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Gear oils based on Polyglycols - New solution for the lubrication of large industrial gear drives

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1. Introduction

Increasingly stringent requirements for large enclosed geardrives, nowadays necessitate the use of synthetic oils.

Although the feedback is positive regarding the use of synthetic gear oils based on polyglycol, there continues to be a residual uncertainty concerning their usability in terms of elastomer seals and a possible performance restriction due to their water-solubility.

The favorable friction behavior of polyglycols has meant that these oils have become widely adopted for lubricating worm gears.

This paper intends to show that polyglycols also constitute a fully viable solution for use in large gears, which may even be more advantageous than using the polyalphaolefins.

For the tests described in the paper a mineral oil and two different polyglycol gear oils were selected.

The basic raw material used for producing the various synthetic lubricants, which include the polyalphaolefins and polyglycols, is ethylene, which is obtained by cracking crude oil.

When ethylene and propylene react with oxygen, we obtain ethylene oxide (EO) and propylene oxide (PO), from which the polyalkylene glycols are produced by means of polymerization.

The principal cause of the distinctive behavior of polyglycols, however, is the bonded oxygen, which lends the polyglycols their particularly polar character.

Behaviour with water

By reason of their structure, polyglycols absorb a greater or lesser amount of water. Firstly, this behavior is dependent on the ratio of ethylene glycol to propylene glycol, and secondly, a distinction also has to be drawn between absorption due to admixture of water, water-solubility and absorption due to atmospheric moisture, hygroscopicity.

Seal resistance

The seal materials customarily used in gears are elastomers based on NBR and FKM. While the use of NBR elastomer seals in combination with mineral oil and polyalphaolefins is regarded as non-critical, the use of polyglycols always raises the question of compatibility with the elastomer being used.

Tests performed under dynamic conditions show that the polyglycol gear oils involved have no adverse effect either on the NBR qualities used or on the FKM seals.

Properties of polyglycols – the influence of water

The polyglycols used as gear oils exhibit good water-solubility, thanks to their EO/PO ratio of 1:1. The anti-corrosion properties, which can be assessed using a variety of test procedures are accordingly of particular interest.

The anti-corrosion properties of lube oils are determined with the stirring procedure using a round steel rod. Test results confirm similar corrosion protection for polyglycols vs mineral oils and polyalphaolefin.

The influence of water on polyglycols in rolling bearing lubrication

The influence of water in the lube oil on the wear behavior and the lifetime of rolling bearings is adequately known from various studies and publications in the rolling bearing industry. from a publication of FAG [03], illustrates the influence of water on the relative bearing lifetime.

Possible variations in dependence on the base oil used, however, are not differentiated. In order to determine possible influences of the lubricant on the bearing's lifetime, life tests are required. In conjunction with the Institute for Machine Elements (IME) in Aachen, life tests were accordingly conducted on a radial-bearing test rig.

The studies at the IME were designed to discover what influence water has on lubrication with polyglycols. For comparison purposes, studies were also carried out with a mineral oil.

The results show that when 2 % of water is admixed to the PAG (20,000 ppm), there is no measurable influence on the bearing's lifetime. Random-sample testing with 5 % of water in the polyglycol revealed a 70 % reduction in bearing lifetime if the water is dissolved mathematical lifetime is reached. The

Scuffing load capacity

From the studies carried out by Bayerdörfer [06] at the FZG regarding the influence on the tooth profile load-carrying strength of operationally entailed changes to the lubricant, it is known that the toothing, too, can be prematurely damaged by water in the oil.

Bayerdörfer's basic studies, too, were conducted with mineral oil, so that no conclusions can be drawn in regard to polyglycols.

In initial trials, the scuffing behavior of polyglycols with a water content of 5 % was accordingly determined in an FZG Special Test, A10/16,6R/60.

By comparison, a mineral oil with likewise a 5 % water content was also tested
As in the reference run, the damage occurs in load stage 7 for polyglycol with 5 % of water. For the polyglycol, there are no detectable changes afterwards. For the mineral oil, the change is slight.

Summary

In large gears, the use of synthetic gear oils cannot be dispensed with. When polyglycols are used, there are uncertainties regarding how to factor in their effects on elastomers and their behavior in the presence of water. The paper describes the special features of polyglycols in regard to their water-solubility. Since in gear construction it is predominantly water-soluble polyglycols which are used, the influence of water on polyglycols was examined. The results obtained show that the oils tested are still able to meet CLP requirements, even with a high water content.

The results merely demonstrate that the effects for polyglycols in conjunction with water need not be regarded as more critical in terms of function than for mineral oils.