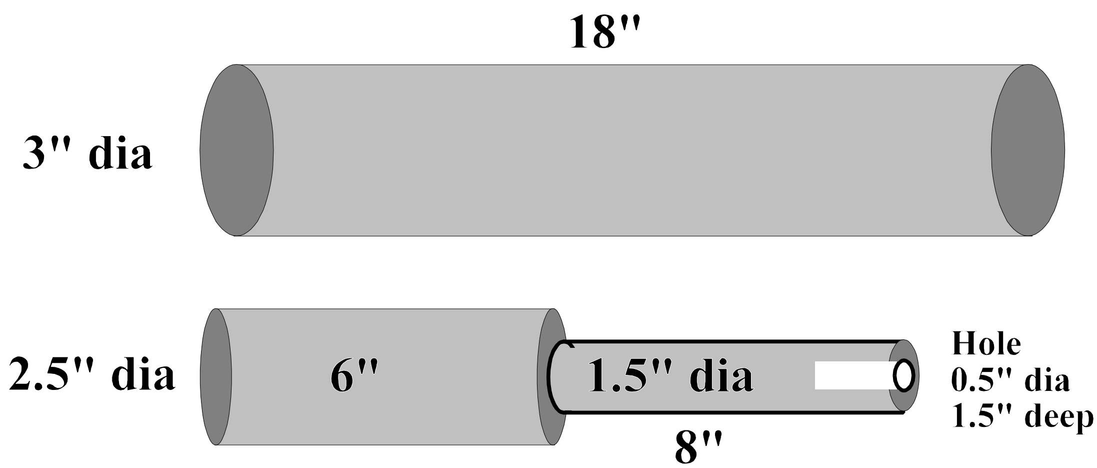
Solutions to Homework Number Four

Due Saturday November 14, 2015 (12 Noon)



1) Using the operations performed in the first machining practica (5th Week). Explain how you would make the following part shown at the bottom from the stock shown at the top.

Facing, parting, and turning are lathe operations used to reduce the dimensions of a cylinder. As in all lathe operations a tool is placed against a spinning work piece. The combination of the large centrifugal force (caused by the spinning workpiece) and the small cross sectional area of the tool (definition of sharp) creates a high stress at the surface of the workpiece enabling material removal.

Facing, parting, and turning differ in the manner in which material is removed.

- Parting is the separation of the workpiece. A piece is "cut-off". A sharp tool is moved completely through the workpiece. The motion is in the radial direction.
- Facing is similar to parting, in that the tools move in the same direction. However, facing involves removing a small amount of material from the end of the workpiece. It is used to level, the surface.
- Turning is used to remove small amounts of material from the surface of the cylindrical workpiece. A tool moves longitudinally along the cylinder and small amounts of material are removed.

Please note there are numerous correct answers as well as numerous incorrect answers.

Step 1: Face both ends of the 3" diameter stock (18" in length) to ensure there are common points of reference.

Step 2: Use the parting tool to ensure that the overall length is 14.5", this would ensure that there is some room for error.

Step 3: Face the surface remaining from parting. This again ensures that there is a common point of reference.

Step 4: Use turning to reduce the diameter to 2.5", make sure the depth of cut is no more than 0.10". It is always better to err on the side of caution. Thus 5 turning operations would be necessary.

Step 5: Use turning to reduce the diameter of the 8" section to 1.5" again make sure the depth of cut is no more than 0.10". It is always better to err on the side of caution. Thus 5 turning operations would be necessary.

Step 6: Center drill the spot where you want to place the hole.

Step 7: Start by drilling a 1/8" hole, then 1/4", then 3/8" and then 1/2". For each diameter use 0.25" increments.

The key is trying not to remove too much metal at a given time. Facing is necessary to ensure common reference points and finally I would create the hole as the last step for better stability while turning. I prefer not to have a hole in a chuck unless absolutely necessary.

2) Determine the power required for the second prescribed turning operation in problem 1. Assume that your feed rate is $1.5\text{x}10^{-3}$ mm/rev, that the lathe is running at 600 rpm, and that the material has a specific energy of 6.0 J/mm^3.

During the first turning operation the diameter of the workpiece was reduced from 24mm to 23mm. This means the depth of cut was 1mm. According to the specifications the process occurred at 770rpm.

The cutting speed is,

$$V = N\pi D = \left(770\min^{-1}\right)\pi\left(24mm\right) = 57.6\times10^{3}\frac{mm}{\min}$$

The material removal rate is,

$$Q = Vdf_r = \left(57.6\times10^{3}\frac{mm}{\min}\right)\left(1mm\right)\left(2.5\times10^{-3}mm\right) = 145\frac{mm^3}{\min}$$

The required power is,

$$P = UQ = \left(4.7\frac{J}{mm^3}\right)\left(145\frac{mm^3}{\min}\right) = 682\frac{J}{\min}$$

$$\left(682\frac{J}{\min}\right)\left(\frac{1\min}{60\sec}\right) = 11.4W$$

Note that J/min is not an appropriate unit of power. The conversion to Watts is needed.

