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Two-way force feed oiling systems.
Selecting elements and basic parameters.

A lubricating system used on a machine or technical device, in order to ensure efficient lubrication, should have appropriate construction elements selected and other values which condition the determined proper operation. Preparatory works for using the lubrication system are conducted during designing and cover the following operations:

- selection of dosing distributors (feeders) of delivery corresponding to the demand of individual reception points for lubricating medium,
- setting frequency of lubrication
- selection of pipe diameters
- selection of pump according to its delivery and pressure produced.

1. APPLICATION, CONSTRUCTION AND OPERATION OF CENTRAL LUBRICATION SYSTEMS

The two-way force feeding oiling systems [3] are mainly recommended for lubricating high-load machines and devices operating in difficult conditions, having a large number of friction nodes located at large distances and requiring intensive lubrication. So far, the equipment has been used in ironworks, steelworks, non-ferrous metal smelters, strip mine equipment, cement mills, sugar factories, forging plants and other complexes with similar equipment and work conditions. The two-way oiling systems consist of the following elements (Fig. 1):

- central lubrication pump,
- controlling distributor (hydraulic or electromagnetic) which changes the direction of feeding lubricant,
- dosing distributors (two-way feeders) located on the lubrication main conduit lines at the points where the grease is received and passed to the reception points,
- system operation controller,
- filling pump,
- pipes and connectors.

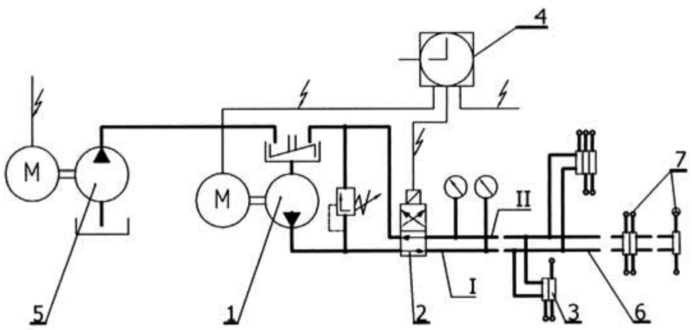

Fig. 1 Construction diagram of the two-way force feed oiling system:
1 - central lubrication pump, 2 - control distributor, 3 - dosing distributors, 4 - controller,
5 - tank-filling pump, 6 - lubrication main conduit lines (I,II), 7 - lubricant reception points

System operation consists of cyclical forcing of lubricant by a pump to one of two lubrication main conduit lines alternately. This cyclical change of pressure in the lines activates dosing distributors which feed lubricant to reception points. The amount of lubricating medium depends on variations of dosing distributors used in the system as well as their delivery preset with the controller programme.

The program of POLNA Automatic Machinery Plant covers all necessary devices to construct two-way systems in many variations [5].

2. SELECTING DOSING DISTRIBUTORS (TWO-WAY FEEDERS)

A feeder is selected according to the amount of lubricant which should be fed to the friction node in a specific period of time. The amount is estimated, according to various sources, at 10—40 g of lubricant per 1m² of lubricated surface, during one hour of operation.
More precise results may be calculated from the following dependence: [4]

$$q = 11\, k_1 k_2 k_3 k_4 k_5 \qquad cm^3/(m^2 \times h), \qquad (1)$$

where:

q - - the amount of lubricant (cm^3) which should be fed to $1m^2$ g of lubricated surface, during one hour of operation,

11 - maximum consumption of lubricant (with reference to a bearing of diameter 100 mm and up to 100 rpm), $cm^3/m^2 \times h$

k_1 - coefficient which takes into account the bearing diameter (Table 1)

k_2 - coefficient which takes into account demand for lubricant depending on the bearing speed of rotation (Table 2)

k_3 - coefficient which takes into account quality of execution of friction surfaces k_3=1-1,3

k_4 - coefficient taking into account temperature of bearing operation

for t<70°C k_4=1
for t=75-150°C k_4=1,2

k_5 - coefficient which takes into account the bearing loading

for regular load k_5=1
for high load k_5=1,1

Table 1 Coefficient k_1 for the dependence (1)

Specification	Bearing diameter [mm]				
	100	200	300	400	500
For slide bearings	1,0	1,4	1,8	2,2	2,5
For rolling bearings	1,0	1,1	1,2	1,25	1,3

Table 2 Coefficient k_2 for the dependence (1)

Specification	Bearing speed of rotation [rpm]			
	100	200	300	400
For slide and rolling bearings	1,0	1,4	1,8	2,2

On the basis of the above data it is possible to calculate delivery of the distributor's dosing section with the following dependence:

$$V = qAt \ \ cm^3/cycle \qquad (2)$$

where:

A - bearing friction face, m^2,
t - frequency of lubrication, h.

