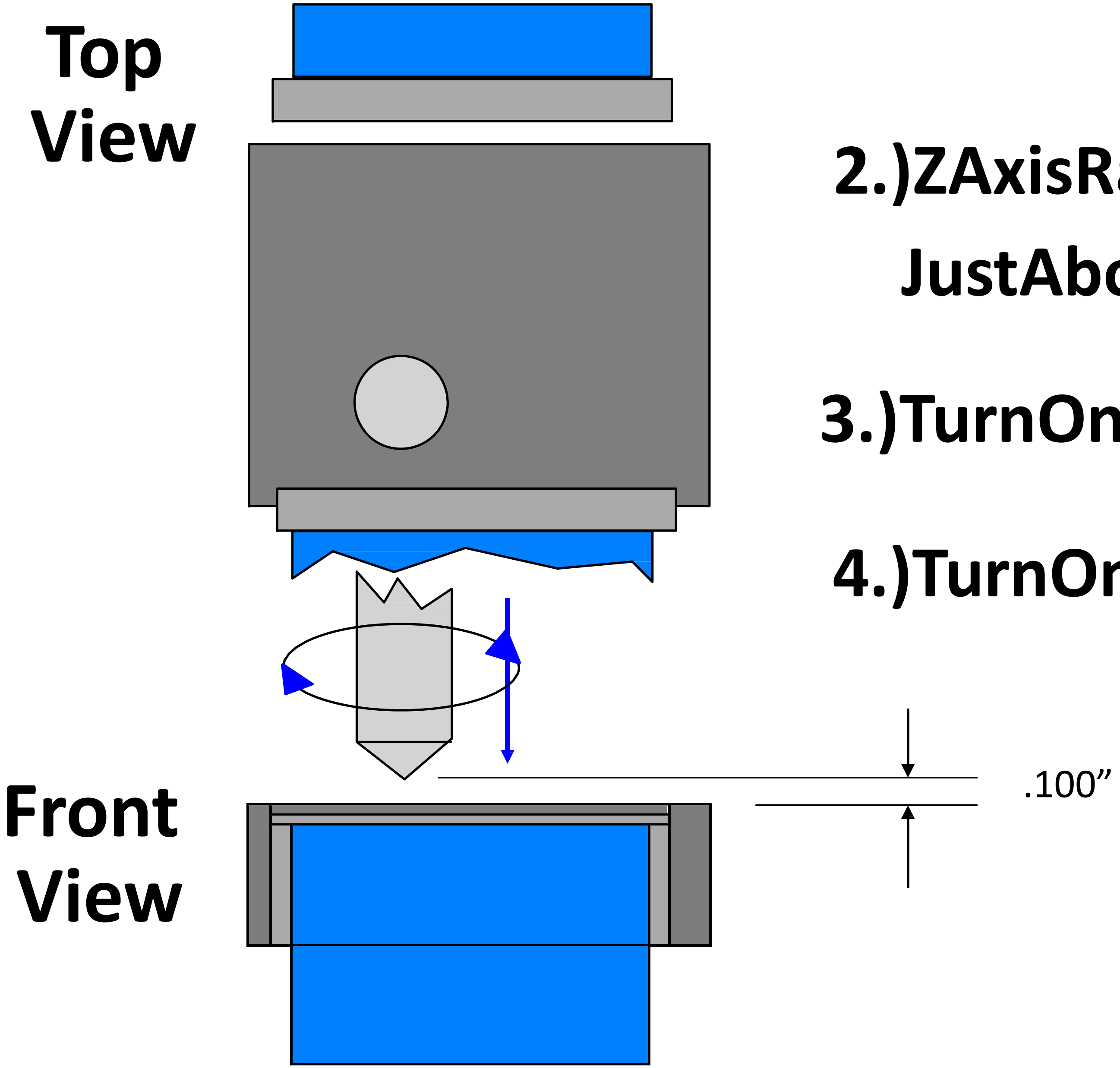


ToolHome

Top View

1.)X&YRapidToHolePosition

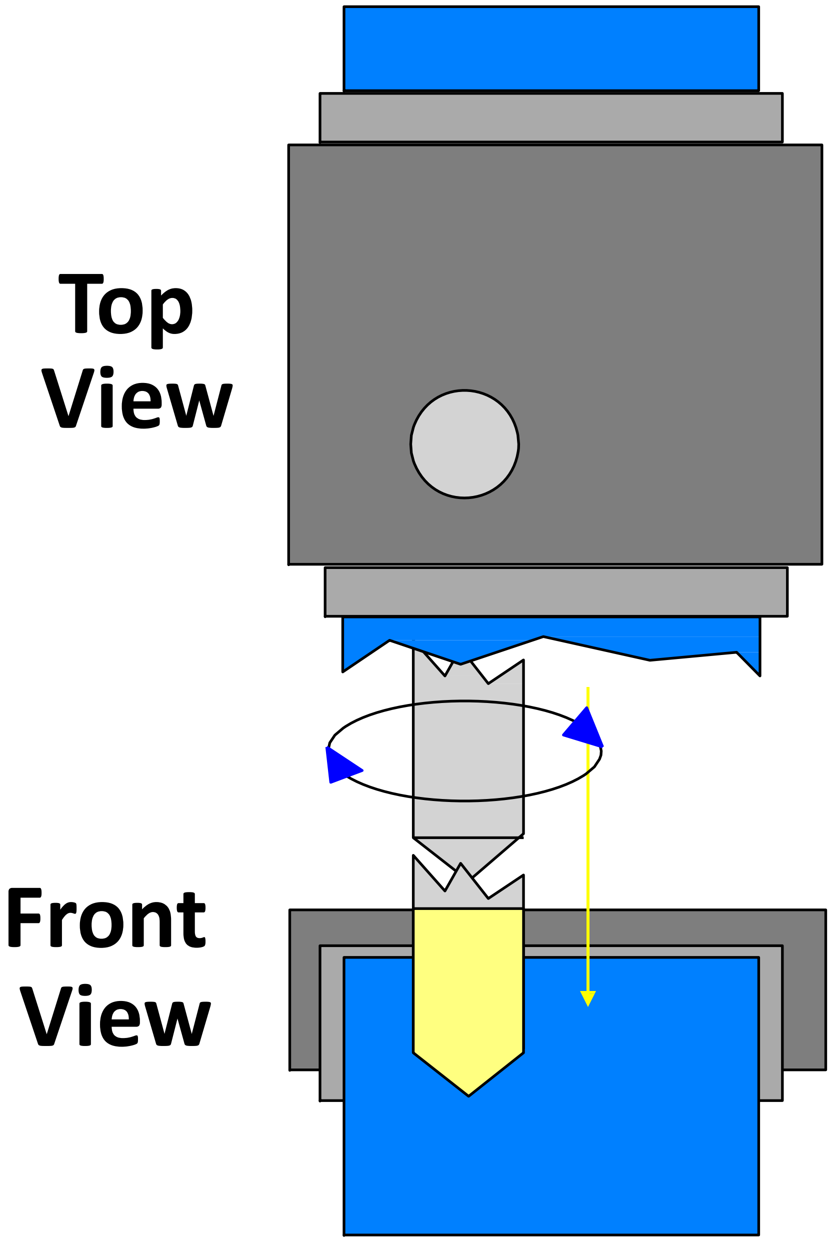
Front View



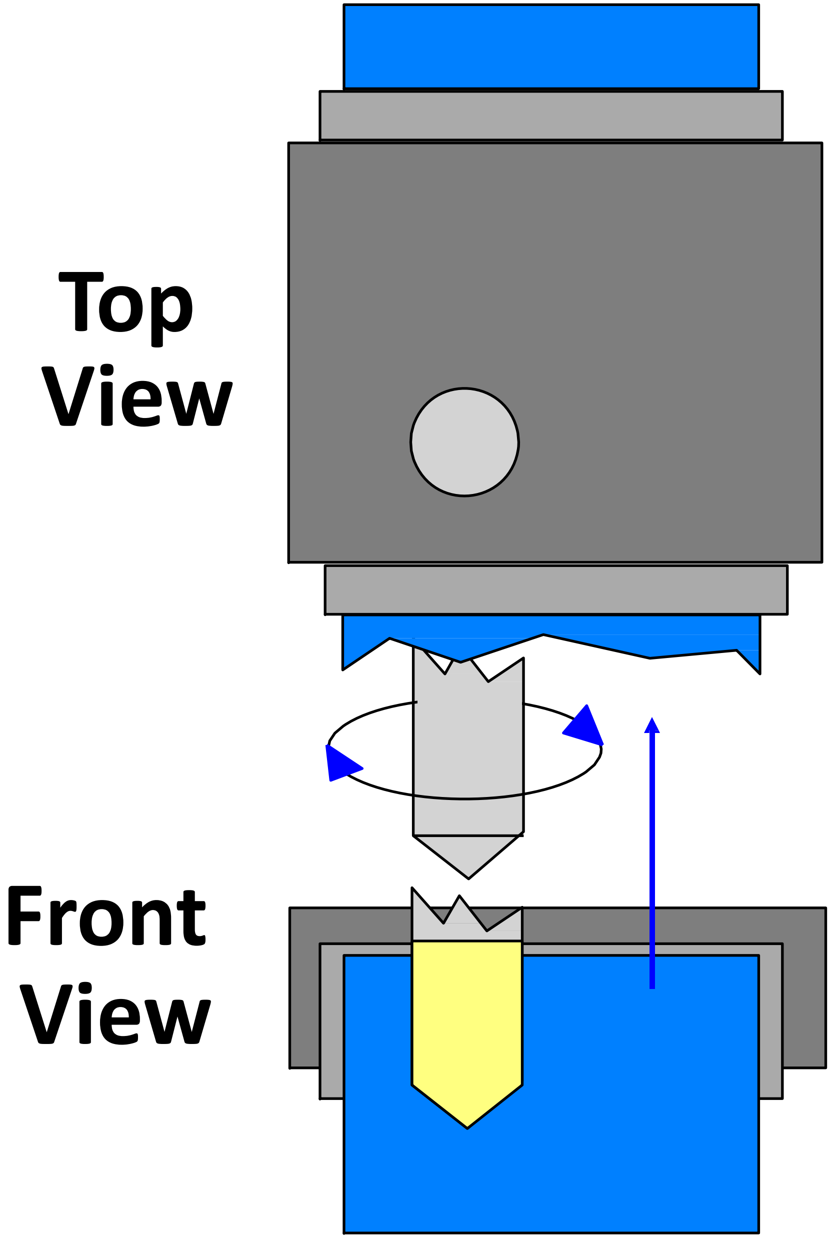
2.)ZAxisRapidMove JustAboveHole

3.)TurnOnCoolant

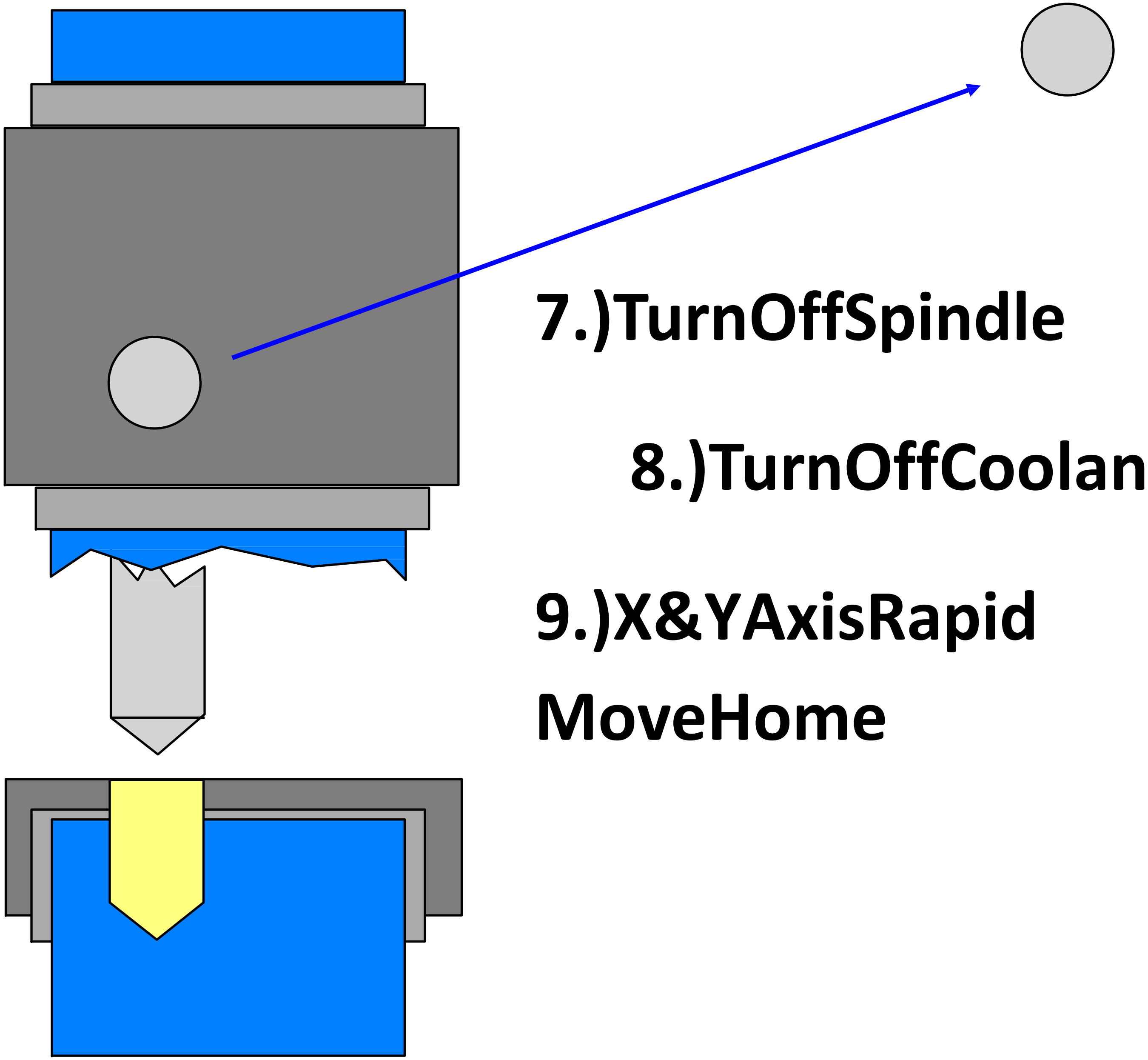
4.)TurnOnSpindle



5.)ZAxis FeedMoveto
DrillHole



6.)RapidZAxisMove
OutOfHole



Top View

Front View

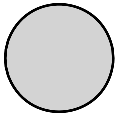
7.)TurnOffSpindle

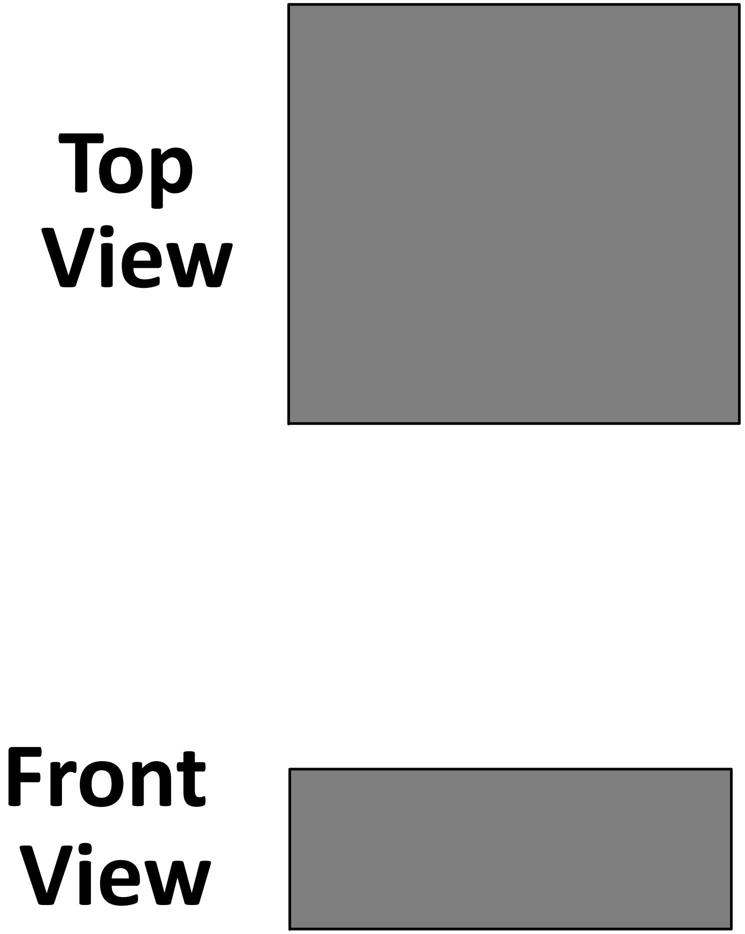
8.)TurnOffCoolant

9.)X&YAxisRapid MoveHome

