ME3210 Spring 2016 HW4 Solution

11.6

The main benefits to infiltration of a metal P/M part with another metal or polymer resin are:

(a) There can be a significant increase in strength;

(b) the infiltration can protect the P/M part from corrosion in certain environments;

(c) the polymer resin can act as a solid lubricant;

(d) the infiltrated part will have a higher density and mass in applications where this is desired.

11.13

Cold isostatic pressing (CIP) and hot isostatic pressing (HIP) both have the advantages of producing compacts with effectively uniform density (Section 11.3.3). Shapes can be made with uniform strength and toughness. The main advantage of HIP is its ability to produce compacts with essentially 100% density, good metallurgical bonding, and good mechanical properties. However, the process is relatively expensive and is, therefore, used mainly for components in the aerospace industry or in making special parts.

11.63

The volume of the cylindrical compact is $V = \pi[(25)^2/4]15 = 7360\ \text{mm}^3$. Loose, fine iron powder has a density of about 1.40 g/cm^3 (see Fig. 11.6a). Density of iron is 7.86 g/cm^3 (see Table 3.1). Therefore, the weight of iron needed is

$$\begin{aligned} W &= \rho V \\ &= (7.86\ \text{g/cm}^3)(7360\ \text{mm}^3)(10^{-3}\frac{\text{cm}^3}{\text{mm}^3}) \end{aligned}$$

or $W = 57.8$ g. Thus, the initial volume is

$$V = \frac{W}{\rho} = \frac{57.8}{1.40} = 41.3\ \text{cm}^3$$

10.34

Review Section 10.10 and Chapters 6 and 7. Note also that this topic is briefly described in Section 10.10.9. Applying traditional metalworking techniques to shaping of plastics is advantageous for several reasons. Since the stock shapes are similar (sheet, rod, tubing, etc.), well-known and reliable processes can be applied efficiently. Being able to utilize similar machines and many years of research, development, and experience associated with machine design and process optimization will have major significance in plastics applications as well.

10.48

The finishing operations required vary for different rapid prototyping applications. For example, in stereolithography, the part has to be cured in order to fully develop its mechanical properties (the laser does not fully cure the photopolymer), and then the part may need to be sanded or finely ground to obtain a desired surface. Also, often decoration is needed for aesthetic purposes. On the other hand, in fused deposition modeling, the finishing operations would involve removal of support material, followed by sanding and painting, whenever necessary. For a prototype of a toy automobile, the finishing processes would be as discussed.

10.67

The type of defect shown in Fig. 10.57 also occurs in metal forming (because of the flow of the material into the die cavity) and casting processes (because of excessive, localized surface shrinkage during solidification and cooling in the mold). This is described in various handbooks, but it should be noted that sink marks is a terminology restricted to polymer parts. For example, in Bralla, J.G., *Design for Manufacturability Handbook*, 2nd. ed., pp. 5.51, the sink marks are referred to as dishing for investment casting, and on p. 5.64 the same features are referred to as shrink marks.

12.11

Similarities: Both require electric power source, arcing for heating, and an electrically-conductive workpiece. Differences: the electrode is the source of the weld metal in

12.15

As descried briefly on p. 733, in solid state welding, the metals to be joined do not melt; there is no liquid state in the interface. Note that there are six processes listed under this category.

12.30

Inspecting the fusion zones, in Fig. 12.31, it is obvious that higher forces and speeds both result in more pronounced fusion zones. The relevant material properties are strength at elevated temperatures and physical properties such as thermal conductivity and specific heat. Because all materials soften at elevated temperatures, the hotter the interface, the more pronounced the fusion zone. Note also that a uniform (optimum) zone can be obtained with proper control of the relevant parameters.

6.13

The flash is excess metal which is squeezed out from the die cavity into the outer space between the two dies. The flash cools faster than the material in the cavity due to the high a/h ratio and the more intimate contact with the relatively cool dies. Consequently, the flash has higher strength than the hotter workpiece in the die cavity and, with higher frictional resistance in the flash gap, provides greater resistance to material flow outward through the flash gap. Thus, the flash encourages filling of complex die cavities.

6.28

There are advantages and disadvantages to each. Rolling at high speed is advantageous in that production rate is increased, but it has disadvantages as well, including:

- The lubricant film thickness entrained will be larger, which can reduce friction and lead to a condition where the rolls slip against the workpiece. This can lead to a damaged surface finish on the workpiece.
- The thicker lubricant film associated with higher speeds can result in significant orange-peel effect, or surface roughening.
- Because of the higher speed, chatter may occur, compromising the surface quality or process viability.
- There is a limit to speed associated with the power source that drive the rolls.

Rolling at low speed is advantageous because the surface roughness of the strip can match that of the rolls (which can be polished). However, rolling at too low a speed has consequences such as:

- Production rate will be low, and thus the cost will be higher.
- Because a sufficiently thick lubricant film cannot be developed and maintained, there may be a danger of transferring material from the workpiece to the roll (pickup), thus compromising surface finish.
- The strip may cool excessively before contacting the rolls. This is because a long billet that is rolled slowly will lose some of its heat to the environment and also by conduction through the roller conveyor.

6.118

This problem requires the same approach as in Problem 6.86 above. Thus, referring to Example 6.8,

$$1.25\epsilon_1 = n + 1$$

and hence

$$\text{Max reduction per pass} = 1 - e^{-(n+1)/1.25}$$

This means that, as expected, the maximum reduction is lower than that obtained for the ideal case in Example 6.8.