KMU 479 MATERIALS SCIENCE AND TECHNOLOGY II
Midterm Take-Home Examination, Fall 2009
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Background

I. Weibull statistics for failure strength analysis

Strength of brittle materials such as ceramics and glasses depends on the size of flaws and its distribution in the material. The distribution of strength in ductile materials such as metals and most thermoplastic polymers can be represented by a narrow Gaussian distribution curve whereas a Weibull distribution curve would best represent the wider scatter in brittle materials as shown in Figure 1.

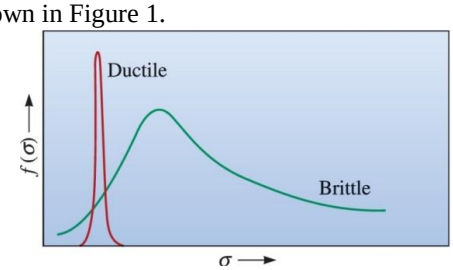

Figure 1: Weibull distribution showing fraction of samples that fail at any applied stress σ (Askeland & Phule, 2006)

Thus, Weibull distribution is an indicator of the variability of strength of materials resulting from a distribution of flaw sizes. The failure distribution for brittle materials shown in Figure 1 indicates that a small fraction of samples contain flaws that are large enough, i.e. larger than the critical size, to cause failure at low stresses, most samples fail at intermediate applied stresses, and few samples contain only small flaws which can withstand large stresses.

II. Ceramics in automotive applications

The automotive industry has always been in a search to improve the life and performance of the engine, brake and gear-box systems and to lower cost, emissions and fuel consumption by replacing the critical mechanical components with higher technology ceramics. Such ceramics may offer unique heat, wear, and corrosion resistance, and enhanced electrical and thermal insulation properties as well as reduce the total vehicle weight due to their light weight.

Goals

We are interested in finding the failure probabilities of ceramic materials used in the automotive industry, such as aluminum oxide (Al_2O_3) used for clutch/break systems (McCoy, 1999), C/C–SiC ceramic matrix composites with superior tribological properties used for advanced friction systems (Krenkel & Berndt, 2005), and others.

As it is common practice to use the Weibull theory to calculate the failure probabilities of ceramic materials, you are asked to:

1. Find literature, preferentially a journal paper that presents empirical data (minimum 20) on the failure vs. strength (applied stress) properties of ceramics used as automotive parts. Other material properties that show Weibull distribution behavior are also acceptable.
2. Write this data in Matlab and use the wblfit built-in function to determine the constant parameters of the Weibull distribution, σ_0 and m. If the journal paper already provides calculated values for σ_0 and m, compare your results with the published values (They should be similar).
3. Plot a graph of the Weibull probability distribution function of failure with respect to strength using the built-in Matlab function wblpdf.

This project is intended for groups of two students only.

Please submit your project both in print and electronically in report format, i.e. including an abstract/summary of your analysis, introduction, methodology, discussion of results, conclusion, references, and appendix, where you include your Matlab codes and a copy of the journal paper from which the data was extracted.

Use Times New Roman 10 pt and single spacing.

References

Askeland, D. R., & Phule, P. P. (2006). *The Science and Engineering of Materials* (5 ed.). Toronto: Thomson.

Krenkel, W., & Berndt, F. (2005). C/C–SiC composites for space applications and advanced friction systems. *Materials Science and Engineering: A , 412* (1-2), 177-181.

McCoy, S. L. (1999). Ceramic clutches and brakes live longer. *Machine Design (USA) , 65* (14), 55-56.