Here’sTheCNCProgram!

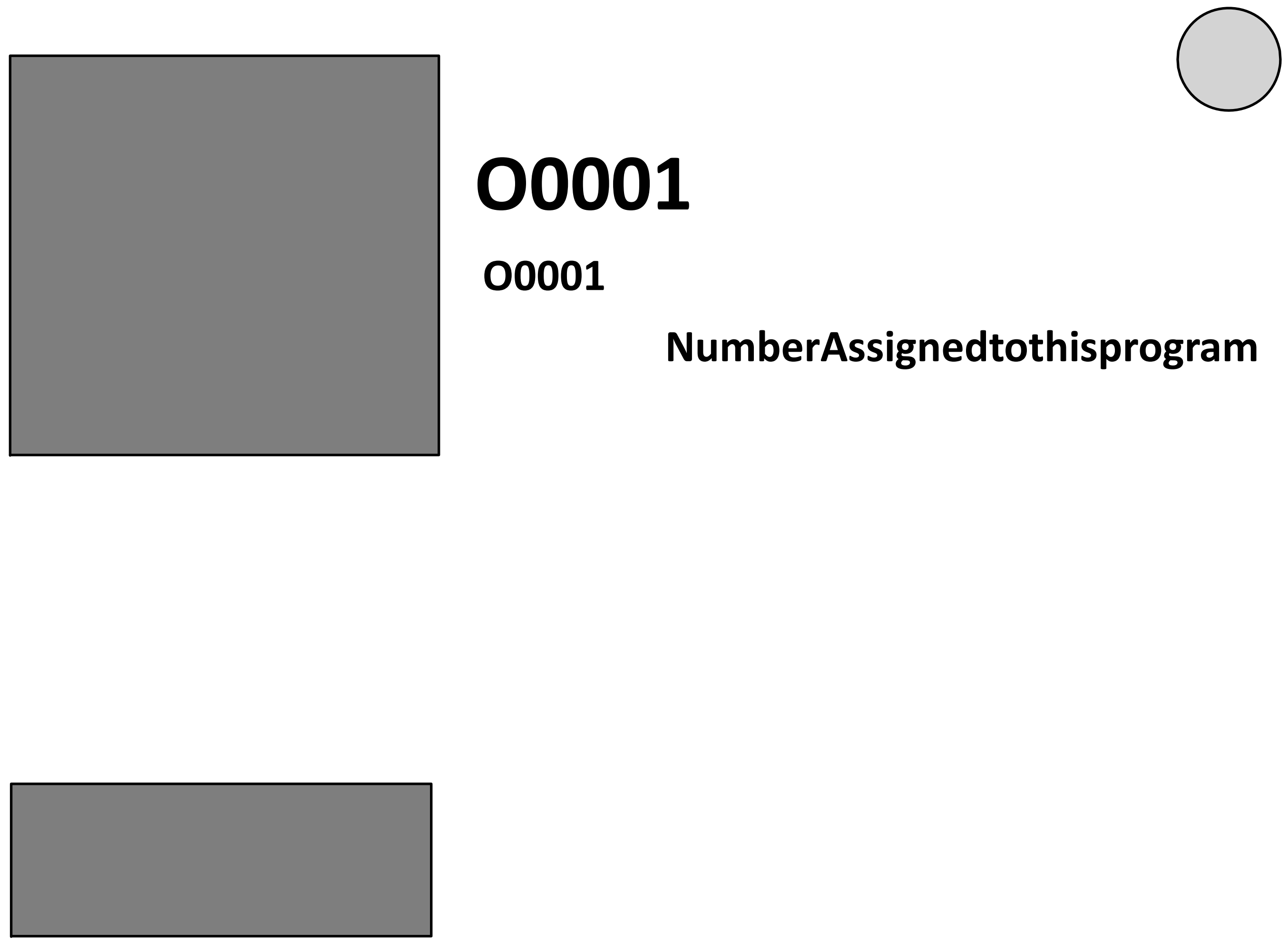
ToolAtHome





```
O0001
  N005G54G90S600M03
  N010G00X1.0Y1.0
  N015G43H01Z.1M08
 N020G01Z-.75F3.5
 N025G00Z.1M09
 N030G91G28X0Y0Z0
 N035M30
```

ToolAtHome



Top View

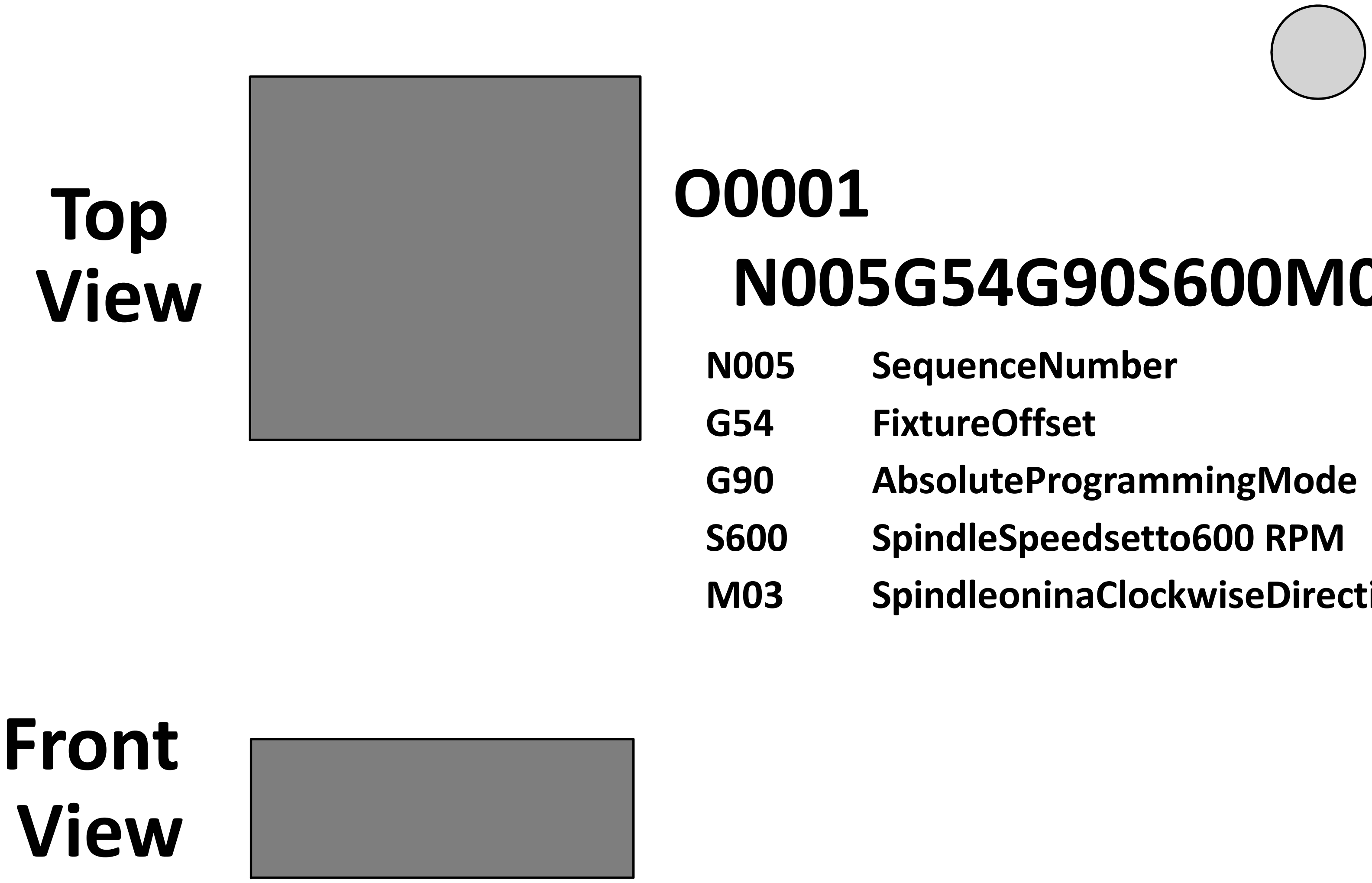
O0001

O0001

NumberAssignedtothisprogram

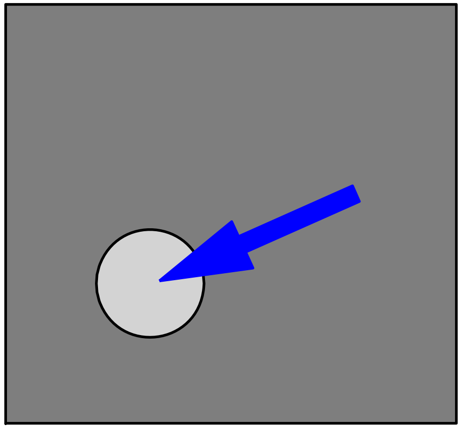
Front View

ToolAtHome



```
O0001
N005G54G90S600M03
```

N005	SequenceNumber
G54	FixtureOffset
G90	AbsoluteProgrammingMode
S600	SpindleSpeedsetto600 RPM
M03	SpindleoninaClockwiseDirection

