MANUFACTURING PROCESSES & PRODUCTION

Questions

1. Name TWO main metals that are used in pressure die casting industry and explain the main difference in the casting ability of the two metals

2. Name TWO processes that can be used to manufacture an Aluminium alloy piston for an internal combustion engine. (Neglect any machining operations) and explain two major advantages and disadvantages of both processes.

3. Give an example of THREE components that have used the broaching process. Use a sketch/picture of each component and indicate on the sketch/component the surfaces that have been produced by the broaching process

4. Describe TWO methods used to overcome the difficulty of machining continuous chip forming materials

5. With the aid of a simple sketch describe all the movements of a 5-axis machining centre

6. Describe the difference between the Solid-State and Fusion welding processes. State TWO advantages and disadvantages for each of the above processes. Also name THREE commonly used Solid-State and Fusion welding processes

7. State TWO main advantages of using 3-D printing process

8. Explain the purpose of using support material when manufacturing a 3-D model. Describe how the support material is removed from the model after the manufacturing process is completed.

9. Name and describe the manufacturing process used to make the plastic mild bottle. Use a sketch to aid your explanation

10. Carbon Fibre is now being extensively used in manufacturing industry. State why this process has superseded existing manufacturing processes. Explain ONE major disadvantage of using this material

Solution

A. Manufacturing Process: (5 marks for each question)

1. Name TWO main metals that are used in pressure die casting industry and explain the main difference in the casting ability of the two metals

   Solution : The two metals are Aluminium and Zinc

   Zinc : -Easily castable , high impact strength , high ductility and most economical .

Aluminium :-Lightest castable metal , good dimensional stability , high corrosion resistance and high thermal conductivity .

2. Name **TWO** processes that can be used to manufacture an Aluminium alloy piston for an internal combustion engine. (Neglect any machining operations) and explain two major advantages and disadvantages of both processes.

Solution: Aluminium alloy piston are manufactured from Casting process and forging process

CASTING PROCESS		FORGING PROCESS	
Advantages	Disadvantages	Advantages	Disadvantages
High dimensional accuracy	Not economical for large scale production	Better strength	Initial cost is very high
High compressive strength of cast objects	Poor surface finish	Good fatigue life	Machinability is poor

3. Give an example of THREE components that have used the broaching process. Use a sketch/picture of each component and indicate on the sketch/component the surfaces that have been produced by the broaching process

Solution

Figure 1 (a,b)[2]

