66 / 66 PTS

1. An automated fixture is being considered to improve a manufacturing process (see current rate information, below). If it is implemented, it will reduce the cycle time by 10.8 s to 43.2 s/part. It will also allow a 4.8% reduction from the current operator cost as less trained labor will be required, and it will allow the use of older machines that have already been depreciated – saving 19.20% off of the current machine rate. If the current MARR is 9% APR, compounded monthly, what is the ***maximum*** that can be spent to construct the tooling, if it must meet a 3 year payback?

Current Rates:

R = Labor Rate: $18.75/hr

R_m = Machine Rate: $8.04/hr

N = Production Req'd: 640 pieces/yr

$R_t = (\$18.75/HR)(1-.048) = \$17.85/HR$ 3 pts

$R_{mt} = (\$8.04/HR)(1-.192) = \$6.50/HR$ 3 pts

$t = \frac{43.2s + 10.8s}{pc} = \left(\frac{54 s}{pc}\right) \Rightarrow \left(\frac{54 s}{pc}\right)\left(\frac{1 HR}{3600 s}\right) = 0.015 HR/pc$ 3 pts

$t_t = \left(\frac{43.2 s}{pc}\right)\left(\frac{1 HR}{3600 s}\right) = 0.012 HR/pc$ 3 pts

$i = \frac{r}{m} = \frac{.09/yr}{12 mo/yr} = .0075/mo$ 3 pts

$n = (3 yr)\left(\frac{12 mo}{yr}\right) = 36 mo$ 3 pts

SOLVING FOR TOOLING COST: $(R+R_m)t - (R_t + R_{mt})t_t \geq \frac{C_t}{N}\left[\frac{i+(1+i)^n}{(1+i)^n - 1}\right]$

$$\Rightarrow C_t = \frac{N\left[(R+R_m)t - (R_t + R_{mt})t_t\right]}{\left[\frac{i+(1+i)^n}{(1+i)^n-1}\right]}$$

SUBSTITUTING & COMPUTING:

$$C_t = \frac{(3 YRS)\left(\frac{640 PCS}{YR}\right)\left[\left(\frac{\$18.75}{HR} + \frac{\$8.04}{HR}\right)\left(\frac{.015 HR}{PC}\right) - \left(\frac{\$17.85}{HR} + \frac{\$6.50}{HR}\right)\left(\frac{.012 HR}{PC}\right)\right]}{\left[\frac{.0075(1+.0075)^{36}}{(1+.0075)^{36} - 1}\right]}$$ 3 pts

$$C_t = \frac{(\$1920)\left[(\$.40185) - (\$.2922)\right]}{\left[\frac{.0098148}{.3086454}\right]} = \frac{\$210.528}{.0317997} = \$6\,620$$ 1 PT

24 PTS TOTAL

2. A lathe is used to turn the diameter of an SAE 1040 steel work piece at 185 BHN from 2.40 inches to 1.85 inches. The cutting speed chosen is 110 (not to be exceeded), and the feed is 0.016. The length of the cut is 14.93 inches.

a. What are the most appropriate U.S. Customary units for the cutting speed?

1 PT FEET PER MINUTE

b. What are the most appropriate U.S. Customary units for the feed?

1 PT INCHES PER REVOLUTION

c. Assuming sufficient power, is it appropriate to make this depth of cut if it is a roughing cut? (Briefly justify your answer from the presented slides.)

$$d = \frac{D_o - D_f}{2} = \frac{(2.40\text{ IN} - 1.85\text{ IN})}{2} = .275\text{ IN}$$

4 PTS SINCE $0.1\text{ IN} \leq 0.275\text{ IN} \leq 0.75\text{ IN}$, YES IT IS APPROPRIATE

(REF. SLIDE 12, LECT. 04)

d. Calculate the cutting time required to make the cut, as specified.