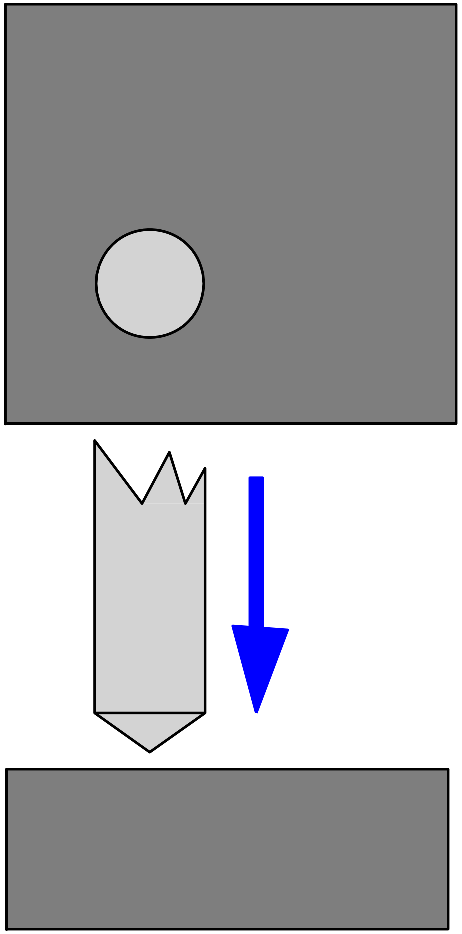


Top View

```
O0001
  N005G54G90S600M03
 N010G00X1.0Y1.0
```

G00	RapidMotion
X1.0	XCoordinate 1.0 in.fromZero
Y1.0	YCoordinate1.0in.fromZero

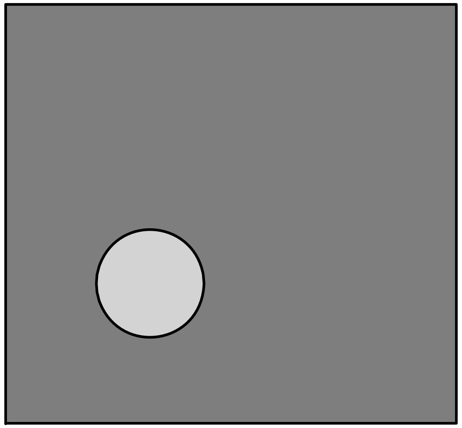
Front View



```
O0001
  N005G54G90S600M03
 N010G00X1.0Y1.0
 N015G43H01Z.1M08
```

G43	ToolLengthCompensation
H01	SpecifiesToollengthcompensation
Z.1	ZCoordinate .1in.fromZero
M08	FloodCoolantOn

Top View



```
O0001
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  N010G00X1.0Y1.0
  N015G43H01Z.1M08
 N020G01Z-.75F3.5
```
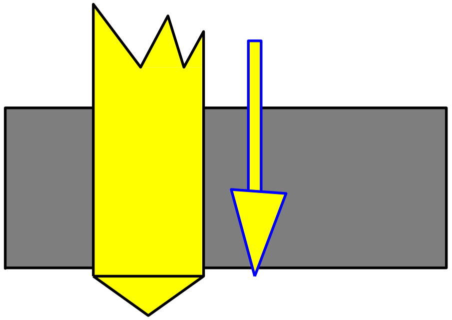
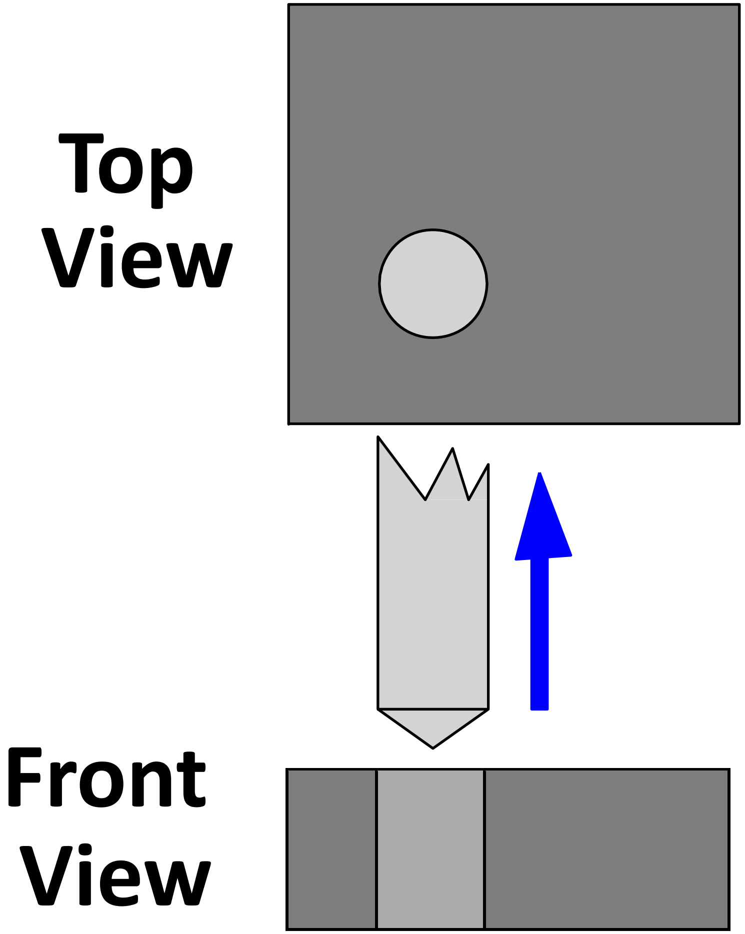

Front View

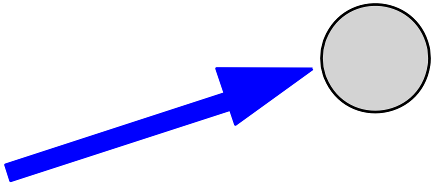


G01	Straight LineCutting Motion
Z-.75	ZCoordinate-.75in.fromZero
F3.5	FeedRate set to3.5 in./min.

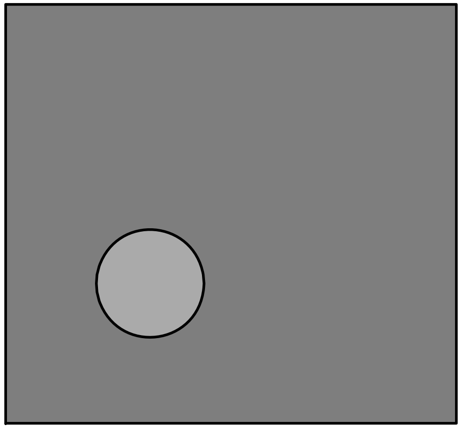


```
O0001
  N005G54G90S600M03
  N010G00X1.0Y1.0
  N015G43H01Z.1M08
 N020G01Z-.75F3.5
 N025G00Z.1M09
```

G00	RapidMotion
Z.1	ZCoordinate.1in.fromZero
M09	CoolantOff



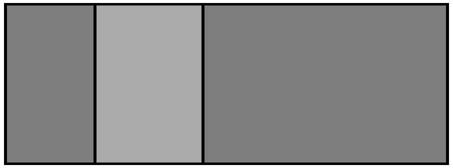
Top View



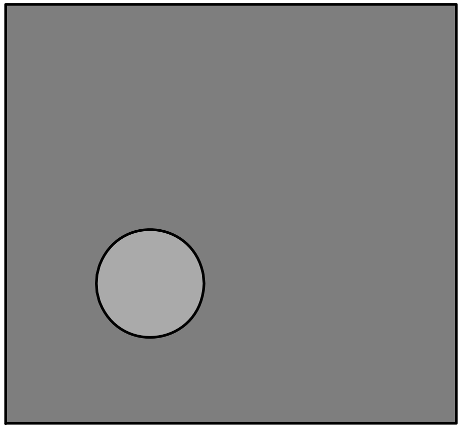
```
O0001
  N005G54G90S600M03
  N010G00X1.0Y1.0
  N015G43H01Z.1M08
N020G01Z-.75F3.5
N025G00Z.1M09N030
G91G28X0Y0Z0
```

G91	IncrementalProgrammingMode
G28	ZeroReturnCommand
X0,Y0,Z0	X,Y,&ZCoordinatesatZero

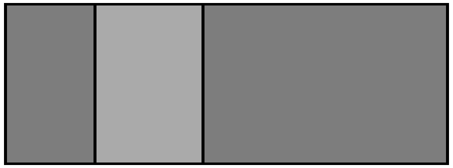
Front View

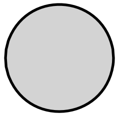


Top View



Front View

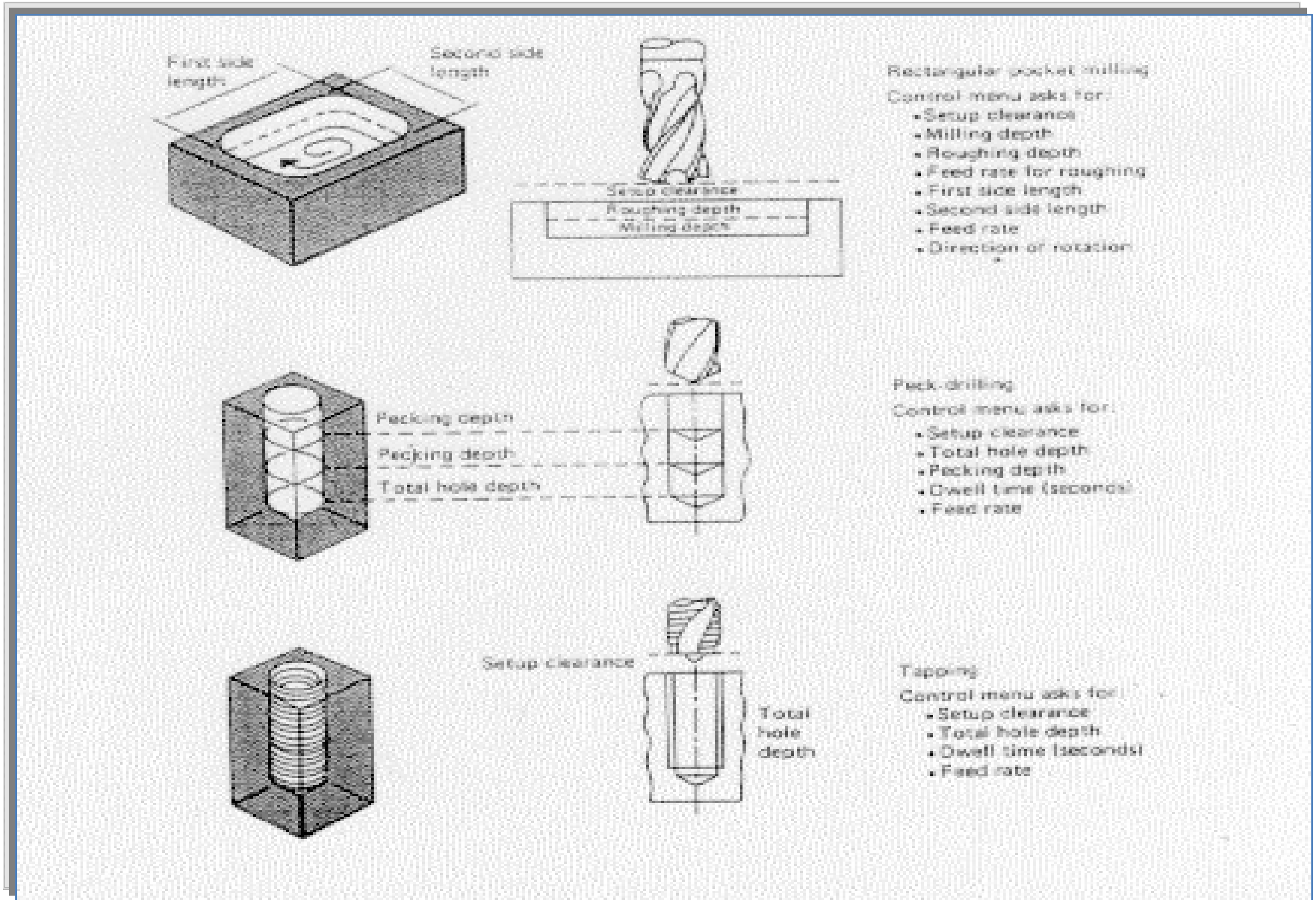




```
O0001
   N005G54G90S600M03
  N010G00X1.0Y1.0
  N015G43H01Z.1M08
N020G01Z-.75F3.5
N025G00Z.1M09
N030G91G28X0Y0Z0
N035M30
```

M30 EndofProgram

Output:NCCode-CannedCycles



Rectangular pocket milling

Control menu asks for:

- Setup clearance
- Milling depth
- Roughing depth
- Feed rate for roughing
- First side length
- Second side length
- Feed rate
- Direction of rotation

Peck-drilling

Control menu asks for:

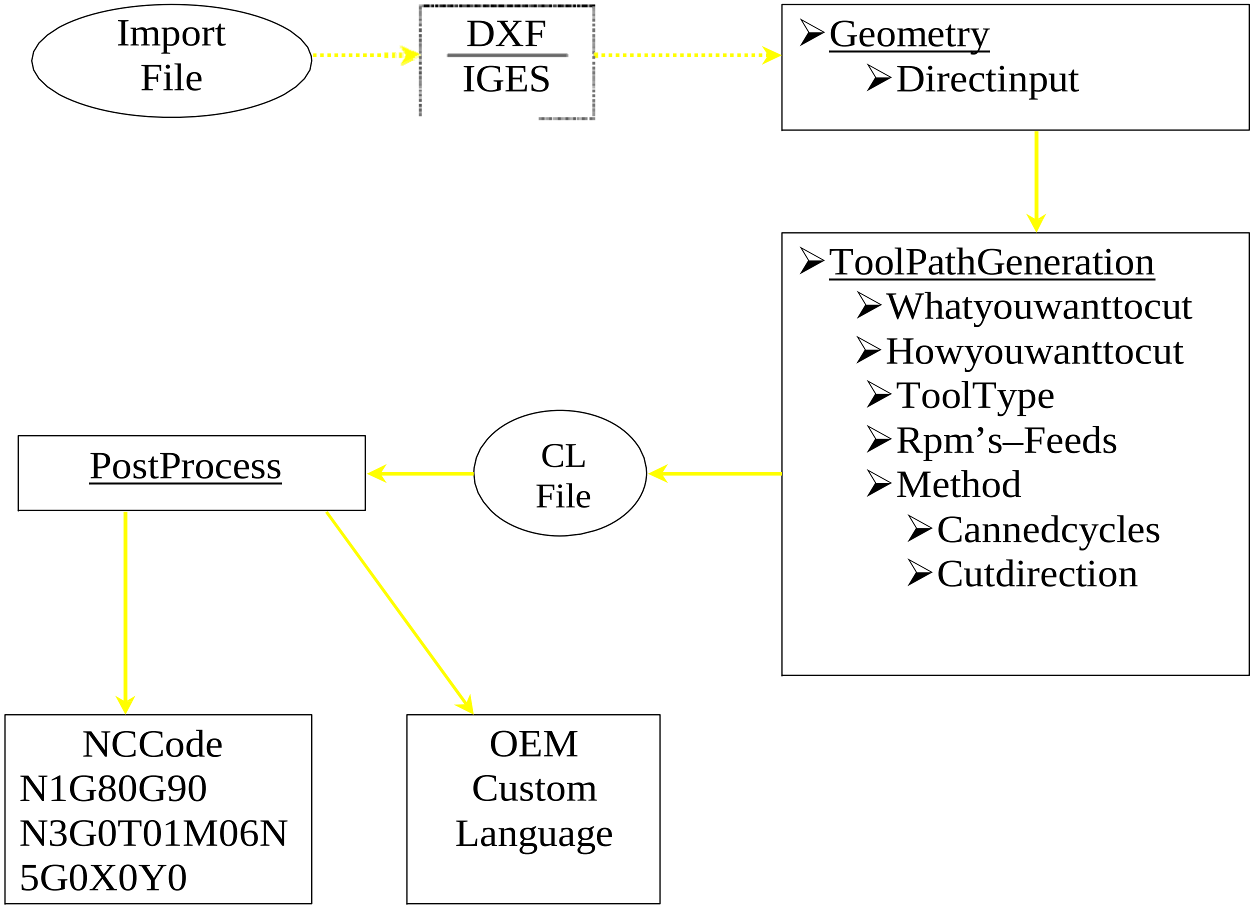
- Setup clearance
- Total hole depth
- Pecking depth
- Dwell time (seconds)
- Feed rate

