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PUMP CLINIC 4

VISCOSITY
How does it affect centrifugal pump performance?

The performance of centrifugal pumps will vary when viscous liquids are pumped. For medium and high viscosities, the power requirement increases considerably, whilst the head, and to a lesser extent the flowrate, is reduced. With the aid of *Table 4 (Page 3),* the characteristics of centrifugal pumps pumping viscous liquids can be calculated, providing the characteristics for pumping water are known. (This diagram may also be used as an aid in the selection of a pump for required duty).

The correction factors established from the diagram are sufficiently accurate for general application within the limits given below. If more accurate values are required, a test should be performed with the particular liquid.

When pumping highly-viscous liquids, it is recommended that the running costs are investigated to establish whether other types of pump (eg rotary positive-displacement-type) could be more economic due to the steep drop in efficiency of centrifugal pumps under these conditions..

The limits of centrifugal pumps are:

For nominal discharge pipe diameters;

≤ 50mm	-	approx 120 – 130 mm²/s
≤ 150mm	-	approx 300 – 500 mm²/s
> 150mm	-	approx 800 mm²/s

Limitations and notes on the use of Table 4

* The diagram should only be used for centrifugal pumps with radial impellers within the normal Q-H range. The diagram must not be used for pumps with mixed flow and axial flow impellers or for special pumps for viscous or heterogeneous liquids. *Table 4* is not applicable to side-channel pumps.
* The diagram may only be used if sufficient NPSH ($NPSH_{avail}$) is available to prevent cavitation.
* The diagram may only be used for homogeneous Newtonian fluids. For gelatinous liquids, widely-scattering results are obtained in practice, depending upon the special properties of the liquid.
* With multistage pumps, the head per stage must be used in the calculation.
* When pumps have double-entry impellers, one half of the flowrate must be used in the calculations.

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Determining the size of a pump for a viscous liquid

(Approximate determination of an equivalent operating point for water)

Subscripts: vis = viscous liquid
w = water
opt = best efficiency point

Given: Q_{vis} in m³/h, kinematic viscosity v in mm²/s
H_{vis} in m, ρ_{vis} in kg/dm³

Required: Q_w in m³/h } to determine a suitable pump for which only
H_w in m } performance data relating to water are known

P_{vis} in kW to determine the driver power

To establish the correction factors from the diagram, the following procedure is used:

Starting with the flowrate Q on the horizontal axis, move vertically up to the intersection with the required head H, then proceed horizontally (to the right-hand side or to the left-hand side) to the intersection with the viscosity v of the liquid, thence vertically up to the intersection with the lines of the different correction factors.

To determine the correction factory C_H for total head, the curve I.0 x Q_{opt} is to be used.

This gives: $Q_w \approx \frac{Q_{vis}}{C_Q}$, $H_w \approx \frac{H_{vis}}{C_H}$, $\eta_{vis} \approx C_\eta \times \eta_w$

Example: $Q_{vis} = 100 m^3$ $v = 100 mm^2/s$
$H_{vis} = 29.5 m$ $\rho_{vis} = 0.90 kg/dm^2$

From the diagram the correction factors are found as follows:

$C_H = 0.94$ $C_Q = 0.98$ $C_\eta = 0.70$

With this data the water values can be calculated:

$Q_w \approx \frac{100 m^3/h}{0.98} \approx 102 m^3/h$, $H_w \approx \frac{29.5 m}{0.94} = 31.4$

A pump with $\eta_w = 75\%$ is used.

Therefore, $\eta_{vis} = 0.70 \cdot 75\% = 53\%$

$$\rho_{vis} \approx \frac{Q_{vis} \cdot H_{vis} \cdot \rho_{vis}}{367 \cdot \eta_{vis}} = \frac{100 \cdot 29.5 \cdot 0.90}{367 \cdot 0.53} \text{ kW} = 13.6 \text{ kW}$$

This procedure is to be considered as an approximation only, as the numerical values for rate of flow and total head shown in the diagram apply to water. However, in most cases, this procedure has sufficient accuracy for preliminary pump selections.

If the flowrate is: $Q_w < 0.9 \times Q_{opt}$ or $> 1.1 \times Q_{opt}$

Respectively, the selection should be checked by the more accurate method given in the following section.

