Tool Design: Manufacturing Tooling Introduction

ITCD – 301-001

Monday, August 30

Responsibilities of tool designer

- Cutting tools, tool holders and cutting fluids
- Machine tools
- Jigs and fixtures
- Gages and measuring instruments
- Dies for sheet metal cutting and forming
- Dies for forging, cold finishing and extrusion
- Fixtures for welding, riveting and other mechanical fastening

Objectives of tool design

- Reduce the overall cost of manufacturing a product by producing acceptable parts at lowest cost.
- Increase the production rate by designing tools that will produce parts as quickly as possible.
- Maintain quality by designing tools which will consistently produce parts with the required precision.
- Reduce the cost of special tooling by making every design as cost effective and efficient as possible.
- Design tools that will be safe and easy to operate.

The Tool Design Process

- Statement and analysis of the problem
- Analysis of the requirements
- Development of initial ideas
- Development of design alternatives
- Finalization of design ideas

Statement of the problem

- Problem without tooling
- What the tool is supposed to do?
  - Drill four holes
- Bottleneck in assembly
  - Low productivity with out tooling

Analysis of the requirements

- Must perform certain functions
- Must meet certain minimum precision requirements
- Must keep the cost to a minimum
- Must be available when the production schedule requires it
- Must be operated safely
- Must meet other requirements such as adaptability to the machine tool, etc.

Design alternatives

Create	Analyze in terms of these criteria				
Alternatives	Function	Quality	Cost	Date	Auxiliary
A B . .					

Economics of Design

- Temporary tooling
- Permanent tooling

Break-Even Charts

- Break-even charts are perhaps most widely used to determine profits based on anticipated sales.
- They have other uses, however, such as for selecting equipment or for measuring the advisability of increased automation.

Break-Even Charts

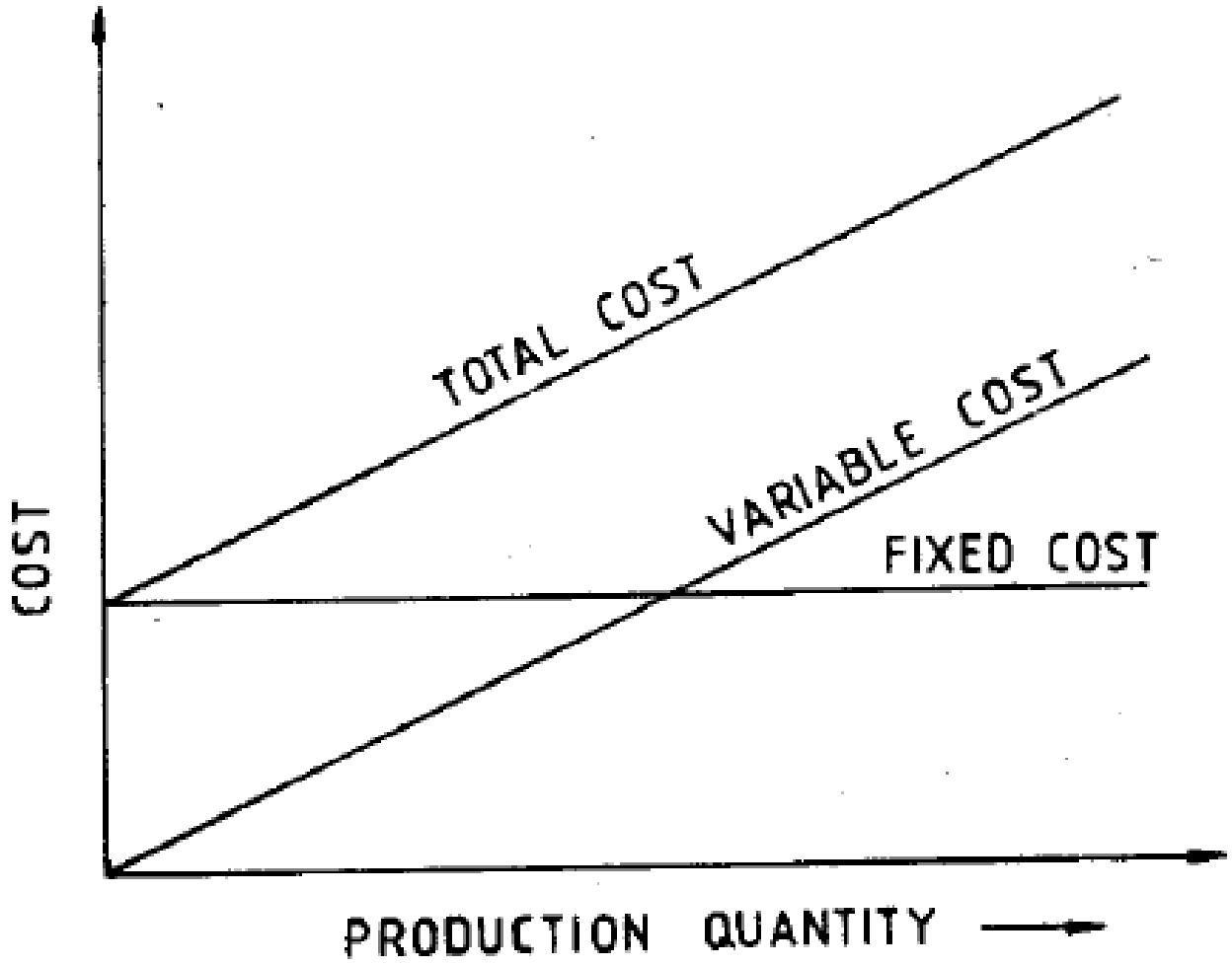
- To determine which of two machines is most economical, the fixed cost and variable cost of each machine are plotted
- The total cost is composed of the sum of the fixed and variable costs.