Tapping

Control menu asks for:

- Setup clearance
- Total hole depth
- Dwell time (seconds)
- Feed rate

CADtoNCCode



Import File

DXF
IGES

- Geometry
  - Directinput

- ToolPathGeneration
  - Whatyouwanttocut
  - Howyouwanttocut
  - ToolType
  - Rpm’s–Feeds
  - Method
    - Cannedcycles
    - Cutdirection

CL File

PostProcess

NCCode
N1G80G90
N3G0T01M06N
5G0X0Y0

OEM
Custom
Language

AdvantagesofCNCMachineTools

- Easeofpartduplication
- Flexibility
- Repeatability
- Qualitycontrolthroughprocesscontrol
- Accommodatessimpletocomplexparts geometry
- Improvedpartaesthetics
- Increasedproductivity
- Technologycostsaredecreasing

AdvantagesofCNCMachineTools

- Reducedset-uptime
- Reducedleadtimes
- Reducedinventory
- Bettermachineutilization
- Jobadvancementopportunities
- CNCmachinetoolsaremorerigidthan conventionalmachinetools
  - Climbmillingrequiresabout10-15%lesshorsepowervs.conventionalcutting,butrequiresaridged machinetoolwithnobacklash
  - Increasedrpm’sandfeeds

ProgrammingMethods

- AutomaticallyProgrammedTools(APT)
  - Atextbasedsysteminwhichaprogrammerdefinesaseriesoflines,arcs,andpoints whichdefinetheoverallpartgeometrylocations. Thesefeaturesarethenusedtogenerateacutterlocation(CL)file.
  - Developedasajointeffortbetweentheaerospace industry,MIT,andtheUSAirforce
  - Stillusedtodayandaccountsforabout5-10%ofall programminginthedefenseandaerospaceindustries

ProgrammingMethods-APT

- Requiresexcellent3Dvisualizationskills

- Capableofgeneratingmachinecodeforcomplicated partprograms
  - 5axismachinetools
- Partdefinition
  - –P1=Point/12,20,0
  - C1=Circle/Center,P1,Radius,3
  - LN1=Line/C1.ATANGL,90
- CutterCommands
  - TLRT,GORT/LN1.TANTO,C1
  - GOFWD/C1,TANTO,L5

ProgrammingMethods-CAM

- ComputerAidedMachining(CAM)Systems
  - Graphicrepresentationofthepart
  - PCbased
  - IntegratedCAD/CAMfunctionality
  - “Some”built-inexpertise
  - Speed&feeddata basedonmaterialandtoolspecifications

  - Tool&materiallibraries
  - Toolpathsimulation
  - Toolpathediting
  - Toolpathoptimization
  - Cuttimecalculationsforcostestimating

ProgrammingMethods-CAM

  - Import/exportcapabilitiesto othersystems
    - Examples:
      - DrawingExchangeFormat (DXF)
      - Initial GraphicsExchangeStandard(IGES)
- Startwithgraphicrepresentationofpart
  - Directinput
  - Importfromexternalsystem
    - ExampleDXF/IGES
  - 2Dor3Dscan
    - ModelorBlueprint

(Atthispointyouhaveagraphicsfileofyourgeometry)

TheProcessCAD toNCFile

- Definecutterpathby selectinggeometry
  - Contours
  - Pockets
  - Holepatterns
  - Surfaces
  - Volumetoberemoved

(Atthispointthesystemknowswhatyouwanttocut)

- Definecutparameters
  - **Toolinformation**
    - Type,Rpm,Feed
  - Cutmethod
    - Example-Pocket millzig-zag,spiral,inside-out
    - Roughandfinish parameters

(Atthispointthesystemknowshowyouwanttocutthepart)

TheProcessCAD toNCFile

- Executecuttersimulation
  - Visualrepresentationofcuttermotion
- Modify/deletecuttersequences

(Atthispointthesystemhasa“generic”cutterlocation(CL)file ofthecutpaths)

- PostProcessing
  - **CLfiletomachinespecificNCcode**
- FiltersCLinformationandformatsitintoNCcode basedonmachinespecificparameters
  - **Workenvelope**
  - **Limits-feedrates,toolchanger,rpm’s,etc.**
  - **G&Mfunctioncapabilities**

GROUPTECHNOLOGY

- ConceptofGroupTechnology
- Partsclassificationand coding
- Productflowanalysis
- Manufacturingcelldesign
- Transferlines

Why Group Technology?

- Average lot size decreasing:

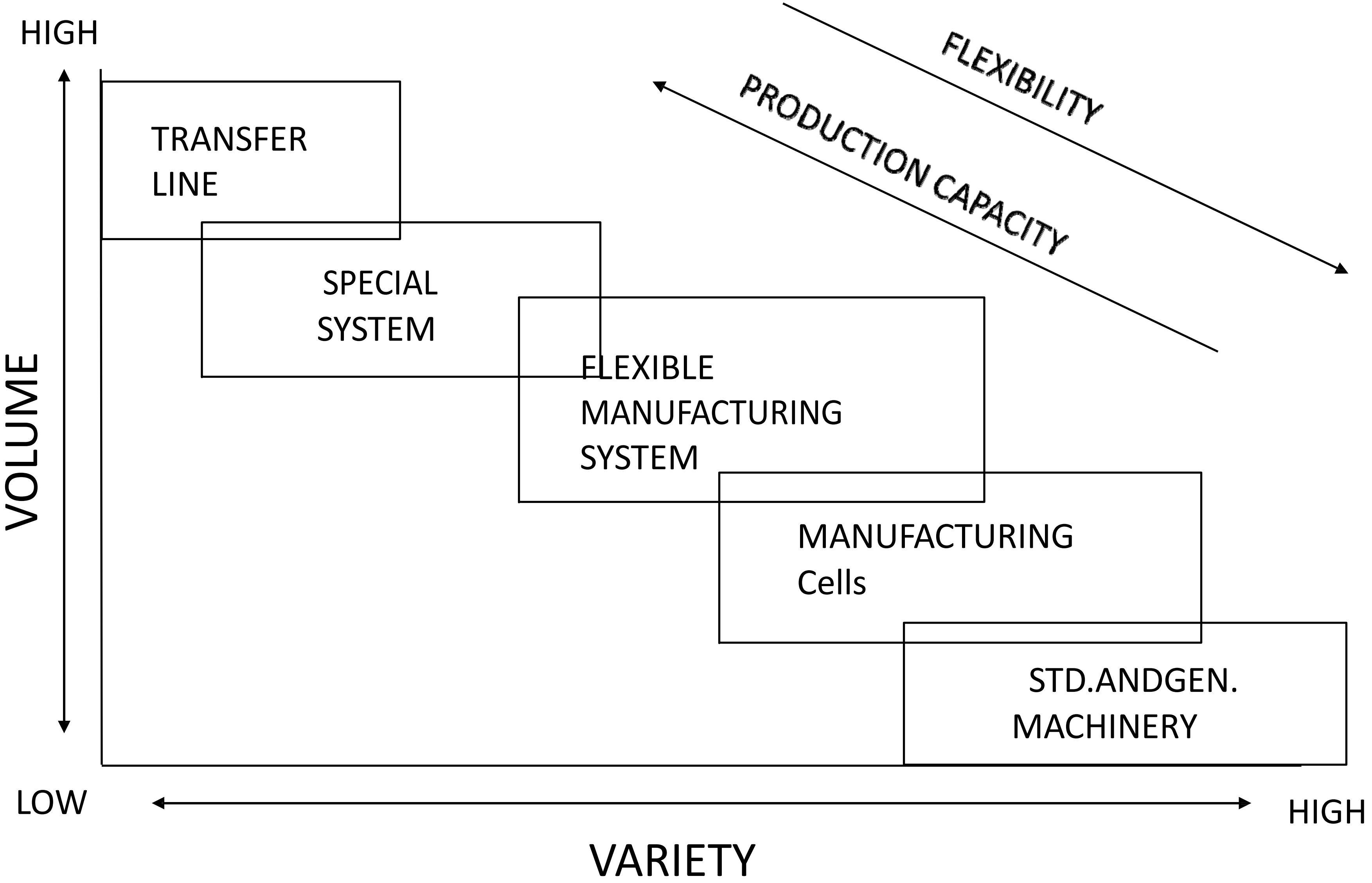
  Parts in medium production quantity range are usually made in batches

  Disadvantages of batch production:

  - Downtime for changeovers
  - High inventory carrying costs

  GT minimizes these disadvantages by recognizing that although the parts are different, there are families of parts that possess similarities

- Partvarietyincreasing
- Increasedvarietyofmaterialswithdiverseproperties
- Requirementsforclosertolerances
- GTexploitsthepartsimilaritiesbyutilizingsimilar processesandtoolingtoproducethem
- GTcanbeimplementedbymanualorautomatedtechniques
  - Whenmanual,thesystemiscalled*cellular manufacturing*
  - Whenautomated,thesystemis called a*flexible manufacturingsystem*



HIGH

VOLUME

LOW

TRANSFER LINE

SPECIAL SYSTEM

FLEXIBLE MANUFACTURING SYSTEM

MANUFACTURING Cells

STD.ANDGEN. MACHINERY

FLEXIBILITY

PRODUCTION CAPACITY

HIGH

VARIETY

GroupTechnology

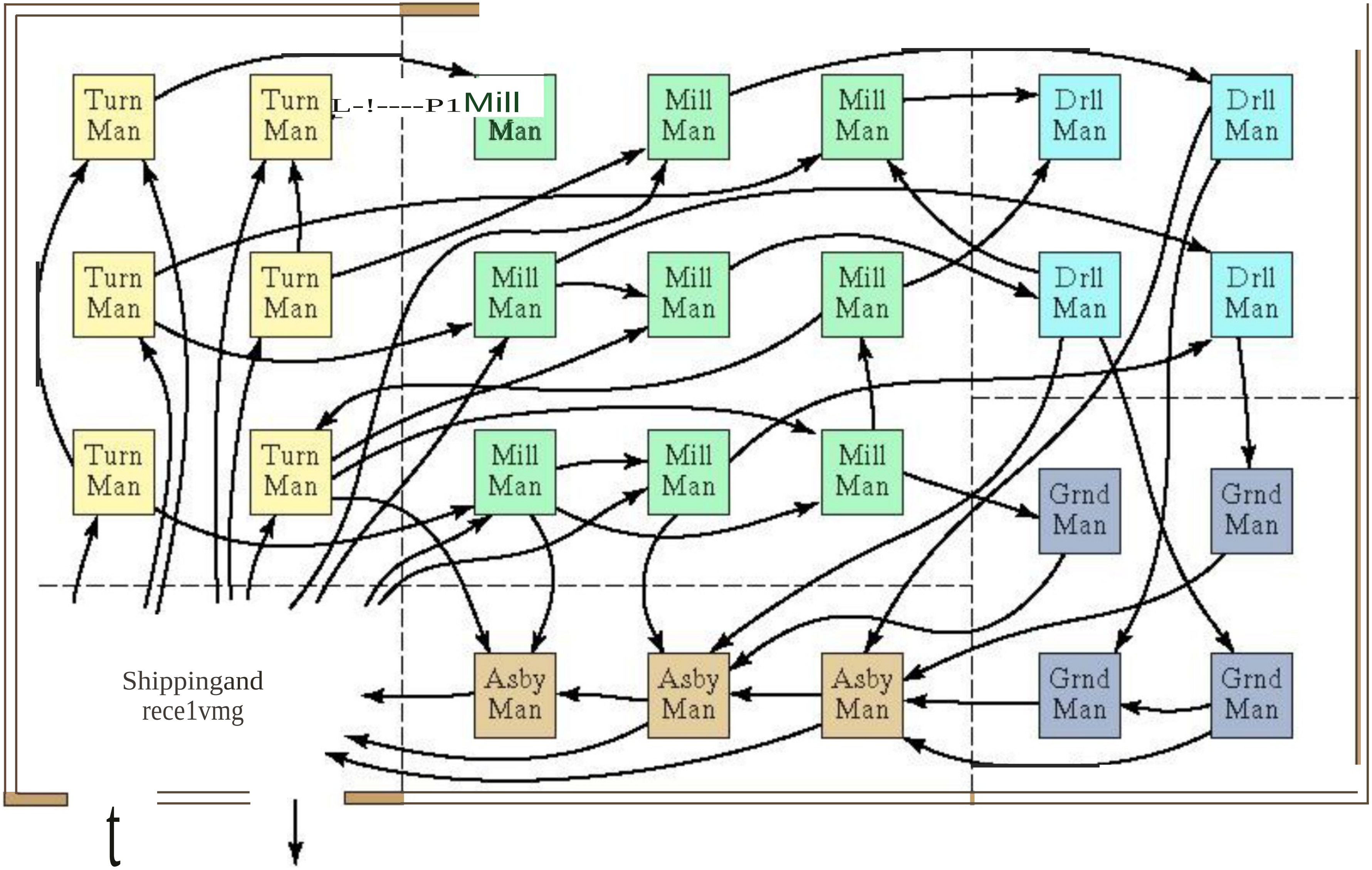
GroupTechnologyisamanufacturingconcept accordingtowhich,variousparts being manufacturedbyacompanyareplacedinsmall batchesorgroupsbasedonsimilaritiesintheir designandmanufacturingprocess.Thesegroupsare calledpartfamilies.

