



WELCOME TO THE COURSE



MANUFACTURING PROCESSES: (TA-202)

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Contents

- Preliminary Information.
- History of manufacturing .
- What is manufacturing?
- Issues related to design and manufacturing:material, aesthetic, production
- Design for manufacture
- Material selection: properties consideration
- Classification of manufacturing processes
- Selection of manufacturing processes
- Assembly and design for assembly
- Quality, TQC, automation, computer application

LECTURE-WISE BREAK-UP:

S. No.	Titles	Suggested of number of lectures
1	Introduction to manufacturing and its evolution	1
2	Conventional material removal processes	4
3	Un-conventional material removal processes	3
4	Computer numerical control and programming	3
5	Micro-fabrication processes	1
6	Layered / generative manufacturing processes	1
7	Engineering metrology	1
	Total number of lectures	14

COURSE POLICIES

Marks distribution: (i) Laboratory + project = 50 % (-5 %), (ii) Theory examination = 50 % (+5%) . It is to be noted that the (i) questions related to laboratory exercises will be a part of the theory exams. with an overall weightage of 5 %. There will be no separate quizz.

ACADEMIC DISHONESTY

FOR CHEATING IN THE EXAMINATION HALL: ZERO TOLERANCE → "F" GRADE FOR URE

PLEASE NOTE IT CAREFULLY

THEORY CLASS ATTENDANCE HAS NO MARKS BUT LAB. ATTENDANCE HAS CERTAIN WEIGHTAGE ALREADY INFORMED THROUGH E-MAIL AND UPLOADED ON THE SITE. PLEASE NOTE THAT THERE IS ALWAYS A GOOD, POSITIVE AND ALMOST LINEAR CORRELATION BETWEEN ALPHABETIC GRADE AND ATTENDANCE.

NO MAKE-UP WILL BE CONSIDERED UNLESS THE STUDENT HAS AUTHORIZED LEAVE REALLY FOR UNAVOIDABLE SITUATIONS. A STUDENT SEEKING A MAKE-UP IS USUALLY AT DISADVANTAGE.

- ❖ ADVANCED MACHINING PROCESSES BY V.K JAIN , ALLIED PUBLISHERS, NEW DELHI (2002)
- ❖ INTRODUCTION TO MICROMACHINING , V.K.JAIN (EDITOR) PUBLISHED BY NAROSA PUBLISHERS, NEW DELHI (2009)
- ❖ NON- CONVENTIONAL MATERIAL REMOVAL PROCESSES BY V.K.JAIN, BLOCK-4, INDIRA GANDHI NATIONAL OPEN UNIVERSITY (IGNOU), NEW DELHI
- ❖ MANUFACTURING ENGINEERING BY S. KALPAKJIAN AND SCHMID, PRENTICE HALL, 2001.

Reference Books

- **Fundamental of Modern Manufacturing: Materials, Processes and Systems: M. P. Groover (John Wiley).**
- **Manufacturing Processes for Engineering Materials: S. Kalpakliam and S. R. Schmid (Prentice Hall).**
- **Fundamental of Manufacturing Processes: G. K. Lal and S. K. Choudhuary (Narosa).**

Activity Roster for Lab-work

Lab Training first five turns:

#Turning (1 Turn), #Milling and Shaper (1 Turn), #Drilling Fitting (1 Turn), #CNC demonstration and job design (1 Turn), #CNC practice (1 Turn)

I First turn : Project groups should be formed. (Emphasize in class)

II Second turn : Project groups name should be given to the tutor.

III Third turn : Project discussion with Technical Staff / Guide with Material List.

IV 4th to 5th turn : Everything should be finalized during the **4th to 5th lab turn**. So the work should start without any loss of time on the 6th lab turn.

•For getting 'D' or better letter grade in this course, one should score total marks $\geq 35\%$, and $\geq 25\%$ in theory that is out of 55% (=14 marks).

•Students are advised to keep their mobiles in the switch off mode that is they are not supposed to use their mobiles strictly in the Lecture Class as well as in the Lab. class (especially when working on the machines in the Lab.).

History of Manufacturing

- Production of the articles made of wood, stone, ceramic etc.(5000-6000 B.C.)
- Initially hammering and casting for production.
- Ornamental objects: Gold, copper, iron.
- Major break through: production of steel A.D. 600-800.
- Today: reinforced plastics, composite materials , super alloys, Tailor-Made materials.
- Till industrial revolution (1750): batch production(no two parts made exactly alike).

History of Manufacturing

For two matching parts (M & F) made at two different places/plants/countries: nut & bolt **would not fit**



What do you need??



Standardization/ Interchangeability

(Example: Easy to replace a broken bolt of a certain size with an identical one purchased years later)

With enhanced automation (automatics , computer control etc.):
production rate has gone up.

Ex: Ten Al. beverage cans/s, cutting speeds:125 m/s, screw & bolts:
thousands/min.

Introduction to Manufacturing Processes

➤ Manufacturing (Latin word) : Manu + factus : Made by hands.