Break Even Analysis

- *Fixed cost*, which relates to the initial investment on the equipment and tools required for the process.
- *Variable cost* on the other hand varies with the actual number of objects made.
- The total cost is the sum of both fixed and variable cost.

$$TC = FC + VC \cdot N$$

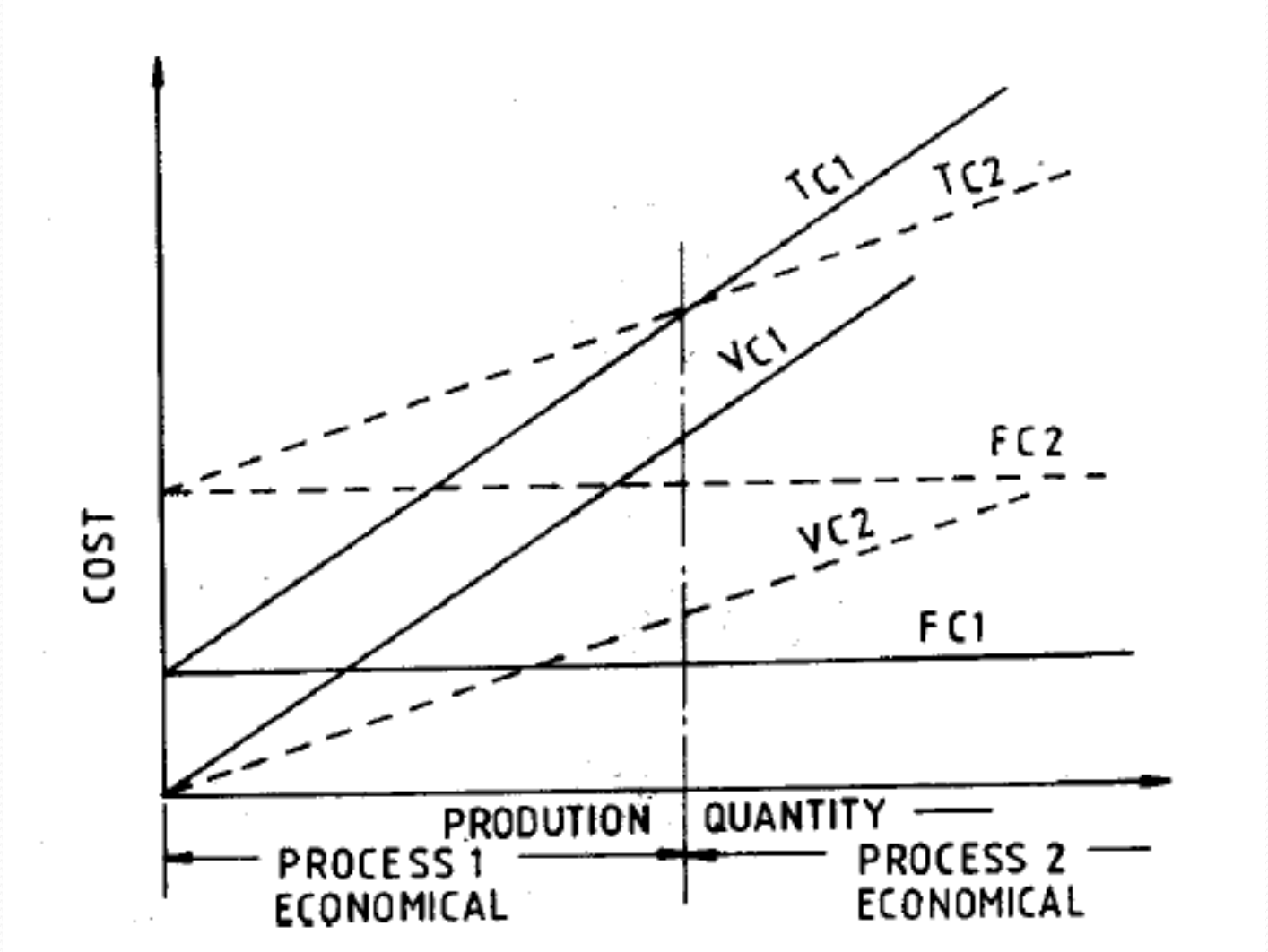
- TC = total cost
- FC = fixed cost
- VC = variable cost per piece
- N = production quantity


