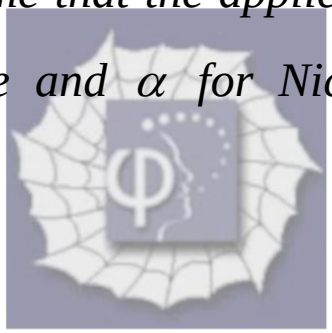
400.

Problem 32.50 (RHK)

A Nichrome heater dissipates 550 W *when the applied potential difference is* 110 V *and the wire temperature is* 800^0 C. *We have to calculate the amount of water that would be dissipated if the wire temperature were held at* 200^0 C *by immersion in a bath of cooling oil. We may assume that the applied potential difference remains the same and* α *for Nichrome at* 800^0 C *is* $4.0\times10^{-4}/\mathrm{C}^0$.



Solution:

We recall that relation between power, *P*, voltage, *V*, and the resistance, *R*, is

$$P=\frac{V^2}{R}.$$

The resistance of the Nichrome wire which dissipates 550 W at 110 V will be

$$R=\frac{V^2}{P}=\frac{110^2}{550}\ \Omega=24.2\ \Omega.$$

Assuming that variation of temperature is given by the relation

$$R(T) = R(T_0)\left(1 + \alpha\left(T - T_0\right)\right),$$

We find the resistance of the wire at 200^0 C from its value at 800^0 C. We have

$$R\left(200^0\ \text{C}\right) = R\left(800^0\ \text{C}\right)\left(1 - 4.0\times10^{-4}\times\left(800 - 200\right)\right)$$
$$= 24.2\times\left(1 - 0.24\right)\ \Omega = 18.39\ \Omega.$$

The dissipation rate of Joule heat at 200^0 C by the Nichrome wire at a potential difference of 110 V will be

$$P' = \frac{110^2}{18.39}\ \text{W} = 657.9\ \text{W}.$$