Dosing feeder is selected according to the amount of lubricant required using the manufacturer's catalogue [6].

Example calculation of lubricant amount for bearings in the fire grate of steam boiler WR25.

Input data:

Bearing dimensions	- 100x160x52 (rolling bearings)
Speed of rotation	- approx. 10 rpm
Temperature of beaarings	- approx. 50°C - 2 bearings of driving shaft approx. 250°C - 2 bearings of rear shaft
Load	- high
Quality of bearing face	- good

Necessary amount of lubricant that has to be fed to the bearing during one lubrication cycle

Amount of lubricant per $1m^2$ of bearing face during 1 hour

$$q = 11 \ k_1 \ k_2 \ k_3 \ k_4 \ k_5 \qquad cm^3/m^2 \times h$$

k_1 - which takes into account the bearing diameter, for d=100 rpm -> $k_1 = 1$

k_2 - coefficient which takes into account demand for lubricant depending on speed of rotation
for $n \leqslant 100$ rpm -> $k_2 = 1$

k_3 - coefficient which takes into account quality of execution of friction surfaces
for rolling bearings -> $k_3 = 1$

k_4 - coefficient taking into account temperature of bearing
for $t \leqslant 70$ °C -> $k_4 = 1$ (1)
for $t \leqslant 250$ °C -> $k_4 = 2,5$ (2)

k_5 - coefficient taking into account type of load, for hard work -> $k_5 = 1,1$

Thus:

$$q_{(1)} = 11 \times 1 \times 1 \times 1 \times 1 \times 1{,}1 = 12{,}10 \qquad cm^3/m^2 \times h$$
$$q_{(2)} = 11 \times 1 \times 1 \times 1 \times 2{,}5 \times 1{,}1 = 30{,}25 \qquad cm^3/m^2 \times h$$

amount of lubricant fed by dosing distributors to the bearing during one lubrication cycle

$$V = F \; q \; T = m \; T \qquad cm^3/cycle$$

Face of the bearing

(In the case of rolling bearings "d", the diameter of the bearing hole is taken)

$$F = (\pi \times d \times L) / 2 = (3{,}14 \times 0{,}1 \times 0{,}052) / 2 = 0{,}008 \; m^2$$

Amount of lubricant that should be fed to the bearing during 1 hour of operation

$$m = F \times q \qquad cm^3/h$$
$$m_{(1)} = 0{,}008 \times 12{,}1 = 0{,}1 \qquad cm^3/h$$
$$m_{(2)} = 0{,}008 \times 30{,}25 = 0{,}24 \qquad cm^3/h$$

Amount of lubricant that should be fed to the bearings during 1 lubrication cycle

$$V = m \times T \qquad cm^3/cycle$$

Lubrication frequency is set at:

$$\mathbf{T = 12\ h}$$

$$V_{(1)} = m_{(1)} \times T = 0{,}1 \times 12 = 1{,}2 \qquad cm^3/cycle$$
$$V_{(2)} = m_{(2)} \times T = 0{,}24 \times 12 \cong 3 \qquad cm^3/cycle$$

Selecting dosing distributors (feeders) of DD type

1) For bearings of drive shaft, feeders DD21 should be used (two-outlet of max. delivery 2 cm^3/cycle)
2) For bearings of rear shaft, feeders DD22 should be used (two-outlet of max. delivery 4 cm^3/cycle)

3. 3. SELECTING PIPE DIAMETERS

After working out the first concept of the pipelines' course, through which lubricant is to be fed in the lubrication system, it is necessary to determine precisely their diameters depending on flow duration and resistance.

At forcing lubricant, a pump must overcome the following resistance: [1]

1. Lubricant flow resistance in the feeding line (active), before the last distributor. In a correctly designed system, this resistance is: $p_1 = 0{,}1 - 0{,}3$ *MPa/rm*

2. Resistance in the dosing distributor: p_2=0,2 - 0,6 MPa

3. Resistance in the line after the distributor: p_3=0,1 - 0,3 MPa/rm

4. Resistance in the lubricant reception point: p_4=0,2 - 0,4 MPa

5. Local resistances in the active line (change of flow direction, change of pipe intersections, etc.): p_5

6. Resistance in the inactive line, at the lubricant return: p_6= aprox. 0,05 MPa/rm

Flow resistance in the pipe depends mainly on the flow intensity, type of lubricant (its penetration) and temperature. Diagrams [5] are used to determine losses. Examples of the diagrams, for the most frequent lines in lubrication systems, are indicated in fig. 2.The diagrams were made at forcing plastic grease of IP1-Z symbol (lime-soda grease on the basis of cylinder oil, of penetration 310-360/50°C, made in former ZSRR)

