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Polymer-Surfactant Complex for Enhancing the Mechanical and Drag Reduction Performances of a Turbulent Flow

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ABSTRACT

Polymer additives in drag reduction (DR) are vulnerable to the mechanical and the thermal degradation. In the present work, an interaction between nonionic polymer Hydroxypropyl cellulose and anionic surfactant sodium Oleate (HPC - S.O) complex in aqueous solution has been studied by using rheology and RDA techniques to evidence complex capability and stability in enhancing the drag reduction and mechanism degradation performance, respectively. The effect of the concentration of the polymer on the drag reduction and the effect of increasing concentration of surfactant to the polymer-surfactant complex in enhancing the drag reduction were studied. In addition, the effect of the rotational speed on the drag reduction has also been studied. A maximum of 48 % DR was observed at 500 rpm with a concentration of 1000 ppm of HPC - S.O complex.

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INTRODUCTION

Drag reduction (DR) has wide applications in industry such as; transportation of oil, wastewater treatment, firefighting, transport of solids in water, heating and cooling rings, hydraulic and jet machinery, and also biomedical applications Gasljevic *et al.*(2001), Harwigsson *et al.*(1996), Hellsten (2002), Zakin *et al.* (1996).

A lot of research work has been done to enhance the DR efficiency of fluids by using Polymer additives(hayder et al. 2005,2008,2009,2010,2011,2012,2013,2014) (PAs) after Dodge *et al.*(1959). Lumley (1996) suggested that there is a serious value of wall shear stress at which the macromolecules become stretched due to the fluctuating strain rate. Though, in the viscous sub-layer close to the wall, polymer coils are not greatly twisted and viscosity does not rise greatly above solvent viscosity. Lumley (1973) concluded that the stretching of randomly coiled polymers due to robust turbulent flow is pertinent for DR. Virk (1975) based on experimental results suggested that DR is incomplete by an asymptotic value. Warholic *et al.* (1999) lead experiments with polymer solutions and concluded that the Reynolds shear stress becomes insignificant near the maximum DR asymptote. Polymer DR was also clarified by viscoelastic effects of the polymer chains in the solution Metzner *et al.* (1970). Tesauro *et al.* (2007) proposed that energy is transported by the velocity fluctuations to the polymer chain; which is kept in the form of stretching of the polymer chain (which in turn wastes the energy into heat), and by easing of the polymer chain from extended to an equilibrium state. But these DR additives are found to be exposed to mechanical and thermal degradation Zhang *et al.* (2005) leading to a damage in the drag reduction effectiveness at strong shear forces or a high temperature. Especially it has been well reported that polymer chains are degraded by severe mechanical force in a turbulent flow field.

Several studies Kim *et al.* (2000), Suksamranchit *et al.* (2006), Gasljevic *et al.* (2007), Suksamranchit *et al.* (2007) found that the addition of surfactant into a polymer solution could be an active technique in decreasing the mechanical degradation of polymer particularly in high temperature flow systems. The precise mechanism of DR by surfactant solutions is still indistinct; though, certain researchers have proposed that viscoelastic effects of surfactant solution could be accountable for turbulent DR Mysels (1949). Polymer and surfactants interact in two ways. First, the interaction is possible for

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