Present perspective: Involves making products from raw material by various processes, machinery, & operations **following a well organized plan for each activity required.** ← Process Plan for a part

➤ WHAT IS VALUE ADDITION?

➤ Price of clay: Rs. 1/kg

Price of a dinner (ceramic) plate –Rs. 50/ piece (200 g)

➤ Clay has gone a number of changes to be as a dinner plate


➤ See the objects around you :fan , chair, pen, etc.


➡ had different shapes at one time.

➡ not found in nature as they appear.

➡ most of these products/objects(made of a combination of several parts made of a variety of materials).

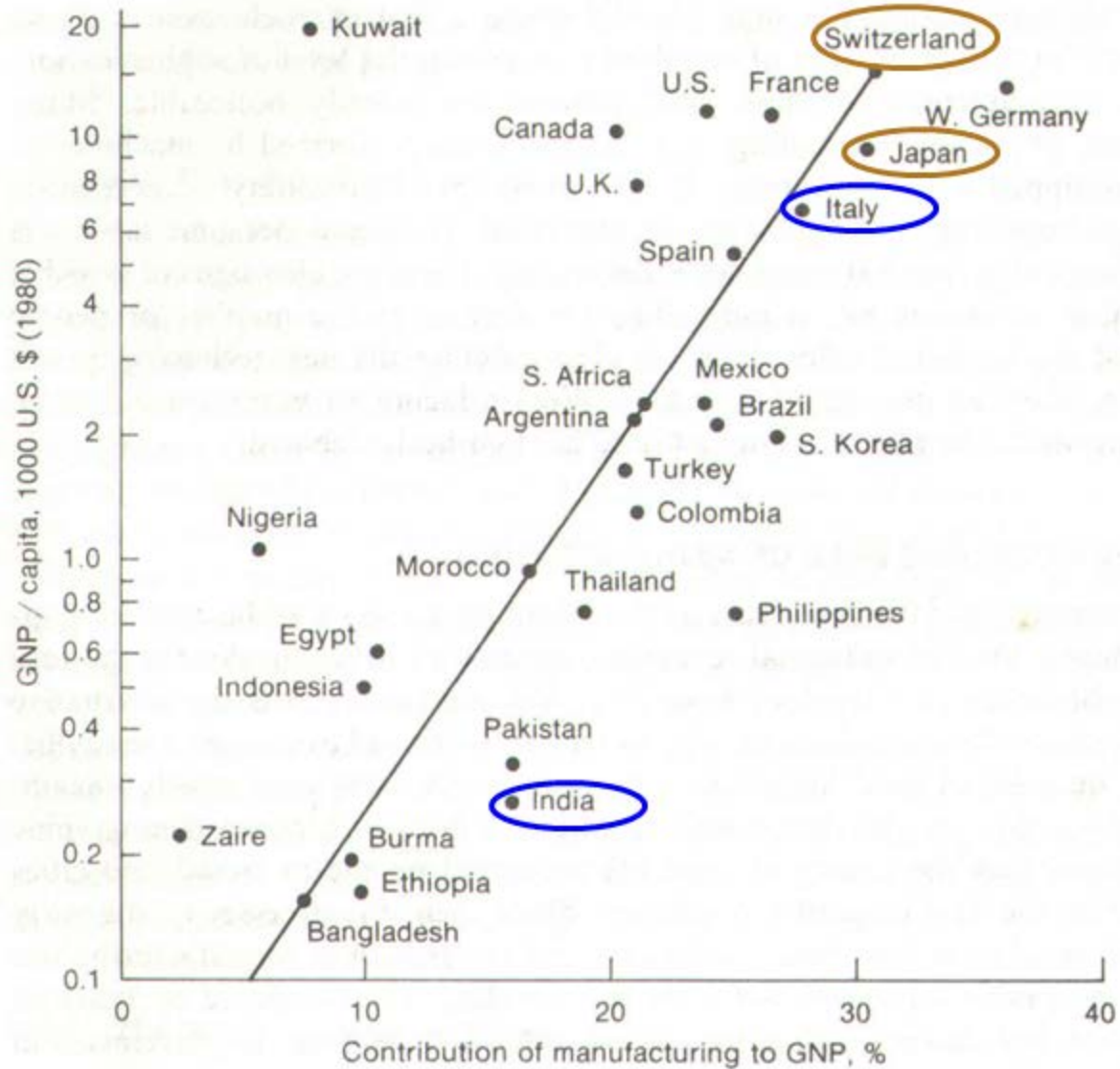
MANUFACTURING: IMPORTANCE

- Manufacturing  backbone of any industrialized nation.
- Related to the economic health of a country.
- Higher the level of manufacturing activity :higher the standard of living(Japan, U.K, China, etc.)
- Machine Tools: (ex- Lathe m/c, presses, milling m/c etc)

metal ore  metal  wire  a paper clip 
similarly other products  hangers, forks ..

- Some objects made of a combination of several parts, made from a variety of materials (ex- bicycle, computer, car:15000 parts etc)
- Manufacturing is a complex activity that involves : people, machinery, tooling with various levels of automation (computers, robots, AGV etc) etc.

