ABSTRACT

The present research work focuses on the theoretical and experimental studies of analyzing the flow behavior of magnetorheological fluid, studying particles separation during finishing process, and estimating the temperature rise due to abrasion. The particle separation phenomena during finishing operation in magnetorheological finishing (MRF) process is studied and the theoretical spindle speed at which the carbonyl iron particles (CIPs) get separated from the MR fluid ribbon is determined by balancing centrifugal force with magnetic force and correlated it with the experimental spindle speed. CIPs detach from the MR fluid ribbon at a spindle speed of more than 900 RPM. The flow behavior of MR fluid is analyzed by employing the computational fluid dynamics modeling technique using Herschel-Bulkley and dynamic viscosity models. Herschel-Bulkley model doesn't capture the variation in the magnetic flux density (MFD), however dynamic viscosity model captures the variation in the MFD. Using standard and proposed viscosity models, total indentation depth (TID) on the workpiece surface is predicted for the flat and freeform surfaces, respectively and it is correlated with the experimental indentation depth. The standard Brinell hardness number (BHN) equation is used to determine the indentation depth using dynamic pressure, abrasive grain diameter, and workpiece properties. The OFHC copper workpiece is finished in vertical MRF configuration setup and a dynamic viscosity model is proposed to take care of MFD variation. After finishing, the thermographic image of the copper workpiece represents the maximum temperature zone in the shape of concentric circles similar to the MFD variation. The TID is predicted and correlated with the indentation depth obtained experimentally. The temperature rise during finishing of thin copper substrate is estimated using wall shear stress, energy partitioning, and basic heat conduction equation. Then the predicted temperature rise results are compared with the thermographic image of the finished surface. The estimated maximum temperature rise overestimates the experimental results by the difference of 4.54 °C, and it is due to heat convection and particle separation. The areal surface roughness (S_a) is reduced by 66.5% in 10 minutes of finishing.

Keywords: *Dynamic Pressure; wall shear stress; indentation depth; FE modeling; MFD; magnetic characterization*