

**22.251 Systems Analysis of the Nuclear Fuel Cycle**  
**Fall 2009**  
**HOMEWORK SET #5**

**The purpose of this problem is to learn about determination of the effects of uncertainties in fuel manufacturing on the determination of the fuel (hot spot factor) temperature and coolant temperature rise (hot channel factors) in a PWR core.**

A fuel manufacturing plant produces nuclear pellets with an average density of 10,200 kg/m<sup>3</sup> and a random distribution standard deviation of 150 kg/m<sup>3</sup>. For simplicity, consider there are 50,000 rods in the core of a PWR, and each rod has 340 pellets. The nominal cylindrical pellet dimensions are 8.5 mm diameter and 11 mm height.

Problem 1. Considering the manufactured fuel density variability alone, answer the following questions:

- 1.1 What is the probability that a pellet will have a density equal to the theoretical density of 10,970 kg/m<sup>3</sup>?
- 1.2 What is the relative uncertainty in the temperature rise of the coolant in the hot channel within two standard deviations? The core is designed to have a nominal average temperature rise of 35 °C. The nuclear radial peaking factor is 1.5. Consider and compare the deterministic approach and the statistical one.
- 1.3 What is the relative uncertainty about the average temperature drop across a pellet, within two standard deviations? Assume that the fuel conductivity is 2.5 W/m °C.

Problem 2 Considering both density uncertainty and pellet diameter uncertainty, when the pellet diameter standard deviation is 0.05 mm, answer the following questions:

- 2.1 What is the relative uncertainty of the total uranium in the core at the level of 3 standard deviations? Use both a deterministic and a statistical approach and compare the results.
- 2.2 What is the answer to question 1.2 above?
- 2.3 What is the answer to question 1.3 above? Consider the deterministic and statistical approaches and compare them.

For temperature considerations in the fuel, Chapter 8 of Volume 1 of Todreas and Kazimi may be helpful. For statistical information, the slides of lecture #4 and Chapter 8 of Volume 2 of Todreas and Kazimi may be helpful.

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