CONTRIBUTION OF MANUFACTURING TO GDP



Manufacturing Activity Should Be Responsive To..

- Meet design requirement(Diameter, length, surface finish, tolerances, etc.).
- Most economic method to minimize cost
- From design to assembly : the quality should be built into the product at each stage.
- Production method should be flexible : meet varying demand (quantity , types, delivery date, etc.).
- **MANUFACTURING ORGANIZATION** : strive for higher productivity and optimum use of all its resources → material, men, machines , money (4M).

DESIGN AND MANUFACTURING OF A PRODUCT

1. YOU CAN NOT MAKE IF YOU CAN NOT MEASURE.
2. YOU CAN NOT DESIGN IF YOU CAN NOT MANUFACTURE.

- Important issues related to Design and MANUFACTURING.
- Ex: Paper clip (clip shape : square or round , wire size : dia, length)
- Functional requirement : **to hold papers with sufficient clamping force .**

- Material issues:
- ***Type of material .Stiffness(deflection/force) & strength (yield stress: stress to cause permanent deformation. If it is too strong, a lot of force will be required but if it is too weak, it may not work in holding the papers etc.).***

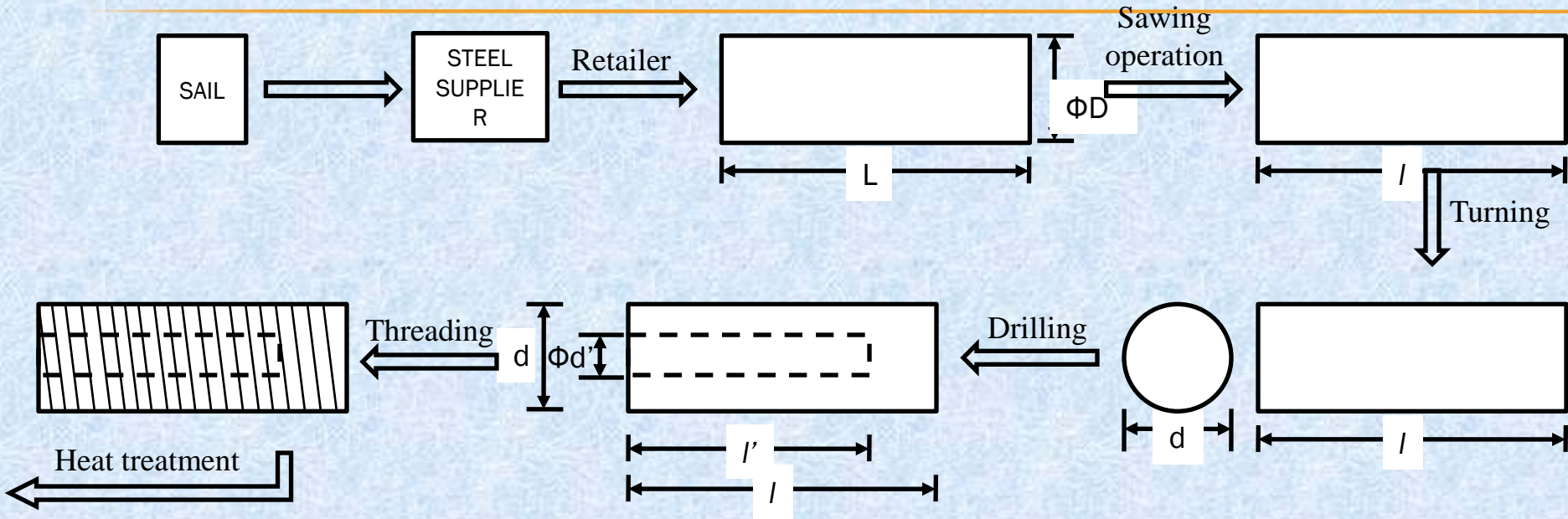
- Aesthetic issues:
- ***Style, appearance and surface finish of the clip. Corrosion resistance is also required (subjected to moisture and other environmental attack).***

- Production issues:
- ***Quantity to be produced: tens , hundreds ,, millions***
- ***Can the wire be bent without cracking/ breaking?***
- ***Smooth edge or burr (undesirable): paper finger.***

WHAT IS MANUFACTURING?

IN CASE OF METALLIC PARTS, STEPS FOLLOWED

ORE → EXTRACT METAL → MELT IN A FURNACE → CASTING → CUT IN PROPER SIZES (LOG) → TRANSPORT TO TRADER



EXPLAIN THE ABOVE STEPS WITH MACHINING CONDITIONS AND TOOLS' DETAILS, IT WILL BE CALLED **A PROCESS PLAN**.

MACHINING CONDITIONS: f , d , v . (cutting fluid / dry cutting)

Tool's Details: Tool material, tool angles.

What has gone into?

- **Value addition**
- Conversion of raw material into useful product → Manufacturing by performing different operation

Final product: Weight 3 kg, Cost – Rs 500/= . RAW MATERIAL COST Rs. 60/= PER Kg.

