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EXPERIMENTAL TESTS OF THE INFLUENCE OF AIR ON THE PRESSURE PULSATION ON GEAR PUMP PRESSURE LINE

Abstract: The article presents results of preliminary experimental tests regarding the influence of phenomena resulting from the occurrence of air lock in the suction line on the pressure pulsation of a gear pump with external gear design, series PGP511 produced by Parker Hannifin. A cycle of measurements was carried out for four pressure values and fixed temperature of hydraulic fluid. The obtained test results were analyzed in domains of time and frequency.

1. Introduction

Despite considerable development in the area of drive technologies, users of the systems with hydrostatic drives still suffer from many failures resulting from air lock in the working medium. Air presence in the system is not only a significant threat for the correct functioning of the hydraulic system components such as pumps, valves and receivers, but also leads to physical and chemical changes in the working medium (increased compressibility, accelerated oxidation, deterioration of lubricating properties, acceleration of chemical decomposition of additives) [6, 8]. Air lock in the fluid results in reducing hydraulic rigidity of the drive and in turn leads to lowering the accuracy of positioning the receivers, especially in the systems with hydraulic servo valves and proportional valves [2, 3]. Air presence also leads to the generation of increased levels of noise and vibration of the drive unit [1, 4, 5, 7]. All this contributed to the necessity of analyzing the phenomena connected with the occurrence of air in the hydraulic systems.

This article focuses on the tests regarding the impact of leakage in the suction line, causing air lock in the working fluid on pressure pulsation in the pressure line.

2. Measuring station and experiment plan

A measuring system (Fig. 1) has been composed of a gear pump with external gear design (series PGP511 produced by Parker Hannifin) with the capacity of 8cm^3, powered by asynchronous AC motor with nominal rotational speed of 1500rpm, a throttle valve 9N600S (regulation of the hydraulic resistance). A leakage was introduced to the suction line by means of the diagnostic conductor with inner diameter ϕ2mm and the length 1500mm. A pressure sensor HDA 4748-H-0250 was mounted at the pressure flange of the pump. Working fluid temperature (mineral oil HLP46) during the experiment was 40°C. Results of the experiment were saved using HYDAC HMG3010 measuring and data-acquisition device.

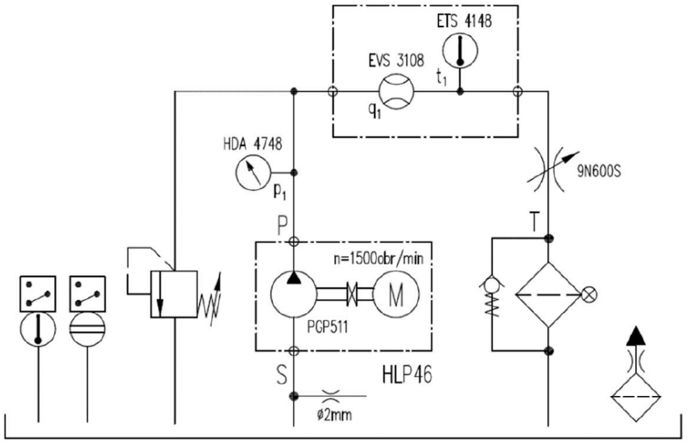

Fig. 1. Simplified hydraulic diagram of the measuring station

Measurements were carried out according to table 1. Variable parameters was pressure in the pressure line. A comparison of pressure pulsation has been made for the fluid with and without air pockets.

Table 1. Experiment plan

No	Designation of research	Pressure value [MPa]	Air lock
1	PC_50	5	No
2	PC_100	10	
3	PC_150	15	
4	PC_200	20	
5	ZC_50	5	Yes
6	ZC_100	10	
7	ZC_150	15	
8	ZC_200	20	

Analysis of air pockets in the suction line has been prepared in domain of time and frequency. The time analysis was carried out in order to determine the peak-to-peak value of pumping pressure that influences fatigue wear of the hydraulic system components and is responsible for generating increased levels of vibration and noise. The frequency analysis was carried out in order to identify the irregularities of frequency response of the examined gear pump, which may be used to detect air pockets in the working fluid [3].

