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APPLICATION OF GEAR REDUCER OILS IN FOOD PROCESSING INDUSTRY

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Abstract: Technological production systems within food processing industry use machines which have specific requirements regarding the lubrication of particular components that come into contact with raw processing material. To satisfy stringent requirements, different types of lubricants have been developed. The problem of lubricating components and assemblies in the processing and packaging machines lies in the fact that the lubricant must possess qualities which allow it to come into contact with tobacco without compromising its safety. This paper gives an example of a synthetic ester-based gear oil used in tobacco industry. This paper reviews an example of gear reducer oil in a circulation system used for lubrication of working components of a cigarette filter making machine - Filter Maker.

Keywords: tobacco industry, gear oil, lubrication

INTRODUCTION

Application of food-grade lubricants in food processing industry demands special types of base oils and additives which must meet stringent requirements set by the NSF (National Sanitation Foundation) Class H1 standard. NSF was established as early as 1944 as the national foundation for standardization, setting special requirements for lubricants used in food industry on American market. The H1 specification refers to food-grade lubricants used in food-processing environments where there is the possibility of incidental food contact [1].

In addition to the discussed criteria, food-grade lubricants meet other international standards in food-processing industry, such as:

- Kosher, and
- Halal – food-safety standards.

Beside requirements related to food-processing compatibility, food-grade lubricants must also meet certain requirements regarding physical/chemical and exploitation characteristics.

Depending on the mode of application (liquid, semi-liquid, solid or aerosol), food-grade lubricants

must often meet stringent requirements of machine exploitation, while remaining safe in contact with processed food [2].

This paper reviews an example of gear reducer oil in a circulation system used for lubrication of working components of a cigarette filter making machine - Filter Maker.

GEAR REDUCER OILS IN TOBACCO INDUSTRY

Machines used for processing and packaging in tobacco industry are specific both design- and application-wise. The problem of lubricating components and assemblies in these machines lies in the fact that the lubricant must possess qualities which allow it to come into contact with tobacco without compromising its safety. Furthermore, just as with other types of standard industrial lubricating oils, all other physical/chemical properties food-grade lubricants must match the quality of conventional mineral oils.

The base oils which are used in food-grade gear reducer oils are manufactured according to HF1 and are predominantly of ester type [3]. The majority of synthetic esters (among various types)

are quickly biologically degradable, almost matching vegetable oils in that respect, as proven by numerous experiments [2,3,4]. However, the advantage of synthetic esters lies in their better oil oxidation properties and flow point at low temperatures. Another advantage is their ability to mix with mineral oils.

Base oils of synthetic esters are used for manufacture of various types of products, including: hydraulic oils, oils for two-stroke gasoline engines, oil mixtures for Diesel engines used in ecologically sensitive environments (forestry, river and lake shipping, etc.), gear reducer oils and all other industrial oils which must meet ecological and food-safety requirements [5].

Generally, the synthetic ester base oils perform exquisitely in comparison with their mineral base counterparts, regarding:

- thermal stability,
- oxidation stability,
- replacement intervals (longer, compared to mineral oils)
- viscosity index (VI) - temperature properties,
- flow properties at low temperatures,
- operating temperature limitations,
- resistance to radiation,
- resistance to flame.

As regards chemical characteristics, gear reducer oils used in tobacco industry must meet following requirements:

- Good corrosion properties, ASTM D-130 copper corrosion test, a three-hour test at 100°C, allowed limits 1a and 1b [6];
- Lower values of total acidity number -TAN, approximately 1 (0.9 – 1.1), as opposed to conventional gear reducer oils which feature 2 and 3 mgKOH/g Oil and higher. Tests are performed according to ASTM D-974 standard [7];
- Resistance to demulsification of food-grade gear reducer oils should also meet high standards. According to ASTM D 1401 10-minute test, mixture of 40ml oil and 40 ml water in a test tube must not result in a visible emulsion. The result is expressed as 40/40/0 (oil/water/emulsion) [8];
- Foaming of gear reducer oils should also be minimized to meet stringent requirements. During first stage of test, oil sample is tested at

24°C for 10 minutes, followed by the second 10 minute stage at 94°C, and the third 10 minute stage at 24°C. This experiment simulates real operating conditions of oil at various temperatures and loads, allowing the foaming to be monitored. The test result should equal zero. One of the most widely accepted specifications for such testing is ASTM D-892 [9];

- Corrosion protection test also shows that this type of oil must meet stringent exploitation requirements. According to ASTM D-665 A&B specification, the result of test should be - pass [10];
- Lubricating characteristics of food-grade gear reducer oils are tested according to various specifications, of which the most widely used are:
 - Four Ball test – a test with four balls where the oil sample is tested for a period of one hour at 75°C, under the 40 kg load and 1200 rpm. The result is a wear trace on the test ball which must not exceed 0.4 mm (ASTM D – 4172) [11];
 - Shell Four Ball EP test (ASTM D-2783) [12];
 - Timken OK wear test (ASTM D-2782) [13];
 - FZG test (DIN 51517), which uses various loads to monitor the intensity of wear between a meshed pair of gears. Test result values depend on the meshed pair used - class 10 corresponds to light loads, while class 12 corresponds to heavy loads;
 - Oxidation stability test by a rotating bomb, according to ASTM D-2272, tested oil should be stable after a 250 minute test interval [14];.

