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TEST OF OIL FILTERS ON LABORATORY TEST DEVICE

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Abstract: This article describes the testing of oil filters on a laboratory test device designed to monitor changes in oil filter flow and pressure, depending on the level of engine oil contamination. The laboratory test device enables testing the suitability of using filters with different filtering capabilities, even with differently polluted engine oil. The measurement results can be used in the design of new filter materials, or in the design of changing replacement intervals, which would mean a benefit from an economic as well as an ecological point of view.

KEYWORDS: laboratory test device, oil filter, oil, hydraulic circuit

1 Introduction

Manufacturers of lubricants are increasingly confronted with the requirement to increase the quality of motor oils and reduce the environmental burden of lubricants used in energy sources. The production of oil of the required quality and acceptable price is becoming more and more difficult, and thus the space is created for the use of oils according to strict performance specifications. At the same time, the average time of replacement intervals of oil fillings in energy resources is monitored with the aim of extending the replacement intervals. Engine oils for extended service intervals, together with car service inspections, include a whole range of measures and checks, the purpose of which is to prevent unexpected engine breakdowns and failure of some parts. It is important to remember that the recommended oil change intervals given by car manufacturers are values that can be achieved under optimal driving conditions. Author [1] in his work focused on monitoring the flow efficiency and characteristics of hydraulic pumps. Determining the extent of oil contamination before use in the test circuit of the laboratory test device is carried out by evaluating the physical-chemical properties of the used engine oil. Oil diagnostics, or state of the oil indicates oil contamination and pollutant elements, warns of a possible malfunction, and allows malfunctions to be prevented [2]. In the case of use with short running times, regardless of the category, engine oils must be changed after 2 years at the latest.

2 Material and Methods

The laboratory test device for the evaluation of motor oil filtration enables separate but also simultaneous testing of the filtration capabilities between different types of filters with different contamination of motor oil [3]. With this device, it is possible to simulate a change in flow, a change in the working temperature of the oil and a pressure drop depending on the pollution of the engine oil and the degree of pollution of the filter insert. From the obtained data, it is possible to determine interdependencies between the monitored parameters and compare the

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measured data with pure oil and the oil filter recommended by the manufacturer. Figure 1 shows how prototype and real model of laboratory test device looks like.