3. Results of experimental tests

Gearwheels of the PGP511 displacement pumps are fitted with 12 teeth; hence the frequency of the teeth engagement, equal to the frequency of the expected capacity fluctuation f_p, is 300Hz. The frequency f_p is connected with the frequency of pump shaft rotation f_n.
Table 2 presents the results for the pressure peak amplitudes, resulting from the pump shaft rotation f_n and the blades entering the pumping phase f_p. Frequency of sampling signals registered during the experiments was 10kHz. 16384 samples analyzed in the rectangular window were taken for the FFT-based data processing.

Table 2. Selected results of the experiment

No	Designation of research	Time domain analysis			Frequency domain analysis			
		p_{t_min} [MPa]	p_{t_max} [MPa]	Δp_t [MPa]	p_n for 25Hz [MPa]	p_p for 300Hz [MPa]	p_{f_max} [MPa]	Frequency f_{max} for p_{f_max} [Hz]
1	PC_50	4,95	5,04	0,09	0,006	0,032	0,032	300
2	PC_100	9,93	10,05	0,12	0,01	0,037	0,037	300
3	PC_150	14,97	15,09	0,12	0,013	0,038	0,038	300
4	PC_200	19,97	20,12	0,15	0,014	0,037	0,037	300
5	ZC_50	4,38	5,41	1,03	0,026	0,032	0,083	6
6	ZC_100	9,71	10,48	0,77	0,049	0,032	0,108	2,4
7	ZC_150	14,34	15,65	1,31	0,021	0,029	0,231	2,4
8	ZC_200	19,21	20,85	1,64	0,055	0,028	0,174	3,6

Selected pressure pulsation curves as a domain of time are presented in fig. 2 and 3.

