A COMPARATIVE STUDY OF THE TRIBOLOGICAL PROPERTIES OF VEGETABLE OILS

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ABSTRACT

During the last years the demand for environmental friendly lubricants increases due to the growing consciousness for ecological questions and promoted by the tightening up of laws for nature protection. In this context lubricants produced of plants gains in importance because of their resource renewability, biodegradability and non-toxicity.

Rapeseed oil is a common representative of this group of lubricants caused by the satisfactory performance in a variety of applications, e.g. total loss systems, hydraulic and power transmission. However, rape is not the only plant with fruits interesting for the industry. Sunflower and palm oils are also in the focus of research activities, especially for producing diesel fuels. Is the technical usable potential of vegetables oils limited to these three plants-certainly not.

This study tries to find an answer of the question, at least from the tribological point of view.

Different vegetable oils, among common used oils, like sunflower, olive or rapeseed oil, and more exotic oils, like peanut or sesame oil, were investigated, whereby the research methods based mainly on existing standards for lubricant testing. The main interest of the research was studying the tribological behaviour but additionally other application relevant properties of oils were evaluated.

At first the typical oil characteristics viscosity and density were measured with common used methods (rotational viscosimetry, density determination with a pyknometer).

According to methods described in DIN ISO 3015, 3016 and 2595 cloud and pour points, flash and fire points, important parameters to judge the oil behaviour at low and high temperatures, were determined. Between the several oils big differences for example in the pour point values ranging from 30 °C to –20 °C appeared.

In the discussion about the use in technical systems, the main argue speaking against vegetable oils is the insufficient oxidation stability. The changes in the chemical composition and variations in the neutralisation number give valuable indications for judging the oxidation stability. The chemical composition of plant oils aged at higher temperature and under air supply were analysed with IR spectroscopy and compared with the one of the initial state. The neutralisation number of fresh and aged lubricants was determined by colour indication titration (DIN 51558).

An other important point which limits often the application range of a lubricant are undesirable (chemical) interactions with materials in the environment of the technical system, e.g. plastics of seals, steel parts of gears or sheets made of copper and aluminium alloys in lubricated forming processes. Therefore in this study although centre pointed to the tribological issues of vegetable oils tests to determine the compatibility to common used technical materials were also included. One test configuration researched the protection of steel against corrosion in oil contaminated with water. In an other test series an elastomer was stored during a defined time in an oil bath and next the dimensions and the hardness of the plastic piece were measured. Based on the differences to the initial values conclusions could be drawn to the influence of the plant oil on the elastomer (e.g. swelling).

The tribological tests were performed in a sphere-flat contact under reciprocating sliding conditions and boundary lubrication at an SRV test rig. The test parameters, like load and speed, were the same ones as fixed in the standard DIN 51834 for testing lubricants with an SRV machine. As counter body a ball made of the steel AISI 52100 (100Cr6) was chosen to simulate adhesive mechanisms and a ceramic ball (Al2O3) was selected to simulate abrasive wear against the 100Cr6 disk. The facility of the vegetable oils to avoid or reduce abrasive or adhesive damages was tested at a high contact pressure kept constant. By increasing the applied load from 50 to 2000 N during the test, the load carrying ability of films of plant lubricants were analysed. If the applied load could not be compensated by the lubricant, the friction rise dramatically due to cold welding effects in the contact zone. After the tests the wear of ball and disk was measured by optical or profilometric methods, respectively.

In view of the obtained results, it is considered that the properties of vegetable oils vary in a wide range but single representatives of this lubricant group have the potential for using in technical applications.