Fluid Mechanics - Course 223

VISCOSITY

There are many factors which affect the manner in which a fluid flows and, of all these factors, viscosity requires the greatest consideration.

Viscosity may be defined as the fluid property which causes the fluid to have resistance to shear. The shear stress in a fluid is directly proportional to viscosity.

Let's consider lubricating oil for a moment. We all know that in the mid winter the oil is reluctant to flow and in the summer flows more freely. What causes this change? There is no significant volume change and thus the density, ie, mass/ unit volume doesn't change. This change in behaviour is due to the change in viscosity, due to temperature.

VISCOSITY depends only upon TEMPERATURE

For liquids, viscosity decreases as temperature increases. Viscosity is a property concerned with flow and has no effect on fluids in a static situation.

In a lubrication application, where one body is moving relative to another, separated by an oil film, as in a shaft and bearing application, a shearing action of the oil film occurs. The force required to shear the oil film depends upon the viscosity and thus on the temperature.

For interest, a definition of viscosity is,

$$\frac{\text{the shear stress in a liquid}}{\text{the rate of shear strain in a liquid}}$$

This ratio is 'dynamic viscosity' denoted by μ (mu) and dimensionally has units of

$$\frac{N.s}{m^2}$$

There are two basic types of flow which may occur, laminar and turbulent. The criterion for the change from one type of flow to the other is a function of the dynamic viscosity divided by the density. This ratio is called the 'kinematic viscosity' denoted by ν (nu).

Thus $$\nu = \frac{\mu}{\rho} \quad \frac{m^2}{s}$$

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Kinematic viscosity is used in many ways when considering fluid flow calculations. Figures 1.1 and 1.2 show how the dynamic viscosity varies with temperature for a variety of fluids. From Figure 1.2 we can see that the dynamic viscosity of water is almost 100 times that for air. You can see that gases do not change viscosity in the same manner as liquids.

