Optimizing Design of Soil Mixing Equipment through COMSOL Simulations

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Introduction: Soil mixers are widely used to mix biochemical agents and additives to remediate contaminated soils or drill cuttings and sludges. Figure 1 shows a photo of a mixer performing remediation of percholoroethylene-contaminated soil by injecting and mixing sodium permanganate. For optimum remediation, uniformly mixing of these agents and additives with contaminated soil is needed. The ability of a mixer to achieve uniform mixing in the field depends on soil properties such as soil type (e.g., sand vs. clay) and water content, mixer specifications such as the geometric configuration of the blades and capacity of the motor, and mixer operations such as the rotational and translational speeds. The main objectives of this project are: (1) to evaluate the effect of geometric configuration of the blades and rotational speed on mixing performance; and (2) to optimize the tool design and operations of various soil mixers.

Figure 1. Example of soil mixer used for environmental remediation

Computational Methods: To achieve the project objectives, a numerical model is developed using COMSOL Multiphysics to simulate the complex interaction between fluid-solid mixtures and mixing tools during soil mixing. In the developed model, rheological models readily available in COMSOL Multiphysics are used to model the complex rheological behavior of fluid-solid mixtures. Various components of a mixer such as the main shaft and blades are modeled as interfaces or boundaries that can have rotational and translational motions as demonstrated in Figure 2..

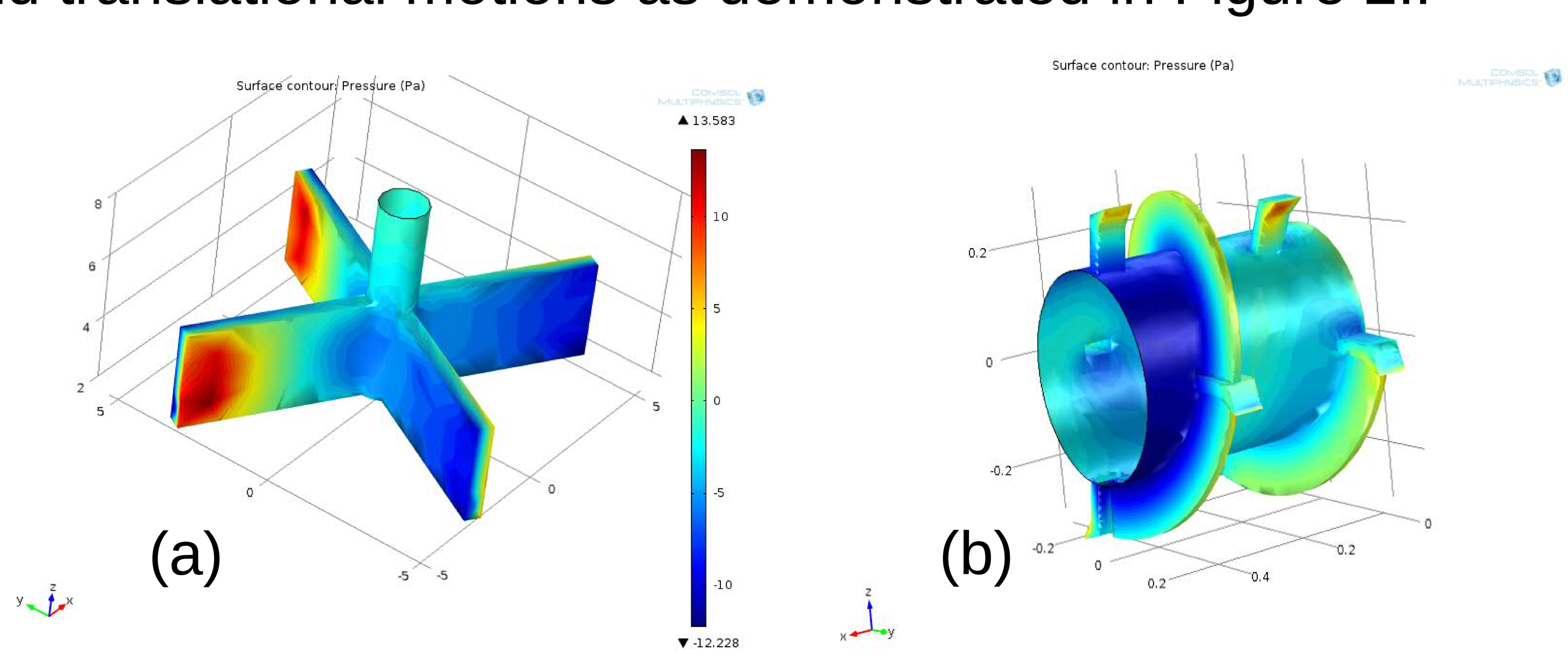

Figure 2. Pressure contour on mixer: (a) a four-blade mixer; (b) a mixing drum with helix

