November 8, 1999

NOTE TO FILE

FROM: Joe Joyce

ALLEGATION NO. NRR - 1999 - A - 0057

SUBJECT: Phone Calls with Two Experts on Texture Analysis of Zirconium Alloy Tubing.

Summary of Teleconference Call to Dr. K.L. Murty

A teleconference call between Dr. K.L. Murty, Professor in the Nuclear Engineering Department of North Carolina State University, and the staffs of NRR and NMSS was held on October 28, 1999, to discuss various aspects of texture analysis of zirconium alloy tubing.

In summary, it was Dr. Murty's opinion that the techniques employed for texture analysis cannot inadvertently be used to qualify substandard material. However, it was also his opinion that poor sample preparation (i.e., surface roughness or waviness) and the improper operation of the equipment used to obtain the texture analysis results can produce inaccurate results. In performing texture analysis, the identification of both the magnitude of the maximum peak intensity and the location of peak maxima in relation to the radial direction of the basal direct pole figures is one way to evaluate the texture of the zirconium alloy material. Using the basal direct pole figure, substandard material would be identified if peak intensities and/or the locations of the peak maxima were outside their acceptable ranges. It was also Dr. Murty's opinion that texture analysis, alone, cannot be used to determine the intrinsic mechanical properties of the tubing material. Rather, texture analysis can be used to estimate mechanical properties relative to certain directions of the tubing. For example, the results of a texture analysis may show that the tensile strength of the tube in the axial direction is larger, or smaller, than the tensile strength in the radial direction.

Other participants:
Kim Gruss, NMSS
Greg Cwalina, NRR
Jim Davis, NRR

Summary of Teleconference Call to Ron Kesterson

A teleconference call between Ron Kesterson, Fellow Engineer of Materials Fuel Rod Design, in the Commercial Nuclear Fuel Division of Westinghouse Electric, and the staffs of NRR and NMSS was held on November 2, 1999, to discuss various aspects of texture analysis of zirconium alloy tubing.

Mr. Kesterson indicated that Westinghouse Electric Company (WE) employs a test that evaluates the contractile strain ratio (CSR) as a check on the control of the tubing manufacturing processes. The mechanical properties of the cladding are correlated to the CSR. When the calculated CSR is found to be within a specified range, the mechanical properties of the material are found to be acceptable. WE does not conduct texture analyses, i.e., direct pole figures, on a

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routine basis to evaluate to characteristics of the tubing that it manufactures. Rather, texture analyses are performed more typically as part of an evaluation of new product material or a new manufacturing process. In addition to the CSR, WE also performs a tensile test to evaluate the mechanical properties of the cladding on a per lot basis. Mr. Kesterson also indicated that it is more cost effective to use the CSR method to evaluate WE's tubing rather than conducting texture analysis.

It was Mr. Kesterson's opinion that the techniques employed for texture analysis cannot inadvertently be used to qualify substandard material. The data from a properly prepared specimen, using equipment that has been adequately prepared for texture analysis, will produce results that are representative of the specimen's (or material's) texture. Mr. Kesterson noted further that the mechanical properties of cladding material that is tested using an axial tensile test would be about the same regardless of whether the cladding has a predominant radial or a predominant circumferential texture. However, the mechanical properties of radially oriented versus circumferentially oriented texture could be different if the material was tested using a biaxial rod pressurization test.

Other participants: Kim Gruss, NMSS

Conclusion:

Based on the phone calls with the experts, we have concluded that the techniques employed for texture analysis cannot inadvertently be used to qualify substandard material. We believe that texture analysis may be used to ensure the tubing manufacturing process(es) are adequately controlled. There are other techniques, such as calculation of the contractile strain ratio, tensile testing, burst testing, etc., that may be used to determine whether tubing material that is manufactured in bulk quantities meets the fabricator's acceptance criteria for cladding mechanical properties. Not knowing for sure how GE Nuclear uses the test results from Lambda Research, one could speculate that, perhaps, the data (including the pole figures and Kearn's numbers) are being used to validate a new manufacturing process.

Therefore, we don't need to send a referral letter to GE Nuclear. Instead we will write a closeout letter to the alleger stating his concerns were not safety significant and the basis for that conclusion. This is consistent with our recommendation to the board.

Recommended Experts:

1. K.L. Murty, North Carolina State University, Professor, Nuclear Engineering Department, specializes in texture analysis and creep of zirconium alloys, has written many refereed papers on texture and creep of zirconium alloys. 919-515-3657. Appointment: Thursday, 10:30am, 10/28/99.

2. P.L. Rittenhouse, formerly employed at ORNL but is now retired, specialized in texture analysis, has also written many refereed papers on texture and creep of zirconium alloys.

