**Smart Damper for Turbomachinery Applications**

Electro-rheological (ER) fluids have made possible new developments that include smart clutches, fast-acting hydraulic valves, shock absorbers, brakes, and many others. Unlike magnetorheological fluids, ER fluids can operate at higher temperatures and do not require complex arrangements to create magnetic fields. A key factor in the application of ER fluids is the speed of its response to alternating current. However, despite this unique characteristic, the change in viscosity of today's ER fluids has not met the demanding requirements of many modern applications. Achieving a controlled change in viscosity and concomitant speed has been a challenge and the understanding of active fluids has not been fully achieved. This research aims to create a novel approach to generate controllable nanofluids and to develop and evaluate active and controllable novel damper prototypes for turbomachinery applications. The proposed approach uses functionalized nanoparticles (NPs) as additives that incorporate charged molecules. When an electrical field is applied to the resulting ER fluid, the NPs align together so as to change its viscosity. The high responsive rate is achieved by the elimination of diffusion and because of the size of nanoparticles, they simply rotate for alignment.

The first year of the project focused on developing a damper fluid with charged 2D nanoparticles capable of fast rotation and alignment when subjected to an electric field. This functionality was evaluated and validated with basic laboratory tests. The feasibility was proven on one type of nanoparticles. In parallel, a damper design was developed with the capability of applying a voltage potential while directly leveraging the benefits of variable fluid properties to enhance its dynamic response. The second phase of the project will consist of building the damper prototype and characterizing its dynamic performance in a controlled-motion test rig. These tests, following well-established parameter identification methodologies, will provide the full set of force coefficients (stiffness $K$, damping $C$, virtual mass $M$) characterizing the damper dynamic load performance. The testing will include multiple frequency excitations to produce physical parameters ($K, C, M$) as a function of frequency of the damper with and without active control.