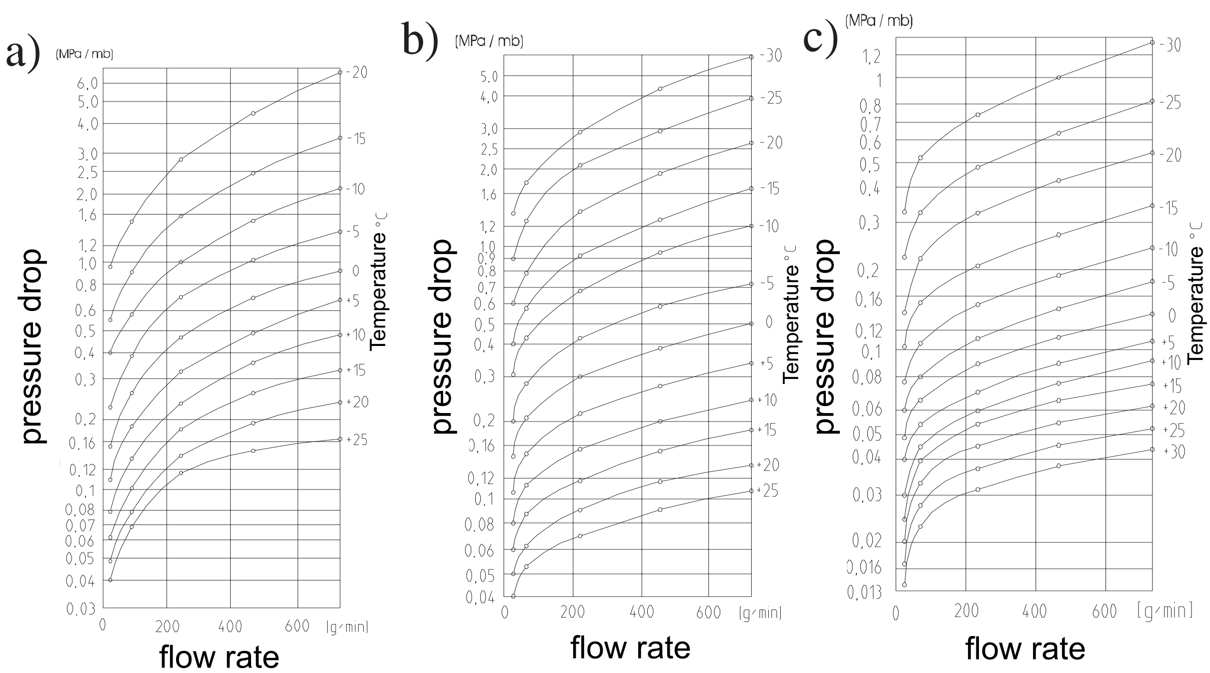

Fig. 2 Diagrams of pressure drops at forcing plastic grease IP1-Z through pipes of nominal diameters: a=9 mm; b=13 mm; c=25 mm.

Due to the complex rheological properties of lubricant (structural viscosity, tixotropic properties, as well as lubricant wall properties), accurate determination of actual flow resistance is very difficult [2]. Thus, the values indicated in paragraphs 1-6 above or read from diagrams (Fig. 2) should be treated as approximate and some excess pressure (generated by the pump) should be taken into account in the designed system to ensure proper operation of the lubrication system.

In order to verify the correctness of selected parameters in the designed system, it is necessary to prepare, on the basis of calculation results, a diagram of pressure drops according to Fig. 3 [1].

