Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

Two fluid modeling of heat transfer in dense suspension flows in Couette cells PRANAY P. NAGRANI, School of Mechanical Engineering, Purdue University, West Lafayette, Indiana 47907, USA, FEDERICO MUNICCHI, School of Mathematical Sciences, University of Nottingham, University Park, Nottingham, NG7 2RD, UK, IVAN C. CHRISTOV, AMY M. MARCONNET, School of Mechanical Engineering, Purdue University, West Lafayette, Indiana 47907, USA — We propose a two fluid model (TFM) to capture thermal transport coupled to particle migration in shear flows of suspensions in the non-Brownian regime. Specifically, we introduce a closure relation for the inter-phase heat transfer coefficient as $K_h(\dot{\gamma}, \phi) = K_{h,0}[1+\beta\phi(\|\dot{\gamma}_p\|d_p^2/\alpha_p)^m]$, where ϕ, d_p, $\dot{\gamma}_p$ and α_p are the particle volume fraction, diameter, rate-of-shear-strain tensor and thermal diffusivity, respectively. Importantly, we capture shear-induced effects by using the full tensor $\dot{\gamma}_p$, which is made possible by use of a TFM. We successfully calibrate β and m (and, thus, the TFM) by comparing to experiments in a Couette cell. Next, we perform a parametric study to understand how radial shear-induced migration influences the thermal transport performance in this system for different shear rates set by the rotation of the inner cylinder Ω_{in}, d_p and bulk volume fraction $\phi|_{t=0}$. Compared to a clear fluid, suspensions enhance thermal transport, and our computational model identifies the combinations of $d_p/(R_{out} - R_{in})$, $Pe_p = \Omega_{in} d_p^2/\alpha_p$, and $\phi|_{t=0}$ that maximize transport and/or efficiency.

Ivan Christov
Purdue University

Date submitted: 02 Aug 2020 Electronic form version 1.4