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Strength Testing of Ferrite E-Cores: Manufacturer Comparison

Jonah Carmichael, Kevin Strong, and Brenton Elisberg

Background

- Ceramic ferrites are iron(III) oxide materials doped with metallic elements to create ferrimagnetic materials that are electrically non-conductive.
- Mn-Zn ferrites are used as the core in compact transformers (Fig. 1) used in electronics.
- Large production rates and multiple vendors of these cores makes reliability a concern for high risk industries (e.g. aerospace).

Figure 1. Transformer with two E-core ferrites bonded together.

Approach

- Test E-cores in condition to simulate failure in realistic application.
- Compare strength of two ferrite manufacturers to determine processing-microstructures effects on mechanical performance.
- Analyze tests using Finite Element Analysis to determine stress at failure.

Experimental Method

- A set of specimens from each vendor was tested in three point bending (Fig. 3).
- Two orientations were used in testing to investigate the two outcomes that were of interest (Fig. 2)
- A sample from each manufacturer was polished and etched for microstructural analysis

Weibull Probability Plot

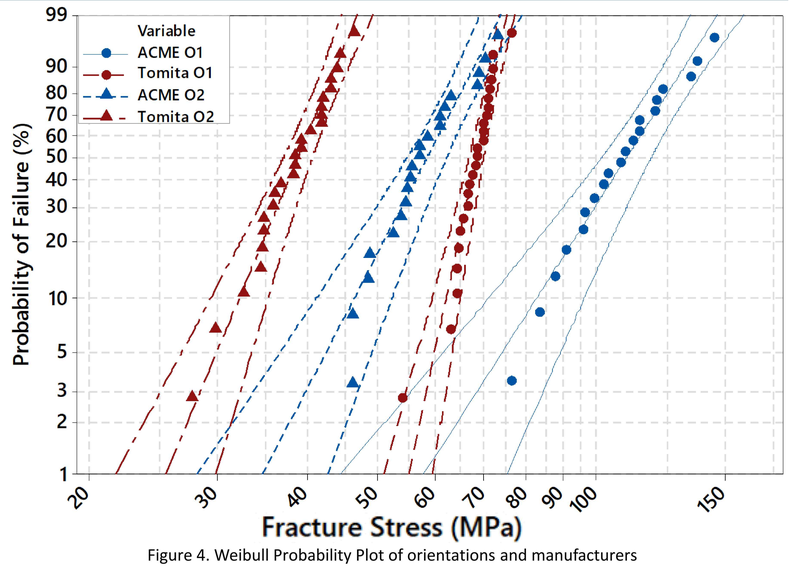

Figure 4. Weibull Probability Plot of orientations and manufacturers

Microstructural Comparison of Vendors

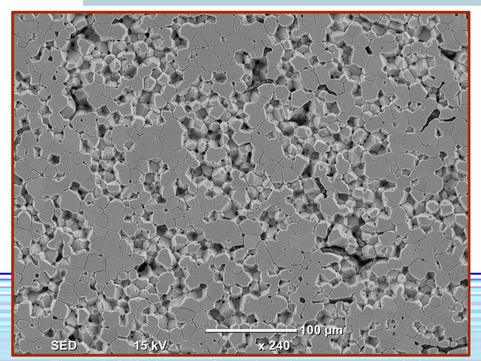

Figure 5. SEM image of Tomita microstructure at 240x

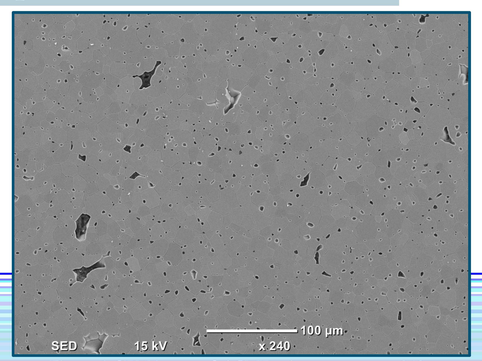

Figure 6. SEM image of ACME microstructure at 240x

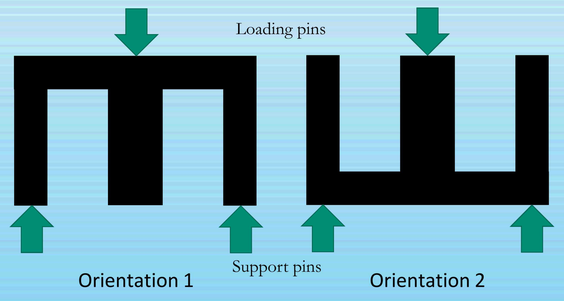

Figure 2. Orientations of the three point bend test

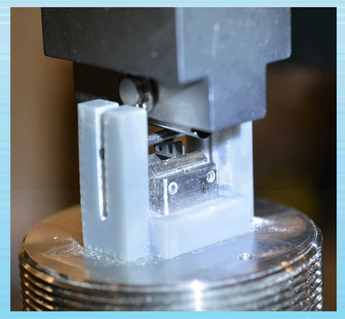

Figure 3. Experimental set-up of specimen in orientation 2.

Analysis

- The unorthodox shape of the bending specimen required the use of FEA to calculate a failure stress.
- The specimens tested in orientation 1 saw lower failure loads but higher failure stresses due to the inner fillet acting as a stress concentrator.
- Failure loads and stresses are likely very sensitive to the fillet radius produced during machining.
- Tomita material has a significantly larger pore structure when the etched material is compared between vendors.

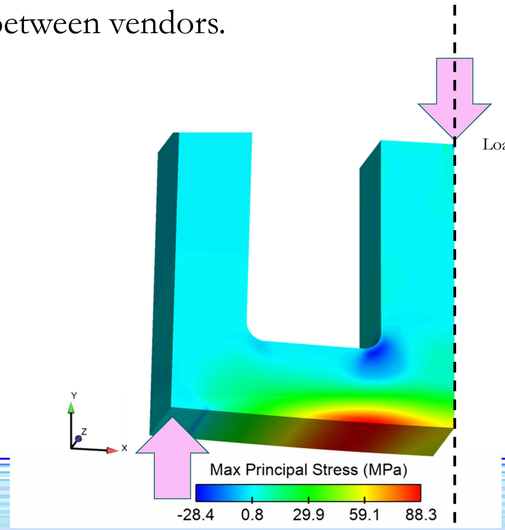

Figure 7. FEA mirror showing the stress concentration on half of a sample tested, in orientation 2

Summary

- The pore structure of the Tomita ferrite is likely what determines the strength difference between the manufacturers' material.
- Orientation 1 saw a higher failure stress due to a lower effective area of material being tested

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