CLASSIFICATION OF VARIOUS MANUFACTURING PROCESSES

❖ PRIMARY FORMING PROCESSES (ADDITIVE OR ACCRETION)

- CASTING AND MOULDING PROCESSES
- POWDER METALLURGY, RAPID PROTOTYPING

❖ DEFORMING PROCESSES (FORMATIVES)

- HOT WORKING
- COLD WORKING
(FORGING, ROLLING, WIRE DRAWING, ETC.)

❖ MATERIAL REMOVAL PROCESSES (SUBTRACTIVE)

- CONVENTIONAL (TURNING, MILLING, ETC.)
- ADVANCED MACHINING PROCESSES (ECM, EDM, LBM, ETC.)

❖ JOINING AND FABRICATION PROCESSES (ASSEMBLY)

- WELDING, REWETTING, BRAZING, SOLDERING, ETC.

❖ FINISHING AND SURFACE TREATMENT PROCESSES

- BURR REMOVAL (DEBURRING)
- MECHANICAL CLEANING AND FINISHING
- CHEMICAL CLEANING
- COATING
- VAPOURIZED METAL COATING

❖ HEAT TREATMENT OR BULK PROPERTY ENHANCING PROCESSES

- HARDENING
- DUCTILITY, TOUGHNESS AND MACHINABILITY
- STRENGTHENING

Methods of Manufacturing

Material deposition

Electro chemical spark deposition

Electro discharge deposition

Chemical vapor deposition

Physical vapor deposition

Rapid prototype / rapid tooling

LIGA

Material Removal

Traditional material removal processes

Advanced material removal processes

Forming / shaping

Rolling

Forging

Extrusion & drawing

Sheet metal

Joining

Welding

Brazing

Soldering

Casting

Sand Casting

Die casting

Investment Casting

Centrifugal Casting

MICROFABRICATION IS GOING TO WITNESS AN EXCELLENCE IN R & D AT A REMARKABLE RATE

MACHINING METHODS

TRADITIONAL

Turning

Milling

Drilling

Grinding



ADVANCED

Mechanical

AJM

USM

AWJM

AFM, MAF, M-RAFF, MPF



Thermal

EDM

EBM

LBM

PAM



Chemical

ECMM

PCMM



HYBRID

ECSM

ECG

EDG

ELID, etc

Design for Manufacturing

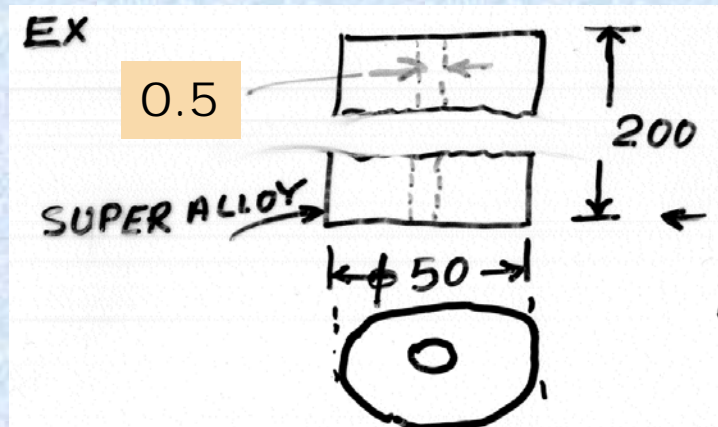
- Every designed product :Should be possible to make as a real product →if so, Design and manufacturing both are *inter related*
- Design a part such that it meets: Functional requirements, Manufacturing requirements+ possible to manufacture with ease and economy

✘

✘

✘

✘



<-- Designed Part

Aspect Ratio = $200 / 0.5 = 400$

SOME QUESTIONS TO CONSIDER?

How to Manufacture so high aspect ratio product?

Will it be economical?

Can you Change the design to make it viable to manufacture economically?

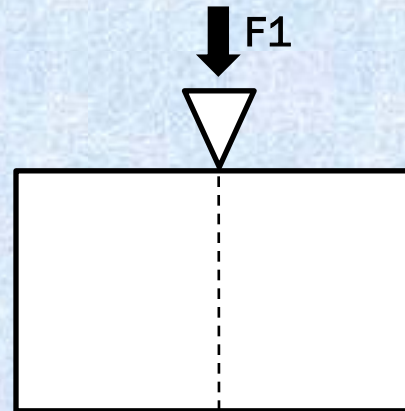
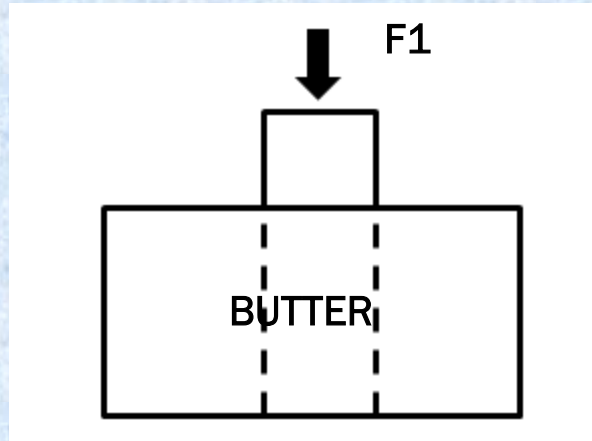
Hence designer should be well acquainted with?