ThusGroupTechnologyistherealizationthatmany problemsare similar,andthatbygrouping similarproblems,asinglesolutioncanbefoundtoasetof problemsthussavingtimeandeffort

WhentoUseGT?

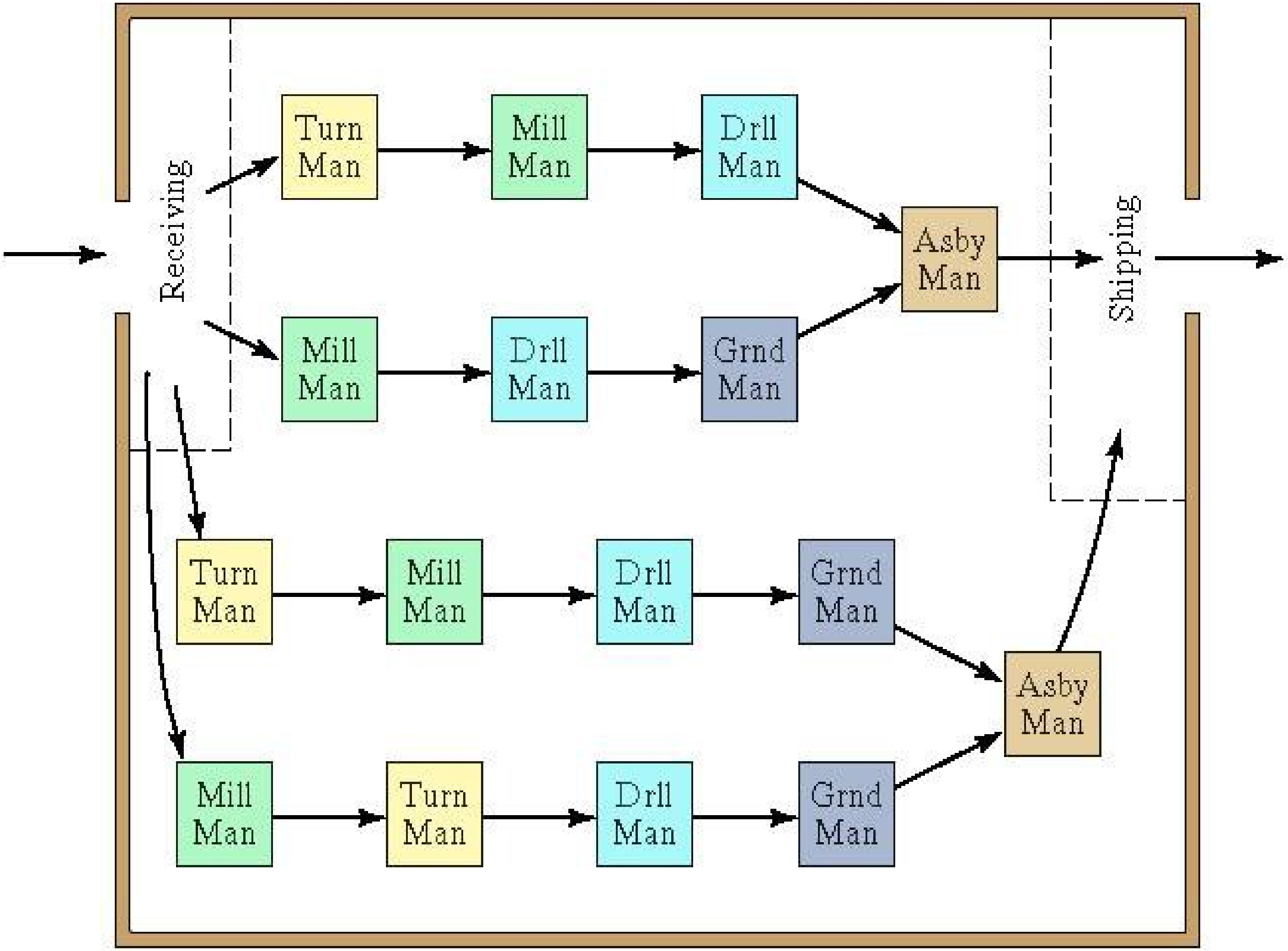
1. Theplantcurrentlyusestraditionalbatch productionandaprocesstypelayout
    - Thisresultsinmuchmaterialhandlingeffort,highin-processinventory,andlongmanufacturingleadtimes
2. Thepartscanbegroupedintopartfamilies
    - Anecessaryconditiontoapplygrouptechnology
    - Eachmachinecellisdesignedtoproduceagivenpartfamily,oralimitedcollectionofpartfamilies,soitmustbepossibletogrouppartsmadeintheplantintofamilies

Traditional ProcessLayout

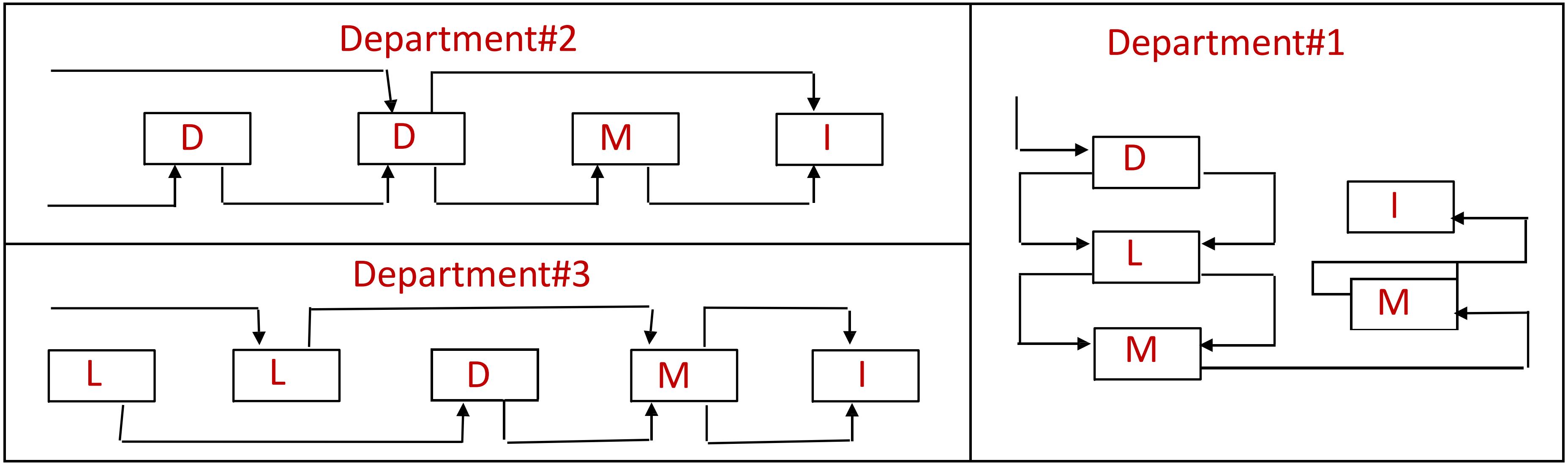


CellularLayoutBasedonGT

Eachcellspecializesinproducingoneoralimitednumberofpartfamilies



CellularLayout



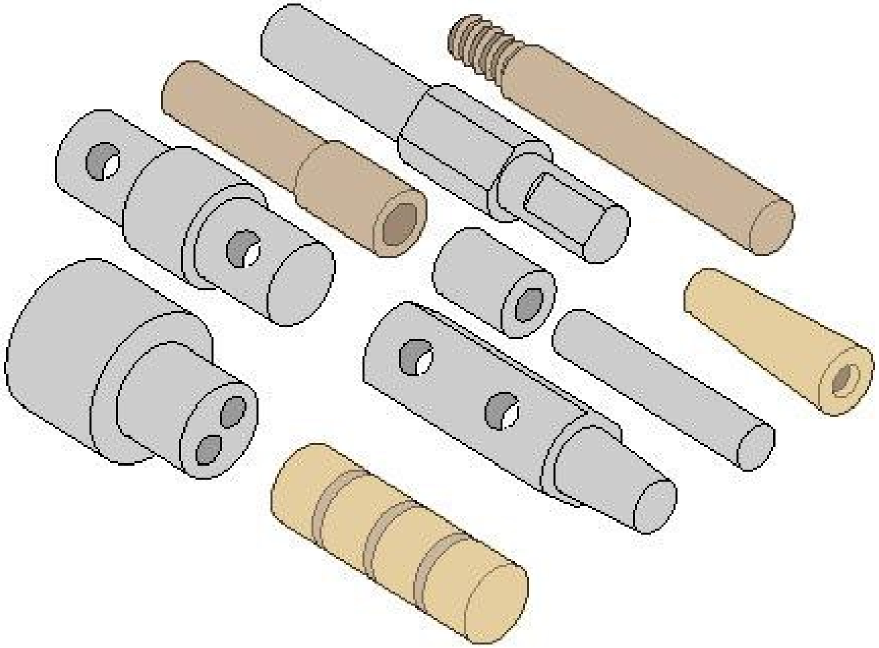
PartFamily

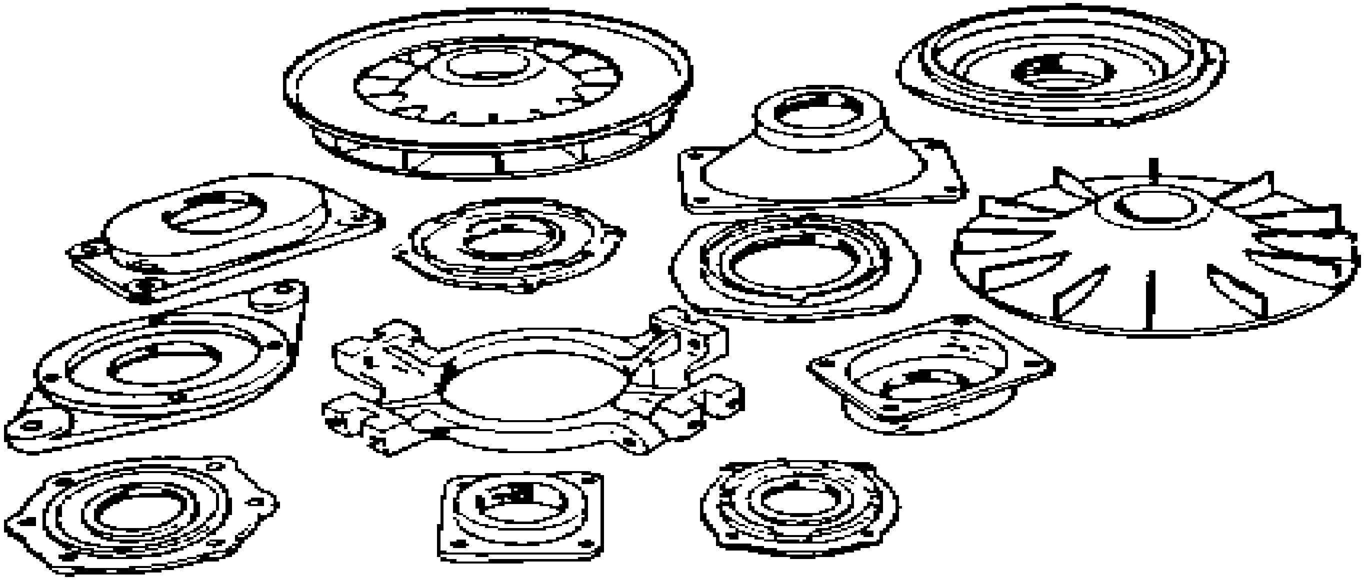
Acollectionofpartsthatpossesssimilaritiesingeometricshapeandsize,orintheprocessingstepsusedintheirmanufacture

- Partfamiliesareacentralfeatureofgrouptechnology
  - Therearealwaysdifferencesamong partsina family
  - Butthe similaritiesare closeenoughthatthe parts canbe groupedinto the samefamily

PartFamilies

- Tenpartsaredifferent insize,shape,and material,butquitesimilarintermsof manufacturing
- Allpartsaremachined fromcylindricalstockby turning;someparts requiredrillingand/or milling





ThirteenpartswithsimilarmanufacturingProcessrequirementsbutdifferentDesignattributes

