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Comparison of oil types regarding air release and foaming in dry case operation

Part One

Abstract

For a safe and trouble-free operation of hydraulic systems oil with a low content of free air and foam is necessary. Especially in mobile hydraulics oil with a rapid air release capability is a must to minimise or eliminate the risks due to the relatively small tanks in mobile hydraulics. Against this background the substitution of mineral oils by optimised synthetic oils could be one possibility to ensure a sufficient oil quality, i.e. a low content of free air. A demonstrative example for an application with very high requirements for the air release capability of the oil is the dry case operation of hydraulic motors in the corresponding hydrostatic drivelines. As the hydraulic motor housing is typically filled with oil (full case operation) significant churning losses occur particularly at high speeds. One possibility to reduce these churning losses and to enhance the overall efficiency of the driveline is to drain the motor housing (dry case operation), which leads to an increased foaming.

To depict the motivation for dry case operation the general concept and the possible power savings on driveline level are presented in the first part of the paper. Measurement results are presented to prove the possible savings, which can reach up to 8 kW. The second and main part of the paper deals with the comparison of two different oil types regarding air release and foaming and their applicability in dry case operation. For this comparison a standard mineral oil (Shell Tellus S2M46) and a special synthetic oil (Shell Tellus S4ME46) were taken into account. The driveline test stand used for the efficiency measurements was equipped with measures to visually observe and document the oil quality i.e. the air content of the oil. First some characteristics of the oil types and fundamentals regarding air separation and foaming are presented. Afterwards the system setup and the procedure to compare the oils are described. At last the results of the comparison are presented. The synthetic oil showed a significantly better performance, whereby the dry case concept becomes applicable.

1 Introduction

For a reliable operation of hydraulic systems oil with a low content of free air and foam is necessary at the suction side of the pump. The presence of excessive foaming and air entrainment may lead to numerous problems in hydraulic systems like unreliable spongy control, erosion, cavitation, noisy operation and in special cases deterioration of the oil with diesel effect. Especially in mobile hydraulics oil with a rapid air release capability is a must to minimise or eliminate the listed risks. The tanks in mobile hydraulics are relatively small and thus the available retention time for air release is short (one minute or less in many applications). In addition the use of complex measures to enhance the air release within the tank is not possible due to costs, robustness demands and space constraints. Against this background the substitution of mineral oils by optimised synthetic oils could be one possibility to ensure a sufficient quality i.e. free or entrained air content of the oil.

A demonstrative example for an application with very high requirements for the air release capability of the oil is the dry case operation of hydraulic motors in the corresponding hydrostatic drivelines. In applications such as telehandlers or small wheel loaders the hydraulic motor has to be run at small swivelling angles for high vehicle velocities. The rotational speed at this operating point can reach 4000 to 5000 rpm. As the hydraulic motor housing is typically filled with oil (full case operation) significant churning losses occur at these high speeds. One possibility to reduce these churning losses and to enhance the overall efficiency of the driveline is to drain the motor housing. The motor is driven in 'dry case'. A challenge that comes along with the dry case operation follows from the increased air entrainment which causes extra foaming of the oil.

In prior works, the possible power savings in dry case operation on component as well as on driveline level have been investigated, including measures within the tank to enhance the air release. In addition the churning losses were modelled and simulations to determine the fuel saving potential in typical load cycles were carried out (see [Rah12] and [Un12]).

This paper deals with the comparison of two oil types, a mineral and a synthetic oil, regarding their air release behaviour taking the dry case operation as an example. First the dry case concept and the possible savings will be described shortly. Second some fundamentals regarding air release and foaming will be given. Following basic characteristics of the compared oils, the test procedure and the corresponding results are described.