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GEARBOX LUBRICATION SYSTEM OPTIMIZATION

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Abstract: The aim of gearbox lubrication is to reduce wear on the sides of the teeth, increase of the efficiency by reducing friction as well as dissipating the heat generated by friction. Lubrication of gearboxes is a discontinuous process, that means, during the meshing every meshed pair of teeth needs to have a new lubrication film created on the surfaces. The geometric shape of the sides of the teeth is conditioned by rolling and sliding movement, therefore gears often work under a mixed friction condition. This is confirmed by damage to gearboxes and by measured power losses. This contribution is devoted to the issue of innovation of the original lubrication of the first stage of the bevel helical gearbox used for the drive of the rope drum.

1 Introduction

The most common gearbox lubrication system is wading lubrication, which currently solves the lubrication of a given bevel helical gearbox. The oil creates the filling of the gearbox and the gear wheels that are waded in the oil moves the oil into the meshing [1-3]. This lubrication system is used for circumferential speeds of $v \leq 12$ m.s^{-1}. It is recommended that, for high-speed gear wheels, the immersion depth does not exceed double the value of the gearing module and should not be less than 10 mm. Because the oil level decreases during operation, the immersion depth of the high-speed wheels tends to be up to four times the gearing module at rest [4,5]. At small circumferential speeds up to 1.5 m.s$^{-1,}$ the immersion depth can be up to 1/6 of the gear wheel pitch diameter.

Another possible way is to lubricate with forced circulation - with central circulation lubrication, in which the oil that is fed to the lubrication areas is drained back into the tank, which makes the oil to circulate [6-8]. Requirements for circulatory lubrication include the reliability of the whole lubrication system as well as its parts, the possibility of choice or control of lubrication areas, the possibility of automation of the operation and reliable control and operation of the control elements [9].

2 Characteristics of the original gearbox lubrication

It is a three-speed bevel gearbox with a gear ratio of 19.706, power of 500 kW. The original lubrication is designed by spraying the wading wheel in an oil filling with a volume of 800 l. This method of lubrication is unsatisfactory at very low speeds (max. input speed approx. 200 rpm, most often speeds from 0 - 100 rpm), as evidenced by the fact that the first gear of the bevel gearbox shows a considerable degree of wear [10,11]. Over the last 10 years, the input side pinion with the counterpart has been changed three times and, in addition, the input side pinion alone, was changed two times more. Drawings of spare parts for these gears as well as for the entire gearbox are not available [12-15].

3 Design of circulating lubrication and description of its activity

On a base of central circulating lubrication of the bearings for the first template and bevel gearing, the circulation system shown in Fig.1 has been proposed.

The description of the operation is as follows. Before putting the device into operation (in case of prolonged shutdown), it is necessary to actuated a thermostat that detects the temperature of the lubricating medium. If the temperature is below the required working value, the lubricating medium must be heated by means of a heating element (spiral) up to the desired temperature. After reaching the desired temperature of the lubricating oil, its heating process is ceased and the device (gearbox) is ready to start. Also during operation of the device, the working temperature of the lubricating medium is monitored and in case of drop below the specified temperature, the heating is switched on and carried out by a heating element.

When the device is put into operation, i.e. when the desired lubrication medium working temperature is reached, central circulatory lubrication can be started by switching on the pump unit. The pump unit consists of a gear monoblock low pressure pump, the speed of which is 960 min^{-1}, the flow pressure of the pump 0.5 MPa (5 bar), max. viscosity of pumped oil 228 mm^2.s^{-1} and flow rate is Q = 0,22 l.s^{-1} (13,2 l.min^{-1}).

