# USE OF MICROSTRUCTURAL DATA FOR VERIFICATION OF FUEL MATERIAL SWELLING MODELS

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This presentation describes methods for verifying proposed models for reactor fuel material swelling using quantitative data obtained from microstructural observations. Because of the range and interaction of the mechanical, thermal, and radiation conditions encountered in reactor fuel elements, microscopic structural observations provide the only source that contains sufficient information to verify fuel swelling models. If theoretical mechanical structural evaluations are to be meaningful, models describing the basic driving force for fuel element failures must be validated. Such validation requires that controlled fuel irradiations, specialized specimen preparation and observation, automated microstructural data collection, probabilistic formulation of fuel swelling models, statistical evaluation and programmed data reduction all be combined into a working system.

Various methods for quantitatively interpreting microstructural data are related to their uses for verifying swelling models. Methods for evaluating accumulative properties (volume increase, bubble density count, specific bubble surface area, etc.) in fuel materials having random spatial distributions (describable by a Poisson process) are used to evaluate empirical models. New methods for estimating these properties are described. Size distributions of bubbles are predicted by some models: thus, methods for estimating such size distributions are used to verify these models. A new development for evaluating statistical estimations of size distributional parameters is described. The most detailed and advanced swelling models make predictions of both the size and spatial distributions of swelling bubbles. The combined probabilistic formulation of these models with specialized statistical estimation procedures provides the means for testing the hypotheses used in these models. An application of this technique to a grain boundary dependent swelling model is described.

As the models become more structured the quantification requirements for the microstructural data become more demanding. Sizing, relative location, and in cases even shape have to be determined. The scanning electron microscope has been used to observe swelling bubble distributions and locate where such observations have been made. A specialized automated system that quantitatively evaluates the scanning electron microscope signals for both spatial and bubble size data is described. Thus, this presentation describes the various elements necessary to validate fuel swelling models with microstructural data and illustrates how these elements are used in actual applications.

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## DISCUSSION

**Q** H. WALTHER, Italy

We learned much from your lecture about methods of analysing measurements on fuel swelling and testing models to explain the phenomena. As in stress analysis we have uncertainties in data for swelling, it would be already useful to have phenomenological results for volume swelling in function of parameters as temperature, dose, pressure, even when the swelling models themselves remain temporarily on the state of hypotheses. Are new data available ?

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Progress has been made in interpreting temperature and fluence dependent models for metallic fuel materials. Application of the same techniques to oxide fuels has encountered observational problems. The evaluations of irradiated oxides that have been made were only felt to be of qualitative value because of difficulties in developing the observational techniques.

Characterization of the unirradiated material is first required to evaluate changes of void size distributions. The quantitative techniques described in this paper are presently being adapted for the unirradiated material and as yet have not been successfully applied to observations of irradiated oxides.