Monitoring Rheology as a Tool for Measuring the Effective Shear Rate in the Bubble Columns

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Effective viscosity (μ_{eff}) is one of the most widely used design parameters in the literature to correlate mass transfer and hydrodynamic parameters for viscous non-Newtonian systems. There are many disagreements in the literature regarding the effective viscosity of a non-Newtonian fluid (Al-Masry and Chetty 1997). The various models that are used frequently to describe the fluid's dependence on the shear rate: 1) The Ostwald de Waele relation (or commonly known Power Law) & 2) Herschel Bulkley model. Thus in order to calculate the effective viscosity the average shear rate in the bioreactor must be known. A commonly used equation for calculating the effective shear rate was developed by (Nishikawa et al. 1977)

$$\dot{\gamma} = 5000U_g \qquad (1)$$

.,
Where, Ug is the gas superficial velocity.

However, Chisti and Moo-Young (1989) has very well proved that this equation was derived by considering the Pneumatic power input into the bubble column. Conversely the turbulence in the bubble column or the shear depends on both the power input and on the transport characteristics of the fluid itself. Moreover the comparison plots of several other equations that are available for the shear rate calculation in the bubble column showed an enormous divergence for the shear rate calculation as shown in Figure 1.

This paper examines the impact of gas injection on rheological behaviour of waste activated sludge. The impact of four different gas flow rates on two different concentrations of sludge on linear and non- linear rheological properties has been determined. The amount of induced shear by gas injection is measured by carrying out the successive rheological measurement in linear regime with non-aerated sludge and then matching the response of non-aerated sludge with the aerated sludge response as shown in Figure 2.

The results showed that gas injection imposes extra shear on sludge and changes its rheological properties. Moreover, the shear induced by gas injection changes with change in concentration as well as with change in gas flow rate. Consequently, the result suggest that monitoring rheology is an effective way of estimating the effective shear rate in the bubble column as it takes in to consideration the transport characteristics of the fluid.

References

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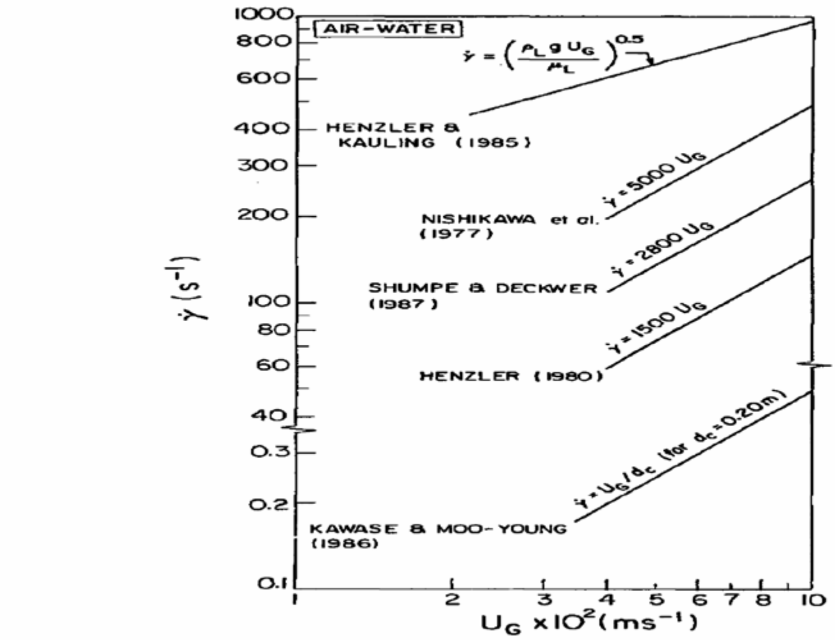

Figure 1: Average shear rate ($\gamma^{\cdot}$) in bubble columns as a function of superficial gas velocity for air-water system.(Chisti and Moo-Young 1989)

