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Measuring Foaming Behaviour of Mobile Hydraulic Oils

Hydraulic drives in mobile machines require good oil quality. For this reason hydraulic oil as a component has been gaining in importance for years. Among other things, the effect of air in the oil is considered important for operating characteristics. In this paper a new measuring method is discussed, which characterizes the foaming tendencies of oil. The measuring method presented here is especially adapted to the oil used in mobile hydraulic systems and, compared to conventional methods, provides extended possibilities for oil assessment.

In hydraulic systems, oil is a central component. In addition to power transmission as its main task, it also provides cooling and lubrication. Several operating characteristics of the hydraulic system depend directly on the physical parameters of the hydraulic oil. Among other characteristics, oil density, viscosity as a function of temperature, the compatibility of the oil with the different materials of a system, air segregation capacity, as well as susceptibility to foaming and stabilization, are important oil properties.

Given the fact that many tractors feature a common oil circuit for the supply of operating the hydraulics and the transmission, very short oil circulation times are frequently a problem. This means that the average time during which the oil remains in the reservoir may be in the second range. This leads to the negative consequence that additional free air in oil cannot be separated from the oil.

A large content of this unsolved air may even lead to oil foaming. An oil-air mixture can be sucked in by the hydraulic pump and cause more severe problems, such as damage to the components and greater susceptibility to vibration in the hydraulic system. *Figure 1* shows the different states of air in oil. If the air content exceeds ~ 50% free air, one speaks of foam instead of a dispersion [1].

The Institute of Agricultural Machinery and Fluid Power of the Technical University of Braunschweig is studying the negative consequences, caused by an increased content of unsolved air in hydraulic oil. These studies focus on the foaming behaviour of mobile hydraulic oils. A novel measuring technique has been developed which complements conventional foam testing methods (ASTM-test [2], Flender test [3] or the concept of the foam test of the Ruhr University Bochum [4]). This new test provides a practical model of the foaming behaviour of different oils in mobile hydraulic systems. The new measuring method is applied in a laboratory device, which has first been built up by the initiative of Volkswagen AG in Wolfsburg for testing lubricating oils. For the measurement and characterization of mobile hydraulic oils, a different device was built by varying the hydraulic circuit and adapting the measuring process. With the aid of the defined measuring method in the laboratory device, the foaming behaviour of oils in tractors and agricultural machines can now be shown in a reproducible manner, if the system is cleaned carefully during oil changes. Reproducible measuring conditions are relevant, because the state of free or unsolved air in the oil very strongly depends on the gene-

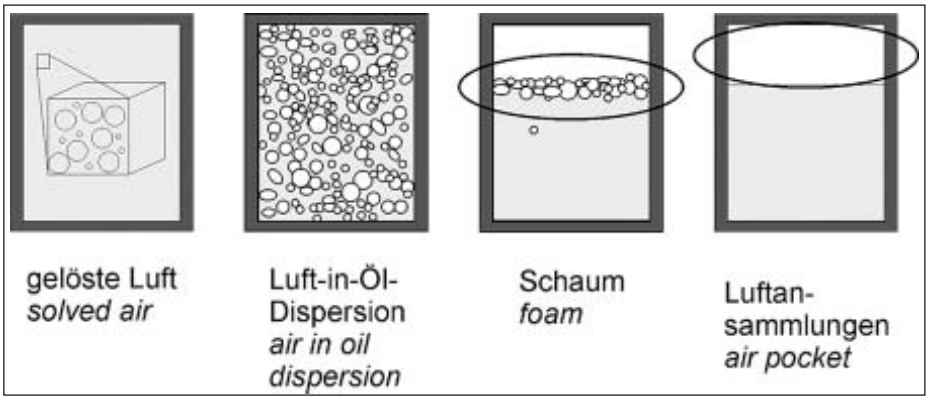

Fig. 1: Different states of air in hydraulic oil

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Keywords

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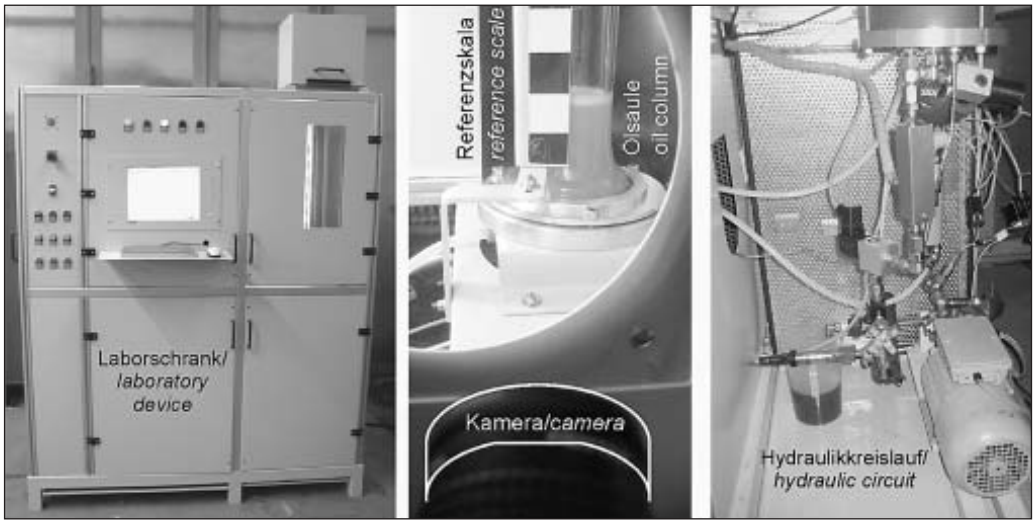