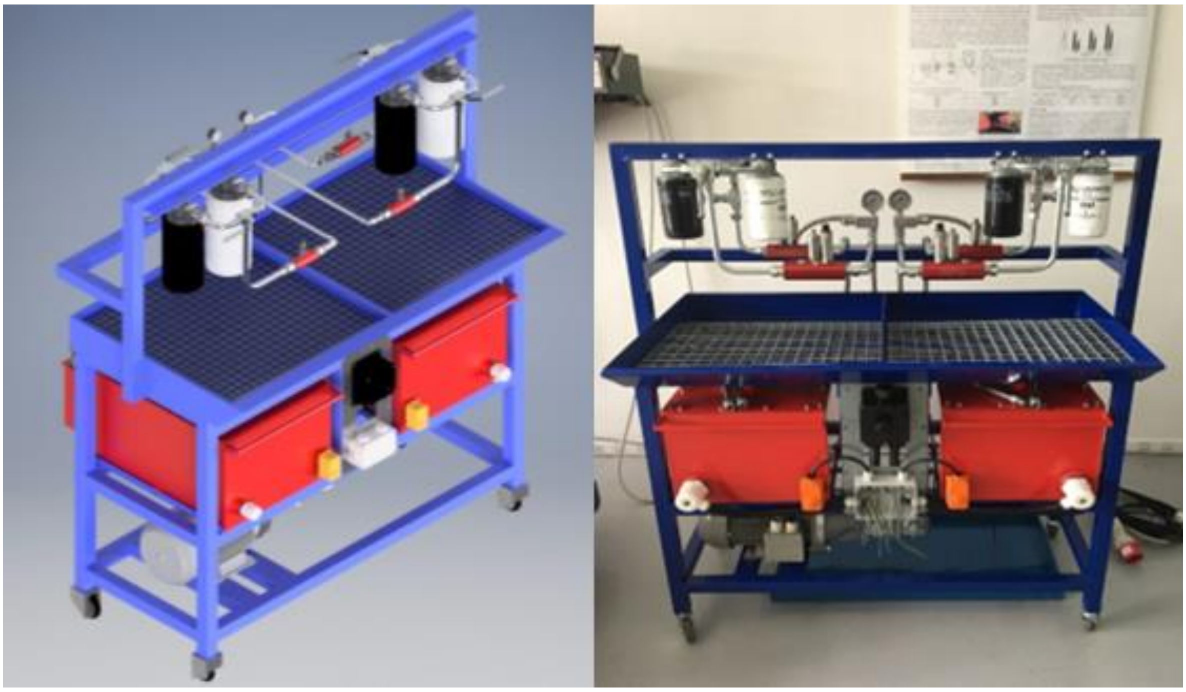

Fig. 1 Laboratory test device (prototype model and real model)

Laboratory test device consists of three hydraulic circuits. Circuit A is a reference measuring circuit, circuit B is a test circuit, circuit C is a control circuit of measuring devices. The propulsion of the device is provided by an electric motor connected to a frequency converter to achieve the required revolutions of the toothed hydraulic pump. Subsequently, a tandem hydraulic pump capable of withstanding high temperatures is connected to the device. Basically, it is an oil pump in the engine of the energy resource, with which we pump the oil through the filter system in the hydraulic circuit A and B. The device itself is enriched with a combined Hydac HMG sensor, which is used to detect operating conditions in the hydraulic circuit, a temperature, pressure, and flow sensor. Figure 2 shows Hydac HMG sensor along with connected flow and pressure sensors, and Figure 3 shows hydraulic diagram of the laboratory test device.

