1. What non-dimensional ratio of material parameters determines Springback?

A) $\frac{\sigma_y}{E}$ B) $\frac{E}{\sigma_y}$ C) $\frac{\sigma_u}{E}$ D) $\frac{E}{\sigma_u}$

$$\Delta K = 1.5K_y\left(1-\frac{1}{3}\left(\frac{K_y}{K_L}\right)^2\right) = 1.5\frac{\sigma_y}{E\frac{h}{2}}\left(1-\frac{1}{3}\left(\frac{K_y}{K_L}\right)^2\right) = \frac{\sigma_y}{E}\times\frac{3}{h}\left(1-\frac{1}{3}\left(\frac{K_y}{K_L}\right)^2\right)$$

---

2. For a sheet metal stock of a steel alloy with $\frac{1}{16}$ inch thickness, determine the minimum tool radius for that will not tear the material. Assume the sheet of material is in pure bending and no additional tension is applied during forming. $\sigma_u = 850Mpa$, $\sigma_y = 510Mpa$, $E = 202Gpa$

A) $377\ mm$ B) $188\ mm$ C) $252\ mm$ D) $157\ mm$

$$r_{min} = \frac{E\frac{h}{2}}{TS} = \frac{202000\times\frac{1}{2\times16}\times25.4}{850} = 188.5mm$$

---

3. Which statement is applicable to sheet metal forming processes?

A) May require many sequential forming stages to produce the final part

B) Use only for low production volumes

C) Are largely used to produce unique and custom parts

D) The production rate is slow

---

4. For the industrial and commercial sheet metal forming processes, what is the typical range of material thicknesses?

A) $0.01 - 10\ mm$

B) $0.1 - 10\ mm$

C) $1 - 2.5\ mm$

D) $0.1 - 2.5\ mm$

---

5. In cutting operation, the shearing force typically scales with the sheet metal's:

A. Yield strength B. Ultimate tensile strength

C. Young's modulus D. Elastic stiffness (EI)

---

6. A cylindrical workpiece is machined on a lathe. The spindle speed of a lathe is 2000 RPM, the feed rate is 0.01 cm/rev, the length of the part is 10 cm, the initial radius of the part is 5.0 cm, and a single cut is taken with depth of 0.1 cm. How long will the turning operation take?

A) 1 min B) 0.5 min C) 0.2 min D) 2.25 min

$x = vt\,, \quad 10 = \left(0.01 \times \frac{2000}{60}\right) \times t, \quad t = 30\ Sec$

---

7. Increasing which of the following parameters will result in an increase in the cutting force?

A) Rake angle B) Relief angle C) Rotation speed D) Feed rate

---

8. Which of the following steps can reduce tool wear while turning with a fixed feed rate?

A) Use a carbide tool instead of a high-speed steel tool

B) Use a ceramic tool instead of a carbide tool

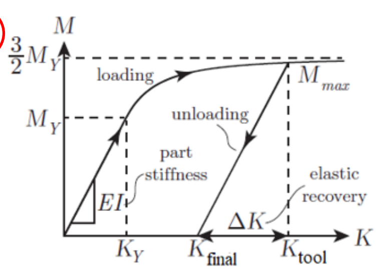
C) Use coolant on the tool

D) All the above

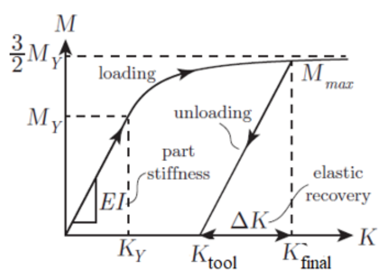
---

9. Which diagram shows the correct labels for a sheet metal forming?

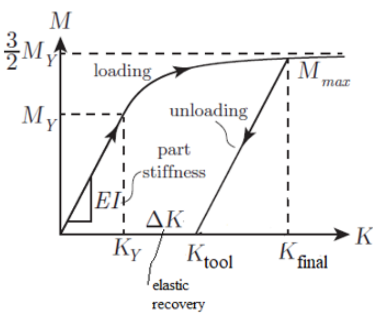
A.



