Given: Gear required to transmit 21,000 lb-in of torque, hub length = 4.00 inch, 2.00 inch diameter shaft, AISI 1020 key material, cold-drawn.

Find: Minimum required key length.

Solution: From Shigley, Table A-20

$S_{ut} = 68 ksi$

$S_{yt} = 57 ksi$

Use a square key. This will result in both the shear and bearing lengths being satisfied by a single equation.

$$L = \frac{4TN_{fs}}{S_{yt}DW}$$

Choose $W = \frac{1}{4}D = \frac{1}{4}(2.00) = 0.5\,in$

Use factor of safety of 2.0

$$\Rightarrow L = \frac{4(21{,}000\,lb\text{-}in)(2.0)}{(57{,}000\,lb/in^2)(2.0\,in)(0.5\,in)}$$

$$= 2.95 \simeq \underline{\underline{3.00\,in}}$$

Given: V-belt sheave transmits 1,112 lb-in of torque to a 1.75 in-diameter shaft. The sheave is made from ASTM class 20 cast iron and has a hub length of 1.75 in. The key material is AISI 1020 cold-drawn steel.

Find: Design a parallel key and key seat.

Solution: Hub material properties (Shigley Table A-24)

$S_{ut} = 22{,}000$ psi. Note that cast iron does not exhibit a yield stress.

$S_{uc} = 83{,}000$ psi.

Key material (Shigley, Table A-20)

$S_{ut} = 68$ ksi

$S_{yt} = 57$ ksi

Since the compressive strength of the cast iron is greater than the yield strength of the key material, the bearing strength of the key will be controlled by the key material.

Choose a square key, and use a factor of safety of 2.0.

$$L = \frac{4 T N_{fs}}{S_{yt} D W}$$

Let $W = D/4 = \frac{1.75}{4} = 0.440$ in

$$L = \frac{4(1,112 \text{ lb-in})(2.0)}{(57,000 \text{ psi})(1.75 \text{ in})(0.440 \text{ in})}$$

$$= 0.202$$

This is much less than the hub length, and good practice would require a key approximately equal to the hub length.