FATS AND PROTEINS RESEARCH FOUNDATION, INC.

Director's Digest

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The Viscosity of Liquid Animal Fats

It is axiomatic that the more viscous and dense a fluid, the more energy will be required to move it - by pumping it, filtering it or mixing it.

In the face of rapidly rising energy costs it becomes imperative to utilize our energy resources as efficiently as possible, both to conserve them and to remain competitive in the world of commerce. The efficient use of energy in the handling of tallow demands that we know something of its behavior under processing and storage conditions so that we neither underdesign nor overdesign plant equipment - metaphorically, that we not send a boy to do a man's job nor hire a man when a boy can do the work. In the past much motorized plant equipment has been selected by rule of thumb rather than by sound calculations based on engineering parameters, ofttimes because the basic physical data were absent.

A case in point is the energy required to pump a fluid such as liquid fat, say, through a pipe. This energy can be viewed as the force needed to overcome the numerous interacting frictional factors of the fluid and the confining pipe. They include the mass (m), density (ρ) and absolute viscosity (μ) of the fluid, the diameter (D) and length (L) for the pipe and the velocity (v) at which the fluid is moving through the pipe.

For comparative measurements, it is convenient to refer to the kinematic viscosity (ν) of the fluid. This term combines absolute viscosity and density in the relationship $\nu = \mu/\rho$ and permits us to relate the viscosities of liquids of different densities. If we maintain the dimensions of the pipe constant, measuring the time required for two liquids to flow through the pipe under otherwise identical conditions will give us a ratio of their kinematic viscosities. In laboratory measurements this pipe becomes a standardized capillary tube, known as a viscometer, through which the flow time by gravity of the experimental fluid is compared with that of a reference fluid (such as water) of known kinematic viscosity.

Until recently few published data on the viscosity of animal fats were available, especially in the temperature ranges commonly used in the fats and oils industries. To fill this need, Sambuc and Reymond of the University of Aix-Marseille (France) have now carefully measured the kinematic viscosities of eleven different animal fats (Table I) at temperatures from 40^{o}-211^{o}C. (104-412^{o}F.).

Although there is considerable variation in the viscosities of fats from specie to specie, those of the most common fats of the rendering industry, crude and refined beef and pork fats, differ by no more than the experimental error of the measurement method. Refining does not appear to have an important influence on viscosity. For the extrapolation of viscosities to temperatures other than those reported in Table I, Sambuc and Reymond developed a regression equation which correlates well with the experimental data:

$$\log \nu_t = a \log t + b$$

where ν is the kinematic viscosity at temperature t ^{o}C and a and b are experimentally determined coefficients (Table II).

These viscosity data can be related to filtration rates if interstitial or pore space of the filter cake is looked upon as a bank of very fine capillary tubes. As flow rate varies with the fourth power of the diameter of the tube, it is evident that the rate of filtration (as in the bleaching of tallow) will fall off very rapidly with a decrease in pore diameter when a finer filter aid is used. Two corollaries to this dictum are that filtration rates can be accelerated and pump horsepower reduced by increasing the temperature and thereby reducing viscosity.

Literature for further reading:

"A propos de la viscosité des corps gras animaux", E. Sambuc and G. Reymond, Rev. franç. corps gras, 26, 73 (1979)

"Unit Processes and Principles of Chemical Engineering", J. C. Olsen, Van Nostrand, New York, 1932.

"Unit Operations", G. G. Brown, John Wiley & Sons, Inc., New York, 1950.

"Chemical Engineer's Handbook", J. H. Perry, et al., 4th Edition, McGraw-Hill Book Co., New York, 1950.

"Transport Phenomena for Engineers", L. Theodore, International Textbook Company, Scranton, Pa., 1971

"Flow Through Porous Media...", I. F. MacDonald, et al., Ind. Eng. Chem. Fundam., 18, 199 (1979).

Table I. Kinematic viscosities (in centistokes) of animal fats

Nominal Temperature (°C)	A	B	C	D	E	F	G	H	I	J	K
	Fats**										
40	(*)	(*)	(*)	(*)	35.7	36.3	(*)	(*)	(*)	(*)	(*)
56	24.9	24.7	23.1	23.9	21.2	21.1	25.6	24.3	25.5	25.7	25.5
66	19.2	19.1	18.9	18.4	16.3	16.5	19.5	18.6	19.6	19.1	20.5
100	8.75	8.60	8.45	8.40	7.90	7.95	9.05	8.70	8.60	8.40	8.40
131	5.27	5.17	5.15	5.09	5.03	4.90	5.46	5.15	5.14	4.92	5.19
174	3.18	3.10	3.06	3.13	2.93	2.93	3.20	3.15	2.98	3.89	3.03
211	2.27	2.22	2.24	2.27	2.25	2.15	2.49	2.21	2.06	2.09	2.24

*Fats were incompletely melted at this temperature

**A - crude rendered beef tallow
B - refined beef tallow A
C - crude lard
D - refined lard C
E - horse fat
F - horse oil
G - lard oil
H - bone fat
I - extracted animal fat (FFA below 10)
J - extracted animal fat (FFA above 10)
K - rendered animal fat

Table II - Regression equation coefficients

Fat	Constants	
	a	b
A	- 1.822	4.58651
B	- 1.835	4.60683
C	- 1.797	4.52049
D	- 1.793	4.51529
E	- 1.685	4.26404
F	- 1.709	4.30925
G	- 1.797	4.55186
H	- 1.815	4.56503
I	- 1.097	4.74864
J	- 1.910	4.74854
K	- 1.876	4.69555