Applications of Laser Doppler Velocimetry, YBCO Superconductor Vortex Pinning, and Heat-Treatment Effects on Magnetoelastic Torque Transducers

This thesis focuses on work performed in three areas of materials physics, and reports work completed throughout the candidate's graduate career. The first section reports the results of a characterization test performed on a fluid catalytic cracking (FCC) nozzle to determine average particle sizes and velocities while the candidate was completing an internship at Argonne National Laboratory. The FCC nozzle is used in the process of producing petroleum byproducts such as gasoline. The objective was to determine the effects of nozzle design on performance to produce the next generation of FCC nozzle. Measurements were made with a Phase Doppler Particle Analyzer (PDPA). The PDPA is based on the laser Doppler velocimetry technique. A spherical particle that passes through the probe volume of the PDPA produces a Doppler burst. Measurements were made at air to water ratios of 1.2%, and 2%. Larger air to water ratios resulted in higher particle velocities and smaller average particle sizes. Heights of the air inlet were varied over a 12" range and data indicated that as the height of the air injection was increased the average particle size decreased.

The second section reports work completed with the WIU superconductivity research group. Colbalt (Co) substitutions for Copper (Cu) atoms in the crystalline lattice of the superconductor $YBa_2Cu_3O_{7-x}$ produced marked enhancement effects in the magnetic field and temperature dependence of the transport critical current density. These samples were subjected to four-wire probe critical state investigations at temperatures from 44K to 90K and magnetic fields up to 1.2 Tesla. The 0.15% dopant level demonstrated the most enhanced in-field performance of the critical current density without noticeable degradation of the resistivity versus temperature curve for the sample. Both the control sample and the 0.15% Co-doped samples were then subjected to 8 days of neutron irradiation. A sizeable enhancement of the in-field critical current density was seen in both cases due to the neutron irradiation, however, the doping did not appear to improve the performance of the irradiated samples in terms of the pure field dependence of the critical current density.

The final section reports work completed at WIU in collaboration with Magnetoelastic Devices Inc. (MDI). Recent experiments have indicated that a torque transducer can be constructed based on local bands of naturally stabilized remanent circumferential magnetization within a hollow steel shaft. This is an extension of a previously developed, more complex ring-type sensor. A strong coercive force and crystalline anisotropy combine to stabilize the circumferential magnetization of the sensing area. These steel shafts can be improved in their torque transducer functions by appropriate sequential heat treatments in an inert atmosphere. A large retentivity and high coercive force are both needed circumferentially to maintain the magnetization of the sensory region in that direction, while a small retentivity and low coercive force are desirable in the axial direction to allow for maximum torque sensitivity of the sensory region, as well as to consistently void the region of previous torque history. Subsequent to the optimal heat treatment cycle, our results showed a 10 - 20% decrease in both axial coercive force and remanent magnetization. Correspondingly, a 50% increase was observed in the torque sensitivity, accompanied by a higher saturation limit and improvement in zeroing reliability. Additionally, the heat treatment cycle significantly widened the originally broad circumferential hysteresis loops, resulting in a substantial increase in remanent magnetization, with little change in circumferential coercive force. This should contribute to the stability of the originally magnetically conditioned sensing region.