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Powder suspensions with log-normal size distribution: minimizing the viscosity through mixture design

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Abstract – In this work, we look to optimize, using Design of Experiments, the blend ratio of ternary mixtures of spherical iron powders with different modes, to get the minimum viscosity in Magneto-rheological Fluids. In one case with powders ‘A’ (coarse); ‘B’ (medium); and ‘C’ (fine), the minimum viscosity was found on an edge of the triangle diagram: a specific binary blend (A-C 37:63) had the lowest viscosity. In another mixture, with powders ‘D’ (coarse), ‘E’ (medium) and ‘F’ (fine), the lowest viscosity was found on one of the corners of the triangle diagram, with only ‘D’ (coarse) powder, without blending.

Magneto-rheological fluids (MRF) can be considered composite or multiphase materials. They are commonly prepared with some ferromagnetic phase dispersed in a chemically inert, non-volatile liquid. Typical materials include iron powders and mineral, silicone or synthetic oils. MRF have the ability to change their rheological properties, when a magnetic field is applied to them, they can change from a fluid to a near solid in a reversible way – with a relatively fast response time (~ 10 milliseconds). The rheological properties can be controlled by the field strength, which makes them very promising for several technological devices, especially in mechatronics.

The magneto-rheological effect of MRF increases with the volume fraction of the active phase, the iron powder. However, one of the challenges in formulating a good MRF is to keep the so-called “off state viscosity” (the viscosity without magnetic field) as low as possible. The relative viscosity is a function of the volume fraction commonly fitted by an exponential growth.

To increase the maximum packing volume fraction and to reduce the viscosity for powders of uniform spheres with different size ratios, the ideal blend ratio of binary, ternary, quaternary or quinary mixtures is well established in the literature [1]. For powders with log-normal size distribution, however, this task is not so simple. More recently, He and Ekere, through computer simulation have suggested that, for concentrated suspensions of noncolloidal particles with log-normal distribution, the viscosity decreases as the standard deviation of particle diameters increases [2].

In this work, we look to optimize experimentally, using Design of Experiments (DOE), the blend ratio of ternary mixtures of spherical iron powders with different modes, to get the minimum viscosity in magneto-rheological fluids. In one case with powders ‘A’ (coarse); ‘B’ (medium); and ‘C’ (fine), the minimum viscosity was found on an edge of the triangle diagram: a specific binary blend (A-C 37:63) had the lowest viscosity. In another mixture, with powders ‘D’ (coarse), ‘E’ (medium) and ‘F’ (fine), the lowest viscosity was found on one of the corners of the triangle diagram, with only ‘D’ (coarse) powder, without blending.

The results obtained clearly shows the power and robustness of mixture experiments to minimize the viscosity of concentrated suspensions of powders with log-normal size distribution.

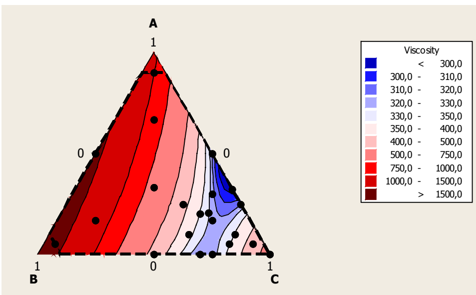

Figure 1: Contour plot of viscosity for the ternary mixture A-B-C.

References

[1] Lee, D.I., “Packing of spheres and its effect on the viscosity of suspensions” – *J. Paint Technology* 42 (1970), pp. 579-587.
[2] He, D. and Ekere, N.N., “Structure simulation of concentrated suspensions of hard spherical particles” – *AIChE Journal* 47 (2001), pp. 53-59.