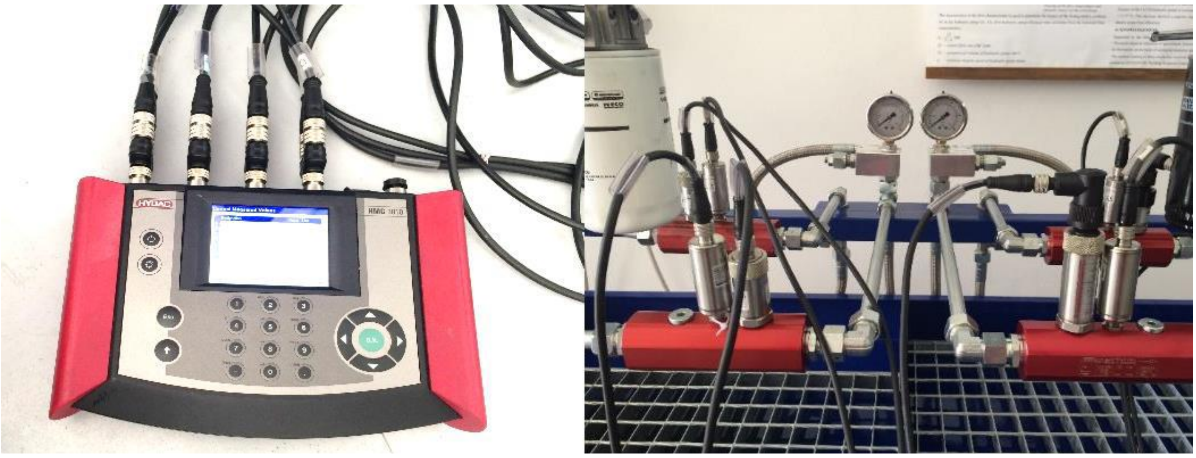

Fig. 2 Hydac HMG 3010 sensor along with connected flow and pressure sensors

Laboratory test device for the evaluation of motor oil filtration

1, 22 - heaters; 2 - tandem hydraulic pump; 3 - clutch; 4 - speed sensor; 5 - frequency converter; 6 - electric motor, 7, 23 - tanks; 8, 24 - safety valves; 10, 19, 26, 35 - pressure sensors; 11, 18, 27, 34 - flow sensors; 12, 21, 28, 37 - temperature sensors; 13, 15, 29, 31 - three-way valves; 14, 32 - original filter materials; 16, 30 - tested filter materials; 9, 17, 25, 33 - sampling sites; 20, 36 - throttle valves; 38 - computer with software; HG - tandem hydraulic pump; H_1, H_2 - heaters; N_1, N_2 - tanks; FM - frequency converter; SP - clutch; SO - speed sensor; PV_1, PV_2 - safety valves; $Q_{1.1}$, $Q_{1.2}$, $Q_{2.1}$, $Q_{2.2}$ - flow sensors; $p_{1.1}$, $p_{1.2}$, $p_{2.1}$, $p_{2.2}$ - pressure sensors; $t_{1.1}$, $t_{1.2}$, $t_{2.1}$, $t_{2.2}$ - temperature sensors; $F_{1.1}$, $F_{1.2}$, $F_{2.1}$, $F_{2.2}$ - filters in circuit A and B; $TV_{1.1}$, $TV_{1.2}$, $TV_{2.1}$, $TV_{2.2}$ - three-way valves; $OV_{1.1}$, $OV_{1.2}$, $OV_{2.1}$, $OV_{2.2}$ - sampling site; M - electric motor; $ŠV_1$, $ŠV_2$ - throttle valves

A - reference measurement circuit, B - test measurement circuit, C - recording and evaluation circuit

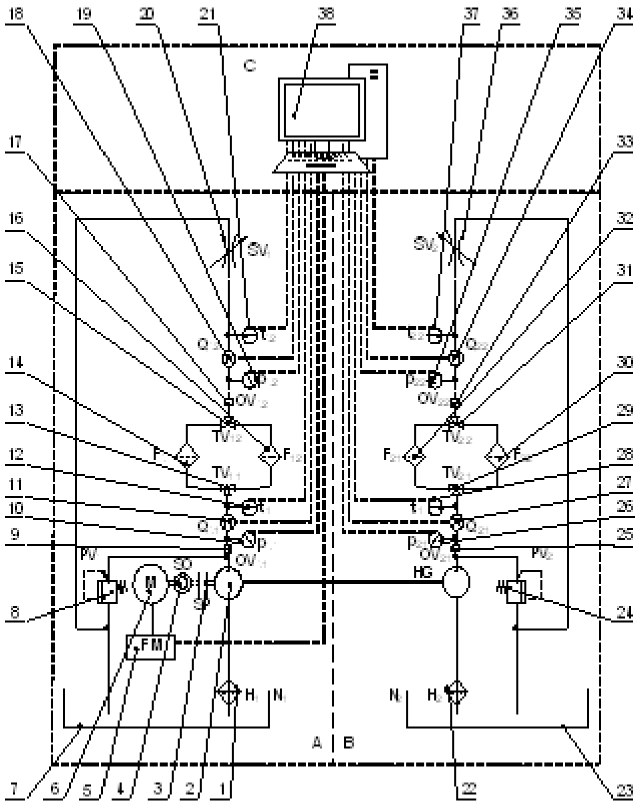

Fig. 3 Hydraulic diagram of laboratory test device

3 Results

The actual testing of the oil filters took place over a period of 60 seconds, where a recording interval of 0.02 seconds was set. From the entire measurement, we therefore recorded a total of 3000 measured values for each measured quantity of flow and pressure with sensors located before and after the oil filters. We performed verification measurements in the reference hydraulic circuit and the test hydraulic circuit at an engine oil temperature of 60 °C with uncontaminated and contaminated Urania FE LS engine oil using MANN W950/26 and CNH Industrial 2992242 oil filters. When measuring the pressure drop behind the filter in the case of the MANN W950/26 filter, it follows that the pressure drops, when verified with uncontaminated engine oil, represented an average value of Δp = 0.08 MPa and with contaminated engine oil Δp = 0.02 MPa. In the case of the flow drop with uncontaminated engine oil, it represented a value of $\Delta Q = 1.62\ dm^3.min^{-1}$, and with contaminated engine oil, it represented a value of $\Delta Q = 1.25\ dm^3.min^{-1}$. For comparison, we also performed measurements in the case of the CNH Industrial 2992242 filter. From the measurements, we found that the pressure drops, when verified with uncontaminated engine oil, represented an average value of Δp = 0.06 MPa, while in the case of contaminated engine oil the value was Δp = 0.01 MPa.

Subsequently, the flow drops with uncontaminated engine oil reached the value ΔQ = 1.61 $dm^3.min^{-1}$, while in the case of contaminated engine oil the value was ΔQ = 1.25 $dm^3.min^{-1}$.