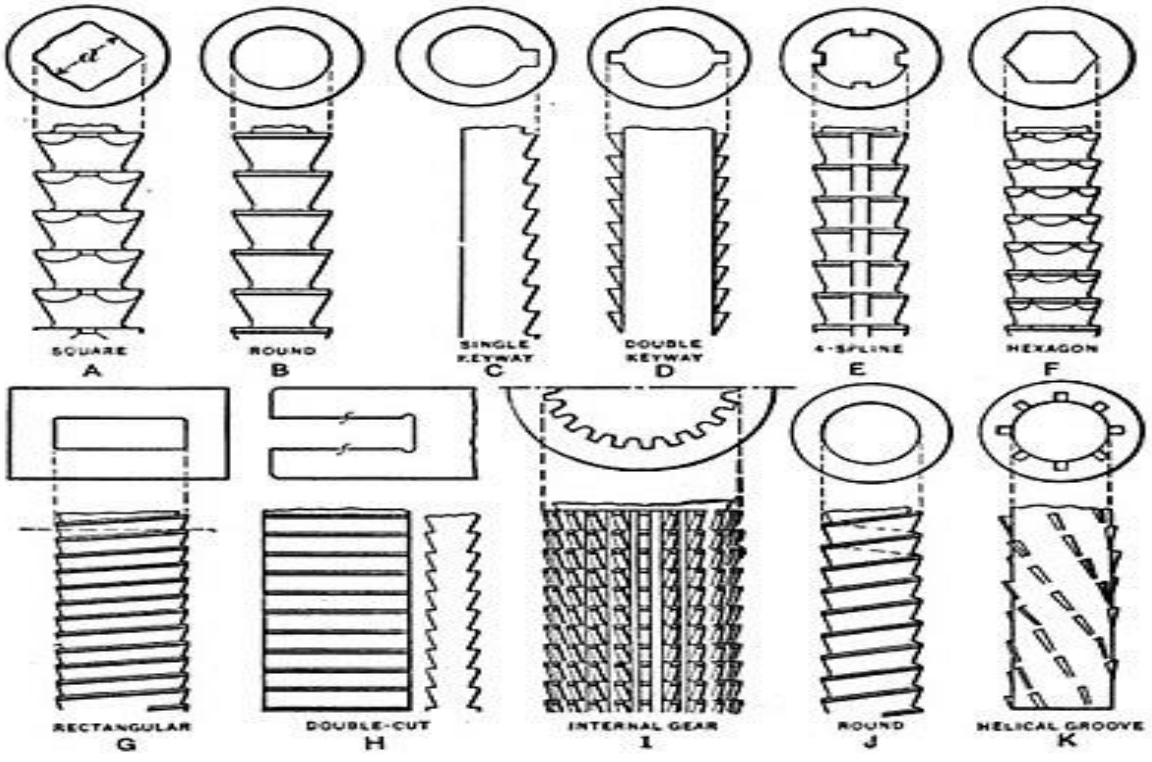

Figure 2 [2]

4. Describe TWO methods used to overcome the difficulty of machining continuous chip forming materials

   Solution:-

   - ❖ Reduce the cutting speed of machining process to break continuous chip formation .

- ❖ Keep the small rake angle .
- ❖ Use tool insert with chip breaker .

5. With the aid of a simple sketch describe all the movements of a 5-axis machining centre

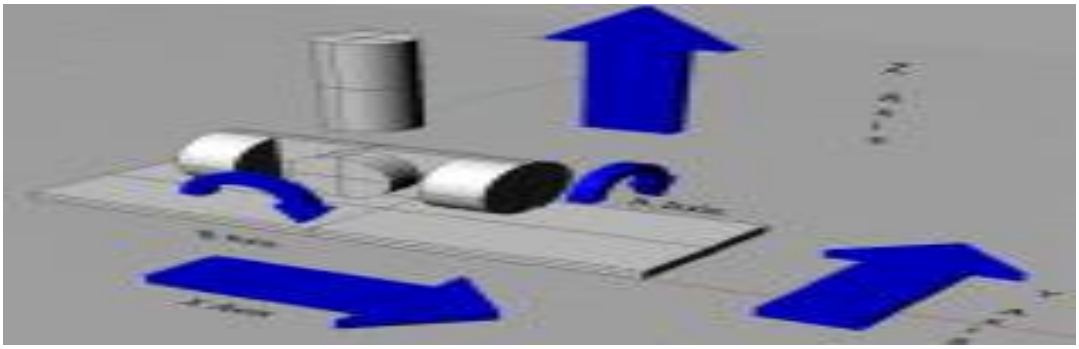

Figure 3

6. Describe the difference between the Solid-State and Fusion welding processes. State TWO advantages and disadvantages for each of the above processes. Also name THREE commonly used Solid-State and Fusion welding processes

Solution

	SOLID STATE WELDING	FUSION WELDING
Difference	Joining of two metals occurs in solid state	Joining of two metals occurs in liquid state
Advantages	Good surface finish	Easily set up
	Ability to join dissimilar materials	Welding cost is very less
Disadvantages	Expensive equipments	Wastage of metal
	Special fixtures are required for different process	proper alignment & care of electrode is required
Process	Friction welding	Oxyacetylene Welding
	Ultrasonic welding	Gas-Tungsten Arc Welding
	Forge welding	Submerged Arc Welding

7. State TWO main advantages of using 3-D printing process

Solution:

- ❖ Reduce overheads cost due to additive manufacturing. No wastage of material , no labour cost .
- ❖ Creativity / Imagination planned on 3d modelling software before 3d printing , so no chances of mistakes due to computer aided manufacturing .

