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Mini Review

Influence of Various Size and Volume Fraction of Suspended Particles on the Rheological Properties of Shear Thickening Fluids for Soft Armour Applications: A Review

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Abstract

The shear-thickening phenomenon behavior occurs in most of the concentrated colloidal dispersions such as clay–water, calcium carbonate–water, polystyrene–silicon oil, iron particles–carbon tetrachloride, titanium oxide–resin, silica–polypropylene glycol, and silica–polyethylene glycol have attracted the attention of protective systems development applications. The rheological properties of Shear Thickening Fluids (STF) can be controlled by the composition of the carrier fluid molecular weight with chain length and solid particles influence a few parameters, such as particle size, volume fraction, and critical shear rate range. The methodology used in this study, numerous material parameters impacting shear thickening behaviour and the usage of STFs in protective systems are examined, with a focus on the nature of solid phase nanoparticles. This analysis includes investigations of important parameters, such as particle size and volume fraction, majorly influencing the Shear Thickening Fluid (STF).

Keywords: Shear thickening fluid; Polyethylene glycol; Surface chemistry; Dispersions

Important Parameters of Shear Thickening Fluid (STF)

The prepared STF suspensions have solid particles dispersed in the career liquid that will effect shear thickening behaviour, as stated by 1989 [1] to at present. From this, we gather that the variables relating to particles including size, weight/volume fraction, surface chemistry and shape all have an effect on the resultant rheology when mixed with a fluid. When attempting to understand the effect of physical variables on rheology [2,3], the response between the carrier fluid and the particles is also worth examining to some extent. From this, a relationship can be developed that can quantify the effect of differing particle and carrier fluid material properties on the resultant rheological behaviour of the STFs. Shear thickening is a type of non-Newtonian behaviour that describes any rheology in which the effective viscosity increases as the shear rate increases. We first describe the basic aspects of some of the primary types of shear thickening documented [4], because there are multiple different types of shear thickening, each characterised by particular distinguishing criteria and likely attributable to various causes [5]. The researchers concluded a review article based on the shear thickening effect occurs when most of the solid particles and liquid dispersion occur in the mixed suspension [6]. However, it only occurs at a shear rate measurable in current commercial rheometers with a few well-chosen dispersions.

According to fluid performance, parameters that control shear thickening behaviour are particle size and particle size distribution, particle volume fraction, particle shape, particle-particle interaction, continuous phase viscosity, and the type, rate, and time of deformation.

To some extent, all of these variables have been investigated. It demonstrates that a coherent description of the phenomena is now attainable using some well-described data from recent tests [7]. However, only a few simulations have been done to estimate shear thickening dispersion flow curves and the shear rate at which shear thickening begins. The parameters identified as being of importance for the characteristics of the colloidal dispersions are the size of the particles, the volume fraction of particles, their shape, the viscosity of the carrier fluid and the particle-particle interactions. Due to the complex and sometimes contradictory behaviour reported in the literature, constitutive modelling of suspension fluid mechanics has been difficult.

Influencing of Particle Size in STF

The findings of rheological studies show that decreasing particle size increases suspension viscosity, increases critical shear rate, and decreases the frequency of transition to an elastic state for shear thickening fluids [7]. At each shear thickening fluid concentration, the samples incur less deformation and can tolerate bigger weights as the particle size is reduced. The reduction in particle size has a considerable influence on the load-bearing capability of the textiles at low and medium concentrations (15 and 25 wt%). At 35wt% concentration, the difference in maximum stresses withstood by the fabric is insignificant for both the 12- and 60nm particles.

Influencing of Particle Volume Fraction in STF

As the nanoparticle volume fraction increases, the viscosity of nanofluid increases. All the nano-fluids come under Newtonian and non-Newtonian fluid flow behaviours [8-10]. They can be seen for low and high volume fractions, respectively, in nanofluids. In comparison to low-viscosity nanofluids, high-viscosity nanofluids are frequently Newtonian. The most important component determining shear-thickening is the solid-volume fraction, which is the fraction of the total volume of the system filled by particles. It's worth noting that there's a minimum amount of solid volume fraction that must be met.

Conclusion

Shear Thickening Fluid (STF) has attracted attention for impact protection due to its unique properties subject to impact. STF is a non-Newtonian fluid and shear thickening behaviour is triggered by a sudden increase in shear rate in the STF, which causes colloidal dispersions to concentrate, exhibiting an abrupt increase in viscosity. STF performance is extensively dependent on many factors like solid particle size, shape, aspect ratio, volume fraction, and career fluid molecular weight. The particle size and volume fraction are major criteria for preparation of novel shear thickening fluids.

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