- × Materials and their properties
- × Manufacturing processes & capabilities
- × Related Manufacturing machines & equipments
- × Assembly and inspection procedures
- **General types of materials:** Iron and steels, Non-ferrous metals and alloys, Plastics , polymers, Ceramics , glasses, diamonds etc., Composite materials

Hence designer should be well acquainted with?

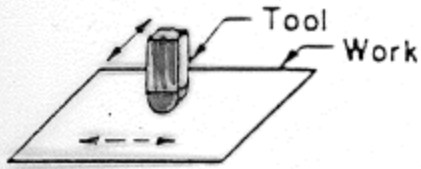
- **Finishing and surface treatment processes:**
- Burr removal(deburring),
- Mechanical cleaning and finishing,
- Chemical cleaning,
- Coating, Vaporized metal coating
- **Heat treatment or bulk property enhancing processes**
- ✗ Hardening
- ✗ Ductility , toughness and machinability
- ✗ Strengthening

TO CUT A PIECE OF BUTTER IN TWO PARTS

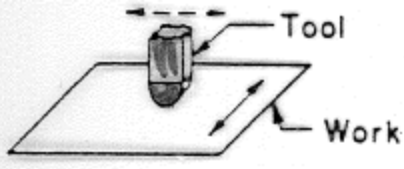


- ✗ What about stresses S_1 and S_2 ?
- ✗ Are they equal or different when the block just starts cutting?

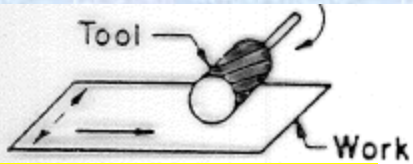
Shaping



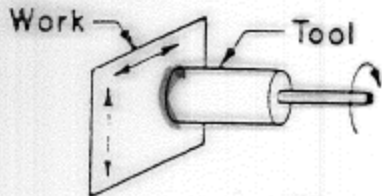
Planing



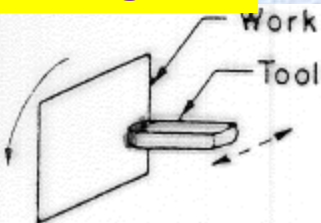
Milling (slab)



Milling (face)