The mixing performance is monitored by injecting and tracing particles with the same density as the fluid, as demonstrated in Figure 3. The torque developed on a mixer is calculated based on the pressure distributions on the mixer.

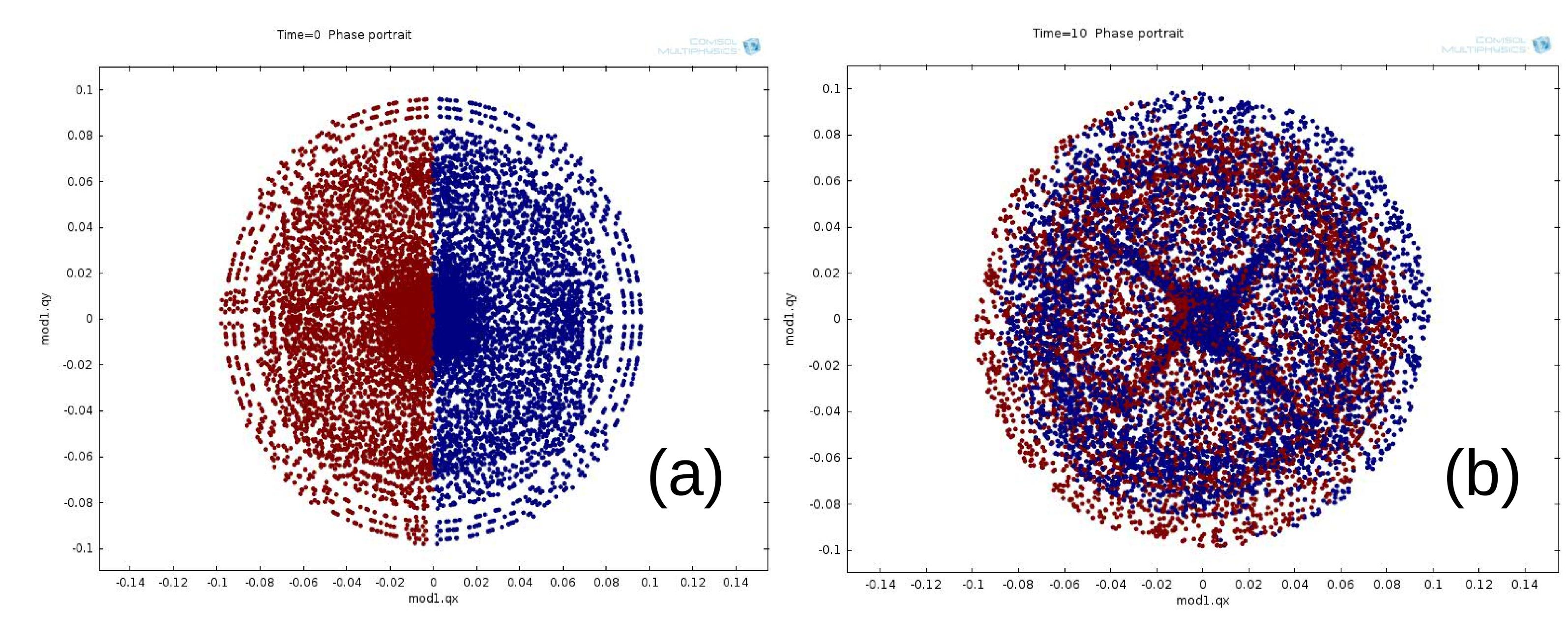

Figure 3. Evaluation of mixing performance through particle tracing: (a) at the beginning of mixing; (b) after 10 seconds of mixing

Results: For simplicity, a mixer as shown in Figure 2(b) and typical properties of fluid-solid mixtures are considered in this abstract as a proof of concept for the proposed numerical model. Figure 4 presents the torque vs. time at different rotational speeds and for the drum with and without helix. The torque on the shaft is induced by resistance from the fluid-solid mixture. Figure 4 indicates that the torque increases with rotational speed and with the presence of helix.