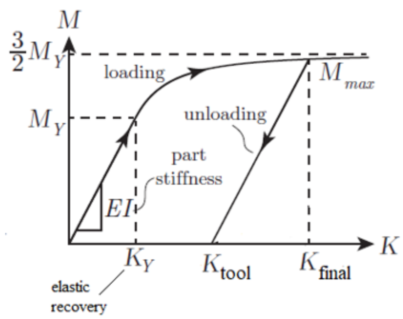
B.



C.



D.



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10. Which of the following influence the required cutting power during a turning operation?

A) Spindle Speed, Rake angle, Workpiece radius, Material strength

B) Rake angle, Workpiece radius, Material strength

C) Spindle Speed, Workpiece radius, Material strength

D) Spindle Speed, Rake angle, Material strength

Power=(MRR)(SCE), MRR=(Cutting Speed)(Feed Speed)(Depth of Cut), Rake angle does not affect Power.

11. How does the modulus of elasticity E , of a thermoplastic change with increasing temperature?

A) It increases until the glass transition temperature, then remains constant

B) It is constant until the glass transition temperature, then increases

C) It decreases gradually until the glass transition temperature, then drops suddenly at the glass transition temperature.

D) It decreases until the glass transition temperature, then remains constant

---

12. Why is it important to design injected molded parts to have uniform thickness?

A) For better strength B) So that the plastic cools uniformly

C) To reduce the risk of flash D) To prevent burn marks due to overheating of the plastic

---

13. If the gage pressure at the inlet of an injection mold cavity is 12 MPa, and the cavity has a length of 0.25 m, and a width of 0.04 m, estimate the average clamping force required.

A. 12000N B. 60000N C. 10000N D. Not enough information

$F = \frac{1}{2} \times \Delta P \times A = \frac{1}{2} \times 12000000 \times 0.25 \times 0.04 = 60000\ N$

---

14. Residual stresses in injection mold parts arise primarily due to:

A. Too high of pressure inside the mold

B. Insufficient packing pressure

C. Premature freezing of the gate

D. Uneven cooling in the mold

---

15. What may cause flash to form?

A) Low pressure B) High pressure C) Low temperature D) High temperature

---

16. How is over-molding different from insert-molding?

A. Over-molding must use a soft and a hard plastic, while insert molding places a metal component into the mold prior to injection.

B. Over-molding uses two plastics, while insert molding presses a metal insert into a part that is first injection molded.

C. Over-molding uses two plastics, while insert molding places a metal component into the mold prior to injection.

D. Over-molding uses two plastics, while insert molding uses a plastic and a resin.

17. Comparing injection molding to sheet metal forming, which statement is correct?

A. Injection molding has a higher process flexibility

B. Injection molding has a higher production rate

C. Injection molding has a higher part quality

D. Injection molding has a higher production cost

18. Estimating the cooling time of an injection molding part is important prior to production planning. In practice, as a rule of thumb, we often assume that T_m- T_w is about 10 times of $T_e - T_w$. Which of the following can be used as an initial estimation of cooling time?

A) $\frac{h^2}{4\alpha}$ B) $\frac{h^2}{\alpha}$ C) $\frac{h}{2\alpha}$ D) $\frac{h^2}{10\alpha}$

$$t_{cool} = \frac{h^2}{10\alpha} Ln\left(\frac{4}{\pi} \times \frac{T_m - T_w}{T_e - T_w}\right) = \frac{h^2}{10\alpha} Ln\left(\frac{4}{\pi} \times 10\right) = \frac{h^2}{4\alpha}$$

In fact, this approximation is very common in practice.

19. Increasing the temperature of a plastic decreases its viscosity. Why may a manufacturer <u>not want</u> to increase the temperature?

