Magnetorheological Elastomers (MREs) for Adaptive Friction Control in Mobility Aids: Fabrication, Tribological Testing, and Optimization

Chadha, Annika (School: duPont Manual High School)

Slips, Trips, and Falls (STFs) are major sources of accidents among various populations. About 38 mill falls happen each year in the US alone, with more than 50,000 associated with mobility aids. Almost universally, all friction solutions for assistive devices are passive and unable to adapt to changing surface conditions. Three goals were identified: Create Magnetorheological Elastomers (MREs) with the optimal Carbonyl Iron Powder (CIP) for maximum traction; design and build a custom low-cost friction testing rig; and fabricate a proof-of-concept prototype for real-world application in mobility aids. MREs were created by combining UV-curable photopolymer resin with CIP at concentrations of 0%, 4%, 8%, 10%, and 12% by weight and 3D printing the mixture into 25 x 25 x 1 mm sheets. A low-cost Ender 3 3D printer was repurposed into a custom friction testing rig for under $50, compared to thousands of dollars for a lab-grade tribometer, enabling rigorous tribological testing across 30 conditions and 273 trials. All three goals were successfully achieved. Results showed a maximum force improvement of 107% at 12% CIP with magnetic activation. An unexpected magnetic reversal effect was discovered at 12% CIP on wet surfaces, where friction was reduced by 29%. Dusty surfaces outperformed dry surfaces at 8-10% CIP, suggesting particle interlocking. A concentration of 10% CIP emerged as optimal, delivering the most consistent performance across all surfaces. A proof-of-concept cane tip was fabricated using the 10% CIP formulation, with no batteries or electronics, at 95% savings over current tips. This is the first time MREs have been integrated into a mobility device for fall prevention, demonstrating a meaningful step toward reducing STFs among mobility-impaired populations.

Awards Won:
Third Award of $1,200