Fig. 2: Pictures of the laboratory device for foam measuring

ral conditions, such as temperature, pressure, humidity, flow conditions and oil additives. Slight changes in the test conditions influence oil foaming very much.

Novel Measuring Methods

The special characteristic of this newly developed technique is that an oil sample, which first circulates in a hydraulic circuit, is mixed with a constant quantity of air. Depending on the type and condition of the oil, a certain foam structure develops on the oil surface from this dispersion. After a defined time, circulation is stopped and the height of the generated foam is measured and characterized with regard to its dissolution. *Figure 2* shows photos of the laboratory device including a view of the oil column and the hydraulic circuit.

This measuring method not only allows fresh oils from the barrel to be compared, but also new oil formulations to be optimized by checking the interaction of different additives. In addition, the effective quantities of foam inhibitors can be measured. Hence, the presented foam test provides the possibility to determine meaningful parameters of mobile hydraulic oils with regard to foaming behaviour.

Control of the Air Content and Foaming

In the laboratory device, the set content of free air in the hydraulic oil is 5 vol.-%. This air content is a realistic limit for the content of free air in a mobile hydraulic system. The content of unsolved air can only be controlled with the aid of a new control method, which uses an air content sensor. This air content sensor measures the free air content on-line while the oil-air mixture flows through the sensor. If the actual value does not conform to the set value, more or less air is admitted to the system on the pump inlet side of the circuit, according to a special control algorithm, until the deviation from the set value is zero. The measuring accuracy of the capacitive air content sensor was able to be defined with the aid of reference tests. It is in the +/- 1% range. After the oil in the circuit has been mixed with air, the dispersion forms characteristic foam in the measuring cylinder. *Figure 3* illustrates this foaming in the glass cylinder. Figure 3a) shows the oil without free air. The oil-air dispersion with 5% free air is shown in Figure 3b), and Figure 3c) illustrates foaming on top of the oil over time.

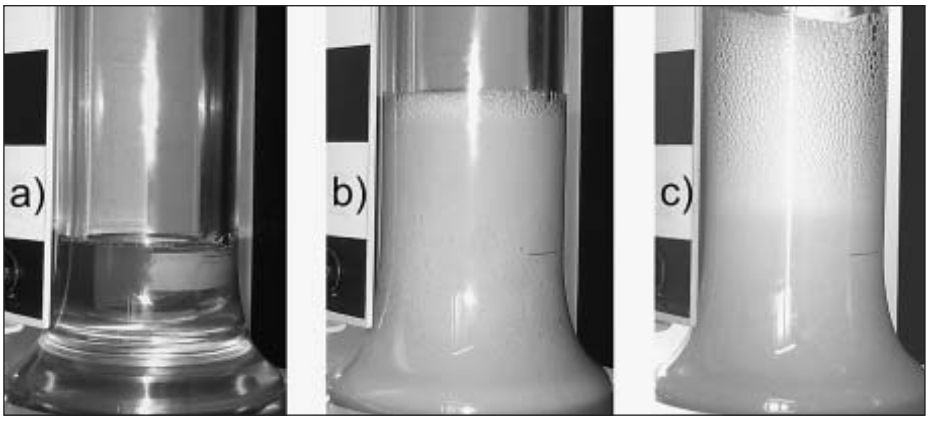

Fig. 3: Foaming in the glass cylinder

Relevance of the Foam Test for the User

The user of mobile machines has the possibility to measure different oils from the hydraulic system with the goal of judging oil quality. This means that problems caused by the foaming of mobile hydraulic oil can be defined. If a laboratory test shows particularly poor oil behaviour, an oil change may be necessary. If the foam test does not show any unusual results, an extended analysis of the reasons as part of the search for errors in the design of the hydraulic system is meaningful. Especially the examination of the foaming behaviour during the use of a machine can provide important results regarding the suitability of an oil filling for use. Since oils are often mixed during the period of use of one oil filling in mobile machines and tractors due to change of mounted implements, the foam test allows critical oil mixtures to be detected.

Literature

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