Basics in non-Newtonian Mixing for Handling of Tailings and Other High Concentration Slurries

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Abstract

A precise knowledge of the rheological behavior of highly loaded slurries is essential to design mixing equipment for such applications. Laboratory research with transparent test fluids showing the same flow behavior as the original slurry, the application of analytically-derived models and system cross checking by means of CFD, allows reliable design of large scale mixing equipment. A comparison of these different methods will be shown, followed up by a scale-up to an industrial installation.

Keywords: Non-Newtonian slurry; rheology; mixing; cavity formation; CFD; scale-up.

1. Slurry data

To design efficient and reliable mixing equipment, it is essential to have a close look at the physical properties of the liquid to be mixed. In a first step it is necessary to clarify the basics of properties and definitions to establish a common understanding.

Dispersions

A system in which particles are dispersed in a continuous phase:

- Molecular dispersion $d_P \leq 1$ nm
- Colloidal dispersion $d_P > 1$ nm < 1μm
- Coarse dispersion $d_P > 1$ μm

Suspensions

A system as coarse disperse Dispersion:

- Fine suspension $d_P > 1$ μm ≤ 100 μm → Red mud
- Coarse suspension $d_P > 100$ μm ≤ 1 000 μm → Desilication slurry

Figure 1. General definition of slurries.

The above definitions are trivial, however necessary to clarify what shall be further outlined in detail. Considering the particle composition of the two fluids, we can verify that we are dealing with a fine suspension in the case of red mud (dp80 < 100 μm), while the desilication slurry (dp80 > 100 < 900 μm) is surely categorized as coarse suspension. All slurries are in general polydisperse, with a broad particle distribution.

The detailed composition of the respective media to be examined is listed in Fig. 2.
This data shall constitute the basis of the following considerations, knowing well that there are wide deviations in the one direction or another.

			Bauxite slurry	Red Mud
Solids density	ρ_S	[kg/m³]	2 800	3 000
Continuous phase density	ρ_L	[kg/m³]	1 250	1 000
Slurry density	ρ_{SL}	[kg/m³]	1 800	1 600
Solids mass concentration	C_G	[%]	55	57
Solids volume concentration	C_V	[%]	35	30
Solid mass	C_{ms}	[g/l]	990	900
Particle size 80 % passing	d_P	[µm]	800	70

Figure 2. Physical composition of slurries considered.

2. General slurry rheology parameters

The main influencing parameters can be summarized as in Figures 3 to 5.

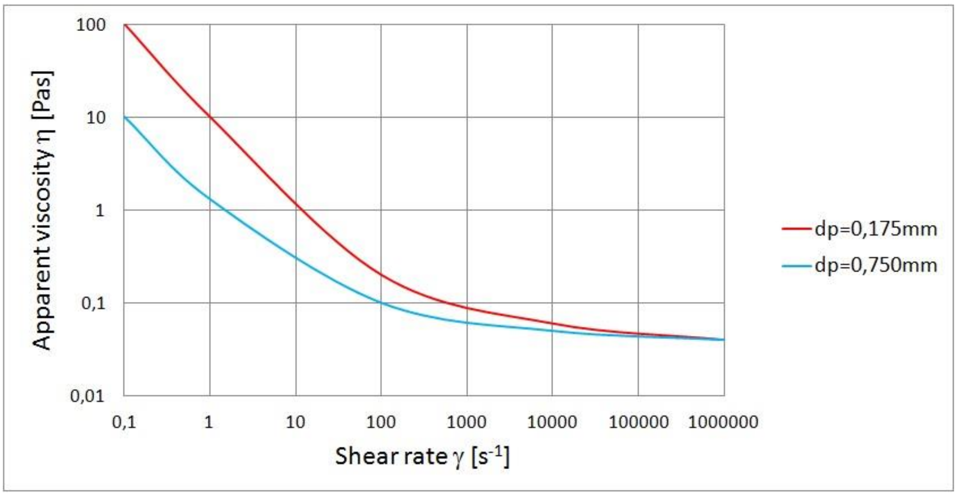

Figure 3. The impact of particle size on viscosity. [1]

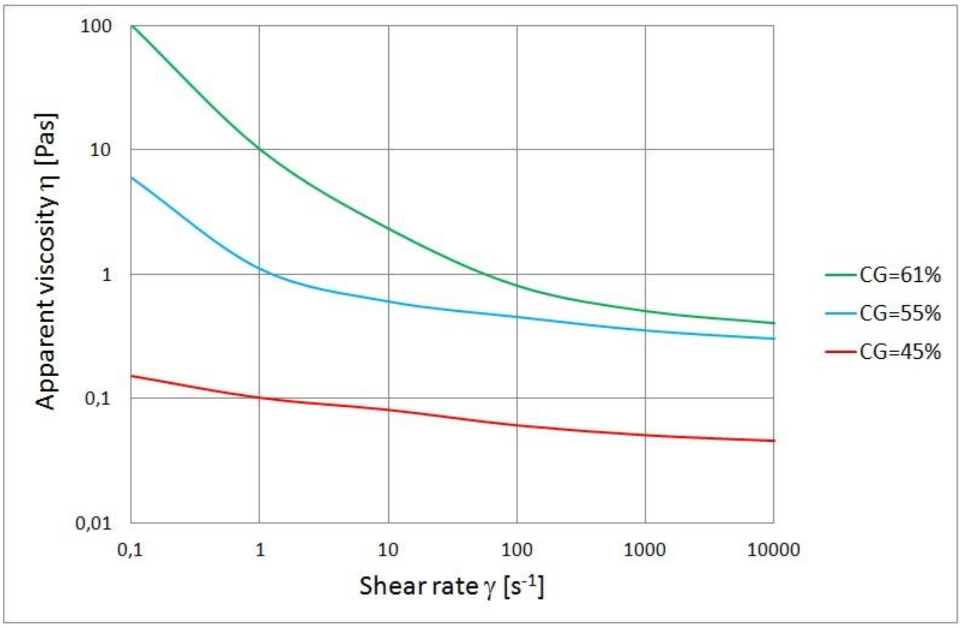

Figure 4. The impact of solids concentration on viscosity. [1]

6. Conclusions

- Reliable mixer design requires
  1. Precise definition of the mixing requirements
     1.1. Specifying mixing task and quality of mixture
  2. Exact verification of slurry data
     2.1. Composition and flow behavior
  3. Use of available design tools and data
     3.1. State of the art analytical calculation methods
     Use of CFD Tools for flow
     Use of FEM Tools for mechanics
  4. Employing lab tests for problem visualization
     4.1 Flow visualization in transparent media
     Verification of physical data of the slurry
     Determination of mixing parameters as mixing time and mixing quality

7. References

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