Methodsof groupingpartsinto partfamilies

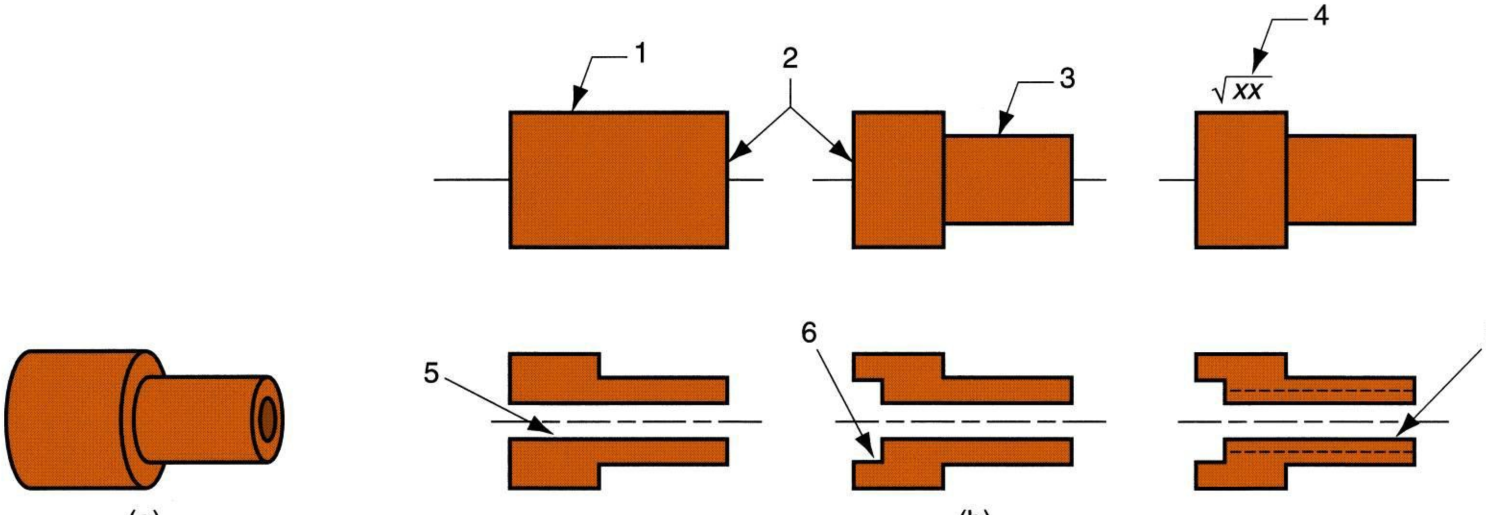
1. Visualinspection
    - Usingbestjudgmenttogrouppartsintoappropriate families,basedonthepartsorphotosoftheparts
2. CompositePartmethod
3. Partsclassificationand coding
    - Identifyingsimilaritiesanddifferencesamongparts andrelatingthembymeansofacodingscheme
4. Productionflowanalysis
    - Usinginformationcontainedonroutesheetstoclassifyparts

CompositePart Concept

Acompositepartforagivenfamilyisahypothetical partthatincludesallofthedesignand manufacturingattributesofthefamily

- Anindividualpartinthefamilywillhavesomeof thefeaturesof thefamily,butnotall
- Aproductioncellfor thepartfamily would consistofthosemachinesrequiredtomakethecompositepart
- Suchacellwouldbeabletoproduceanyfamily member,byomittingoperationscorresponding tofeaturesnotpossessedbythatpart

Figure-Composite partconcept:(a)thecompositepartforafamilyofmachined rotationalparts,and(b)theindividualfeaturesofthecompositepart.



(a)

(b)

	Designfeature	Correspondingoperation
1.	External cylinder	Turning
2.	Faceofcylinder	Facing
3.	Cylindrical step	Turning
4.	Smooth surface	Externalcylindricalgrinding
5.	Axial hole	Drilling
6.	Counterbore	Counterboring
7.	Internal threads	Tapping

PartsClassificationandCoding

PartsClassificationistheprocessofgrouping ofpartsonthebasisofessential featuresof theparts,while**coding**istheprocessof assigningthecodesoftheparts.

PartsClassificationSystems

Mostclassificationandcodingsystemsareoneof the following:

- Systemsbasedonpartdesignattributes
  -Usefulfordesign standardization
- Systemsbasedonpart manufacturingattributes
  - Usefulforcomputeraidedprocessplanning,to oldesignandotherproductionrelated functions.
- Systemsbased onbothdesignandmanufacturing attributes
  - combinesattributesandadvantagesofabove twotypesofsystems.

DesignandManufacturingAttributes

PartDesignAttributes

Basicexternalshape
Basicinternalshape
Material
Partfunction

PartMfg.Attributes

MajorprocessesMinoroperationsFixturesneededProductiontimeAnnualproduction

Length/diameterratio

Surfacefinish

Tolerances-----machinetool
Operationsequence

Majordimension
Tooling
Batchsize

PartsCodingsystems

Partscodingsystemconsistsofasequenceof symbolsthat identifypartsdesign and/or manufacturingattributes.

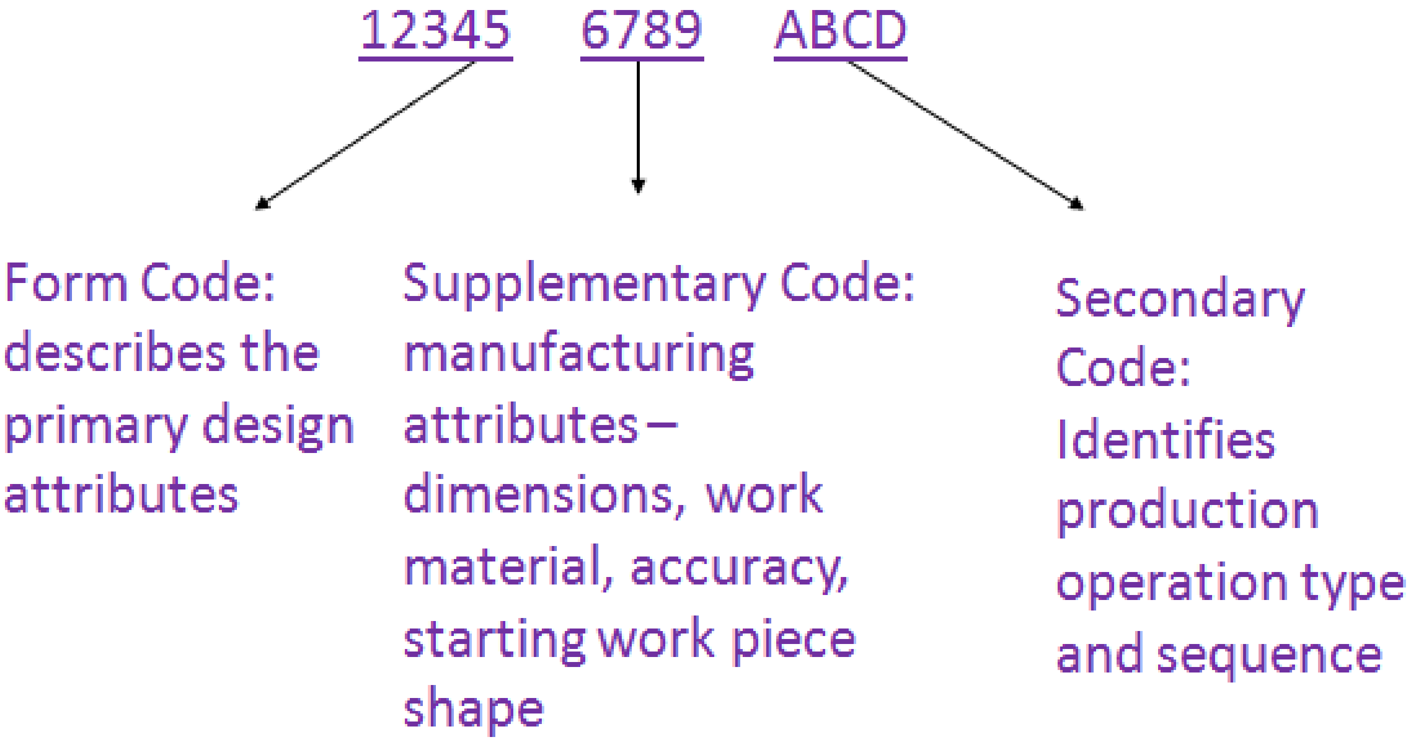
1. Hierarchicalstructure(monocode)
   - Interpretationofeachsuccessivedigitdependson thevalueoftheprecedingdigit
2. Chain-typestructure(polycode)
   - Interpretationofeachsymbolisalwaysthesame
   - Nodependenceonpreviousdigits
3. Mixed-codestructure
   - Combinationofhierarchicalandchain-type structures

CommercialPartsClassificationandCoding Systems

1. OPTIZSystem
2. CODESystem
3. BRISCHSystem
4. KK-3System
5. MICLASSSystem
6. DCLASSSystem
7. COFORMSystem
8. TOSHIBASystem

The OPTIZ Classification System

- Developed by Professor H. Optiz of Achene Technical University, Germany.



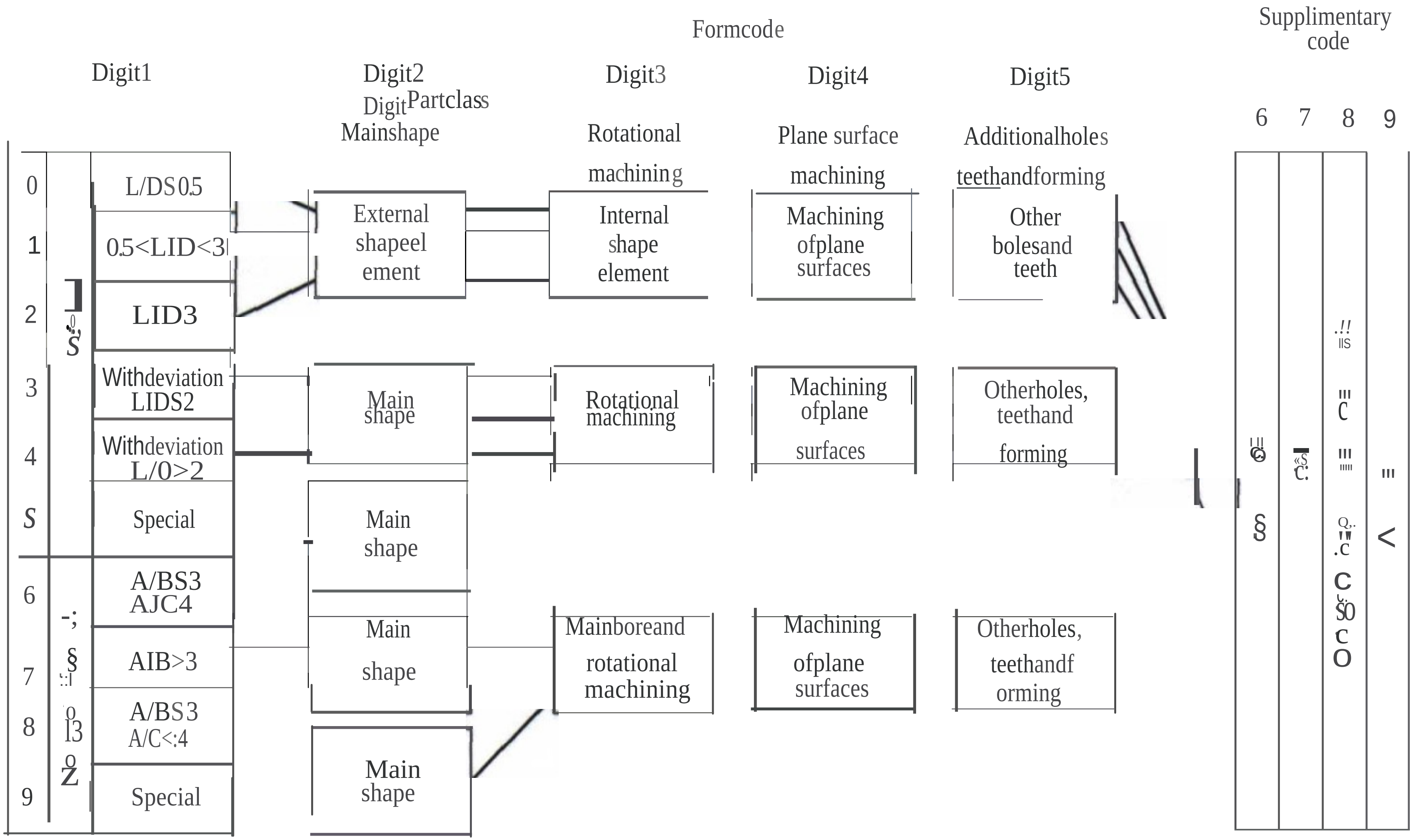
12345 6789 ABCD

Form Code: describes the primary design attributes

Supplementary Code: manufacturing attributes – dimensions, work material, accuracy, starting work piece shape

Secondary Code: Identifies production operation type and sequence

Opitz codingandclassificationsystem



Formcode

Supplimentary code

Digit1

0	L/DS0.5
1	0.5<LID<3
2	LID3
3	Withdeviation LIDS2
4	Withdeviation L/0>2
S	Special
6	A/BS3 AJC4
7	AIB>3
8	A/BS3 A/C<:4
9	Special