8. Explain the purpose of using support material when manufacturing a 3-D model. Describe how the support material is removed from the model after the manufacturing process is completed.

Solution :

When layers widen towards the top, when the extrude needs to be positioned on some material, hence supporting layers needs to be printed. The support is a lower dense mesh that can be easily removed and later the surface can be polished with sandpaper for a better finish .

9. Name and describe the manufacturing process used to make the plastic mild bottle. Use a sketch to aid your explanation

Solution :

Injection molding is a process of making plastic bottles .

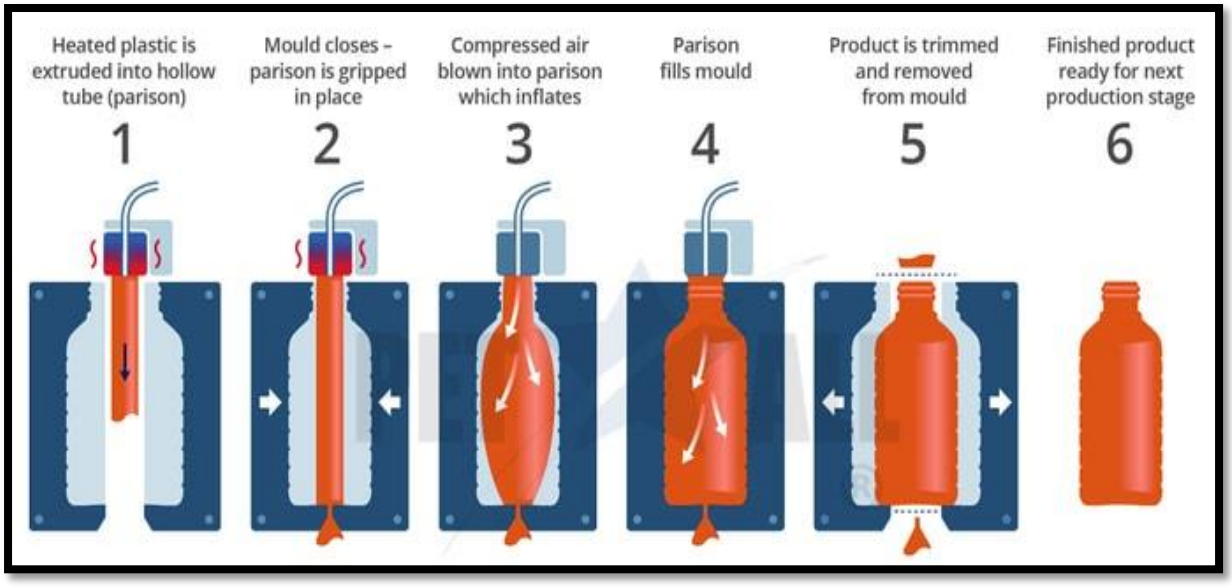

Figure 4 [3]

- ❖ The PET is extruded in hollow tube .
- ❖ Then compressed air is blown in the extruded PET till it takes the shape of mould cavity .
- ❖ Product is trimmed and removed from mould .

10. Carbon Fibre is now being extensively used in manufacturing industry. State why this process has superseded existing manufacturing processes. Explain ONE major disadvantage of using this material

Solution :

The strength to weight ratio of carbon fibre is very high therefore it is preferred over conventional materials.

The major disadvantage is its cost per kg is very high as compared to other material .