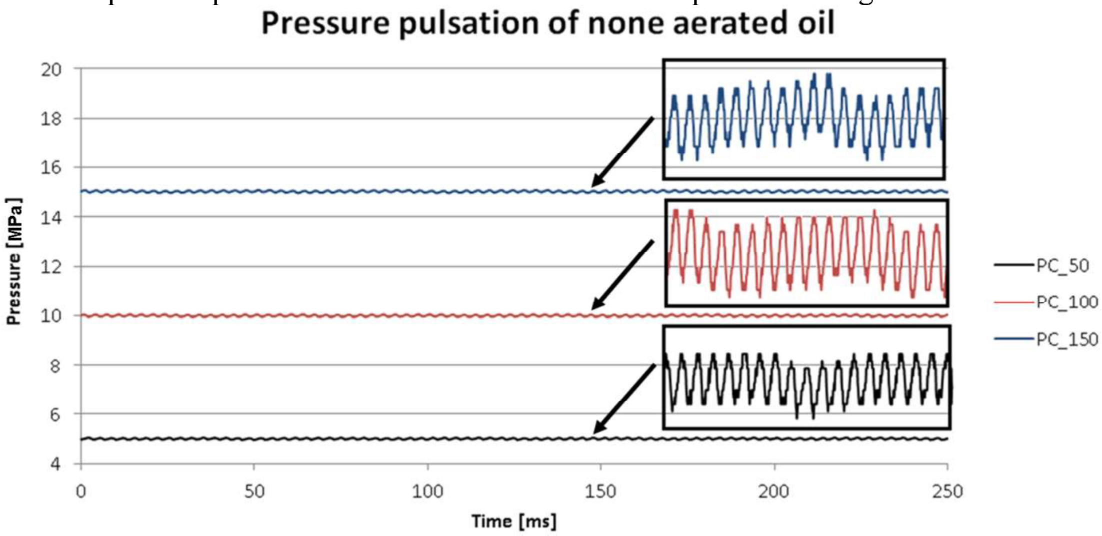

Fig. 2. Curves of pressure pulsation for the none aerated oil

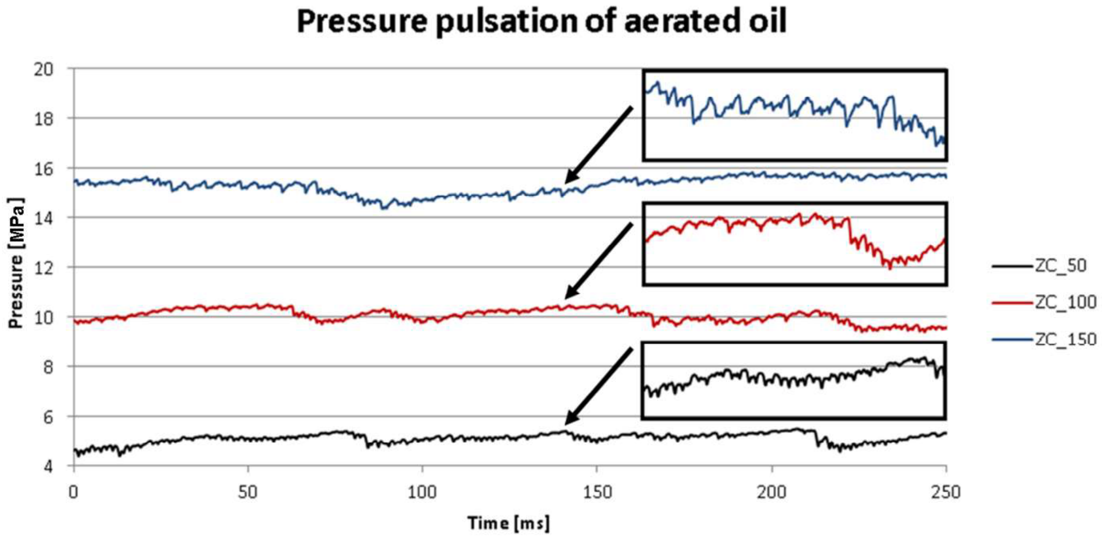

Fig. 3. Curves of pressure pulsation for the aerated oil

It should be remembered, that on the results of conducted experimental test affects not only the parameters of the pump, but also parameters of the pressure line, including bulk modulus of hydraulic fluid [5].

Frequency spectrums of pressure for experiments are presented in fig. 4 and 5.