Subsequently, a comparison was made of the pressure drops, found when measuring at a temperature of 60 °C, when using an uncontaminated liquid (Figure 4) as well as a contaminated liquid (Figure 5), in the case of a comparison of both tested filters. As can be seen on both figures, from the obtained data and their subsequent comparison, it is possible to draw the conclusion that there were no significant differences in pressure drops depending on the oil filter used.

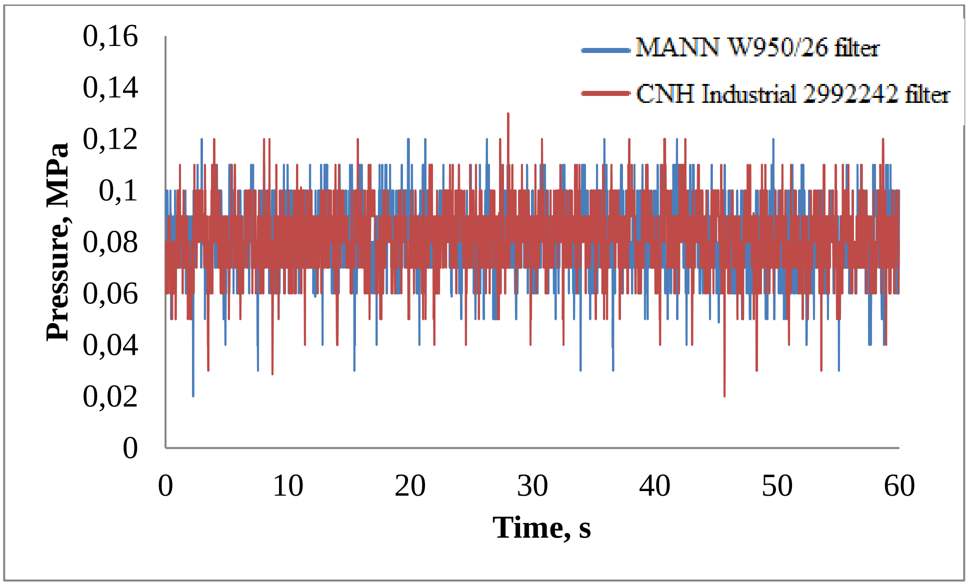

Fig. 4 Pressure drop measurement with uncontaminated engine oil with MANN W950/26 oil filter and CNH Industrial 2992242 at a temperature of 60 °C

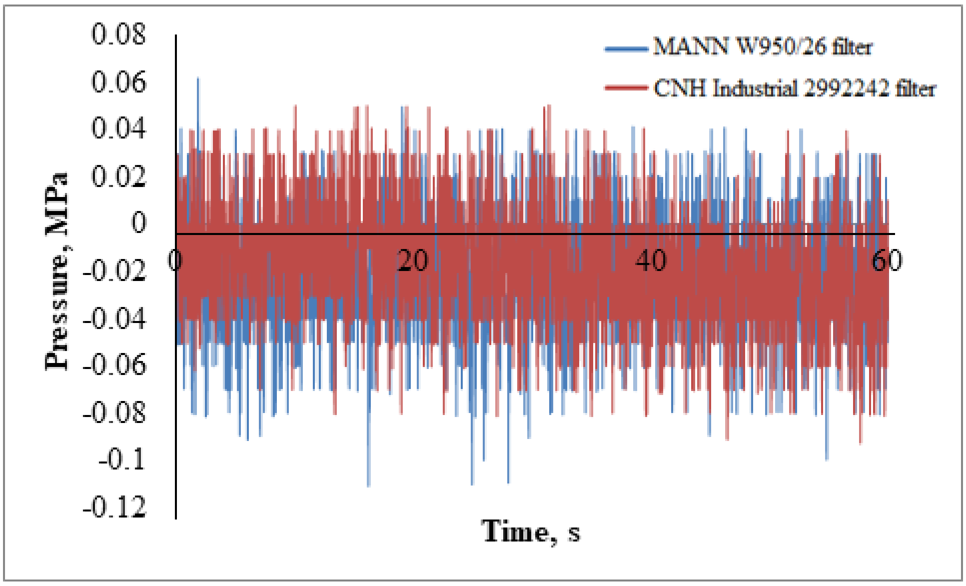

Fig. 5 Pressure drop measurement with contaminated engine oil with MANN W950/26 oil filter and CNH Industrial 2992242 at a temperature of 60 °C

Subsequently, the flow drops, found when measuring at a temperature of 60 °C, were compared when using an uncontaminated liquid (Figure 6) as well as a contaminated liquid (Figure 7), in the case of comparing both used filters. As can be seen in both images, from the obtained data and their subsequent comparison, it is possible to conclude that there were no significant differences in the flow rates depending on the oil filter used.

