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SELECTED ADVERSE OPERATIONAL EFFECTS OF HYDROSTATIC SYSTEMS

This paper discusses the operational and environmental aspects of hydrostatic systems. Requirements which such systems must meet and criteria for evaluating the latter are specified. The noisiness of operation of hydrostatic systems and the reduction of their environmental impact have become new major criteria. The interrelationship between pressure pulsations, mechanical vibrations and the noise (especially low-frequency noise) emitted to the environment is identified. Possible effective passive and active ways of reducing the adverse impact of hydrostatic systems are indicated.

Even though the current rapid advances in the technology and design of machines and devices equipped with hydrostatic systems bring about positive effects such as new areas of application, improvement of operational properties (e.g. hydraulic and mechanical efficiency), they are accompanied by certain (often unknown before) dangers related to problems in the construction, material and operational areas (e.g. operation in new environmental conditions). Foremost among them are dangers connected with vibroacoustic processes, i.e. mechanical vibrations and noise. The most noxious to the environment and most difficult to combat is low-frequency noise. Unfortunately, the latter has not been explicitly defined yet. In the literature on the subject the term low-frequency noise which applies to the frequency range of 10-250 Hz is increasingly commonly used.

In order to comply with the noise restrictions the following three principal methods of reducing the noisiness of machines and devices are used:

- operational methods – consisting in removing the causes of noise or reducing noise emission through remedies applied to the noise source,
- passive methods – limiting the area of propagation of sound waves from the source of their emission through sound scattering and absorption,
- active methods – using secondary sound sources to suppress primary source noise.

The noisiness requirements set for contemporary machines cannot be satisfied using solely passive methods. The best results in noise reduction are achieved through the simultaneous use of operational, active and passive methods.

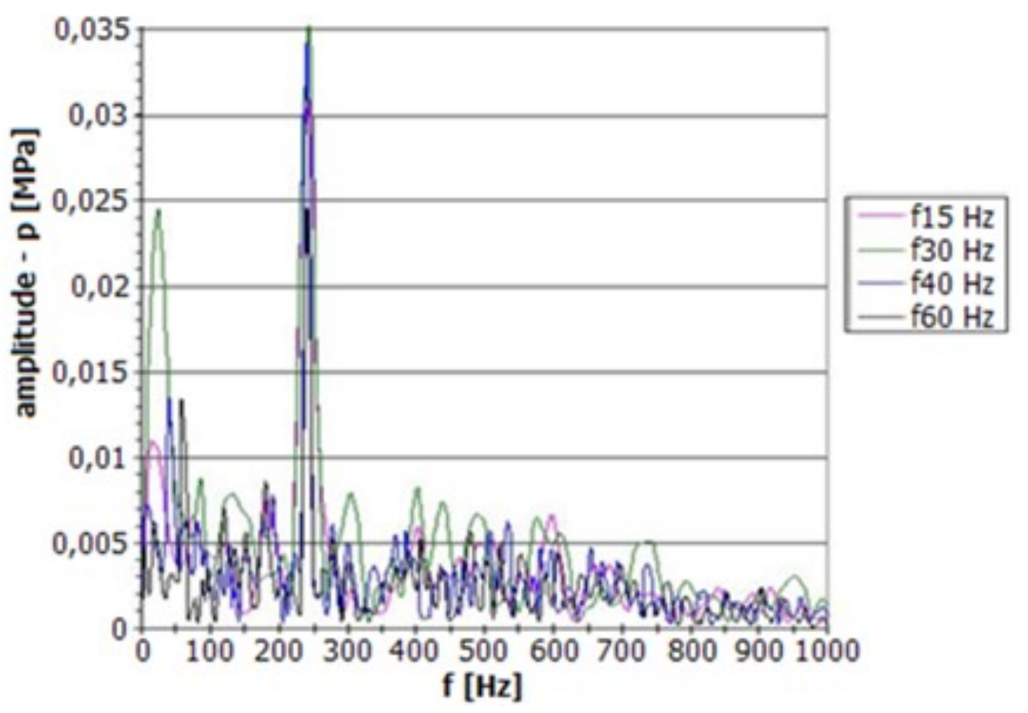

Fig. 1. Amplitude-frequency spectrum of pressure pulsation in hydraulic system with conventionally electrically controlled single-stage slide valve forced with frequency f = 15, 30, 40 and 60 Hz. Mean pressure 2 MPa, mean flow rate 6.5 dm3/min.

Figure 1 shows the effect of external mechanical vibrations acting on a conventionally electrically controlled distribution valve (the direction of forcing consistent with the direction of slide movement). The pressure pulsation were measured with a PCB-ICP piezoelectric sensor located just before kinematically forced distribution valve. The user of a machine with a hydrostatic drive should be aware that supporting structure vibrations with a frequency of up to 100 Hz can occur and can result in the excitation of the control elements of hydraulic valves, such as overflow valves, distribution valves and proportional valves.