Digit2

DigitPartclass

Mainshape

External shapeel ement

Main shape

Main shape

Main shape

Main shape

Digit3

Rotational machining

Internal shape element

Rotational machining

Mainboreand rotational machining

Digit4

Plane surface machining

Machining ofplane surfaces

Machining ofplane surfaces

Machining ofplane surfaces

Digit5

Additionalholes teethandforming

Other bolesand teeth

Otherholes, teethand forming

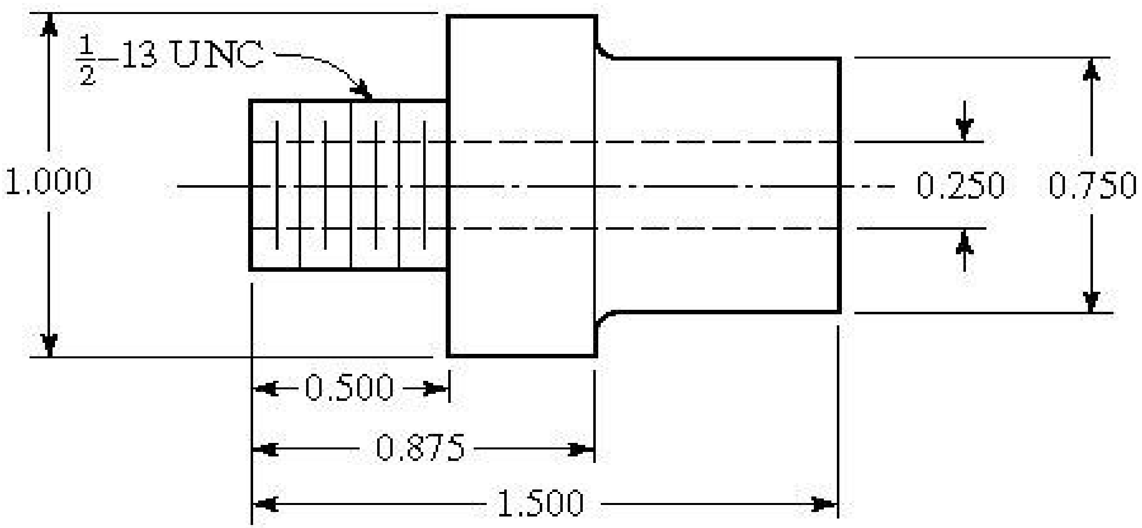
Otherholes, teethandf orming

6 7 8 9

OpitzFormCode(Digits1through5)

	Digit1	Digit2	Digit3	Digit4	Digit5
	Partclass	Externalshape,externalshapeelements	Internalshape, internalshapeelements	Planesurface machining	Auxiliaryholes andgearteeth
0	LID*0.5*	Smooth,noshape elements	Nobole, nobreakthrough	Nosurface machining	Noauxiliarybole
1	0.5<LID<3	Noshape elements	Nosbape elements	Surfaceplaneand/or curvedinonedirection,external	Axial,notonpitch circlediameter
2	LID2:3	Thread	Thread	Externalplanesurfacerelatedbygraduationaroundthecircle	Axialonpitch circlediameter
3		Functional groove	Functional groove	Externalgroove and/orslot	Radial,noton pitch circle diameter
4		Noshape elements	Noshape elements	Externalspline(polygon)	Axial and/orradial and/orother direction
5		Thread	Thread	Externalplanesurface and/orslot. externalspline	Axialand/orradial onPCDand/or otherdirections
6		Functional groove	Functional groove	Internalplanesurface and/orslot	Spurgearteeth
7		Functionalcone	Functionalcone	Internalspline (polygon)	Bevelgearteeth
8		Operatingthread	Operatingthread	Internalandexternalpolygon,groove and/orslot	Othergearteeth
9		Allothers	Allothers	Allothers	All others

Example:OpitzFormCode



FormcodeinOpitzsystemis15100

• **Length-to-diameterratio,L/D=1.5**	**Digit1= 1**
• **Externalshape:steppedon bothendswithscrewthread ononeend**	**Digit2=5**
• **Internalshape:partcontainsathrough-hole**	**Digit3=1**
• **Planesurfacemachining:none**	**Digit4=0**
• **Auxiliaryholes,gearteeth,etc.:none**	**Digit5=0**

Theparts'sform codeintheOpitzsystemis **15100**

ProductionFlowAnalysis(PFA)

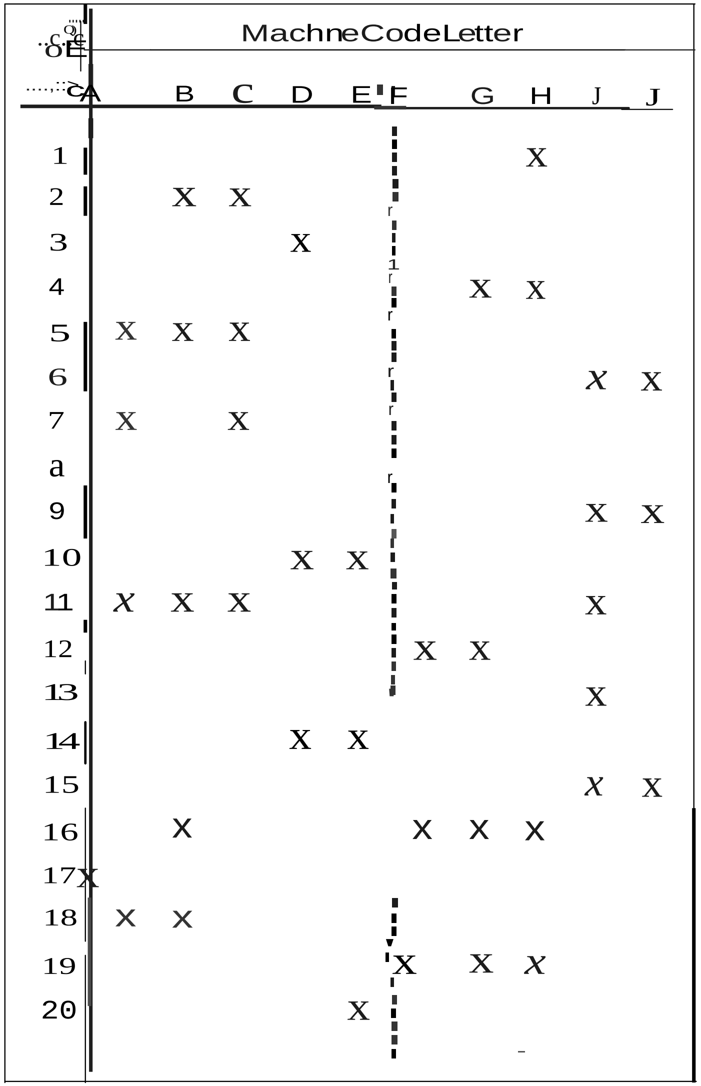
Methodforidentifyingpart familiesand associated machinegroupings based onproductionroutesheets ratherthanpart designdata

- Workpartswithidenticalorsimilarroutesheetsare classifiedinto partfamilies
- Advantagesof usingroutesheet data
  - Partswithdifferentgeometriesmayneverthelessrequirethesameorsimilarprocessing
  - Partswithnearlythesamegeometriesmay nevertheless requiredifferentprocessing

StepsinProductionFlow Analysis

1. Datacollection–operationsequenceandmachineroutingforeachpart
2. Sortingofprocessroutings–partswithsame sequencesand routingsarearrangedinto“packs”
3. PFAchart–eachpackisdisplayedonaPFAchart
   - Alsocalleda*part-machineincidencematrix*
4. Clusteranalysis–purposeistocollectpackswith similarroutingsintogroups
   - Eachmachinegroup=amachinecell

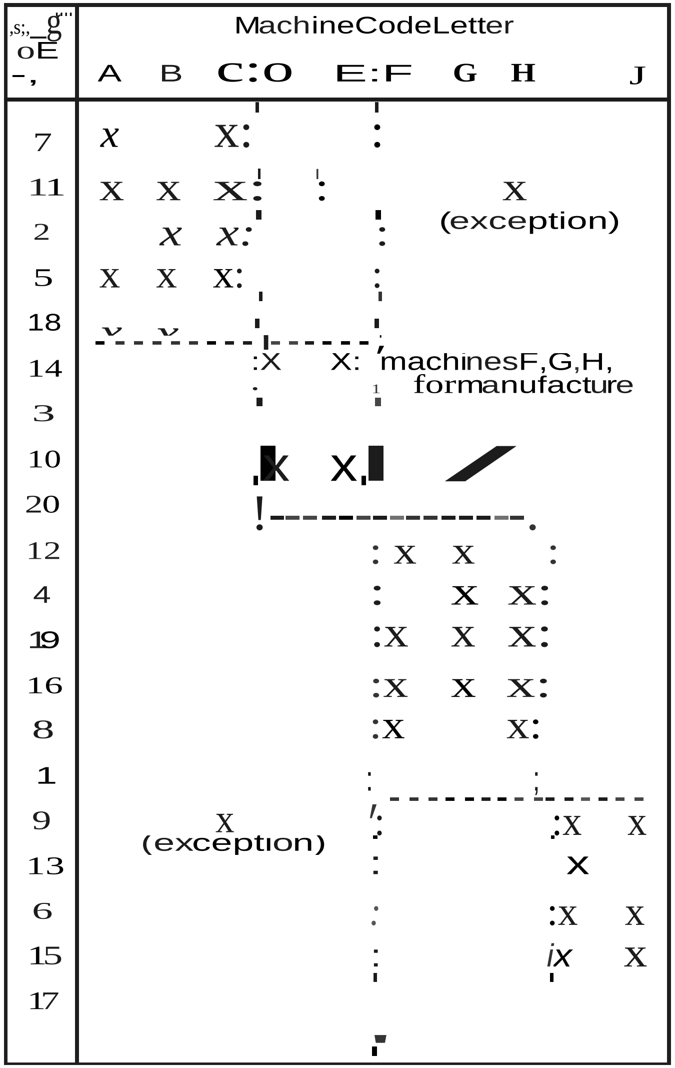
Before Clustering



	Machine Code Letter									
	A	B	C	D	E	F	G	H	J	J
1								X		
2		X	X							
3				X						
4							X	X		
5	X	X	X							
6									X	X
7	X		X							
a										
9									X	X
10				X	X					
11	X	X	X						X	
12						X	X			
13									X	
14				X	X					
15									X	X
16		X				X	X	X		
17	X									
18	X	X								
19						X	X	X		
20					X					

A matrix of jobs (by number) and machine tools (by code letter) as found in the typical job shop.

After Clustering

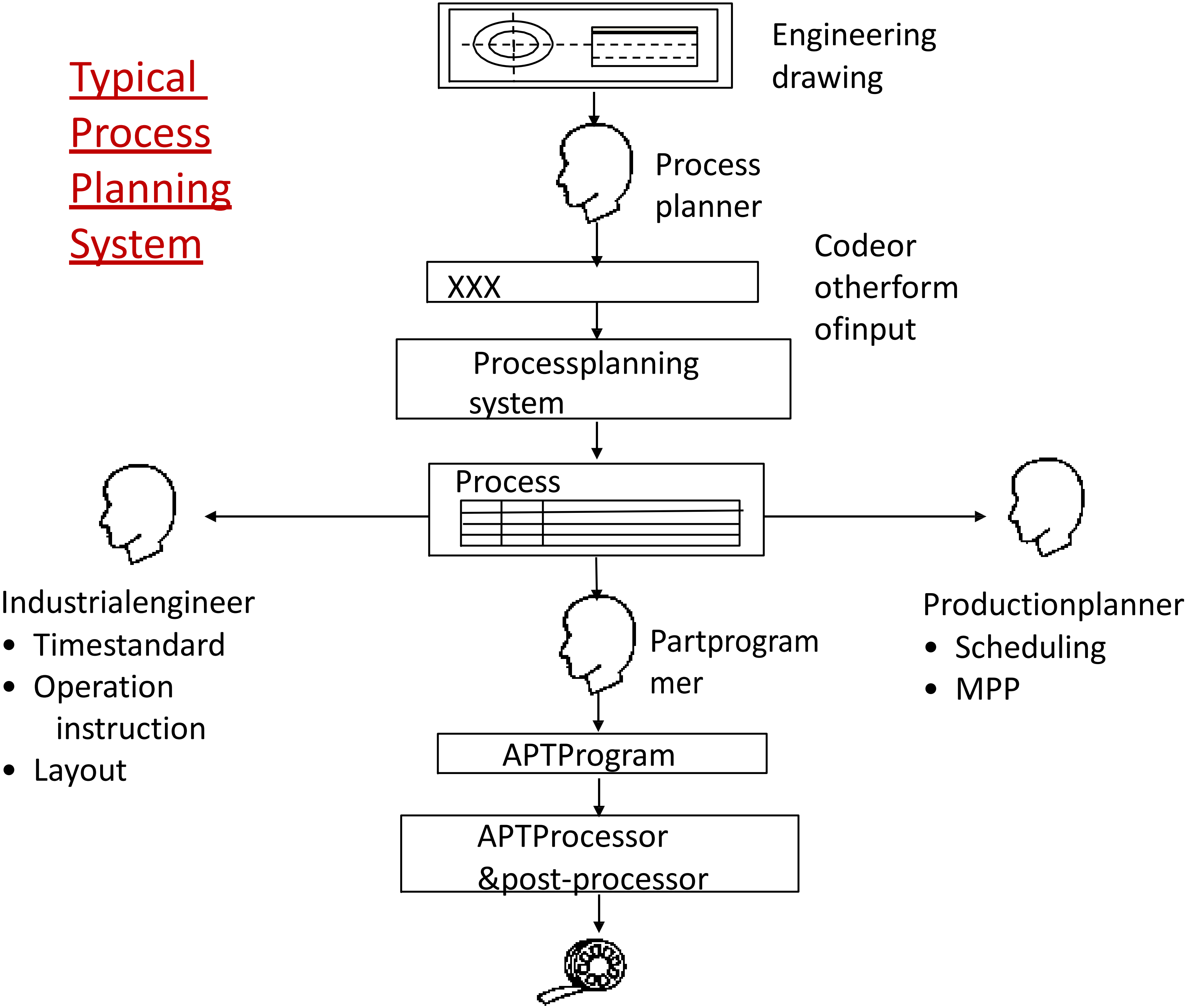


	Machine Code Letter									
	A	B	C	O	E	F	G	H		J
7	X		X							
11	X	X	X					X (exception)		
2		X	X							
5	X	X	X							
18	X	X								
14				X	X					
3										
10				X	X					
20										
12						X	X			
4							X	X		
19						X	X	X		
16						X	X	X		
8						X		X		
1										
9			X (exception)						X	X
13									X	
6									X	X
15									X	X
17										

machines F,G,H, for manufacture

A matrix rearranged to yield families of parts and associated groups of machines that can form a cell.