B. Problem Solving: (10 marks for each question)

1. A cylindrical riser must be designed for a sand-casting mould. The casting itself is a steel rectangular plate with dimensions 7.5 mx12.5mx2.0 m. Previous observations have indicated that the total solidification time (T_{TS}) for this casting is 16 min. The cylinder for the riser will have a diameter –to-height ratio=1. Determine the dimension of the riser so that its $T_{TS} = 20$ mins if knowing:
   - The volume of the rise is calculate by: $V = \frac{\pi D^2 h}{4}$ and
   - Surface area is given by $A = \pi Dh + \frac{2\pi D^2}{4}$
   - Total solidification time: $T_{TS} = C_m \left(\frac{V}{A}\right)^n$ and n=2

   Solution :

   For casting

   Solidification time $t = k \left(\frac{V}{A}\right)^2$

   Volume v = 7.5x12.5x2 = 187.5 m^2

   Area = 2x(7.5 x 12.5 + 12.5 x 2 + 2x 7.5) =267.5 m^2

   $$16 * 60 = k \left(\frac{187.5}{267.5}\right)^2$$

   $$k = 1959.18$$

   For riser (d=h)

   $$V = \frac{\pi D^2 h}{4} = \frac{\pi D^3}{4}$$

   $$A = \pi Dh + \frac{2\pi D^2}{4} = \pi D^2 + \frac{2\pi D^2}{4}$$

   $$\frac{V}{A} = \frac{D}{6}$$

   $$t = k \left(\frac{V}{A}\right)^2$$

   $$20 * 60 = 1959.18 \left(\frac{D}{6}\right)^2$$

   $$D = H = 4.8\, meters$$

   Dimensions of riser are

   $$\boldsymbol{D = H = 4.8\, meters}$$

2. An extruder barrel has a diameter D=50 mm. The screw rotates at N=2 rev/s. Channel depth $d_c = 6$mm and flight angle A=25^0. Head pressure at the end of the barrel $p = 5\ MPa$, the length of the barrel is $L = 2\ m$, and viscosity of the polymer melt is assumed to be $\eta = 100\ Pas$. Determine the volume flow rate of the plastic in the barrel Q_x if knowing
   - Volume drag flow rate: $Q_d = 0.5\pi^2 D^2 N d_c \sin A \cos A$
   - Back pressure flow rate: $Q_b = \frac{p\pi D d_c^3 sin^2 A}{12\eta L}$; and
   - $Q_x = Q_d - Q_b$

   Solution :

   Volume flow rate of the plastic in the barrel $Q_x = Q_d - Q_b$

   Volume drag flow rate: $Q_d = 0.5\pi^2 D^2 N d_c \sin A \cos A$

   $$Q_d = 0.5\pi^2 D^2 N d_c \sin A \cos A$$

   $$Q_d = 0.5\pi^2 * 50^2 * 2 * 6 * \sin 25 * \cos 25$$

   $$Q_d = 0.5\pi^2 * 50^2 * 2 * 6 * \sin 25 * \cos 25$$

   $$\boldsymbol{Q_d = 56621.2\ mm^3/sec}$$

   Back pressure flow rate: $Q_b = \frac{p\pi D d_c^3 sin^2 A}{12\eta L}$

   $$Q_b = \frac{p\pi D d_c^3 sin^2 A}{12\eta L}$$

   $$Q_b = \frac{5 * \pi * 50 * 6^3 * sin^2 25 * 10^6}{12 * 100 * 2000}$$

   $$\boldsymbol{Q_b = 12618.52\ mm^3/sec}$$

   $$Q_x = Q_d - Q_b$$

   $$Q_x = 56621.2 - 12618.52$$

   $$\boldsymbol{Q_x = 44002.67\ mm^3/sec}$$

C. Case Studies: Analyse existing products (50 marks)

Case 1: Continuous Positive Airway Pressure (CPAP) device (Figure 1)is used for Obstructive Sleep Apnoea (OSA) treatments. This product consists of many part assembly and mainly made by plastic.

Figure 5: CPAP device model [1]

Solution :

PART 1 : WATER CHAMBER

Figure 6: CPAP device model [1]

- List three main project requirements

  - ❖ Water chamber should be light in weight.
  - ❖ Water chamber should be compact and easily fitted in assembly
  - ❖ Easily remove from equipment for cleaning purpose .

