

Fig. 1. Solidification diagram for continuous casting.

2. Three cylinders were made of the same material. All cylinders had the same diameter of 4 cm and height of 3 cm. High temperature axial compression tests were performed on all cylinders at the same temperature. In all tests, a very efficient lubrication was used that completely prevented barreling effects. The first cylinder was subjected to the load of 1.25 t (1 t = 1000 kg) applied for the time interval of 100 s. The cylinder's height decreased from 3 cm to 1.9 cm. The second cylinder was subjected to the load of 1.5 t applied for the time interval of 50 s. The height of the second cylinder decreased from 3 cm to 2.1 cm. The third cylinder was subjected to the load of 1.35 t applied for the time interval of 2 min.
 - a) Estimate by calculation the height of the third cylinder after the deformation if the material had the strain rate sensitivity exponent equal to 0.5.

- b) Comment briefly on the expected accuracy of the obtained height estimate.
3. A wire with the diameter of 3.0 mm has to be drawn to the diameter of 0.75 mm. The deformation properties of the wire were tested by a tensile test using a specimen with the initial gauge section length of 4 cm and the diameter of 3.0 mm. In this test the maximum tensile force equal to 2.5 kN was reached when the length of the gauge section increased by 12 mm.
- a) Estimate by calculations the number of drawing passes that would be necessary to obtain the required final diameter assuming that the drawing conditions are ideal without friction and redundant work effects, and the plasticity of the metal is fully restored between the passes using annealing in vacuum.
- b) For the die geometry shown in Fig. 2 and the friction coefficient equal to 0.2 estimate by calculation if drawing can be performed using the number of passes obtained in part a) in real conditions.

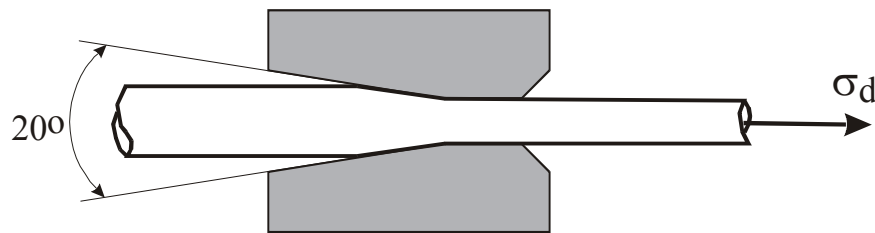


Fig. 2 Principle scheme of the drawing process and die geometry.

4. A 30 cm long workpiece is stretched by force F as shown in Fig. 3 until $\alpha=30^\circ$. The original cross-section area of the workpiece is 2.0 cm^2 . The material has a strain hardening curve described by:

$$\sigma = 250 \cdot \varepsilon^{0.45} \text{ MPa}$$

Assume that the ends of the workpiece are pin support clamped (i.e., are free to rotate) and that there is no friction between the stretching tool and workpiece (i.e., assume the free sliding of the load application point).

- a) Find the total work done during stretching.
- b) Find the maximum value of α that can be reached before necking begins.

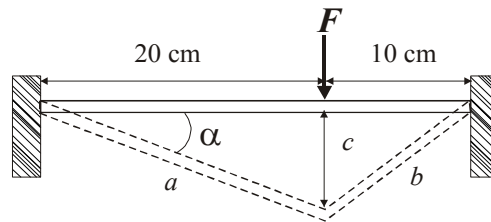


Fig. 3

5. An orthogonal machining operation is performed on a steel part 20 mm wide. The tool cutting depth is 0.2 mm, thickness of the chip is 0.22 mm and the tool rake angle is 12° . The cutting force is measured as 1920 N. Determine the shear angle and the friction coefficient between the chip and tool face, and estimate the yield strength of the workpiece material.
6.
 - a). Describe briefly the major advantages of the metal injection moulding process as compared to other powder metallurgy processes.
 - b). What are the driving force(s) and mechanism of densification during the sintering process used in powder metallurgy?
- a) List three major groups of fusion welding processes. For each group list two types of welding processes belonging to it.