3) A carbide tool is used to part cast iron. If the tool speed is 500 ft/min, the tool life is 60 minutes. If the tool speed is 600 ft/min, the tool life is 20 minutes. How much more expensive (based on tool costs alone) would it be to increase the tool speed from 500 ft/min to 700 ft/min?

The cost will increase due to two factors: 1) the increased energy requirements, and 2) the increased cost of tooling due to the decreased tool life.

<u>Not asked in ? But included as a study guide.</u>

Energy costs are proportional to the power required. Power is proportional to material removal rate, which for lathe operations is proportional to cutting speed. Thus the increased energy costs are:

$$\frac{C_2}{C_1} = \frac{V_2}{V_1} = \frac{700\,ft\ /\ \text{min}}{500\,ft\ /\ \text{min}} = 1.4$$

The energy costs would increase by 40%.

To determine the increase in tool cost, one must determine the decrease in tool life. The relationship between tool life (t) and cutting speed (V) is described by the Taylor equation.

$$Vt^n = C$$

where n and C are material constants. In order to determine the tool life at a cutting speed of 700 ft/min, it is necessary to calculate n and C from the given data.

n and C can also be found algebraically. n can be determined by taking a ratio.

$$Vt^n = C$$

$$\frac{V_1 t_1^n}{V_2 t_2^n} = \frac{C}{C} = 1$$

$$\frac{V_1}{V_2} = \left(\frac{t_2}{t_1}\right)^n$$

$$\ln\left(\frac{V_1}{V_2}\right) = n \ln\left(\frac{t_2}{t_1}\right)$$

$$n = \frac{\ln\left(\frac{V_1}{V_2}\right)}{\ln\left(\frac{t_2}{t_1}\right)} = \frac{\ln\left(\frac{500\,ft\ /\ \text{min}}{600\,ft\ /\ \text{min}}\right)}{\ln\left(\frac{20\,\text{min}}{60\,\text{min}}\right)} = 0.17$$

With n known, it is possible to determine C from the Taylor equation.

$$Vt^n = C = (500\,ft/\min)(60\min)^{0.17} = 1000$$

With n and C known, it is possible to calculate the tool life at a cutting speed of 600 ft/min.

$$Vt^n = C$$

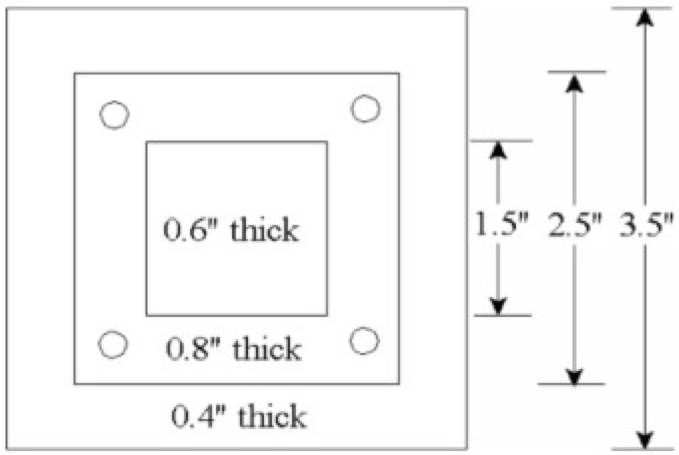
$$t^n = \frac{C}{V}$$

$$t = \sqrt[0.17]{\frac{C}{V}} = \sqrt[0..17]{\frac{1000}{700}} = 8\min$$

Thus at a cutting speed of 700 ft/min the tool life will be 8 minutes. This means the tool replacement costs would be 7.5x the original value.

Therefore increasing the cutting speed to 600 ft/min (from 500 ft/min), results in a 20% increase in energy cost and a 500% increase in tooling costs.

4) Consider the desk decoration shown below. Each hole is 1/8” in diameter, and ¼” deep. The thicknesses refer to the how thick the metal is as measured from the bottom surface. Assume this part is to be made from a 4in x 4in x 1in block of cast aluminum. Explain how you would make this part using the processes in the second machining practica (6th week).



The block of cast aluminum would have to be machined (like you did to make the base of the pencil holder). The first step would be to broach the sides and slab mill the surfaces to “square-up” and “level” the workpiece. Following this the workpiece must be carefully measured to ensure that the accuracy and precision of the next operations.

- First the entire piece should be slab milled until the thickness is 0.8". Following this step the holes could be drilled.
- The next step would be to use slot milling to reduce the thickness of the outer region to 0.4".
- Finally, one could use end milling to create the inner square.
- Following this one could drill the holes.

5) Your supervisor is confused because the costs of tool replacement and power are directly related in lathe operations but not in slab milling. Explain this to them.

The key here is to understand the source of confusion. Tool life is inversely proportional to tooling costs. Were one to plot tool costs and power costs for a lathe operation, one would see an apparent trend. This would not be the case for slab milling.

The required for a machining operation is the product of the specific energy of the material (U) and the material removal rate (Q). In lathe operations the material removal rate is proportional to the cutting speed (V). This is not the case in slab milling. Therefore, power and cutting speed are directly related in lathe operations but not slab milling. The life time of a tool decreases as cutting speed increases, which would increase tooling costs. Therefore in lathe operations both tool life and required power are related to the same parameter cutting speed. This makes them seem related. This is not true in slab milling.