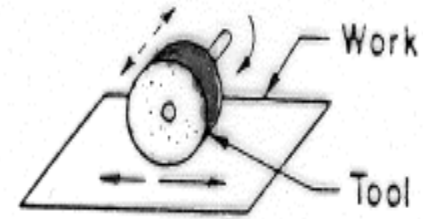


Facing



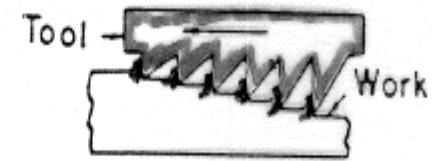
Abrasive machining

Abrasive machining



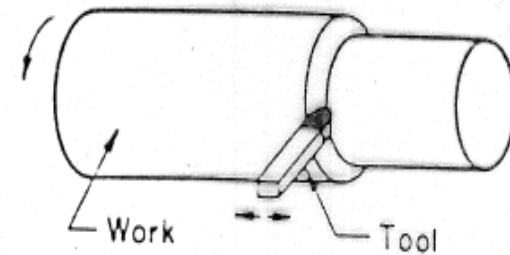
Broaching

Broaching



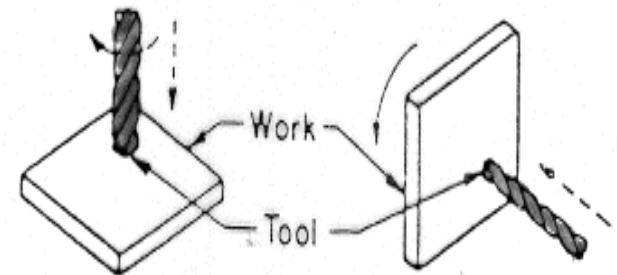
Turning

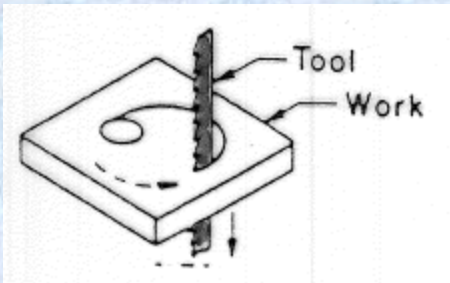
Turning



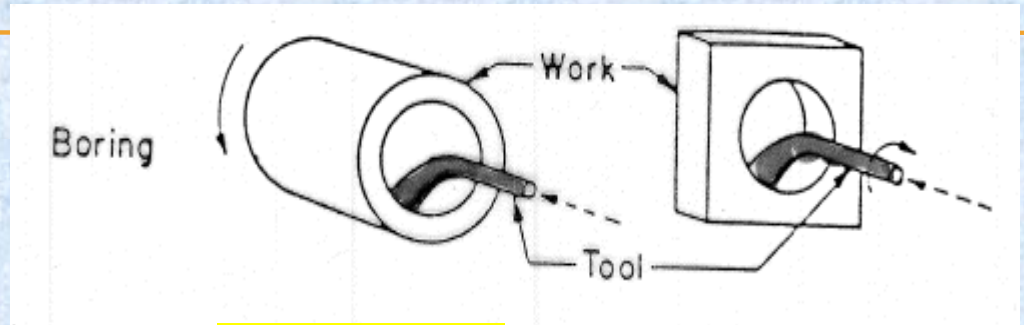
Drilling

Drilling

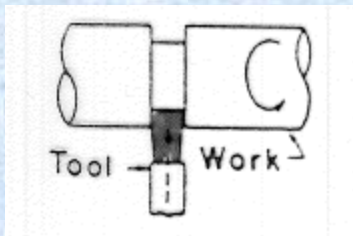




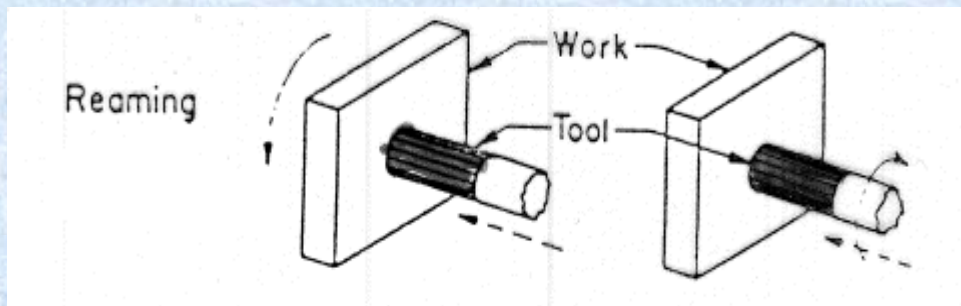
Sawing



Boring



Cut-Off



Reaming

SELECTION OF MANUFACTURING PROCESSES

- **Quantity to be produced (small, medium, large).**
- Shape to be produced(circle, square, rectangle etc.).
- Material & its properties.
- ✘ Metal or non-metal ; electrical conductivity , light reflecting or not,... brittle/ hard/ soft, magnetic / non-magnetic
- ✘ Dimensional and surface finish requirements
tolerance $10_{-0.02}^{+0.02}$ 10_{-1}^{+1} , fits (roughness value), surface finish
 $R_a = 1 \mu m$ $R_a = 0.1 \mu m$ $R_a = 0.01 \mu m$
- Cost : (selected mfg. process)
- What will happen if selected material & mfg. process are improper? Rejection / Failure of the part.

SELECTION OF MANUFACTURING PROCESSES

- **The product will fail.**
- **When will call it failed?**
 - ✘ Stops functioning.
 - ✘ Does not function properly.
 - ✘ Becomes unreliable or unsafe.

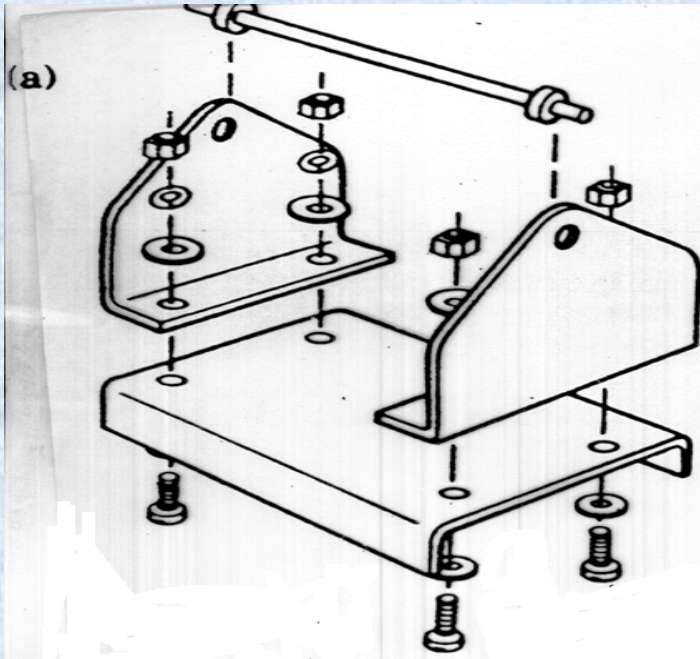
Assembly

- Assembly requires consideration of putting parts together .
- Ways of assembly:
- ✗ **Manual**
- ✗ **Automatic equipment**
 - Ex: hand driven screw driver & electric driven (Semi Automatic)
- **Permanent** → adhesive → aircraft & automobile
- ✗ **Riveting**
- ✗ **Welding**
- ✗ **Brazing**
- ✗ **Soldering**
- Separation is possible by damaging the joined parts .
- Low production rate.
- ✗ **Temporary**
- ✗ **Rivets** → Aero plane wings , river bridges (old), etc.
- ✗ **Nut & bolt (+ washer)** Requires preparation of holes → drilling(reduce part life)/punching
- ✗ Separation is possible by damaging the joined parts .

