8 Transport Viscose Liquids

1. Terms and Units

The test presented in Fig. no. 16 explains viscosity and its characteristics in an illustrative way:

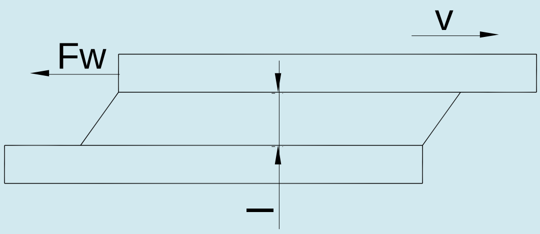

Fig. 16

Between two parallel plates, with the bottom one being stable, there is a liquid. If the upper plate is given the speed v, a considerable resistance will be noticeable. Whereas the outer liquid layers stick to the plates, the internal layers resist a mutual shift. This characteristic of liquid and gas substances is also known as viscosity. The resulting resistance F_W increases with the increase in viscosity η, speed v and dimensions of the moistened surface A. An increase in the distance l leads to the reduction of the resistance. Under the condition of a linear speed increase in the fissure the result will be:

$$F_W = \frac{\eta \cdot v \cdot A}{l} \qquad (21)$$

once η is solved:

$$\eta = \frac{F_W}{A} \cdot \frac{l}{v} \qquad (22)$$

and with F_W / A as a shear stress τ

$$\eta = \tau \cdot \frac{l}{v} \qquad (23)$$

We obtain the special definition of <u>dynamic</u> viscosity η.

Equation (22) provides the unit:

$$1 \frac{kp \cdot s}{m^2} = 98{,}1 \text{ P} = 9{,}81 \text{ Pas}$$

There is the following connection with the units of the dynamic viscosity in the previous <u>physical</u> system of units:

$$1 \frac{g}{cm \cdot s} = 1 \text{ Poise [P]} = 0{,}1 \text{ Pas}$$

1 Centipoise [cP] = 1 mPas

With the unit of the dynamic viscosity in the <u>technical</u> system of units:

$$\frac{N \cdot m}{m^2 \cdot m/s} = \frac{N \cdot s}{m^2} = \text{Pas}$$

In the case of flows, and particularly gas flows, the density of the transported material plays a decisive role. This is why the fluid mechanics prefers the so-called cinematic viscosity ν. Cinematic viscosity can be obtained by dividing dynamic viscosity by density:

$$\nu = \frac{\eta}{\rho} \qquad m^2/s$$

The unit m^2/s leads to unpractical values which is why the unit mm^2/s is generally used more often. The resulting values also correspond with the Centistoke [cSt] physical unit that was used in the past.

2. Transport Viscose Liquids

The characteristic curves of the centrifugal pump generally refer to cold water as transported material. If liquids with higher viscosity are transported, there will be minor or major deviations, depending on the degree of viscosity, the width of the channels and the type of a pump. The conversion of the characteristic curves applied for water into the characteristic curves for liquids with higher viscosity is not possible in theory. One must rely on the tests, whose results, strictly speaking, apply to the type and size of pump examined

The change in characteristic curves of a medium rotary pump that runs on transmitted liquids with different viscosity is shown in Fig. no. 17.
According to this, the viscosity at zero delivery has little effect on the pump head pressure. An increase in transmission flow leads to a reduction in the pump head pressure in comparison with water transmission ($1 mm^2/s$); the reduction increased with viscosity. In the case of a higher viscosity, the power consumption is larger over the whole transmission range by almost the same amount. This tendency of the change of a characteristic curve is observed in the case of rotary pumps for larger transmission flows; this does not allow for a conclusion regarding the behaviour of pumps of

different design and size. Major deviations occur in the case of rotary pumps for smaller transmission flows. In this case and in contrast to what occurs in large pumps, the pump head pressure in the part load range will exceed even the characteristic curve applied to water.

