Quiz 5 **EMA 4714 - Materials Selection and Failure Analysis**
Friday, March 28, 2008 **Name ____**

Open Book/Open Notes

1. [10 points] Two batches [10,000 pieces each] of self-tapping steel fasteners were received from a heat treating facility who claimed that one batch had been tempered for twice the time as the other. The paperwork had been misplaced and there was no way of knowing which batch was which. A series of hardness measurements performed on pieces selected at random from each batch resulted in data contained within the table below. For your convenience, I have calculated means and standard deviations for the two sets of sample data. Based on your statistical analysis, and using a level of significance [α] of 0.05, does the data allow a determination that the two batches were subjected to different tempering times? Please show work!

Batch 1	Batch 2
51	47
50	44
52	45
52	39
48	46
52	44
48	41
47	42
49	47
51	49
Mean = 50.0	Mean = 44.4
s_1 = 1.89	s_2 = 3.06

s_2^2/s_1 = 9.378/3.556 = 2.638, less than F(table) = 3.180

Use Statistical Test 6, s unknown and $s_1 = s_2$ $s_{p2} = [(n_1-1)s_{12} + (n_2-1)s_{22}]/[n_1+n_2-2]$ = 6.467; $s_{x(bar)1-x(bar)2}$ = $[s_{p2}(1/n_1+1/n_2)]_{1/2}$ = 1.137
t_{obs} = $[x(bar)_1-x(bar)_2]/s_{x(bar)1-x(bar)2}$ = 4.924
H_o: $m_1 - m_2 = d = 0$
H_1: $m_1 - m_2$ not equal to 0
t_{dist} for n_1+n_2-2 =18 = 1.734 (1 tail) or 2.101 (2 tail); either way, t_{obs} lies in critical region - therefore null hypothesis can be rejected and there is a significant difference in the two batches with respect to hardness measurements. Therefore a difference in tempering times is statistically significant with batch 2 being tempered for a longer time.

2. [10 points] Modulus of rupture, i.e., 3 point flexure tests were performed on ceramic bars with dimensions l = 100 mm and b = d = 10 mm. The median value of σ_r was 300 MPa. The ceramic is to be used for components with dimensions l = 50 mm, b = d = 5 mm loaded in simple tension along their length. Calculate the tensile strength, σ_{ts}, which will give a probability of failure, P_f, of 10^{-6}. Assume m = 10. [l is span length, b is the width and d is the depth of a rectangular beam.]

a) Difference in volume: $\sigma_1 = [(V_2/V_1)^{1/m}]\ \sigma_2$ = 300MPa (10000 mm^3 / 1250 $mm^3)^{0.1}$ = 368 MPa

b) Difference in prob. (survival): $\sigma_2 = [(\ln P_{s1} / \ln P_{s2})^{1/m}]\ \sigma_1$ = $\{[\ln (0.5) / \ln (0.999999)]^{0.1}\}$ 369MPa = 96 MPa

c) Difference in loading: $\sigma_{tension} = \sigma_{MOR} / [2(m+1)^2]^{1/m}$ = 96 MPa / 1.73 = **<u>55.5 MPa</u>**

3. [10 points] Usually in the production of commercial optical fibers, a proof test is required guarantee a specific strength value. What is the physical mechanism by which the manufacturer can proof test these fibers? This method was discussed in class several times.

The fibers are tested in tension by having two spools used in the winding of the fiber as the fiber is being produced. The first spool rotates at a different speed than the second spool such that a tension is placed on the fiber at a pre-determined stress, e.g., 300 ksi. A laser monitor is used to adjust the speeds of the two relative to one another so that the stress is kept at that pre-determined stress level. Any part of the fiber that passes is guaranteed to have a strength of at least the pre-determined value.