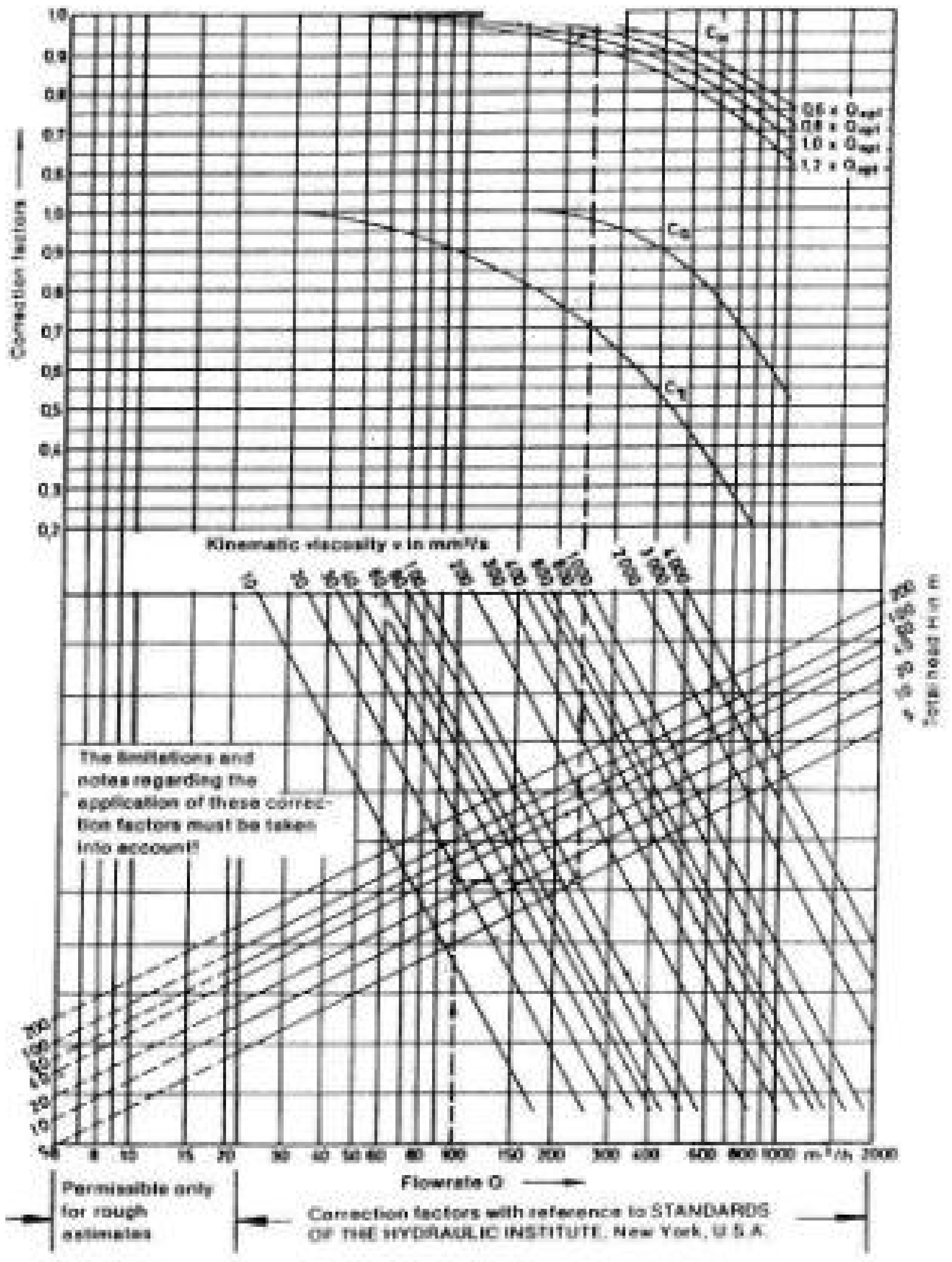

Table 4 Correction factors for converting Q, H and η when centrifugal pumps with radial impellers are used to pump viscous liquids.

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Establishing the characteristics of a pump for viscous liquids

(Conversion of the pumps water characteristics)

Using the available water characteristics of the pump, Q_{opt}, H_{opt}, and η_{opt} are determined.

Based on these values the correction factors

C_H for { $0.6 \times Q_{opt}$
{ $0.8 \times Q_{opt}$
{ $1.0 \times Q_{opt}$
{ $1.2 \times Q_{opt}$

C_Q and $C\eta$ can be found from the diagram using the procedure outlined in the previous section.

It is expedient to convert the performance data in tabular form, see example.

When plotting the characteristics it should be noted that the shut-off head H_0 remains approximately constant.
Example (see Fig. 60 for the characteristics):

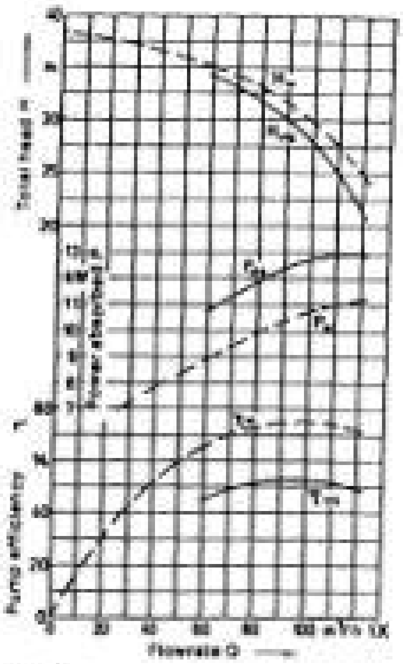

Fig. 60

				$0.6 \cdot Q_{opt}$	$0.8 \cdot Q_{opt}$	$1.0 \cdot Q_{opt}$	$1.2 \cdot Q_{opt}$
water	Flowrate	Q_w	m^3/h	60	80	100	120
	Total head	H_w	m	35	33	29.8	24.5
	Efficiency		%	65	73	75	71
Kinematic viscosity of the liquid pumped			mm^2/s	100			
Correction factors			C_H	0.97	0.96	0.94	0.91
			C_Q	0.98			
			C_η	0.70			
viscous liquid		$Q_{vis} = C_Q \cdot Q_w$	m^3/h	58.8	78.4	98	117.6
		$H_{vis} = C_H \cdot H_w$	m	34	31.7	28	22.3
		$\eta_{vis} = C_\eta \cdot \eta_w$	%	45.5	51.1	52.5	49.7
	ρ_{vis}		kg/dm^3	0.90			
	Pump power absorbed	$P_{vis} = \frac{Q_{vis} \cdot H_{vis} \cdot \rho_{vis}}{367 \cdot \eta_{vis}}$	kW	10.8	11.9	12.8	12.9