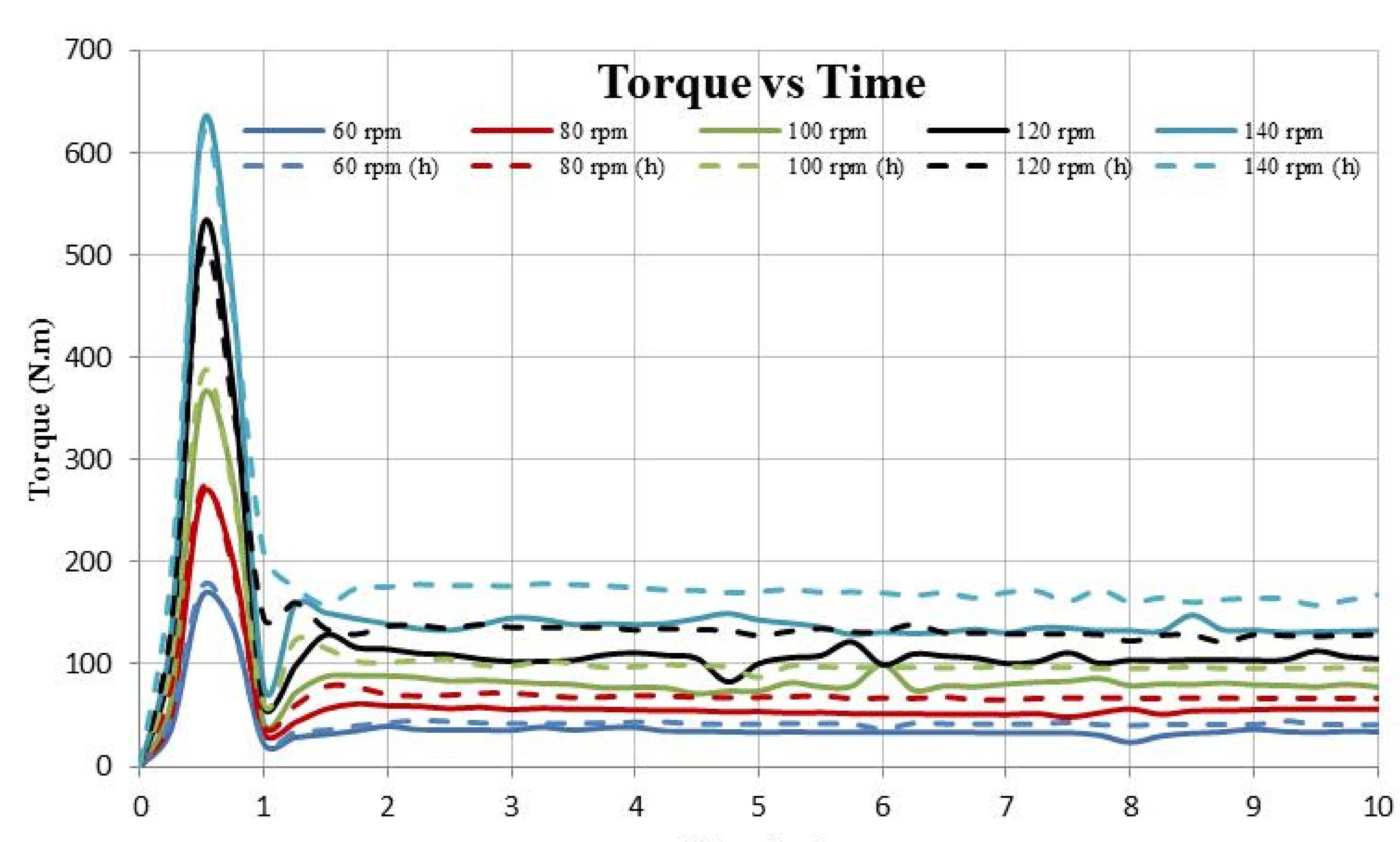

Figure 4. Effect of rotational speed and helix on torque vs. time

Conclusions: Preliminary results of this project demonstrate that COMSOL Multiphysics can be used to model the complex interactions between fluid-solid mixture and mixing tools during soil mixing, and can be utilized to perform simulations to optimize the design of mixing tools and operations.