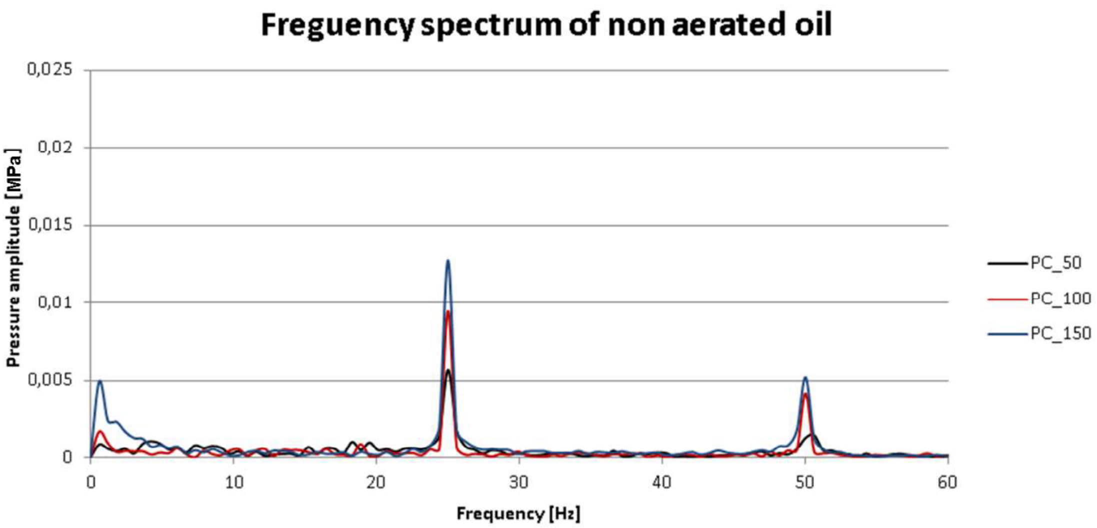

Fig. 4. Frequency spectrum for the none aerated oil

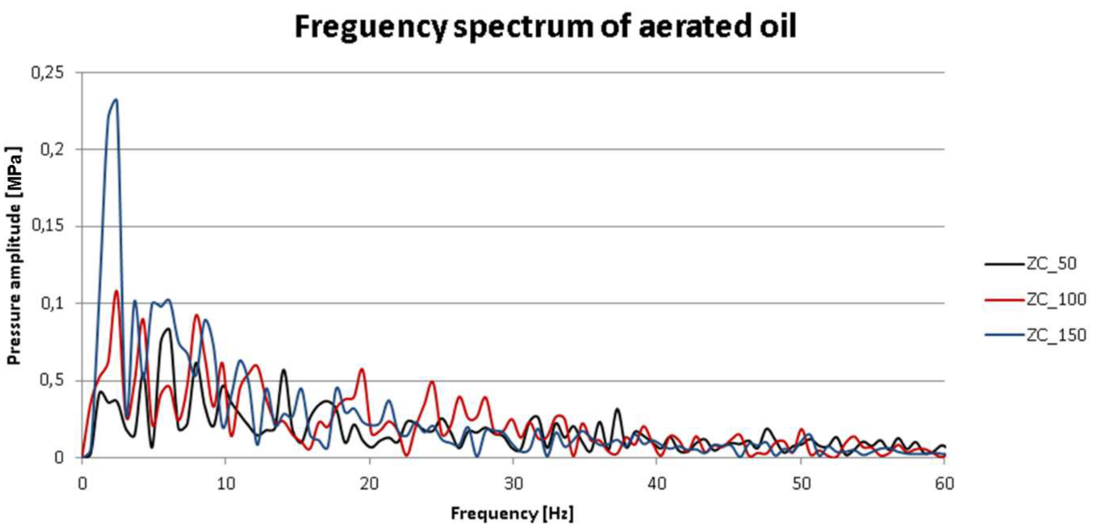

Fig. 5. Frequency spectrum for the aerated oil

4. Conclusion

Analyzing the curves of pressure pulsation as a domain of time, a significant increase (by an order of magnitude) of pressure peak-to-peak values was registered. Considerable differences in the curves of fluid pressure pulsation were observed. Fluid without air lock is characterized by the regularity of pressure curves, on the contrary to the fluid with air in it.

In case of the fluid without air lock, the amplitude of pressure pulsation resulting from temporary change of pump capacity caused by the teeth engagement is much higher than pulsation resulting from the pump gearwheel eccentricity. Increase of pressure values results in the increase of pressure pulsation amplitude resulting from the rotational speed of the shaft. The highest amplitude of pressure pulsation occurs for the frequency resulting from the teeth engagement (frequency 300Hz). In the fluid without air lock, in the range of low frequencies (below 20Hz), pressure pulsation was not observed.

Air lock in the suction line result in the significant increase in pressure pulsation on the pressure line. The highest amplitudes of pressure pulsation for the analyzed pressure values on the pressure line were registered at low frequencies. The air lock affects the dynamic changes of hydraulic fluid bulk modulus and leads to variation in pump pressure pulsation.

Considerable increase of pressure pulsation values resulting from air lock in the working fluid lead to the accelerated fatigue wear of the hydraulic system components.

The observed phenomenon requires additional tests.

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