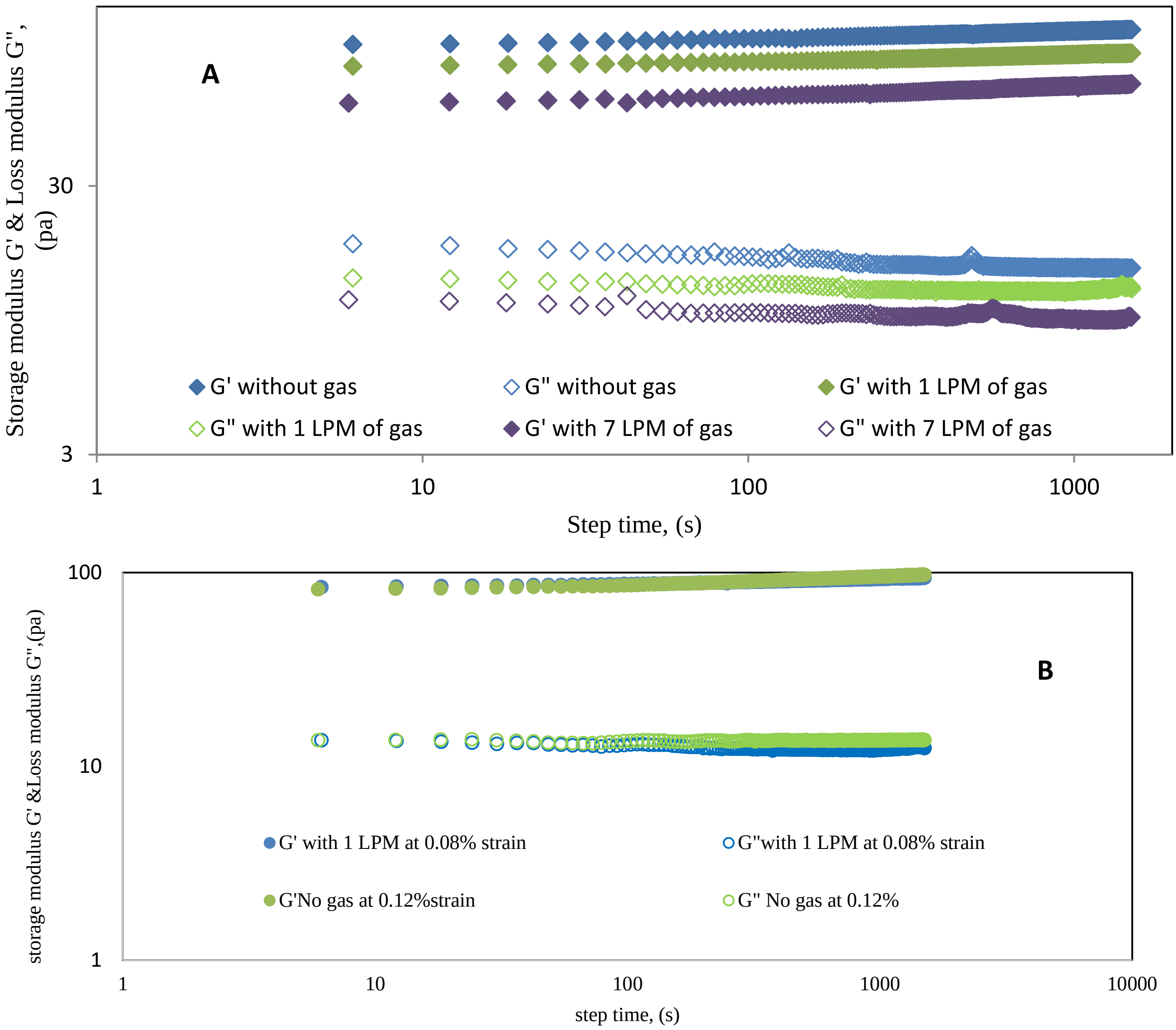

Figure 2 : (A) Impact of gas injection on 3% of WAS rheology in linear region & (B) Stress imposed by 1 LPM of gas injection on 3% of WAS.