COST
TOTAL COST
VARIABLE COST
FIXED COST
PRODUCTION QUANTITY

$$F\ C_1 + V\ C_1 \cdot N = F\ C_2 + V\ C_2 \cdot N$$

$$N = \frac{F\ C_2 - F\ C_1}{V\ C_1 - V\ C_2}$$

N = Break even quantity


TC1
TC2
VC1
FC2
VC2
FC1
COST
PRODUTION QUANTITY
PROCESS 1
ECONOMICAL
PROCESS 2
ECONOMICAL

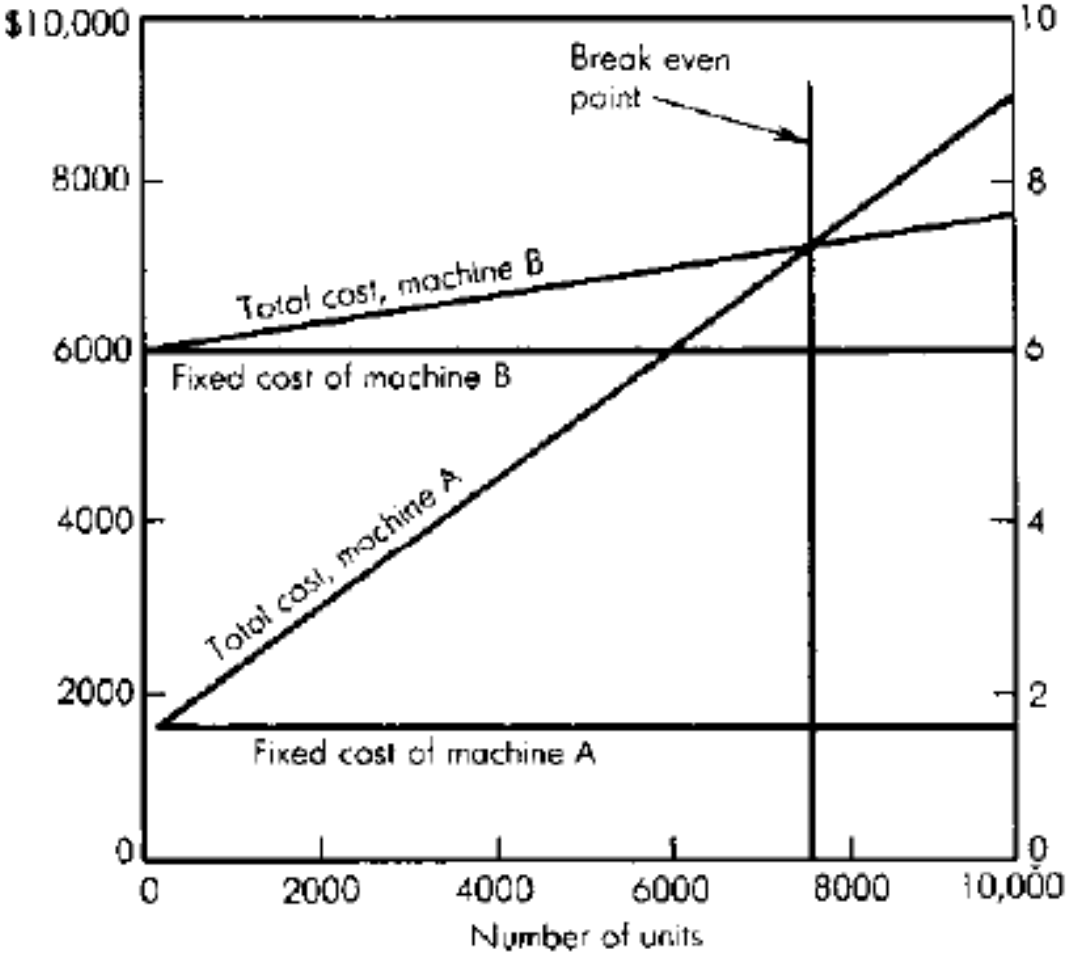
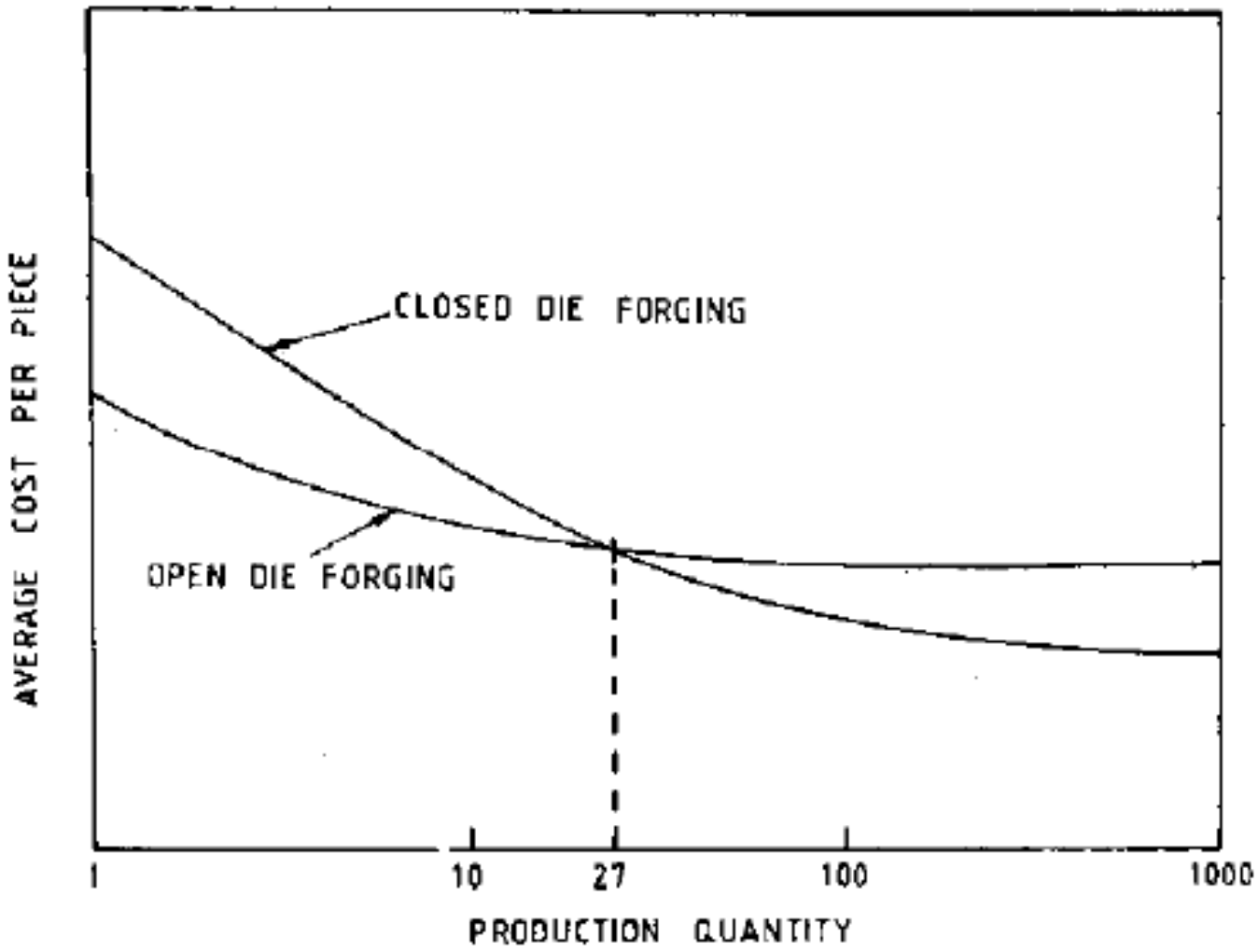


