# Effect of Geometry on the Mechanisms for Off Bottom Solids Suspension

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## Abstract

Solid-liquid mixing processes are operated at complete off-bottom suspension conditions. This operational requirement can be satisfied by running the process at just suspended speed, $N_{js}$. There are a number of experimental techniques either visual or instrumental and some correlations to determine the $N_{js}$; however, there is a gap in fundamental knowledge regarding the mechanisms which drive solids suspension. This makes it difficult to develop robust dimensionless groups and general correlation forms for $N_{js}$.

In a fully turbulent stirred tank two velocity components are always present: mean velocity and turbulent fluctuating velocity. Solids suspension requires the combination of two mechanisms related to these velocity components: mean drag and turbulence. There have been some attempts to investigate these mechanisms to better understand solids suspension. Baldi and Alaria (1978) focused on the fluctuating velocities. At complete off bottom suspension conditions particles circulate in the tank, then settle down at the bottom of the tank for no more than 1 or 2 seconds and be suspended again (Zwietering, 1958). Baldi and Alaria (1978) attributed the re-suspension of solids to fluctuating velocities, and in particular eddies with a size of the same order as the particle size. Applying this approach and using an energy balance they suggested a correlation; however, the velocity profiles were not measured and the suggested mechanism was not verified.

In this study, we propose that a similar critical condition exists at the bottom of the tank at complete off-bottom suspension conditions, given the same solids and solids concentration, and a similar tank geometry. If mean flow convection across the tank bottom is the dominant mechanism for solids suspension, then all the mean velocity profiles should collapse onto a single profile for all clearances. If it is the turbulent eddies which dominate, then the axial rms velocity profiles should collapse onto a single profile for all clearances. To prove this hypothesis two Lightnin A310 impellers were tested: D=T/3 and T/2, at varying off bottom clearances. The mean radial velocity and the fluctuating axial velocity profiles were measured over a horizontal plane close to the tank bottom using PIV experiments and large eddy simulations (LES). The velocity profiles

were normalized with the $N_{js}$ of a unimodal slurry of 1.5 wt% glass beads to try to identify the critical condition at the bottom of the tank.

The results of the PIV experiments are given in Figure 1. For the T/3 impeller the rms velocity profiles collapse onto a single profile over two thirds of the tank diameter. For the T/2 impeller the rms velocities vary with clearance, but the radial mean velocity profiles collapse onto a single profile over the outer third of the tank. This suggests that $N_{js}$ is achieved at a minimum rms velocity for the small impeller diameter, and at a minimum radial velocity for the large impeller diameter. Considering the magnitude of the velocities, the T/3 impeller generates relatively more flow and less turbulence at the bottom of the tank, and thus $N_{js}$ is limited by turbulence production. The T/2 impeller generates relatively more turbulence and less flow, and thus its $N_{js}$ is achieved at the point where the radial convective velocity reaches the critical value.

We conclude that part of the complexity of the $N_{js}$ problem is that both the mean radial velocity, which sweeps particles toward the tank walls, and the axial rms velocity, which lifts individual particles off the bottom of the tank, play important roles in solids suspension. The balance between these two mechanisms is clearly very sensitive to the impeller and vessel geometry.

**keywords:** solids suspension mechanisms, turbulence, mean drag

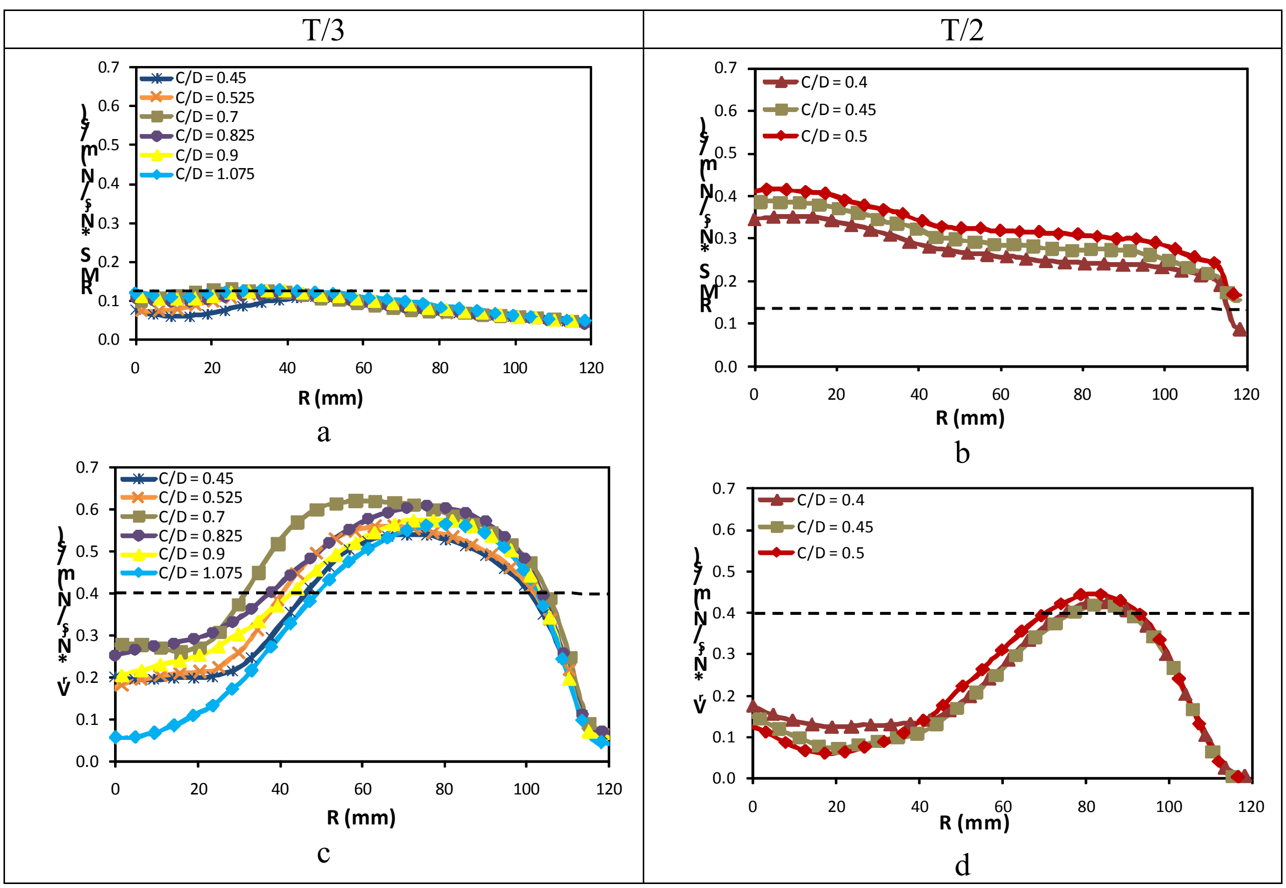


**Figure 1.** Scaled velocity profiles. a-b. rms velocity profiles c-d. radial velocity profiles

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