A. Increasing the temperature can degrades the plastic.

B. Higher temperature increases the cycle time.

C. Higher temperature requires more energy per part produced.

D. All above apply

20. Which of the following is the function of reciprocating screw in an injection molding machine?

reciprocating screw

A) Eliminate the center cooler temperature of the plastic inside the barrel, Transforming the raw material through the barrel, Mixing the plastic and create a uniform mixture of plastic inside the barrel, Generating heat

B) Eliminate the center cooler temperature of the plastic inside the barrel, Transforming the raw material through the barrel

C) Eliminate the center cooler temperature of the plastic inside the barrel, Transforming the raw material through the barrel, Mixing the plastic and create a uniform mixture of plastic inside the barrel

D) Transforming the raw material through the barrel

Explained in this video:

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21. A molten Polypropylene with a viscosity of μ=85 $Pa.Sec$ flow into a rectangular box of $100 \times 50 \times 2.5\ mm$ ($length \times width \times thickness$), if the pressure drop in the mold is about ΔP=3MPa. Estimate the time it takes to fill in the mold?

A) 0.55

B) 0.75

C) 0.95

D) 0.35

The pressure drops across the cavity ΔP can be estimated as:

$$\Delta P = \frac{12\mu QL}{Wh^3}$$

The time to fill the mold can be calculated as: $t = \frac{LWh}{Q}$

From these two equations, the required time to fill in the rectangular mold is $t = \frac{12\mu}{\Delta P}(\frac{L}{h})^2$

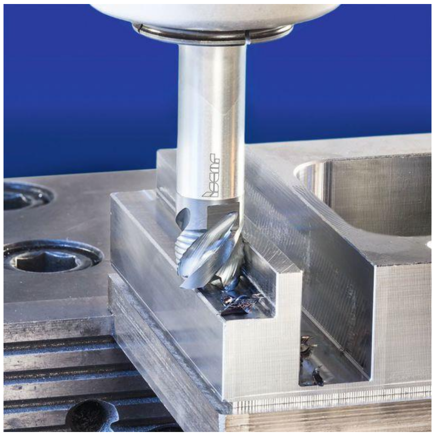
---

22. Which parameter does NOT affect the cutting force?

A) Depth of cut B) Feed rate C) Rake angle D) 4 Rotation speed

---

23. Consider an end-milling tool with diameter d, length L (from the holder to the tip), with n flutes, made of an AHSS with modulus of Elasticity E. Through a modal test (a type of vibration test) the modal mass of the system (the equivalent mass if we model the system as a single degree of freedom) is approximated as m. If we approximate the tool as a linear spring find a formula which roughly estimate the speeds which need to be avoided for a better surface finish? (in RPM)



A) $3.65d^2\sqrt{\frac{E}{mL^3}}$ and $3.65nd^2\sqrt{\frac{E}{mL^3}}$

B) $9.55d^2\sqrt{\frac{E}{mL^3}}$ and $9.55nd^2\sqrt{\frac{E}{mL^3}}$

C) $\frac{d^2}{8}\sqrt{\frac{3E}{mL^3}}$ and $\frac{nd^2}{8}\sqrt{\frac{3E}{mL^3}}$

D) $\sqrt{\frac{E}{m}}$ and $n\sqrt{\frac{E}{m}}$

First, we approximate the tool as a cantilever beam, and model it as a linear spring with stiffness:

$k = \frac{3EI}{l^3}$

$I = \frac{\pi}{64}d^4$

Avoiding resonance at speeds

$\omega = System\ Natural\ Frequencies$

And

$\omega = (number\ of\ flute) \times System\ Natural\ Frequencies$

Here we just consider the first natural frequency which is the dominant:

$\omega = n \times \sqrt{\frac{k}{m}}$ Or in RPM rotation speed= $\frac{60}{2\pi} \times n \times \sqrt{\frac{k}{m}}$

$Rotation\ Speeds\ to\ avoid\ resonance = \frac{60}{2\pi} \times n \times \sqrt{\frac{\frac{3E\frac{\pi}{64}d^4}{l^3}}{m}}$

---

24. Analyzing the chip thickness during machining may provide some useful information. Which case probably results in a better machining:

A) Smaller ratio of depth of cut to chip thickness

B) Larger ratio of depth of cut to chip thickness

C) Continuous chip

D) Chip with a lower temperature

Please see in class lecture notes (scan document camera Module#1 on Canvas).

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25. How to eliminate the Springback in sheet metal forming process?