Figure 1-7. **Break-even chart for machine selection; choice is based upon volume production.**


AVERAGE COST PER PIECE
CLOSED DIE FORGING
OPEN DIE FORGING
1
10
27
100
1000
PRODUCTION QUANTITY

Tool Drawings

- Draw and dimension with due consideration for someone using the drawing to make the item in the tool room.
  - Do not crowd views or dimensions.
  - Analyze each cut to be sure it can be done with standard tools.
- Use only as many views as necessary to show all required detail.

Tool Drawings

- Surface roughness must be specified.
- Tolerances and fits peculiar to tools need special consideration.
  - It is not economical as a rule to tolerance both details of a pair of mating parts as is required on production part detailing.
  - In cases where a hole and a plug are on different details to be made and mated, the fit tolerance should be put on the male piece and the hole should carry a nominal size.

Tool Drawings

- The stock list of any tool drawings should indicate all sizes required to obtain the right amount for each detail.
  - As far as possible, stock sizes known to be on hand should be used, but in all cases, available sizes should be specified. A proper, finished detail is dependent upon starting with the right material.

Tool Drawings

- Use notes to convey ideas that cannot be communicated by conventional drawing. Heat treatments and finishes are usually identified as specification references rather than being spelled out on each drawing.

Tool Drawings

- Secondary operations such as surface grinding, machining of edges, polishing, heat treating, or similar specifications should be kept to a minimum.
  - Only employ these operations when they are important to the overall function of the tool; otherwise these operations will only add cost, not quality to the tool.

Tool Drawings

- Apply tolerances realistically. Overly tight tolerances can add a great deal of additional cost with little or no added value to the tool.
- The function of the detail should determine the specific tolerance, not a standard title block tolerance value.

Tooling Layout

- Layout the part in an identifying color (red is suggested).
- Layout any cutting tools. Possible interference or other confining items should be indicated in another identifying color (blue suggested). Use of the cutting tool should not damage the machine or the fixture.

Tooling Layout

- Indicate all locating requirements for the part. There are three locating planes: use three points in one, two points in the second, and only one point in the third plane.
  - This is called the 3-2-1 locate system. Do not locate on the parting line of castings or forgings. All locators must be accessible for simple cleaning of chips and dirt.

Tooling Layout

- Indicate all clamping requirements for the part.
- Be careful to avoid marking or deforming finished or delicate surfaces.
- Consider the clamping movements of the operator so injury to the hands or unsafe situations are eliminated.
- Be sure it is possible to load and unload the part.

Tooling Layout

- Layout the details with due considerations to stock sizes, so as to minimize machining requirements.
- Use full scale in the layout if possible.
- Indicate the use of standard fixture parts (shelf items) whenever possible.

Tooling Layout

- Identify each different item or detail of any design by the use of balloons with leaders and arrows pointing to the detail in the view that best shows the outline of the item. These should not go to a line that is common to other details.

Safety as Related to Tool Design

- Safety should be designed into the tooling.
- Cutting should never be performed against a clamp, because of vibration and tool chatter. Instead, parts should be nested against pins in order to take the cutter load.
- Rigidity and fool proofing should always be built into the tooling.

Safety as Related to Tool Design

- Make drill jigs large enough to hold without the danger of spinning.
- Small drill jigs should always be clamped in a vise or against a bar or backstop.
- Install plexiglass guards around all milling and flycutting operations where chips endanger workers or work areas.

References

- Fundamentals of tool design, fifth edition, Society of Manufacturing Engineers
- Donaldson, and Lecain, Tool Design, McGraw Hill

Questions?