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Viscosities of various spent sulfite liquors at 26.7°C and other temperatures

Scope

This Technical Information Paper compares the viscosities of different types of spent sulfite liquors, measured by the Oswald Capillary Viscometer at a standard temperature. The differences relate to different liquor compositions as well as different wood sources and pulp grades. New information proposes formulae for liquor viscosity derived by statistical analysis covering a broader range of sulfite liquors and temperatures.

Safety precautions

Sulfur dioxide is a toxic gas that can cause suffocation and death. Gas masks and other safety devices, as prescribed by the industrial and governmental agencies, should be available at all times when dealing with SO₂ and its various compounds. Methanol and ethanol are toxic and flammable solvents and should be similarly handled. Various chemicals that are used for testing SO₂ may be toxic and should not be inhaled or ingested.

Formulae for calculating spent sulfite liquor viscosities

The following relates to Figure 3 and was published in 1984 by the Ministry of Trade and Industry/Energy Department of Finland, and is from a report entitled "Physical Properties of Spent Liquor from Chemical Pulping Processes." Liquor viscosity is only one of 9 physical properties described in this article. The article is essentially a collection of abstracts from 70 world-wide publications covering the various subjects.

Using the data presented in these articles, the authors have derived an empirical equation to relate spent liquor viscosity to solids concentration and temperature. The logic is thus:

$$\ln(V) = A + B/T^3 \text{ for pure water}$$

where

V = kinematic viscosity, mm²/s
T = absolute temperature, Kelvin
A and B = constants

Although not theoretically based, this equation has been shown accurate to within 2% in the temperature range of 0 to 200°C.

This equation can be extended to solution viscosity by constraining the constants A and B to be concentration dependent thus:

$$A = A_{H_2O} + a_1x + a_2x^2 + a_3x^3 + \dots$$

and

$$B = B_{H_2O} + b_1x + b_2x^2 + b_3x^3 + \dots$$

where x = liquor solids content in appropriate units [kg d.s./kg liquor], and $a_1 \dots$ and $b_1 \dots$ are coefficients determined by multiple regression analysis of the published data and are specific as to wood species and type of chemical cook [kraft, soda, acid sulfite, NSSC, etc.].

These regression equations predict the true solution viscosity most accurately with lower solids concentration liquors and at low to moderate shear rates. With high solids liquors measured at high shear rates, the flow departs further from true Newtonian flow and thus the viscosity becomes a function of the shear rate as well as of temperature and solids concentration.

Included is one graph showing the theoretical curves for MgO and NH_3 sulfite liquors (Fig. 3).

Keywords

Sulfur dioxide, Sulfite liquors, Bases, Sulfite pulping, Bleaching, Chemical pulps, Semichemical pulps, Dissolving pulps, Lignosulfonates, Neutral sulfite pulping, Alkaline sulfite pulping.

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6. Refer also to TAPPI TIP 0607-23

Additional information

Units on graphs have been modified to meet TAPPI recommendations for SI format.

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Working Group Members:

Joseph P. Lally – Chairman, Degussa Corporation

Pat McKeough, Weyerhaeuser Company

Walter Erskine, Finch, Pruyn & Company, Inc.