A) Heating the plate before forming

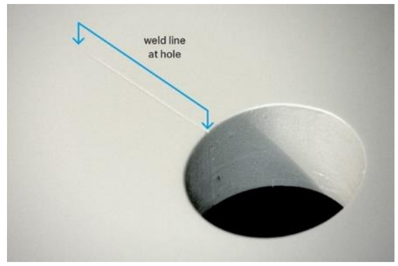
B) Use oil between the mold, plate, and punch

C) Stretch forming, where the sheet is loaded in tension prior to bending

D) Springback is due to elastic energy in a ductile material and there is no solution to eliminate it

---

26. In injection molding, weld lines appear in a part where molten plastics meet each other as they flow from two different parts of the mold. It is a line where two or more flow molten plastics knit together. These lines occur usually around holes or obstructions and cause locally weak areas in the molded part. Which of the following may solve this defect?



A. Adjust the design for the flow pattern to be a single source flow.

B. Increase the injection speed

C. Switch to a less viscous plastic

D. All the above

Reference Sheet

Machining:

Material Removal Rate: $MRR = (\pi DN)(Feed)(depth\ of\ cut)$,

$Feed = \frac{V_a}{N}$, V_a:Tool axial velocity, N: rotation speed
Shearing stress in turning: $\tau = G(\cot(\emptyset) + \tan(\emptyset - \alpha))$

Shearing angle: $\emptyset = \frac{\pi}{4} - \frac{\beta}{2} + \frac{\alpha}{2}$, α: Tool Rake angle
Friction angle $\beta = \tan^{-1}\mu$
Power consumption $P = \frac{MRR.SCE}{e}$, SCE: Specific Cutting Energy, e: efficiency
Shearing angle $\emptyset = tan^{-1}\left(\frac{r\cos(\alpha)}{1 - r\sin(\alpha)}\right)$
$r = \frac{t_0}{t_c}$, t_0: depth of cut, t_c:chip thickness
Feed per tooth in milling: $f = \frac{V}{N.n}$, n: number of teeth, V: tool velocity, N: rotation speed

Tool and Vibrations:

A milling tool can be modeled as a cantilever beam. Deflection of a cantilever beam with lateral force F at the tip: $\delta = \frac{Fl^3}{3EI}$, $I = \frac{\pi}{64}d^4$, vibration of a single degree, non-damped, subjected to harmonic excitation: $x(t) = \frac{\frac{F}{K}}{1-(\frac{\omega}{\omega_n})^2}\sin\omega t$, resonance/chatter for tool happens at ω_n or $(\text{number of flutes}) \times \omega_n$

Sheet Metal Forming:

Required force for cutting a sheet width b, thickness h: $F = \frac{1}{3}b.h.TS$, TS: tensile strength
Required force for forming:

- V-Bending: $F = \frac{4.TS.w.t^2}{3D}$ - Edge-bending: $F = \frac{TS.w.t^2}{3D}$

Springback: $\Delta K = 1.5K_y\left(1 - \frac{1}{3}(\frac{K_y}{K_L})^2\right)$, $K_{final} = K_L - \Delta K$
Yield curvature: $K_y = \frac{\sigma_y}{E\frac{h}{2}}$, K_L: Mold curvature

Minimum allowable radius without tearing sheet stock: $r_{min} = \frac{E\frac{h}{2}}{TS}$

Injection Molding:

Consider a rectangular mold $W \times L \times h$. The pressure drops across the cavity (length L) can be estimated by:

$\Delta P = \frac{12\mu QL}{Wh^3}$, μ: molten plastic viscosity

The time to fill the mold: $t = \frac{LWh}{Q}$, Q: flow rate
The clamping force, can be estimated by: $F = \frac{1}{2}\Delta P \times WL$
Required time for injection molding parts to cool down: $t_{cool} = \frac{h^2}{10\alpha}Ln(\frac{4}{\pi} \times \frac{T_m - T_w}{T_e - T_w})$
T_m: molten plastic temperature, T_w: wall of the mold temperature, T_e: ejection temperature,
α (thermal diffusivity), $\alpha = \frac{K}{\rho C_p}$, K: thermal conductivity, ρ:density, C_p:specific heat.