Typical Process Planning System



Engineering drawing

Process planner

XXX

Codeor otherform ofinput

Processplanning system

Process

Industrialengineer
- Timestandard
- Operation instruction
- Layout

Partprogrammer

Productionplanner
- Scheduling
- MPP

APTProgram

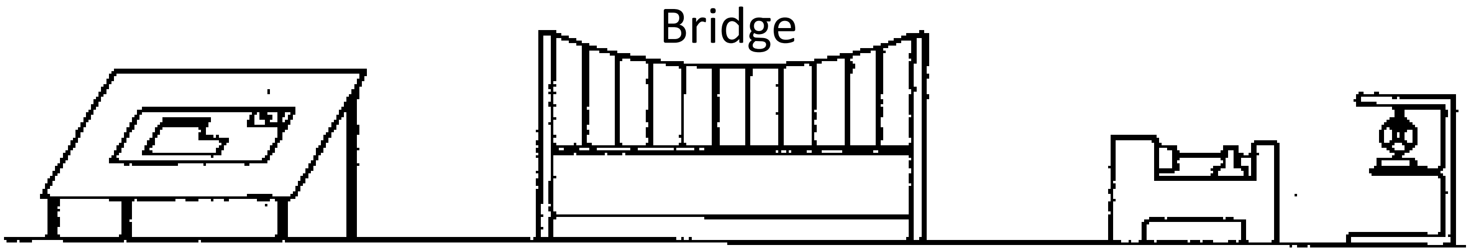
APTProcessor &post-processor

ProcessPlanning

“Processplanning”isthatfunctionwithinamanufacturingFacility thatestablisheswhichmachiningprocessesandParametersare tobeused(aswellasthosemachinescapableofperformingtheseprocesses)toconvert(machine)apiecePartfromitsinitialformtoafinalformpredetermined(usuallybyadesignengineer)fromanengineeringdrawing.

(I.E.Thepreparationofthedetailedworkinstructionsto Produceapart)

Processplanningbridgesdesignand manufacturing



BenefitsofGroupTechnology

Reductionsin

Throughputtime
Set-
uptimeOverdue
orders

Productionfloorspace
Rawmaterialstocks
In-processinventory

Capitalexpenditures
Toolingcosts
Engineeringtimeand costs

Newpartsdesign

Newshopdrawings

Totalnumberofdrawings

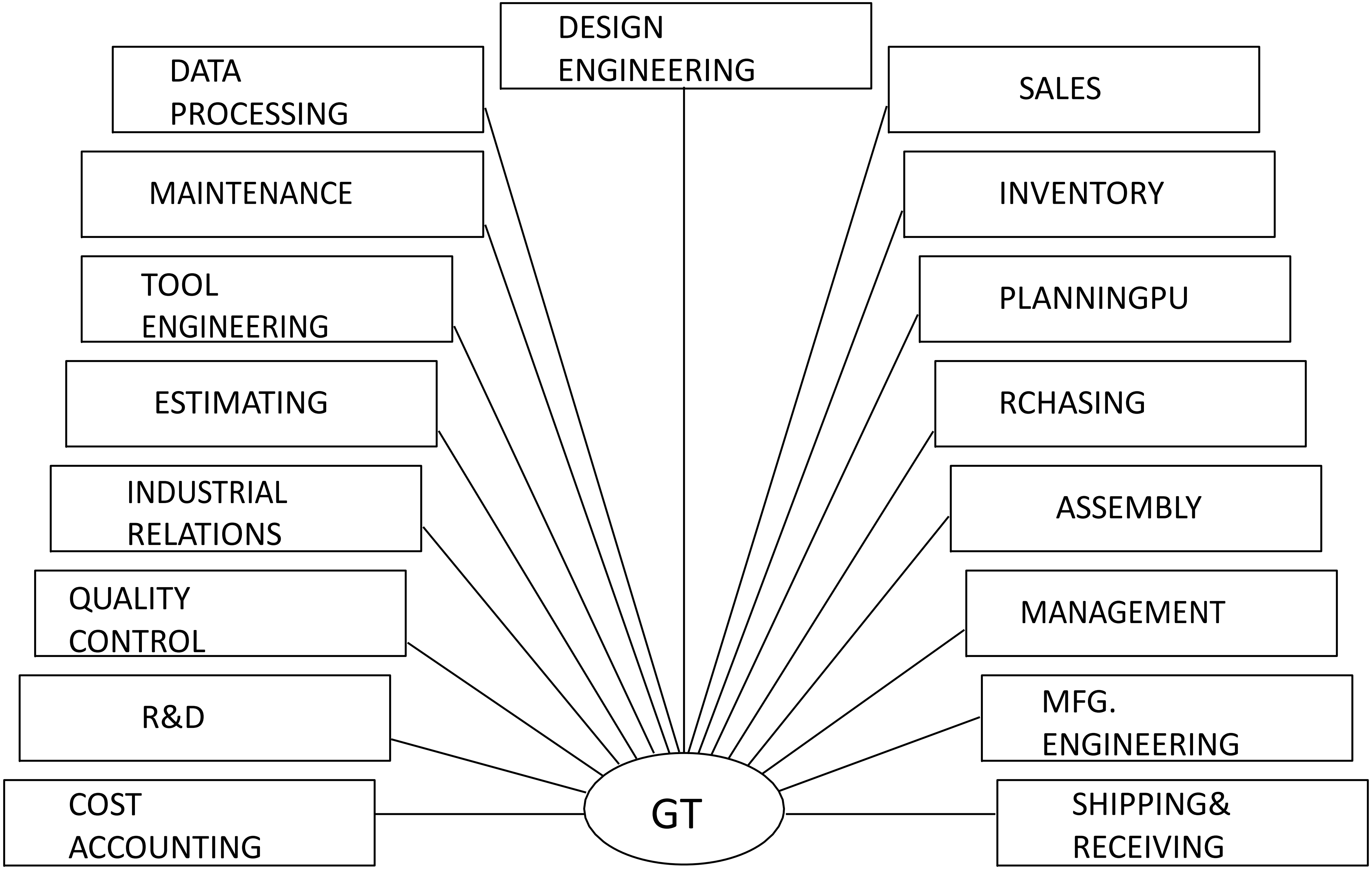
OtherBenefitsOfGroupTechnology

Easiertojustifyautomation
Standardization in design
Dataretrieval
Easier,morestandardized process plans
Increasesinquality

LimitationsofGT

- Lotoftimeandeffortsarerequiredinitiallytomake partfamily.
- Highinitialcost
- Ifrangeofproductsbeingmanufacturedby company changes,GTcodeshavetoberevised.
- TherearenumberofGTcodesbut nosingle classificationand codingsystemsuitsallapplications.
- itistime consumingand costlytorearrangethe machinesintomachinecells.
- Inertiatochange:normallythereisresistancefrom worker,foranychangeinmanufacturingsystem.

GTaffectsmosteveryoperatingandstafffunction.Itis morethanmerelyatechnique,butatotalManufacturingphilosophy.



DESIGN ENGINEERING

DATA PROCESSING

SALES

MAINTENANCE

INVENTORY

TOOL ENGINEERING

PLANNINGPU

ESTIMATING

RCHASING

INDUSTRIAL RELATIONS

ASSEMBLY

QUALITY CONTROL

MANAGEMENT

R&D

MFG. ENGINEERING

COST ACCOUNTING

GT

SHIPPING& RECEIVING

Cellularmanufacturing(Manufacturingcell)

- Amanufacturing cellis aselfsufficientmanufacturingfacilitywhich includesallmachines andequipmentsthatare neededto make a partor subassembly.Thisconceptis calledcellular manufacturing.
- Considersconceptofgrouptechnology.
- Shouldbe wellplannedand designedinorderto operateit profitably.
- It maybe designedforaparticular partfamily.

MachineCellClassifications

- Singlemachine
- Multiplemachineswithmanualhandling
- Multiplemachineswithmechanizedhandling
- Flexiblemanufacturingcell
- Flexiblemanufacturingsystem

TypesofGTCells

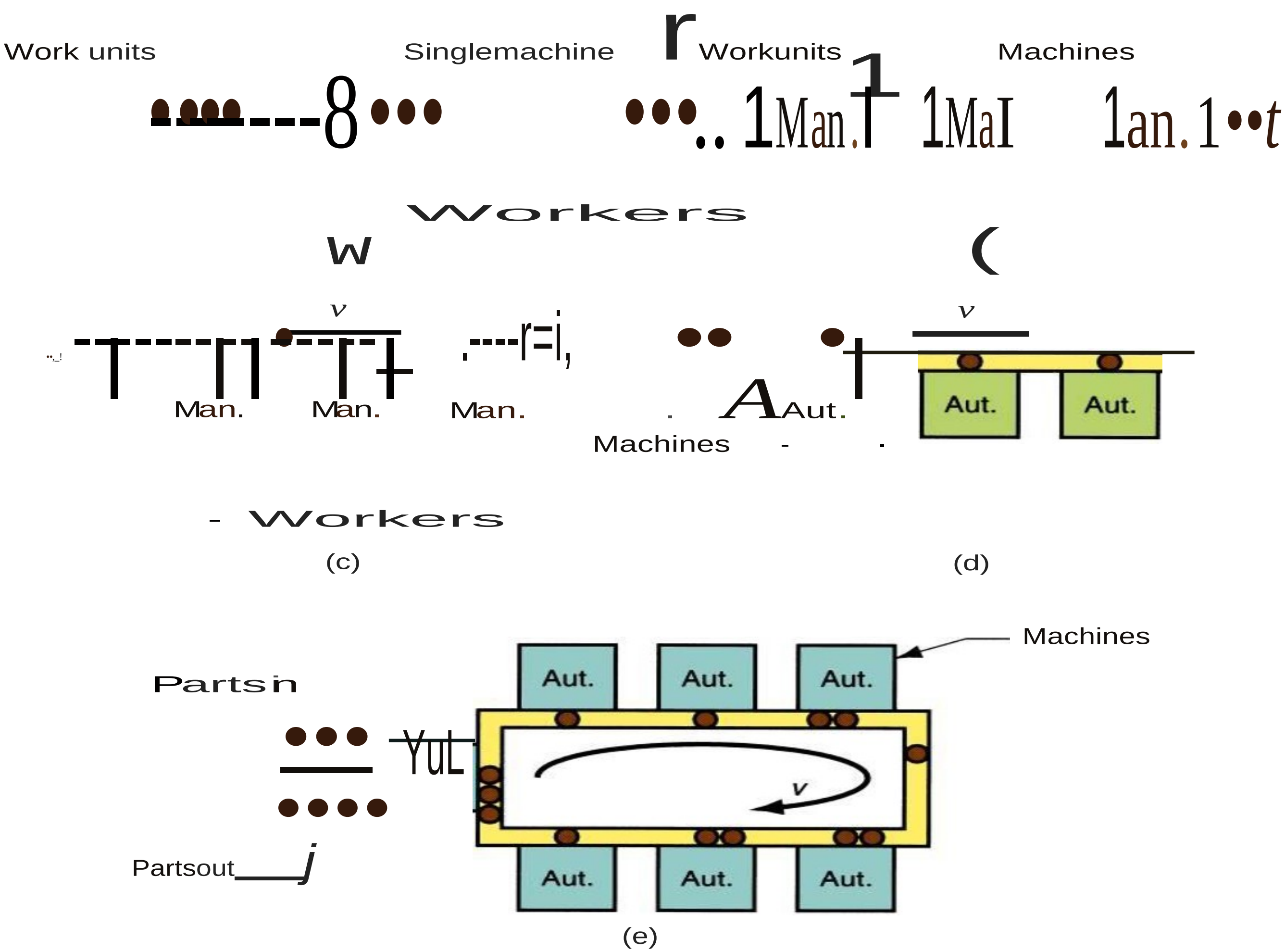


Figure40.4TypesofGTcells:(a)singlemachine, (b)multiplemachineswithmanual handling,(c)multiplemachineswithmechanizedhandling,(d)flexible manufacturingcell,(e)flexiblemanufacturingsystem.

MachineCellDesigns

Factorstobe consideredwhileimplementingcellular manufacturing.

1. Volumeofworktodecidenumberofmachines.

2. Variationin theprocessroutingsofpartsbelongingto apartfamilytodecidetypeofmachinearrangement andmaterialhandlingsystemrequired.

3. Workpieceattributeslike partsize,shape, weight etc. todecidesizeandtypeofmachines,material handlingandotherprocessingequipmentsrequired.

BenefitsofCellularManufacturing

- Toolingandfixturisation
- Materialhandling
- Processplanning
- Productionandinventorycontrol