Analysis of Superconducting Wires

The main goal of superconducting wires is to improve performance for generating higher magnetic fields. The best option for higher field magnets is Niobium-Tin wire (Nb3Sn). The wire is constructed with a tin (Sn) core surrounded by niobium (Nb) rods inserted into a copper (Cu) jacket. An extended heating process is required to fuse the two elements to create the superconductive A15 phase compound. Nb3Sn is a low temperature superconductor, meaning it only passes its superconductive properties when cooled to a temperature of 4K. The Nb3Sn wire strands will first go through a polishing process before being analyzed using Princeton University’s XL30 ESEM-FEG to determine the presence and location of any defects or voids within the preheat treated wire. The wire strands are then be heat treated and analyzed using the scanning electron microscope to see if any voids or cracks have occurred in the Nb3Sn filaments.

First Polishing:
- It was not optimal.
- All 5 of the wire samples were cut to a 1.5’ length.
- The wires’ end with the cutter’s edge were not flattened at first, so when put against the grit it, it destroyed the paper.
- The time spent per sample on the Buehler Optical Fiber Polisher was not recorded.
- The samples were left on the machine until no contact noise between the wire and the grit was being heard by ear. If no noise was heard, then the wire was observed, and if it looked circular and the next grit was put in place.
- The process was repeated three times with a 12, 6, and 1 micron grit.
- The process was strictly objective.

Second Polishing:
- It was more effective.
- The length of the samples did not change from 1.5”. The pieces were then taped together and hand lapped with a water solution using a 600 grit Buehler Optical Fiber Polisher until the surface was clipped by the wire was smooth. Process continued as listed below:
  - Machine lapped wet on 1000 grit, light pressure for 1 hr. (x5 wires) CCW
  - Machine lapped wet on 1,200 grit, light pressure for 1 hr. (x5 wires) CCW
  - Machine lapped wet on 1,500 grit, light pressure for 1 hr. (x5 wires) CCW
  - Machine lapped wet on 6,000 grit, light pressure for 1 hr. (x5 wires) CCW
  - Machine lapped wet on 12,000 grit, light pressure for 1 hr. (x5 wires) CCW
  - Machine lapped wet on 14,000 grit, light pressure for 1 hr. (x5 wires) CCW
  - All samples held in place with 0.008” unsupported length for lapping.
  - 600 grit paper was manufactured by Norton, all others were by BUEHLER FibrMet.
  - Aluminum-oxide abrasive was used for all

Results

First Polishing:
1. The images collected after the first polishing of the wires were not viable as they were unclear.
2. Were not able to get similar results as the reference.

Second Polishing:
1. Improved polishing
2. Faint visual of a few filaments

Conclusion

- Polishing of the wires was more complicated process than we had anticipated.
- Although the polishing of the wires has improved, it is still a process that needs to be worked on.
- Alternate techniques are being researched to improve the quality of the imaging.
- Imaging is critical because we cannot move on to the heat treatment without a viable reference image to compare back to.

Future Work

- Without finer polishing we cannot move on to the next step.
- Change of abrasives from aluminum-oxide to silicon-carbide is being looked into.
- Concentration on manual polishing rather than automatic polishing is more likely required.
- After the viable polished imaging, the heat treatment will be done on the wires and use fundamental fracture mechanics to understand the initial defects and degradation of the wires to mechanical loads.

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