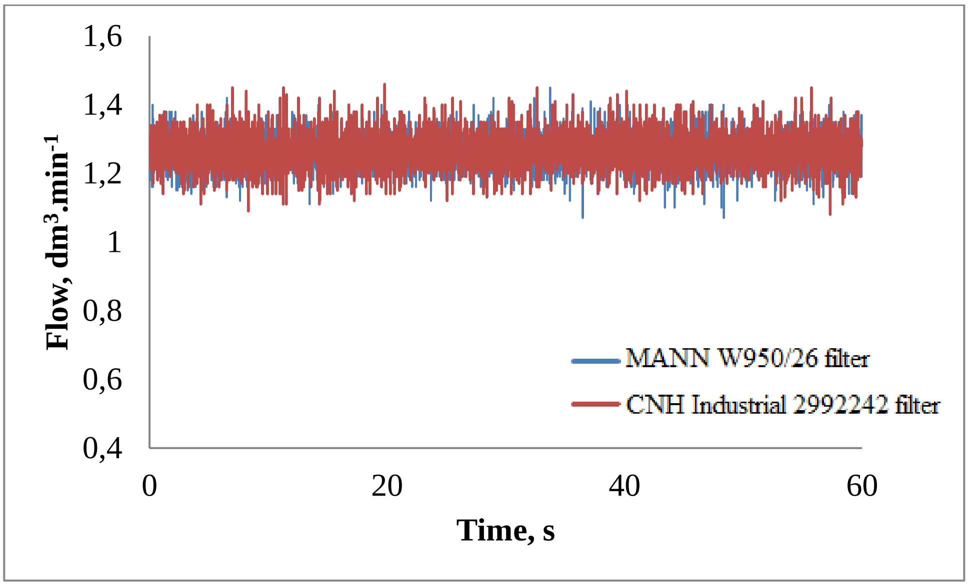

Fig. 6 Flow drop measurement with uncontaminated engine oil with MANN W950/26 oil filter and CNH Industrial 2992242 at a temperature of 60 °C

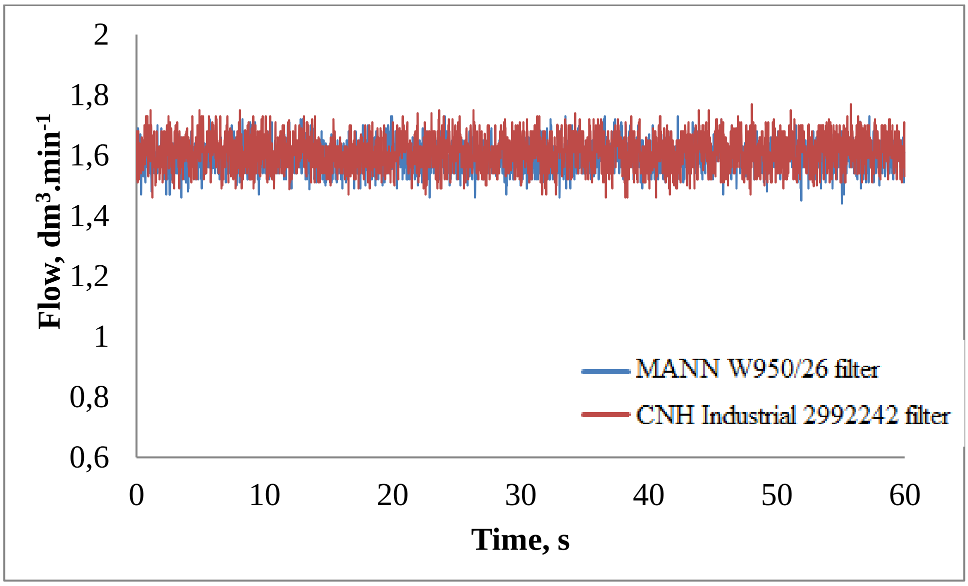

Fig. 7 Flow drop measurement with contaminated engine oil with MANN W950/26 oil filter and CNH Industrial 2992242 at a temperature of 60 °C