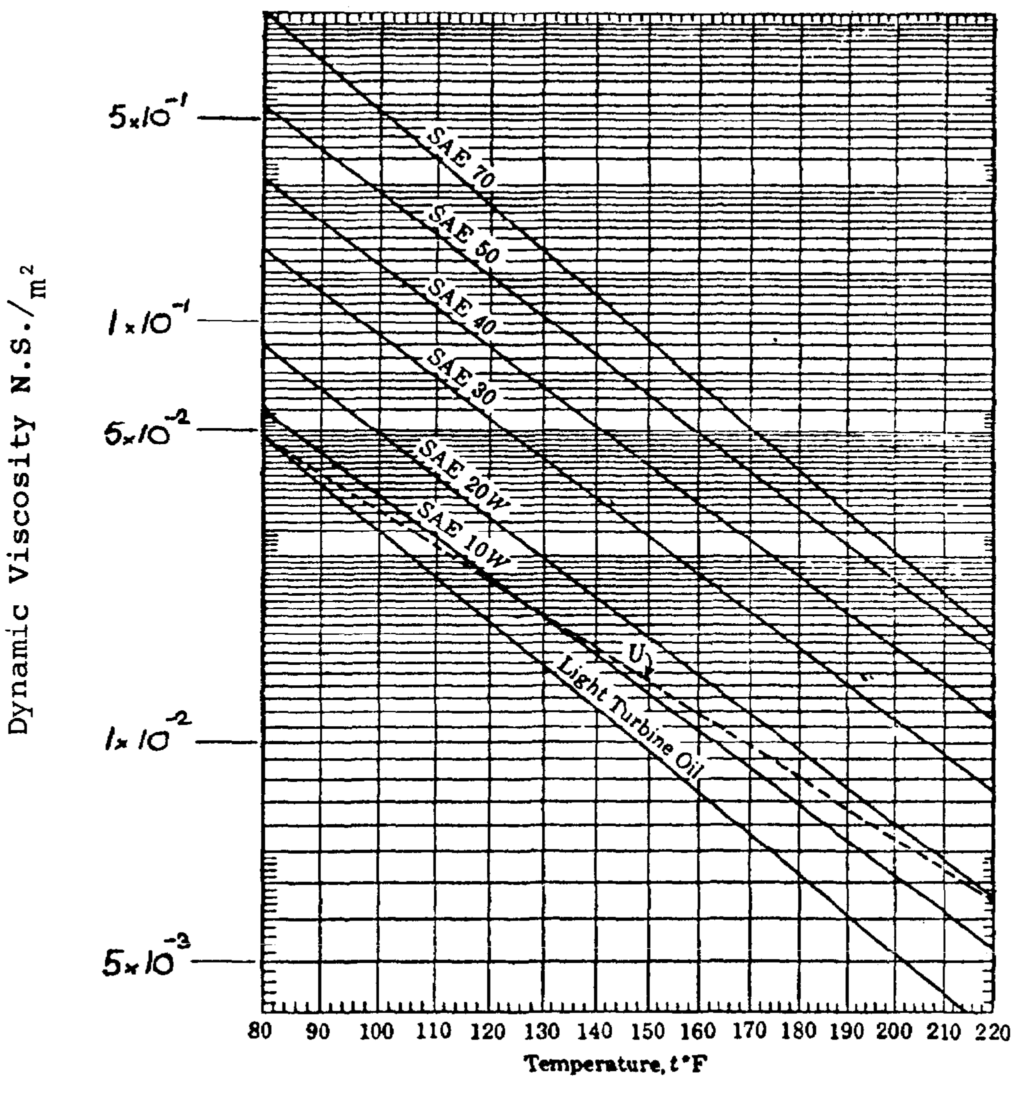
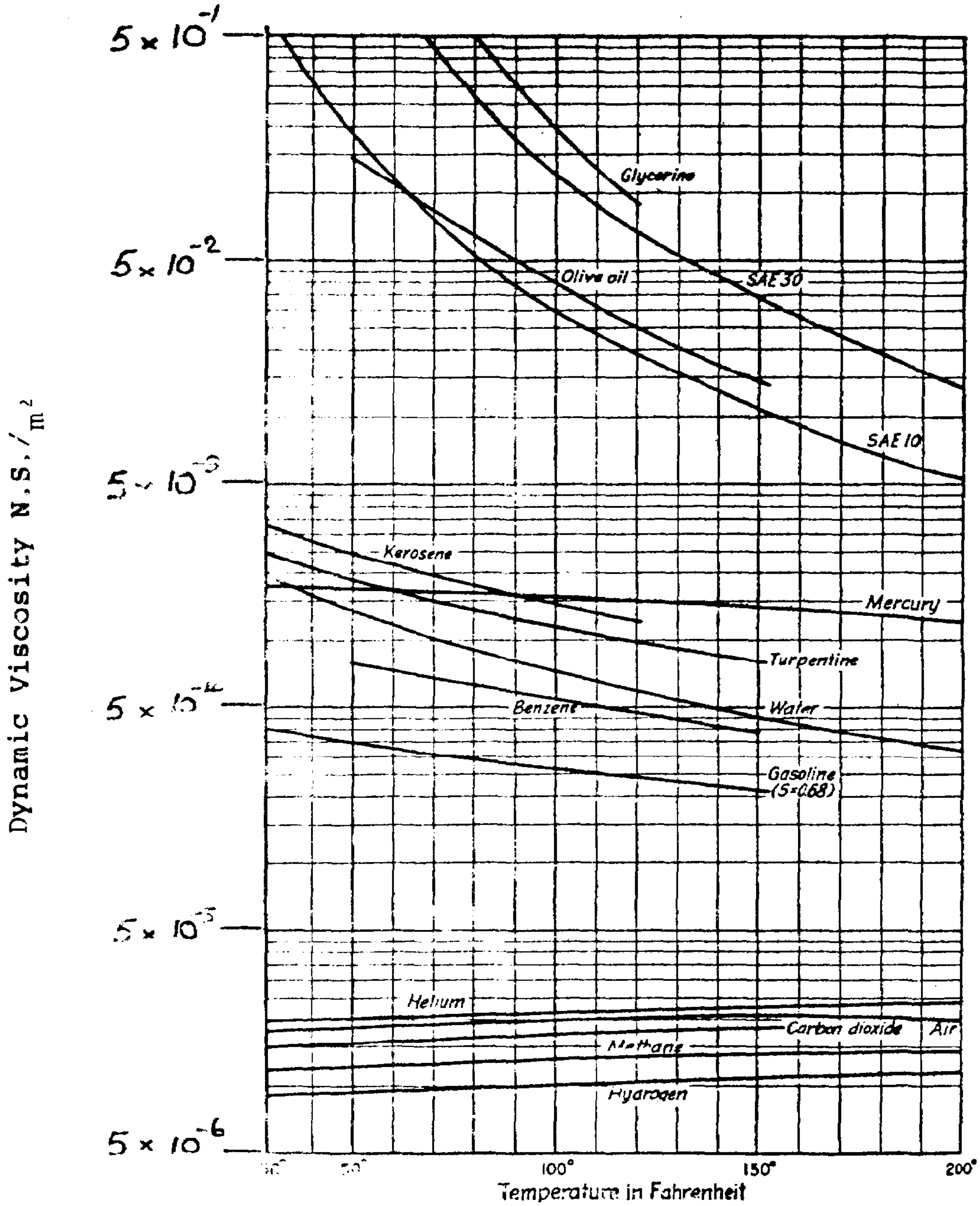


Figure 1.1



Viscosity graph.

Figure 1.2

ASSIGNMENT

1. Describe 'viscosity' in your own words

2. What are the units of dynamic viscosity?

3. Why is 'kinematic viscosity' used in flow calculations?

4. Which of the following oils will absorb the lowest energy when lubricating a journal bearing?

   (a) SAE 40 at 200°F
   (b) SAE 20 at 130°F

5. What factors affect viscosity?

6. How would you expect a multigrade oil SAE 20/50 to behave?

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