Characteristics of Metalworking Fluids - Viscosity

Viscosity may be a concept we all “sort of understand,” but if asked for specifics we reduce to a “red faced” head shaking. On the most basic level, as it applies to metalworking fluids, viscosity can be regarded as a measure of a fluid’s resistance to deformation under shear stress, or how resistant a fluid is to pouring. A product expressed as “thick” is slow to flow or pour versus one that flows easily being “thin.” Past this point, the discussion becomes so theoretical it is of little practical value in the application and management of metalworking fluids.

In the application and management of metalworking fluids, viscosity comes directly into play when:

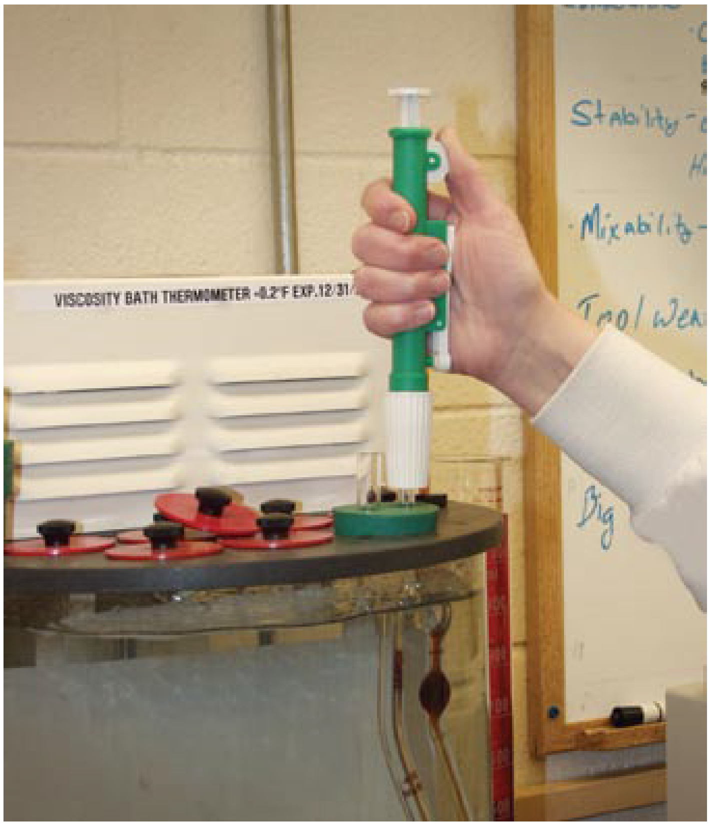
1. Dealing with “straight oils.” Viscosity is probably the single most important physical characteristic in describing an oil. How “thick” or “thin” an oil is largely determines how much hydrodynamic lubrication the oil can provide. Thicker oils have higher hydrodynamic lubricity than thin oils, while thin oils tend to “wet” work surfaces much more rapidly and completely.

2. Selecting pumps to move working solution or concentrate, the viscosity of the fluid has a major effect on the size and type of pump required.

3. Designing bulk storage and delivery systems for straight oils, coolant concentrate and washing compounds. Characteristics of Metalworking Fluids – Viscosity Water cutback working solutions (coolants, stamping compounds, parts washing compounds) have very low viscosity. In fact, they are so close to the viscosity of water that they normally are not measured.

NOTES:

1. Viscosity is very temperature dependent. Typically, the higher the temperature of a fluid the lower its viscosity. The viscosity of metalworking fluids typically is measured at 100° F (38° C), a convenient number because it is the temperature used to rate “standard” oils and is close to the “typical” temperature at which metalworking fluids are used.



2. Dynamic viscosity is represented by the Greek letter “m”; when reported in SI units they are Pascal-seconds (Pa·s), which is defined as 1 kg·m-1·s-1. The cgs physical unit is the poise (P) or more commonly, particularly in ASTM standards, as centipoise (cP). Centipoise is the preferred unit because at 20° C water has a viscosity of 1.0020 cP.
1 poise = 100 centipoise = 1 g·cm-1·s-1 = 0.1 Pa·s
1 centipoise = 1 mPa·s

3. Kinematic viscosity is represented by the Greek letter “v”; the unit of physical measure in SI units is m2·s-1 and in cgs is stokes or sometimes centistokes (cS or cSt).
1 stokes = 100 centistokes = 1 cm2·s-1 = 0.0001 m2·s-1

4. Conversion between kinematic and dynamic viscosity is possible given the formula vp = m.

5. SSU or Seconds Saybolt Universal is an older method of experimentally deriving the viscosity of a fluid. This test measures the amount of time in seconds required for 60 milliliters of liquid to flow through a calibrated orifice under controlled conditions

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as per ASTM D 88.

6. Degree MacMichael (° McM) is a unit used to measure the viscosity, or thickness, of chocolate. Typical values range from around 60° McM (very thin chocolates suitable for pouring into molds) to approximately 190° McM (very thick chocolates suitable for hand dipping or forming around a center). A MacMichael viscometer is used to make the measurement.