Broadband pressure pulsation dampers are used to reduce pressure fluctuations and spikes in hydraulic systems. Such dampers are particularly effective in the low-frequency (infrasound) range. A broadband pressure pulsation damper consists of a passive chamber damper with an internal conduit, and an active damper. Exemplary amplitude-frequency pressure pulsation spectra (which were measured with PCB-ICP piezoelectric sensor located right behind the displacement pump) for a hydraulic system with and without a damper are shown in fig. 2.

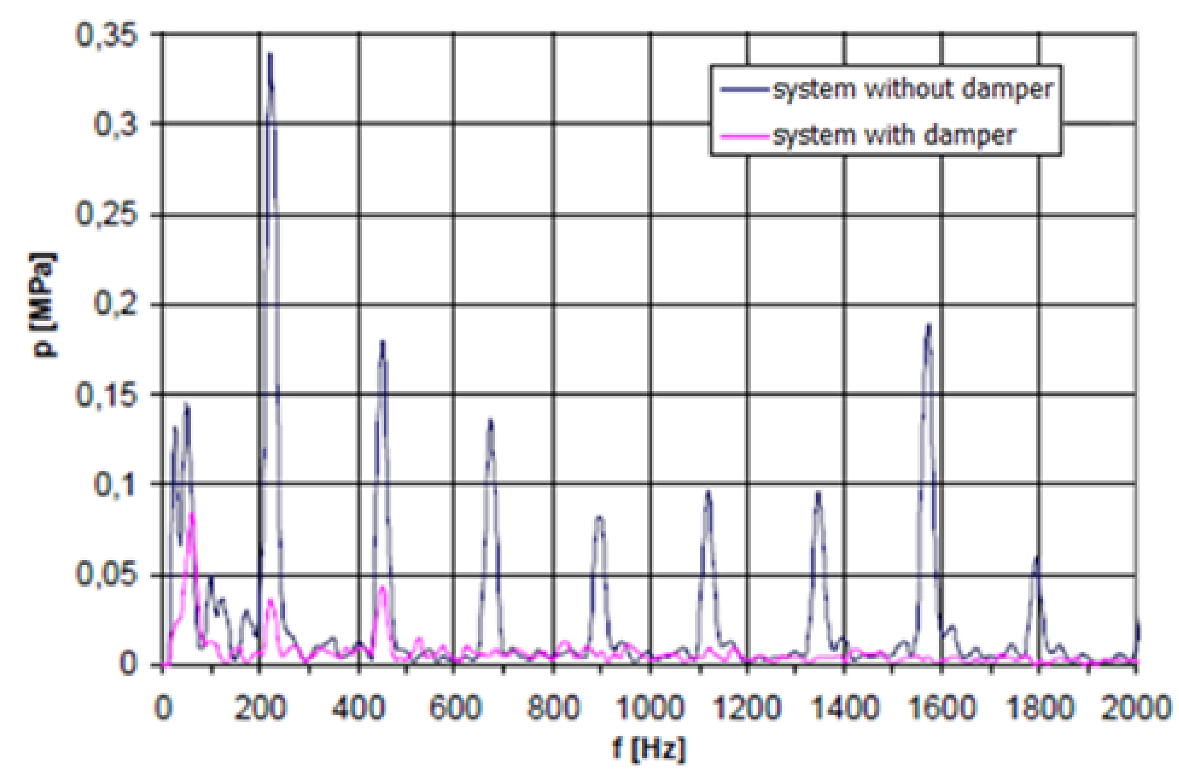

Fig. 2. Comparison of amplitude-frequency spectra for system with and without broadband pressure pulsation damper for mean pressure of 5 MPa