3. R.L. Kesterson, Westinghouse Electric Company, Materials Fuel Rod Design for the Commercial Nuclear Fuel Division, would know about use of texture analysis to qualify materials or fabrication processes. 803-647-3277. Appointment: Tuesday, 3:00 pm, 11/2/99

4. Possible: Seimens Corporation, fuel fabrication, expert on texture analysis, waiting to hear back from a contact at PNNL

Questions to ask the expert:

1. How do fuel cladding manufacturers use texture analyses to qualify the material? Do they use the analyses to validate that the material has certain minimum mechanical properties? Or, do they use the analyses to verify the fabrication processes were done correctly? What are the acceptance criteria?

2. Can the results from texture analyses be used to qualify substandard material?

Letter to Murty

⇒ CC: RES, Thadani +/or Someone else

Jim out Wed, Tues or Thurs best for Jim

Recommended Experts:

1. K.L. Murty, North Carolina State University, Professor, Nuclear Engineering Department, specializes in texture analysis and creep of zirconium alloys, has written many refereed papers on texture and creep of zirconium alloys. @ 919-515-3657 Thurs, 10/28, 10:30 am

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3. R.L. Kesterson, Westinghouse Electric Company, Materials Fuel Rod Design for the Commercial Nuclear Fuel Division, would know about use of texture analysis to qualify materials or fabrication processes 803-647-3277 Thurs., ~~10/28/99~~ 1/30 pm

She-Liang Wu may be best

Questions to ask the expert:

1. How do fuel cladding manufacturers use texture analyses to qualify the material? Do they use the analyses to validate that the material has certain minimum mechanical properties? Or, do they use the analyses to verify the fabrication processes were done correctly? What are the acceptance criteria?

2. Can the results from texture analyses be used to qualify substandard material?

3. What effect does taking a DPF at 2θ located 0.5° away from the max. I take on the DPF (location of peak maxi

4. What would be an acceptable variation in max. 2θ peak inte to take th pole fi

Referral ⇐ Nov. 23rd

to

5. Have you ever seen pole fig data where (0002) planes are positioned ± ≈35° from LD? Oct 28th Initial Contact + hopefully call-out

how to conduct the interviews?

(*) Need a Summary of interviews to put into Allegation files Format?

test would identify bad data? ; allege incompetence?

- make initial phone calls,
- set up phone calls

- safety issues
- get your opinion

Teleconference Call Summary

Thursday, 10/28/99, 10:30am

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1. Can the results from texture analysis be used to qualify substandard material? For example, can substandard material be found acceptable:

   i. from partial direct pole figures (i.e., φ>60°, the specimen tilt angle measured from the surface normal)

   ii. if only one test specimen is prepared (i.e., the RD specimen) vs. 3 orthogonal specimens

   iii. even though the maximum intensity, I_{max}, and the location of the basal plane maxima, φ_{RD}, on a RD-TD (i.e, radial direction-transverse direction) direct pole figure are within the expected ranges

2. What effect does obtaining data from the shoulder of a 2-theta peak (i.e., 0.5° away from the maximum intensity) have on a direct pole figure?

3. Regarding direct pole figures, what would be an acceptable variation in peak intensity (at 2-theta) and location of the basal plane maxima from one sample to another?

4. Have you ever seen pole figure data where the basal planes (i.e., the (0002) planes) are positioned ±35° from the longitudinal direction of a tube specimen on a RD-TD direct pole figure? How would the mechanical properties of cladding with this type of texture differ from cladding material with a basal pole maxima located ±35° from the RD (on a LD-TD direct pole figure)?

Teleconference Call Summary

Tuesday, 11/2/99, 3:00 pm

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1. How do fuel cladding manufacturers use texture analyses to qualify the material?

   a. Do they use the analyses to validate that the material has certain minimum mechanical properties?

   b. Or, do they use the analyses to verify the fabrication processes were done correctly?

   c. What are the acceptance criteria for the texture analyses?

2. Can the results from texture analysis be used to qualify substandard material? For example, can substandard material be found acceptable:

   a. from partial direct pole figures (i.e., φ>60°, the specimen tilt angle measured from the surface normal)

   b. even though the maximum intensity, I_{max}, and the location of the basal plane maxima, φ_{RD}, on a RD-TD (i.e, radial direction-transverse direction) direct pole figure are within the expected ranges

3. What effect does obtaining data from the shoulder of a 2-theta peak (i.e., 0.5° away from the maximum intensity) have on a direct pole figure?

4. Regarding direct pole figures, what would be an acceptable variation in peak intensity (at 2-theta) and location of the basal plane maxima from one sample to another?

5. Have you ever seen pole figure data where the basal planes (i.e., the (0002) planes) are positioned ±35° from the longitudinal direction of a tube specimen on a RD-TD direct pole figure? How would the mechanical properties of cladding with this type of texture differ from cladding material with a basal pole maxima located ±35° from the RD (on a LD-TD direct pole figure)?