
UN1001
Reactor Chemistry and Corrosion

ASSIGNMENT #1

Due: March 26, 2006

Your research team has just completed corrosion testing on three materials that are candidates for replacement tubing in a sea-water-cooled shell & tube heat exchanger at your plant. The corrosion coupons were disks, 2.5 cm in diameter and 2 mm thick. A small hole, 0.5 mm in diameter was drilled near the top of each coupon for mounting purposes. All the samples were immersed in a high flow rate, sea-water environment for one year. The materials being considered are (along with some useful corrosion weight loss data and material properties):

	Carbon Steel	Admiralty Brass	Grade 2 Titanium
Density, ρ (g/cm ³)	7.8	8.5	4.5
Thermal conductivity, k (W/m.K)	60	111	22
Cost per m ² surface area	\$835	\$2 100	\$5 000
Mass before test (grams)	7.55439	8.36286	4.40035
Mass after test (grams)	4.63241	7.62415	4.40085
Mass after descaling (grams)	4.56003	7.53191	4.40002
Mass loss from blank (g/dm ²)	0.00156	0.00125	0.00009

- a) From the corrosion data provided, determine the corrosion rate of each material in the given environment and estimate the service-life of a heat exchanger fabricated with each material given the starting tube wall thickness of 1.7 mm and a minimum allowable wall thickness of 0.35 mm.
- b) Given that the duty of the heat exchanger, Q, is related to material selection through:

$$Q = UA\Delta T \quad \text{and} \quad \frac{1}{U} = \frac{1}{h_i} + \frac{r_i \ln(r_o/r_i)}{k} + \frac{r_i}{h_o r_o}$$

where:

Q = 50 MW	$r_i = 1.10$ cm
$\Delta T = 18^\circ\text{C}$	$r_o = 1.27$ cm
$h_o = 8\,000$ W/m ² .K	A = surface area available for heat transfer (m ²)
$h_i = 4\,000$ W/m ² .K	U = Overall heat transfer coefficient W/m ² K

Calculate the cost (net present value, NPV) of each option for the replacement of the heat exchanger with an expected plant service life of 30 years. Assume an interest rate of 6 % and annual maintenance costs of \$50k, \$50k and \$10k per year for the carbon steel, admiralty brass and titanium respectively. Neglect inflation. Which is the most economical option?