Random Particle Generation for a Failure Analysis on the Coated Fuel Particles of a HTR

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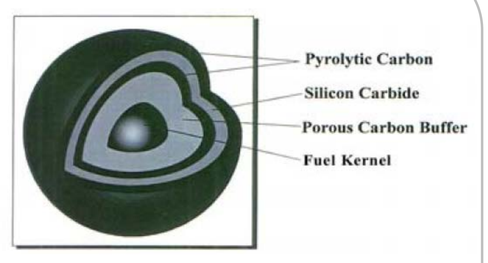
Objectives

- The statistical variations in the sizes and material properties of the coated fuel particle (CFP) components of a high temperature reactor (HTR) must be considered when doing a performance analysis on a batch of CFPs.
- This study describes how to generate random CFPs for a fuel performance analysis, and shows an example of the random particle calculations.



Random Particle Generation

- The CFP quantities (t's) with normal distribution are the diameter of a kernel, the thickness and density of a buffer, the thicknesses, densities, and bacon anisotropy factors (BAFs) of coating layers:

  $t = \bar{t} + y \cdot STD_t$

  where $\bar{t}$ and STD_t = the mean value and standard deviation of *t*, and *y* = the standard normal distribution deviate $\in$ (−∞, ∞) that is given by: $y_1 = \sqrt{-2lnR^2/R^2}(2x_1 - 1), y_2 = \sqrt{-2lnR^2/R^2}(2x_2 - 1)$
  where $R^2 = (2x_1 - 1)^2 + (2x_2 - 1)^2$, and *x* = the uniform distribution deviate $\in$ (0, 1).

- The CFP quantities (y's) with Weibull distribution are the strengths of coating layers:

  $\mathrm{y} = \lambda[-ln(1 - F)]^{1/m}$,
  where *F* = the Weibull cumulative distribution function $\in$ (0, 1), *y* = the Weibull distributed random variable, *m* = the shape parameter (〉0), λ = the scale parameter (〉0).

- A usual random number generator (RNG) produces x and *F* on (0, 1).

Generation Results and Summary

- A method generating random CFPs has been developed that use only a random number generator during a fuel performance analysis.
- The method produces statistical properties of a batch of CFPs using a uniform random number produced by a usual RNG.
- The method is utilized in a statistical fuel performance analysis on a batch of CFPs.

An example of CFP stochastic variables

Layer	Thickness (μm)	Weibull strength	
		Shape parameter	Median strength (MPa)
IPyC	40±0.04	9.5	350
SiC	35±0.035	6	770
OPyC	40±0.04	9.5	350

Calculated ten random particles

No	Thickness (μm)			Strength (MPa)		
	IPyC	SiC	OPyC	IPyC	SiC	OPyC
1	40.094	35.012	39.890	331.858	925.776	386.294
2	39.528	34.387	40.053	277.155	921.432	319.319
3	39.893	35.376	39.911	347.581	724.465	398.108
4	39.885	35.088	39.317	244.809	738.773	368.401
5	39.278	34.875	39.861	384.857	603.836	198.999
6	40.234	34.774	40.622	375.566	902.519	335.816
7	39.618	35.275	40.508	331.89	597.887	272.041
8	39.559	35.259	39.745	351.084	808.441	198.516
9	40.641	34.900	40.062	353.203	955.375	342.118
10	40.282	35.494	40.661	283.092	651.206	363.768