PTS

4 PTS $$N = \frac{Vk}{\pi D_o} = \frac{(110\text{ FT/MIN})(12\text{ IN/FT})}{\left(\frac{\pi}{\text{REV}}\right)(2.40\text{ IN})} = 175\text{ RPM}$$

2 PTS $$f_R = Nf = \left(\frac{175\text{ REV}}{\text{MIN}}\right)\left(\frac{.016\text{ IN}}{\text{REV}}\right) = 2.80\text{ IN/MIN}$$

2 PTS $$T_M = \frac{L}{f_R} = \frac{14.93\text{ IN}}{2.80\text{ IN/MIN}} = 5.33\text{ MIN} \quad (\doteq 320\text{ s})$$

e. Calculate the material removal rate for the cut, as specified.

$$MRR = \frac{\pi(D_o^2 - D_f^2)fN}{4} = \pi\left[(2.40\text{ IN})^2 - (1.85\text{ IN})^2\right]\left(\frac{.016\text{ IN}}{\text{REV}}\right)\left(\frac{175\text{ REV}}{\text{MIN}}\right)$$

5 PTS

$$= 5.14\text{ IN}^3/\text{MIN}$$

f. If the unit power for carbon steel at 185 BHN is 240,000 in-lb/in^3, estimate the cutting force for the specified cut.

$$P_c = F_c V \Rightarrow F_c = \frac{P_c}{V} = \frac{P_u(MRR)}{V}$$

5 PTS $$F_c = \frac{\left(\frac{240\,000\text{ IN-LB}}{\text{IN}^3}\right)\left(\frac{5.14\text{ IN}^3}{\text{MIN}}\right)}{\left(\frac{110\text{ FT}}{\text{MIN}}\right)\left(\frac{12\text{ IN}}{\text{FT}}\right)} = 935\text{ LBS}$$

24 PTS TOTAL

3. A face milling operation is being performed on a brass piece with a 6 inch diameter, 8-toothed HSS cutter.

a. Using a feed of .025 in/tooth, and a cutting speed of 180, find the cutting time (to the nearest second) if the length of the cut is 15.00 inches, and the width of the cut is 2.50 inches.

10 pts

4pts $N = \frac{VK}{\pi D} = \frac{(180 \text{ ft/min})(12 \text{ in/ft})}{\left(\frac{\pi}{\text{rev}}\right)(6 \text{ in})} = 115 \text{ RPM}$

3pts $f_R = N n_t f = \left(\frac{115 \text{ rev}}{\text{min}}\right)\left(\frac{8 \text{ teeth}}{\text{rev}}\right)\left(\frac{.025 \text{ in}}{\text{tooth}}\right) = 22.9 \text{ in/min}$

3pts $T_M = \frac{L + D}{f_R} = \frac{15.00 \text{ in} + 6.00 \text{ in}}{22.9 \text{ in/min}} = \underline{0.917 \text{ min}}$ -OR- 55 s

b. Find the material removal rate for the cut in Question 2a if the depth of cut is 0.025 inches.

3 pts

$MRR = w d f_R$

$= (2.50 \text{ in})(.025 \text{ in})\left(22.9 \frac{\text{in}}{\text{min}}\right)$

$= \underline{1.43 \text{ in}^3/\text{min}}$

c. Assume that the unit horsepower for brass is 0.8 hp-min/in^3. Can this particular cut be made on a 2 hp mill if the tooling is new and the motor is 75% efficient?

5 pts

GIVEN $HP_u = 0.8 \text{ HP-min/in}^3$

IF CUT CAN BE MADE, THEN $HP_G(E) \geq HP_c(MRR)$

$\Rightarrow HP_G \geq \frac{HP_u(MRR)}{E}$

$\Rightarrow 2 \text{ HP} \overset{?}{\geq} \frac{\left(\frac{0.8 \text{ HP-min}}{\text{in}^3}\right)\left(\frac{1.43 \text{ in}^3}{\text{min}}\right)}{.75}$

$\Rightarrow$ IS $2 \text{ HP} \geq 1.53 \text{ HP}$?

$\Rightarrow$ YES THE CUT CAN BE MADE AS SPECIFIED

18 PTS TOTAL