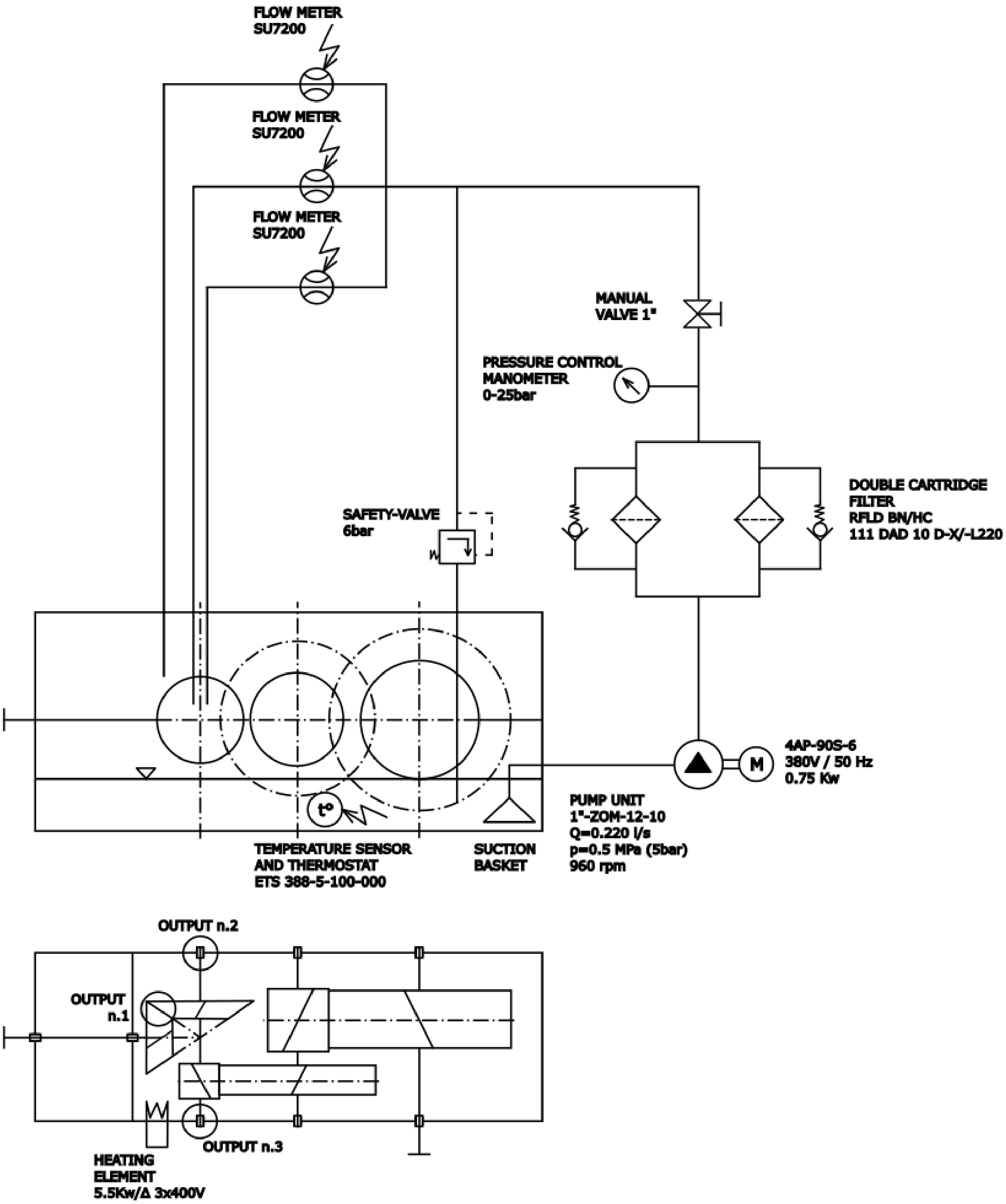
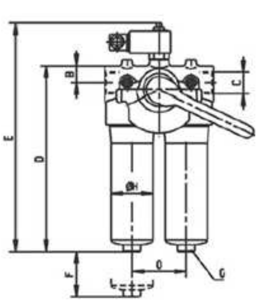


Figure 1 Central circulation lubrication scheme

The pump is powered by an electric motor (which is part of the pump unit) 4AP – 90S – 6 with a power of 0.75 kW (standard three phases asynchronous motor with shortcircuit armature for direct connection to the grid, closed version with its own surface cooling for a voltage of 380V, 50Hz). This pump unit draws the lubricating medium from the gearbox oil bath through the suction basket, the function of which is to prevent coarse impurities from entering the circulatory lubrication system and drives the lubricating medium into the filter.

