TECHNICAL BULLETIN

Understanding

PRODUCT VISCOSITY

In assessing the suitability of APV equipment for use on a particular emulsion or dispersion, it is always necessary to consider the product's viscosity. Aside from the question of improvements in the finished product, one must determine that the piece of equipment in question is mechanically capable of processing the product without difficulty. However, the subject of viscosity is a very complex one, and the many terms used to describe a viscosity can frequently lead to confusion.

A brief description of some of the more commonly encountered aspects of the subject should clarify the situation. At the sacrifice of strict, technical accuracy on some points, the explanations will be brief and as simplified as possible.

Every fluid material has a basic physical property, called its viscosity, which is a measure of its resistance to flow. The "thicker" a fluid is, the higher is its viscosity, because of its greater resistance to flow. One might now assume that the question is simply a matter of assigning every fluid a characteristic viscosity value. Unfortunately, there are different types of viscosity, which complicate matters. A simple example will demonstrate this fact. Which product has a higher viscosity, honey or mayonnaise? One could argue that mayonnaise is higher, because it will not run out of the inverted jar, while honey will. On the other hand, one could argue that honey does, because it is more difficult to stir a jar of honey with a spoon than it is to stir a jar of mayonnaise. This is not a paradox; it is simply evidence that there is more to the discussion of viscosity than simply assigning a number to each fluid. The different types of viscosity relate to the manner in which the various fluids respond to shear forces. Since many widely used processing devices rely on shear forces for their efficiency, this becomes a very important subject to anyone attempting to select such equipment.

A brief description of some of the more common types of viscosity follows.

Newtonian

The viscosity of a Newtonian fluid does not change as the level of the applied shear is changed; thus, a single viscosity number describes the material's flow properties, both at low shear and while subjected to high shear forces. For this reason such viscosities can be called absolute viscosities. Unfortunately, only a few of the commercially important fluids are Newtonian. Common examples of such fluids are: milk, honey, corn syrup solutions, hydrocarbon-type oils, juices and clear soups.

Thixotropic

Generally, these fluids are the ones most commonly encountered, and they show a decrease in viscosity as the shear level is increased. Other viscosity types that show this general type of behavior are plastic and pseudoplastic. Such fluids may also exhibit a yield point; that is, a characteristic minimum amount of force must be applied to initiate flow.

Once this point is exceeded, the material will flow very readily, as the shear is further increased. A final, interesting property of thixotropic fluids is that they will usually recover at least a portion of their initial viscosity, after the shear force is removed. Examples of such fluids are: creams, lotions, gum dispersions, salad dressings, mayonnaise and latex paints.

Dilatant

These fluids, similar to those known as rheopectic, show an increase in viscosity as the applied shear is increased. They may appear to be very fluid when lightly stirred (low shear), but they can actually solidify, if a high level of shear is applied. Fortunately, these materials are not very common. Examples of such fluids are: peanut butter, ceramic slips, high solids clay dispersions and quicksand.

The seeming paradox of the honey and mayonnaise comparison now can be explained readily. Honey has a rather high viscosity at low shear (although not high enough to prevent it from running out of the jar); and, because it is Newtonian, it retains this viscosity as more shear is applied with the spoon. Mayonnaise has an extremely high viscosity at low shear; and, because it is thixotropic, it loses much of this viscosity as one exceeds its yield point by applying more shear with the spoon. Mayonnaise has the higher viscosity at low shear conditions; honey has the higher viscosity at high shear conditions.

This brings us to the final term of importance to our discussion... apparent viscosity. This is a viscosity number given to any non-Newtonian fluid. This number represents that fluid's viscosity at one specific level of applied shear, and it does not give any information about the flow properties of the fluid under any other shear conditions. This is why any stated, apparent viscosity must always be qualified by specifying the type of instrument and procedure used to obtain it. Newtonian fluids are not subject to these restrictions, and viscosity values may be simply stated without such qualifications. However, all viscosity values should specify the temperature at which the measurement was made. This is because many fluids (including Newtonian fluids) will have a lower viscosity at elevated temperatures.

The above information can be very helpful in deciding if a particular piece of processing equipment will be suitable for use on a product of known viscosity. One might assume that a product with an apparent viscosity of 20,000 cP would be too viscous for a colloid mill or homogenizer to handle; but, if the product is thixotropic, it will thin out as soon as shear is applied and, actually, will be quite easy to process. For a Newtonian fluid one may simply observe the flow properties of the fluid at low shear and, using one's familiarity with the equipment, reach a valid conclusion. A dilatant fluid cannot usually be processed with high shear equipment. It can solidify as soon as the shear is applied, resulting in serious mechanical damage to the equipment.

Now that the basics of the subject have been explained, a list of the viscosities of some common fluids will prove helpful. This list will enable one to relate the viscosity of a newly encountered product to a more common product and, thus, develop an intuitive feeling for what the viscosity really means. The values in the attached listing are in the most commonly used units, centipoise (cP), and they are specified as effective viscosities; that is, they represent the viscosity of the fluid at the shear levels normally encountered in a typical pump. This term does not have a precise technical definition, but it is intended to allow one to estimate the apparent viscosity of a non-Newtonian fluid at the shear levels it will be subjected to by the proposed processing equipment. (The viscosities listed are at room temperature unless otherwise noted.)

Occasionally, one will encounter viscosities expressed in units other than centipoise. Many of these other units have arisen because of the numerous instruments and techniques available for measuring viscosities. Since these various methods employ different levels of shear in the measuring technique, there will not be a direct numerical agreement among the results for any non-Newtonian fluids. Fortunately, tables have been prepared which allow for the conversion from most common viscosity units to the equivalent viscosity in centipoise.

Hopefully, this information on the topic of fluid viscosity has created a clearer understanding of this important subject. While it is, admittedly, a complex topic, it is a subject with which one must be familiar in order to effectively select the proper processing equipment for a given product.

FLUID	VISCOSITY	FLUID	VISCOSITY
Auto Lube Oil SAE 40	200 cP @ 100F	Mayonnaise	5000 to 10,000 cP
Bakery Batter	2200 cP	Melted Butter	18 cP @ 140F
Corn Oil	30 cP	Milk	1.2 cP
Corn Syrup	15,000 cP	Sugar Syrup 60 Brix	75 cP
Cough Syrup	190 cP	Sugar Syrup 68 Brix	360 cP
Frosting	10,000 cP	Sugar Syrup 76 Brix	4,000 cP
Gasoline	0.8 cP	Tomato Paste	7000 cP
Honey	1500 cP @ 100F	Toothpaste	20,000 cP
Hot Fudge	36,000 cP	Yogurt	1100 cP

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