The discussed physical/chemical properties are common to all types of gear reducer oils, from conventional to the specific ones. However, they differ with respect to boundary values which are more stringent for food-grade lubricant oils.

LUBRICATION OF CIGARETTE FILTER MAKING MACHINE USING HF1 GRADE GEAR REDUCER OIL

The cigarette filter making machine is specific in terms of operating at very high speeds which range between 8.000 and 20.000 rpm. During operation, a compact circulation system for lubrication, with

a 40 liter tank and lubrication pump capacity of 5.8 l/min, performs the task of lubricating all critical points.

Shown in Figure 1 is a photo image of the machine, while Figure 2 shows the head which rotates at high speed and attaches filters to cigarette paper (position 3, Figure 3).



Figure 1. Filter Maker machine [15]

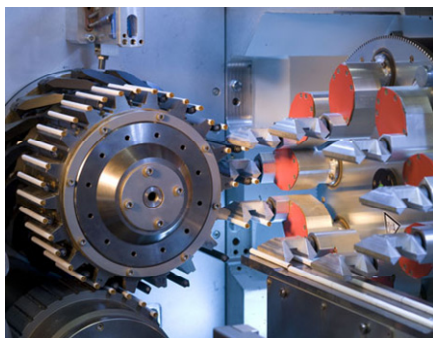


Figure 2. Rotating wheel which attaches filters to cigarette papers [15]

Figure 3 illustrates the lubrication circulation system and the cross-sections of all lubrication points.

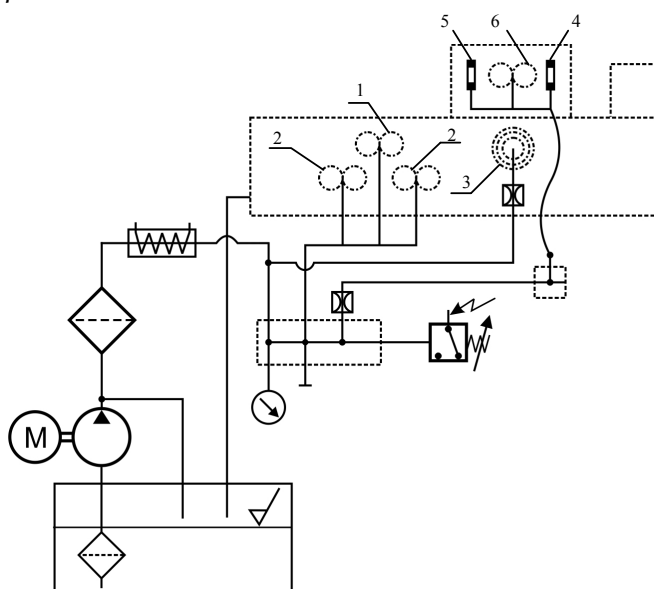


Figure 3: Circulation system for lubrication on the Filter Maker machine [15]

The Filter Maker machine has a total of six lubrication points which are vital to machine operation:

- Worm/worm wheel pair (Position 1) teeth contact is maintained over a point;
- Gear reducer with conical gears (Position 2) - teeth contact is maintained across a line;
- Main axle bearing the rotating head (Position 3);
- Roller bearing DIN 628 (Position 4) - the ball and cage maintain a point contact;
- Roller bearing DIN 625 (Position 5) - the ball and cage maintain a point contact;
- Gear reducer with conical gears (Position 6) - teeth contact is maintained across a line

Due to specific contacts, the worm/worm wheel pair is the most critical component (Position 1), together with the roller bearings (Positions 4 and 5) which maintain a point contact between work elements. In order to reduce wear, gear reducer oil used in the circulation system should, in addition to other properties, possess good EP (Extreme Pressure) and AW (AntiWear) characteristics, i.e., good lubrication properties which are maintained under high load pressures, and friction reduction under high rpms. The compact circulation system provides just the adequate lubrication with a quick circulation of lubricant fluid which takes 8 minutes to pass through the pump and the entire circulation system.

The advantage of gear reducer oil of this type is their solid base, which, beside high fluid throughput also allows a long-lasting oil operation during machine operation. The manufacturer recommends oil change at every 4000 hours of machine operation. However, within the discussed system, this oil retains its lubricating characteristics even after 8000 hours of machine operation. Considering its characteristics, this type of gear reducer oil allows very long exploitation providing regular maintenance (absence of water and solid particles, and stable operating temperature - as provided by the discussed system). Naturally, in order to keep its properties within the required limits throughout exploitation period, the oil must be sampled and tested for physical/chemical characteristics on a regular basis in certified laboratories.

CONCLUSION

Compared to conventional mineral oils, food-grade gear reducer oils possess two key elements:

- Good base component – a high-quality ester base oil which guarantees long-lasting exploitation,
- Package of additives which enhance particular physical/chemical properties.

It is exactly these elements that are key to providing good lubrication to gears and reducers which operate in extreme conditions. It has been shown in real exploitation conditions, that providing the adequate monitoring and maintenance, the oil can withstand long periods of operation without replacement, extending, in some branches of industry, over 20.000 hours of operation. Thus, together with turbine oils, this type of oil can be considered top-quality lubricant. In the future, food processing industry shall be dominated by ester based oil lubricants, gradually replacing the conventional oil types due to their superior characteristics. Moreover, the price of synthetic ester oils keeps dropping which means that in a matter of years these oils shall equal the price of mineral oils, providing yet another reason for their use, especially in the food processing industry.

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