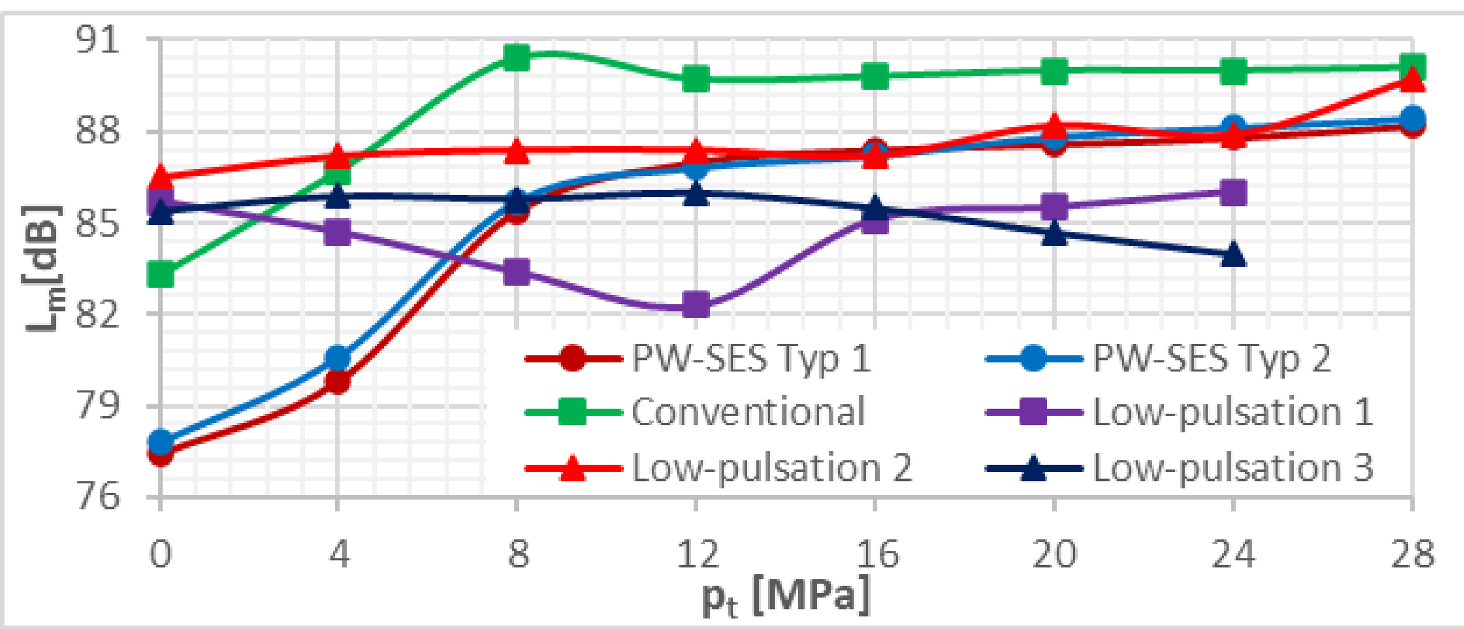

Fig. 3. Acoustic pressure level Lm depending on pressure at 1500 rpm

Since the displacement pump is the noisiest component of a hydraulic system, when investigating the effect of pressure pulsations on noise emission one should analyse the acoustic characteristics of the most commonly used hydraulic pumps, i.e. gear pumps. Figure 3 shows a relationship between acoustic pressure Lm and forcing pressure for six gear pumps. One of them was a conventional pump widely used in industry, three were low-pulsation pumps made by leading manufacturers and the other two were pumps with a lowered acoustic emission level, developed jointly by Wrocław University of Science and Technology and the PHS HYDROTOR S.A. company. Both the low-pulsation pumps and the pumps with a lowered acoustic emission level are characterized by lower output fluctuation nonuniformity during operation than the conventional pump resulting in 2-5 dB lower acoustic pressure level Lm.

Investigations aimed at identifying the place of noise generation in a gear pump were carried out at Wrocław University of Science and Technology. They consisted in measuring sound intensity in the direction perpendicular to the investigated surfaces. The measurements were performed by means of a dual-microphone sound intensity probe made by B&K. The measurement results in the form of a sound intensity distribution on the surface of the pump are shown in fig. 4. The sound intensity distribution on the surface of the pump casing, determined using the radiosity method, indicated a local increase in sound generating vibrations in the region of the pump’s rear cover on the driving wheel axis and on the casing in the area of the forcing chamber. This is evidence of the transmission of sound generating vibrations originating mainly from the pump’s drive and from the pulsations of the working medium.

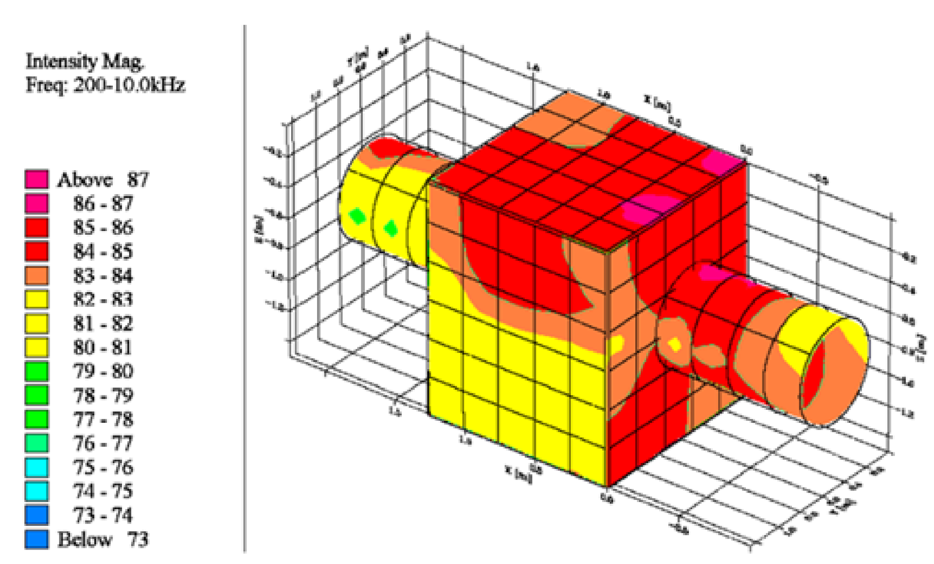

Fig. 4. Sound intensity distribution on surface of PZ-4 series pump for its rated operating parameters