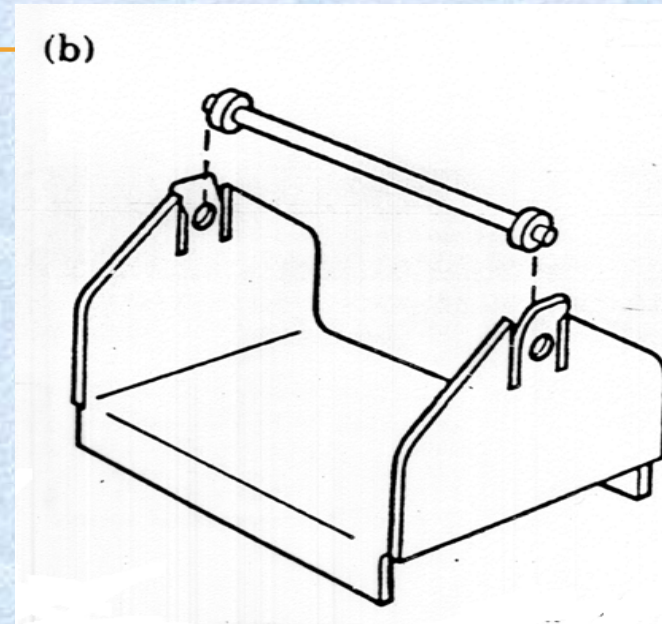
-
- Design For Assembly
 - ✗ **IMPORTANT AREA OF MANUFACTURING.**
 - ✗ **PERMIT ASSEMBLY WITH EASE.**
 - ✗ **REDUCE COST OF ASSEMBLING**

Simplify design by reducing required no of pieces / parts.

EXAMPLE OF EASY ASSEMBLY



Total no. of parts=24



Total no. of parts=2

AN EXAMPLE OF DESIGN FOR ASSEMBLY:

(A) AS DESIGNED, THIS PRODUCT CONSISTS OF MANY COMPONENTS AND TAKES CONSIDERABLE TIME TO ASSEMBLE.

(B) REDESIGNED PRODUCT CONSISTS OF ONLY TWO PARTS AND IS EASY TO ASSEMBLE, EITHER BY HAND OR IN AUTOMATED MACHINERY.

Quality

- Most important aspect of manufacturing.
- ✘ Influences marketability & customer satisfaction.
- High quality and low cost :
- ✘ Quality also mean meeting design specifications.
- ✘ Quality must be built into a product → from the design stage through all subsequent stages of manufacturing & assembly



Total quality control

Quality also means meeting design specifications of the product.

- Customer satisfaction : Are they happy with the quality and price ?



No : to capture the market , customer should be delighted

***CUSTOMER SHOULD NOT BE SATISFIED ONLY, S/HE SHOULD BE DELIGHTED BY QUALITY.**

AUTOMATION AND COMPUTERS IN MANUFACTURING

➤ **WHY AUTOMATION?**

- ✗ Improved productivity
- ✗ Improved quality
- ✗ Minimum cycle time
- ✗ Reduced labor cost / hazard

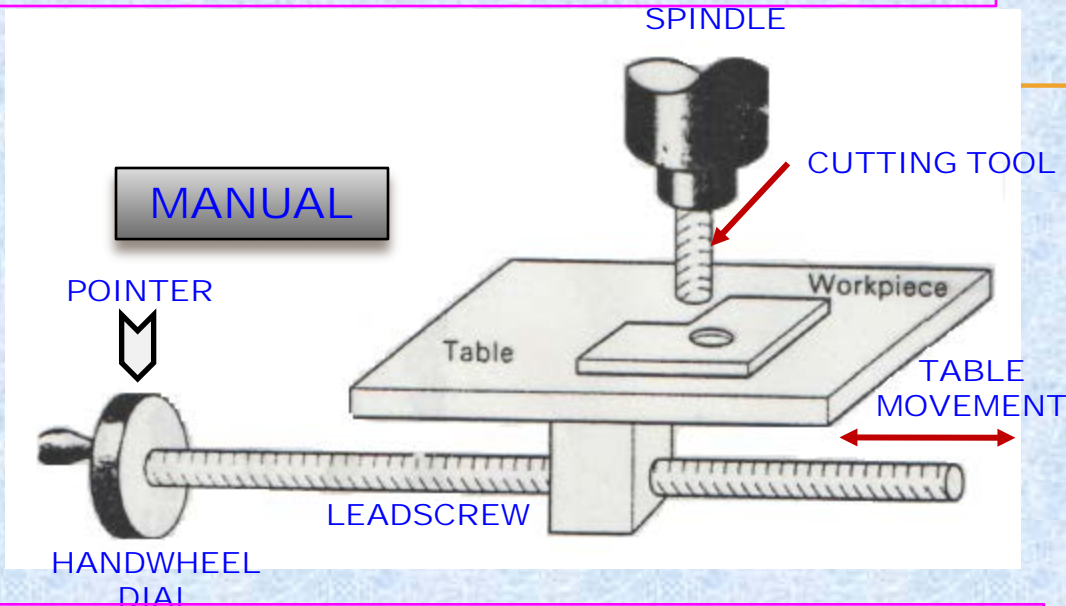
ROLE OF THE COMPUTERS IN MANUFACTURING

- Computer control of manufacturing processes: NC/CNC/DNC
- Optimization of mfg. processes
- Automated material handling system(AGV)
- Automated inspection and testing
- Automated assembly systems
- Robots in manufacturing
 - ✗ Reduced human error
 - ✗ Better quality control