4 Discussion

Authors [4, 5, 6, 7,], in their work at the Department of Transport and Handling TF SPU in Nitra, addressed the issue of designing test hydraulic devices. They created a set of laboratory measuring devices for testing hydrostatic elements and hydraulic fluids. In his work, the author [8] describes the possibilities of digital measurement of the content of impurities and water in the oil using the filter station SN 180 CC, which is intended for the fine filtration of the side stream of hydraulic, lubricating, heat-carrying, transformer, transmission, motor, cooling and possibly other types of oil using alternative types filter elements for individual areas of use (special filter inserts for filtering oils, non-flammable liquids or for oils with a high demand for cleanliness and durability). Filter test apparatus according to US 3478601 A "Filter test apparatus"[9] is another test apparatus that deals with the efficiency and service life of filters from the point of view of removing foreign particles from the lubricating oil. The mentioned device allows the addition of contaminants to the lubricating oil at precisely determined intervals during testing. The device implemented by us makes it possible to add polluting elements to the tank and simultaneously monitor changes in the pressure and flow of the working fluid in the hydraulic circuit, where the advantage of the device is the simultaneous testing of two filters in separate hydraulic circuits, where the first circuit is named as a reference measuring circuit and the second as a test measuring circuit. At the same time, the device, thanks to its versatility, allows the change of oil filters with different degrees of clogging of the filter material. The device for testing the ability of a filter-to-filter contaminants according to patent document US 6619112 B2 "Apparatus for testing the ability of a filter-to-filter contaminants" [10], is aimed at testing the ability of a filter-to-trap contaminants. It focuses on monitoring the effectiveness of filters in filtering solid impurities from liquid. In this case, the lifetime of the filter is monitored depending on the number of contaminants transported to the filter. The disadvantage of the devices known so far for testing filter materials is that the testing is carried out in laboratory conditions, which differ significantly from the operating conditions in normal practice. These devices also do not allow simultaneous testing of multiple filters and comparing their results obtained under the same conditions.

CONCLUSION

The social and economic development of any country depends upon the availability of energy resources. Therefore, the economic growth of any country may be affected by the depletion of fossil fuels, increase in fossil fuel prices and climate change etc. [11]. Nowadays the effective use of mineral resources is at the forefront of interest of the public. It is also the solution of the issue of energy security of mankind in the future when conventional energy sources will gradually be depleted and will have to be replaced by new technologies to gain energy for sustainable growth [12]. The laboratory test device described on which the oil filter tests were performed, enables the monitoring of the service life of the oil filters, with variously contaminated engine oil, with the possibility of extending the service intervals of the engine oil change depending on the changes in the physico-chemical properties of the engine oil and the efficiency of the filters. The mentioned laboratory tests can be carried out simultaneously in two hydraulic circuits, which makes it possible to significantly shorten the time of testing the filtering capabilities of oil filters, without the risk of engine damage, provided that the tests are carried out in operating conditions. In filter tests, laboratory tests are used in practice, which are focused on changes in hydraulic-mechanical characteristics (pressure and flow changes in the hydraulic circuit), filter efficiency, which is determined by the coefficient β, chemical and temperature compatibility, and the permeability of the valves of the filter device. According to author [13], if tribotechnical diagnostics is applied correctly and thoroughly, significant savings can be made in terms of increasing the technical life of machines and equipment, reducing energy consumption, and limiting downtime. The analysis of oils using spectroscopy was dealt with by authors [5, 14], who evaluated the condition of oils based on different absorption (absorption) of chemical substances and their ability to emit (emit) light at different wavelengths. The designed laboratory test device considers the operating conditions of the combustion engine with the possibility of simulating the real operating mode of the lubrication system. The testing of oil filters as well as the obtained results prove that the device is capable of correctly performing the individual tests for which it was designed and constructed.

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