- Discuss the selection of materials,

- ❖ Material used for chamber is high quality plastic , as this water chamber need to carry 420 ml of water so high density plastic is used . Plastic is light in weight as compared to metals/alloys .

- Discuss the selection of manufacturing processes and tooling and supporting processes required for each part

  - ❖ The water container can be manufactured using **injection moulding process.**
  - ❖ The plastic granules are poured from the top and force applied to plastic particles horizontally towards the chamber.
  - ❖ Inside the chamber , the cavity of water container shape is filled by plastic granules by the application of pressure .

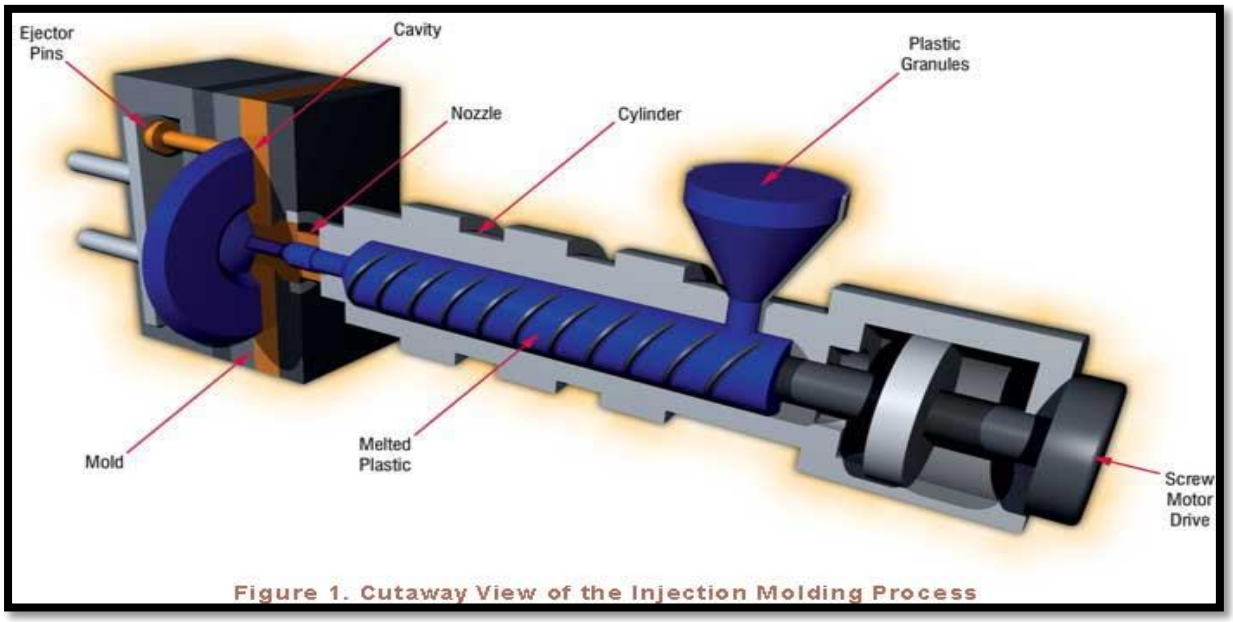

Figure 7: CPAP device model [4]

PART2 : INFO USB

Figure 8: CPAP device model [1]

- List three main project requirements

- ❖ USB should collect the sleeping data of user accurately .
- ❖ USB should be light in weight.
- ❖ USB should be compact and easily fitted in assembly

- Discuss the selection of materials,

  - ❖ Material used for USB cover is plastic , aluminium is used for pcb covering and copper is used as pcb material having silicon connection .

- Discuss the selection of manufacturing processes and tooling and supporting processes required for each part

  - ❖ The plastic part of usb can be manufactured using **injection moulding process.**
  - ❖ The plastic granules are poured from the top and force applied to plastic particles horizontally towards the chamber.
  - ❖ Inside the chamber , the cavity of covers shapes is filled by plastic granules by the application of pressure .
  - ❖ The aluminium cover is manufactured by sheet metal operation .

Figure 9: CPAP device model [5]

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