Computer Aided Manufacturing (CAM)

- Involvement of computer in various phases of Manufacturing and sharing the common database
- ✘ CNC (Computer Numerical Control) part program
- ✘ Computer integrated manufacturing (CIM)
- ✘ Computer aided design (CAD)
- ✘ Computer aided process planning (CAPP)
- ✘ Flexible Manufacturing System (FMS)

A CONVENTIONAL MACHINE'S SLIDE IS MOVED BY AN OPERATOR BY TURNING THE HANDWHEEL. ACCURATE POSITIONING IS ACCOMPLISHED BY THE OPERATOR.



MANUAL MACHINING - FEED, D.O.C.; V SET BY OPERATOR
ERROR, APPROXOMATION, SKILL OF OPERATOR

THE SAME PART CAN BE MADE BY NC OR MANUAL MACHINING. THE INCREASED COST OF NC CAN BE OFFSET BY THE DECREASED MANUFACTURING TIME NAD IMPROVED QUALITY

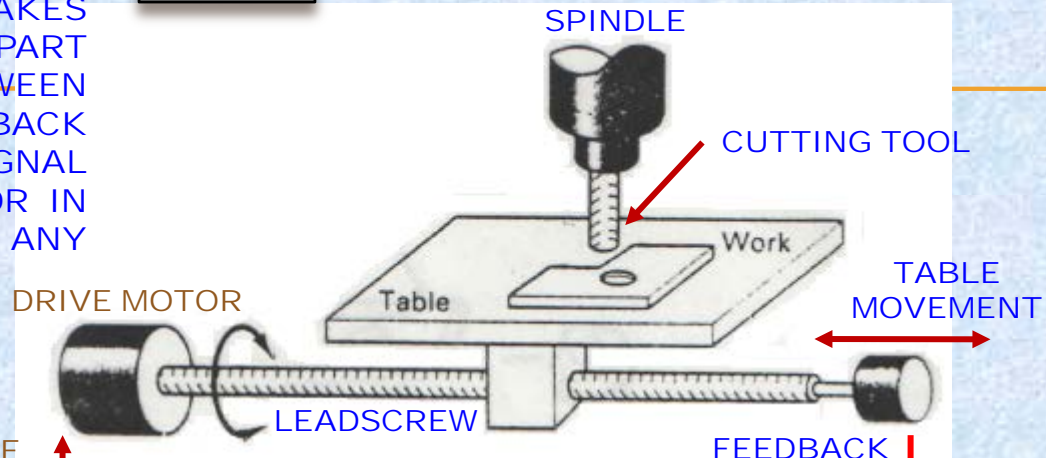
IN N.C. → FEED (f), D.O.C. (d); → CUTTING SPEED (V) → CONTROLLED THROUGH NC PART PROGRAM.

- CARDS / PAPER TAPE
- MAGNETIC TAPE
- FLOPPY / CD

- NC / CNC ADVANTAGES:
- BETTER QUALITY
 - HIGHER PRODUCTIVITY
 - LOWER REJECTION
 - FACTORY OF FUTURE
 - REDUCED INSPECTION

NC

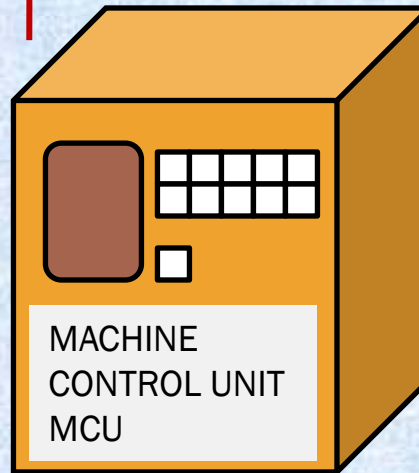
NUMERICAL CONTROL- THE NC MACHINE TAKES THE PROGRAMMED POSITION FROM A PART PROGRAM TAPE -- ANY DIFFERENCE BETWEEN THE COMMANDED POSITION AND THE FEEDBACK SIGNAL READING WILL GENERATE A SIGNAL FROM THE MCU TO RUN THE DRIVE MOTOR IN THE PROPER DIRECTION TO CANCEL ANY ERRORS.



MANUAL OR COMPUTER-ASSIST WORKPIEC PROGRAMMING

COMPUTER PROCESSING

PART PROGRAM TAPE



DRIVE MOTOR SIGNAL

FEEDBACK DEVICE

FEEDBACK SIGNAL



THANK YOU

