MIT 16.90 Spring 2014: Problem Set 8

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Due: Monday April 28, in class

Problem 8. 1 *Monte Carlo Simulation*

Consider the model for turbine blade heat transfer presented in Section 3.3.2 of the online course notes. The matlab code blade1D.m (available on course website) contains the forward model for this problem.
The file contains the following function:
`function [Ttbc, Tmh, Tmc, q] = blade1D(hgas, Tgas, ktbc, Ltbc, km, Lm, hcool, Tcool)`

The function takes as inputs:

- `hgas` : the convective heat transfer coefficient between the thermal barrier coating (TBC) and the gas (W/m^2K)
- `Tgas`: the temperature of the gas surrounding the blade (K)
- `ktbc`: the TBC thermal conductivity (W/mK)
- `Ltbc`: the TBC thickness (m)
- `km`: the blade metal thermal conductivity (W/mK)
- `Lm`: the blade metal thickness (m)
- `hcool`: the convective heat transfer coefficient between the metal and the coolant (W/m^2K)
- `Tcool`: the coolant temperature (K)

The function returns the outputs:

- `Ttbc`: the temperature of the thermal barrier coating (K)
- `Tmh`: the temperature of the metal hot side (K)
- `Tmc`: the temperature of the metal cool side (K)
- `q`: the heat flux across the TBC (W/m^2)

We are interested in analyzing the effects of uncertainty in the TBC thickness (due to variability in the manufacturing process) on the heat transfer of the blade. In particular, we wish to assess how much uncertainty is introduced in the temperature of the blade metal hot side (`Tmh`), which is a key design consideration.

Tasks:

1. Write a MCS code that analyzes the effects of uncertainty in `Ltbc` on `Tmh`. Model `Ltbc` as a uniform random variable over the range 0.25mm to 0.75mm (0.00025m to 0.00075m). For the other inputs, use deterministic values of `hgas` = 3000 W/(m^2 K), `Tgas` = 1500 K, `ktbc` = 1 W/mK, `km` = 20 W/mK, `Lm` = 0.003 m, `hcool` = 1000 W/(m^2 K), `Tcool` = 600 K.

2. Conduct 10 separate Monte Carlo simulations, each using 100 samples. Tabulate your 10 estimates for the mean and variance of `Tmh`.

3. Conduct another 10 separate Monte Carlo simulations, each using 1000 samples. Tabulate your 10 estimates for the mean and variance of `Tmh`.

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