The filter (Fig.2) is mounted on the outlet of the pump unit, it is a double cartridge, switchable with optical-electric indicator of the filter insert clogging (version with a voltage of 220 V). The filter ensures that the flow is at its outlet. The filter must be flexibly connected, not firmly set to the floor, designed for hydraulic systems that operate non-stop. When the filter insert is clogged, it is necessary to replace it. The filter consists of two parts and thanks to this, one part can be cleaned during operation and oil can be filtered with the other one. Another element in the central lubrication system is a pressure control manometer of 0 to 25 bar. This is followed by a manual throttle valve, a safety valve at 1.2 times the pressure in the system, i.e., up to 6 bar. This is followed by a flow divider (from one to three, with the same flow rate equal to one third of the total flow rate in each branch) mounted on the outlet pipe and three lubricating medium flow sensors.



A	= 78 mm
B	= 38 mm
C	G1"
D	= 200 mm
E	= 258 mm
ΦH	= 66 mm
I	= 139 mm
K	= 168 mm
L	M8x16
O	= 85 mm

Figure 2 Filter

Flow sensors (Fig. 3) with ultrasonic sensor and programmable two switching outlets. The first outlet is a flow control of the lubricating medium with a display of the amount of flow in l.min^{-1} and a signalization at insufficient (zero) flow rate. The second outlet can be used to measure the temperature of the lubricating medium in °C.

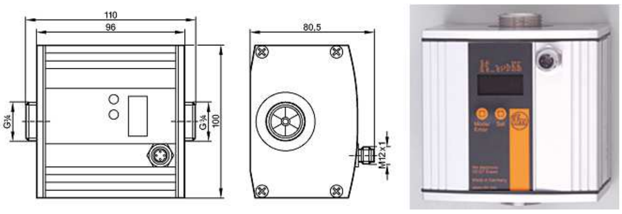


Figure 3 Flow sensor

The final element on each branch is the spraying nozzle. For the supply of lubricating medium to the bearings, it is recommended to use nozzles with a ring shape of spraying and for the supply of lubricating medium to the meshing of a bevel gearing, nozzle with a fan-shaped oil spraying. The oil returns to the gearbox, back into circulation.

The design of the amount of lubricating medium, i.e., the flow rate for lubrication of bearings by the central circulatory system, was based on the outer diameter of the bearing used on the first template (340 mm diameter). Based on reference [3], a lubricating medium flow rate between 0,1 l.min^{-1} and 10 l.min^{-1} is required for this case, noted that higher flow rates are used if the lubricating medium also serves as a cooling medium necessary for heat dissipation. Based on this requirement, a pump unit with flow rate Q = 0.22 l.s^{-1} (13,2 l.min^{-1}) has been selected. The flow rate by which the lubrication areas (bevel gearing meshing and bearings) are equal to a third of the pumping unit flow rate, i.e. the flow rate of 4,4 l.min^{-1}, which corresponds to the required range of oil needed to lubricate the bearings and at the same time meets the requirement of the necessary amount of lubricating medium for lubrication of the bevel gearing during meshing. Due to hydraulic resistances in the branches of circulating lubrication, the resulting flow rate will be even slightly lower, since the flow rate is inversely proportional to the resistance to movement. It is important to fine-tune the lubrication system during operation.

4 Conclusions

Perfect gearing lubrication ensures great durability, small mechanical losses, partially dampens noise and lead away heat. Gearboxes are usually lubricated with oil or plastic lubricant. Oil lubrication is often preferred for better heat dissipation. Lubrication with plastic lubricants is usually limited to the casings of gearboxes that cannot be sealed or can only be sealed at high design costs.

The original lubrication of the bevel helical gearbox was solved by wading the wheels in the oil filling, which was unsatisfactory, and the gearing was damaged. Based on the request, central circulatory lubrication of the bearings of the first template and the first degree of the gearbox consisting of a bevel gearing was designed. The task of lubrication systems is to bring and distribute the lubricant from one central source to all places of the machine where unwanted friction occurs, in an exactly specified quantity and time. Dripping oil flows back into the oil tub. With this method of lubrication, the oil can be filtered and cooled to separate the impurity particles and to dissipate heat.

In order to solve the issue of lubrication by designed central circulatory lubrication, it is necessary to implement a modification in the body of the gearbox.

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