A PROBLEM OF UNDERESTIMATING CONTRACTION FOR A SHRINK FIT

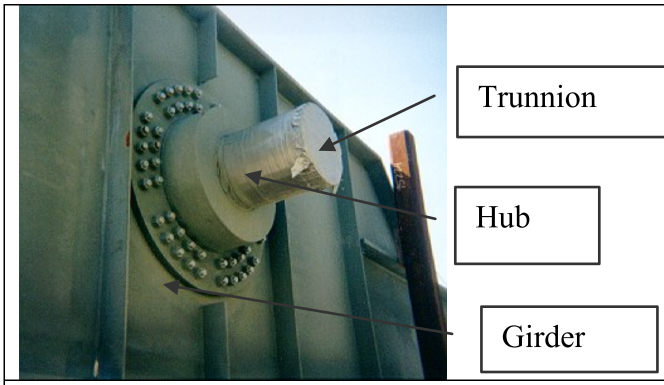

Figure 1 Trunnion-Hub-Girder (THG) assembly.

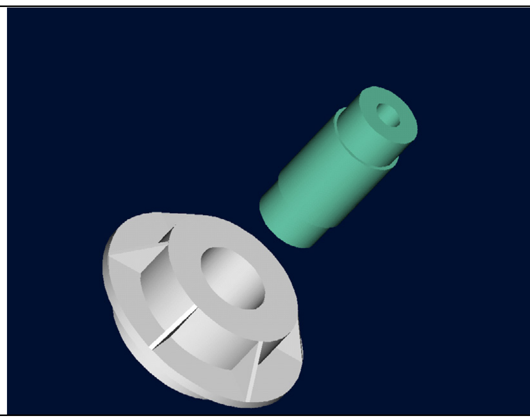

Figure 2 A contracted trunnion about to be slided through the hub after contracting

A trunnion needs to be shrink-fitted into a hub. For doing this, the trunnion is dipped into a cooling medium to contract the outer diameter of the trunnion so that it can be fitted into the hub. The contraction in the outer diameter of a trunnion (a hollow cylindrical shaft) is given by

$$\Delta D = D\alpha\Delta T \qquad (1)$$

where

D = outer diameter of the trunnion,

α = coefficient of thermal expansion coefficient at room temperature, and

ΔT = change in temperature, $\Delta T = T_{fluid} - T_{room}$

Given

$D = 12.363''$

$\alpha = 6.47 \times 10^{-6}$ in/in/°F at 80°F

$\Delta T = T_{fluid} - T_{room}$

T_{fluid} = temperature of dry-ice/alcohol mixture $(-108°\text{F})$

T_{room} = room temperature $80°F$

Assuming coefficient of thermal expansion is a constant is a gross assumption. In fact, coefficient of thermal expansion varies as a function of temperature (see Table 1) and the contraction in the diameter of the trunnion would be instead given by

$$\Delta D = D \int_{T_{room}}^{T_{fluid}} \alpha dT \tag{2}$$

The coefficient of thermal expansion can be approximated by a second order polynomial

$$\alpha = a_0 + a_1 \times T + a_2 \times T^2 \tag{3}$$

whose coefficients can be found by regressing it to the data given in Table 1.

Table 1 Instantaneous thermal expansion coefficient as a function of temperature.

Temperature	Instantaneous Thermal Expansion
°F	μin/in/°F
80	6.47
0	6.00
-80	5.43
-100	5.28
-160	4.72
-180	4.52
-260	3.58
-280	3.33
-300	3.07
-340	2.45

Problems

1. Find the contraction of the trunnion outer diameter using Equation (1).
2. Regress the data in Table 1 to the model given by Equation (3).
3. Find the contraction using Equation (2).
4. If the contraction needed is -0.015", find the minimum temperature of the cooling that would be needed.