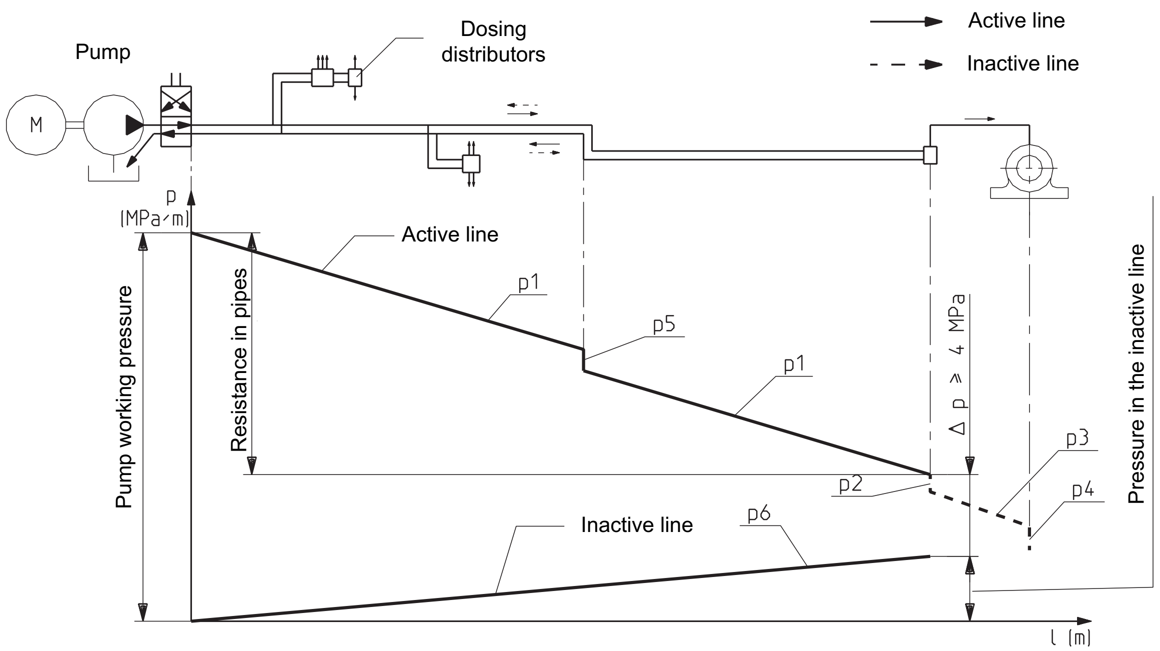

Fig. 3 Diagram of pressure drops in the lines of the central lubrication system.

Data from Table 3 [5] may be used to determine line diameters depending on their length.

Table 3. approximate diameters of lines in central lubrication systems with plastic grease, depending on their length.

Length of line measured from the working pump [m]	Nominal diameter [mm]
100 - 120	50
65 - 75	40
35 - 40	25
20	20
15	16
10	10

When constructing a lubrication system it is necessary to avoid pressure difference at the end of lines (active and inactive) - in the last dosing distributor - lower than 4 MPa (Fig. 3). This is the basic condition for proper operation of a two-way central lubrication system.

On the basis of experience gained in system construction, it has been noticed that the area of lubricated devices covered by one system should not be larger than 80m, and lengths of individual lines (distance from the pump to the last remote dosing distributor) must not exceed 40m. E.g. in a system in which pump PD 31 of 150 cm^3/min and pressure up to 32 MPa was used, the following pipeline dimensions worked:

- main conduit lines - d_w33 (pipe 38 x 2,5), length - 40 m,
- lines connecting distributors with the main conduit - d_w13 (pipe 16 x 1,5), length - 10 m
- lines connecting distributor outlets with bearing housings - d_w8 (pipe 10 x 1), length - 2,5 m.

4. SELECTING A PUMP

When designing a lubricating system it is necessary to select a pump so that it feeds lubrication medium in the amount corresponding to the need of machines and devices and produced pressure ensuring feeding of the medium to all reception points, according to the diagram (Fig. 3) [6].

5. BIBLIOGRAPHY:

[1] BESSER H., „Zachowanie się smarów plastycznych podczas przetłaczania i jego oddziaływanie w urządzeniach centralnego smarowania", materiały III smarowniczej konferencji n-t „Postęp w konstrukcji urządzeń smarowniczych", Katowice, 1971.
[2] CZARNY R., (red), „Systemy centralnego smarowania maszyn i urządzeń" rozdział A i B „NAVIGATOR", Wrocław 2000.
[3] NAUMOWICZ W. „Stan i perspektywy rozwoju krajowej produkcji urządzeń i układów centralnego smarowania" Hydraulika i Pneumatyka 4/2002 str. 22, 23.
[4] WOŁKOW J.R., „Projektirowanije, montaż i eksploatacja centralizowanych sistem gustoj smaski" Rozdział III ORGERMET. Moskwa, 1952.
[5] WYSOCKI M., „Systemy smarowania w przemyśle ciężkim", „Śląsk", Katowice, 1971.
[6] „Urządzenia centrlanego smarowania", (Katalog), ZAKŁADY AUTOMATYKI „POLNA" S.A.,Przemyśl 2007.