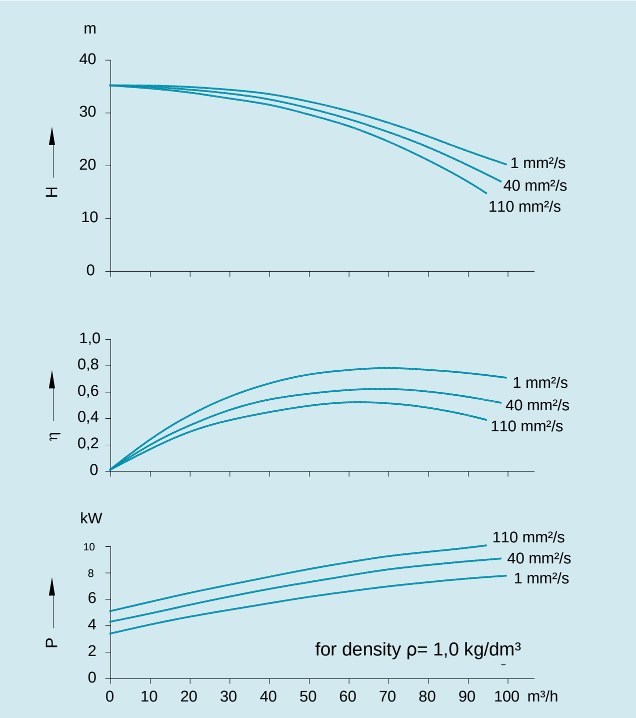

Fig. 17

The differing behaviour of pumps depending on the type and size makes it impossible to create work documentation that is easy to manage. We would therefore request that you ask for an appropriate pump in a factory.

3. Information for the Selection of a Pump

The viscosity of fluids depends on temperature. This is shown in Fig. no. 18.

The choice of proper standards makes it possible to estimate the temperature and viscosity of other liquids by using this diagram, even if we have information only for one temperature. However, one must not forget that due to a different pitch of the respective characteristic curves, a mistake could be made when reading the values.

This applies in particular to low temperatures, and it is the area of low temperature that is of importance for the pump dimensioning. Very often, the temperature of the transmitted liquid is much lower at the beginning of the transmission than the operating temperature set-point. Even if a lower pump capacity is acceptable when the pump starts, the higher power requirement must be considered when you are selecting a motor. In general, for any plant, a motor will be evaluated in accordance with the lowest temperature.

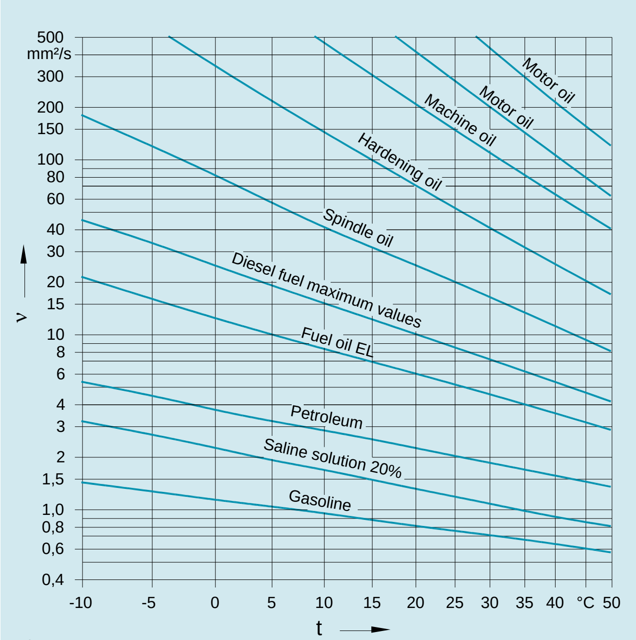

Fig. 18

In the case of the transmission of viscous fluids, the degree of efficiency also changes in addition to the changed pump capacity. The use of a rotary pump is therefore limited when there are high viscosity liquids involved. If certain limits are exceeded, it is rotating positive displacement pumps that should be used instead.

Q [m³/h]	mm²/s
up to 60	115
up to 100	150
over 100	200