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Darko Lovrec
Vito Tič
Editors

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Results of identification and optimization of the parameters of axial piston pump

RADOVAN PETROVIĆ, NENAD TODIĆ, SLOBODAN SAVIĆ & MAJA ANDJELKOVIĆ

Abstract In the development of applicative software for mathematical modelling, identification, and optimization of parameters of axial piston pumps, special attention is paid to the real need of the engineers' practice. We used the original graphical 2D and 3D software for the application in real-time with a simultaneous presentation and processing in 24 windows of high resolution. Here it is mentioned that during optimization and identification of axial piston pump's parameters, we automatically form and present several hundreds of the complex 2D diagrams, which enables to intervene at any point in the study of hydrodynamic processes by the change of input data, where the following flow of identification and optimization is changed.

Keywords: • axial piston pump • mathematical modelling• simulation • identification and optimization • experiment •

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1 Introduction

Developed program for mathematical modelling, identification and optimization of axial piston pumps, enables for the further studies of hydrodynamic processes the development of entire families of the pumps with the analysis of advantages and disadvantages of the axial piston pumps with fixed and variable flow.

2 The applied ultra-rapid measuring system ADS 2000-CADEX

Total number of the data measured in this case was (4+1) x4096 = 20480 per a revolution (cycle), i. e. 204800 for 10 successive cycles. Number of 4096 samples wasn't selected randomly, but it was given on purpose due to the application of the Fast Fourier Transform (FFT) of the measured signals. Measurements were performed for seven operating modes with parameters given in Table 1.

Table 1: The applied operating modes in experimental testing of the pump

Number	Example	Cylinder pressure p_c [bar]	Number of revolutions n [min^{-1}]
1.	R03	180	1000
2.	R04	50	800
3.	R05	160	800
4.	R06	180	800
5.	R07	200	800
6.	R08	200	1000
7.	R09	200	875.6

The structural scheme of the applied ultra-rapid measuring system ADS 2000-CADEX is depicted in Figure 1.

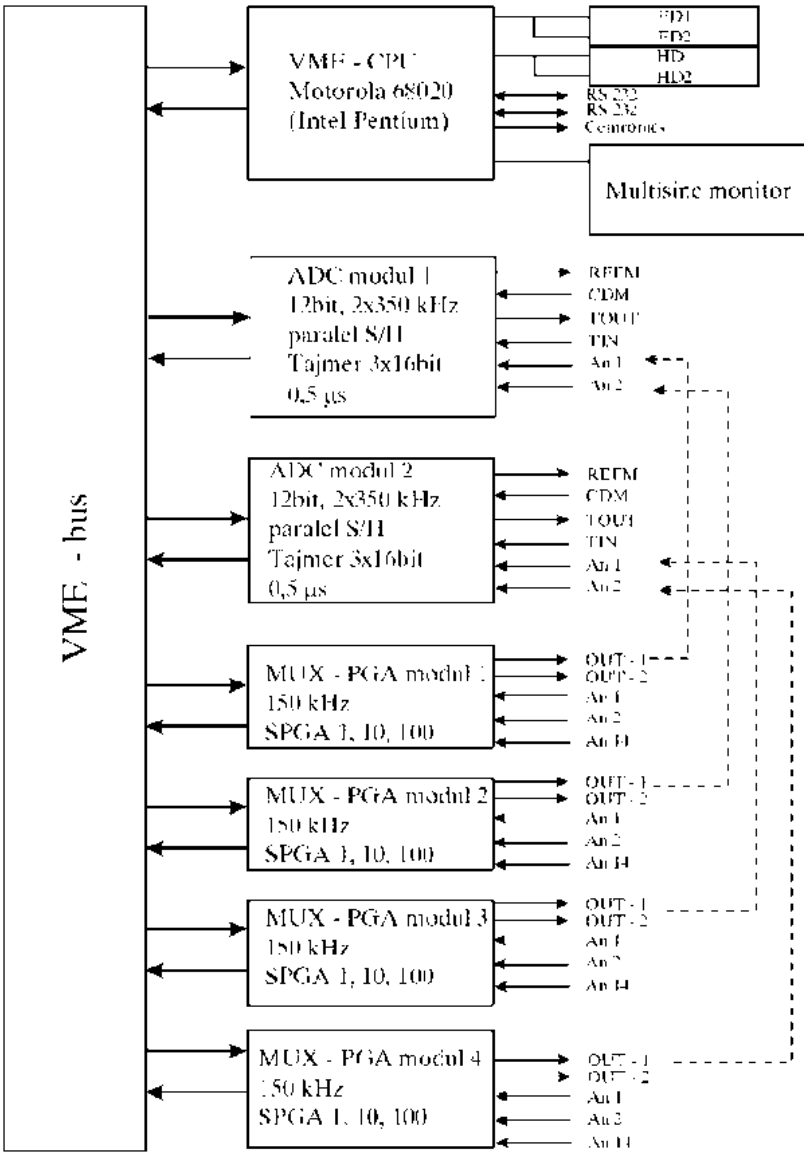

Figure 1: Structural scheme of the applied ultra-rapid measuring system ADS 2000-CADEX.

Figure 2 (a to f) shows the measured pressures for the individual, i. e. ten successive cycles of the examined axial piston pump. The results refer to the experiment labelled by the number 7 and the example R09 at the operating mode p = 200 bar and n = 875.6 min^{-1}.

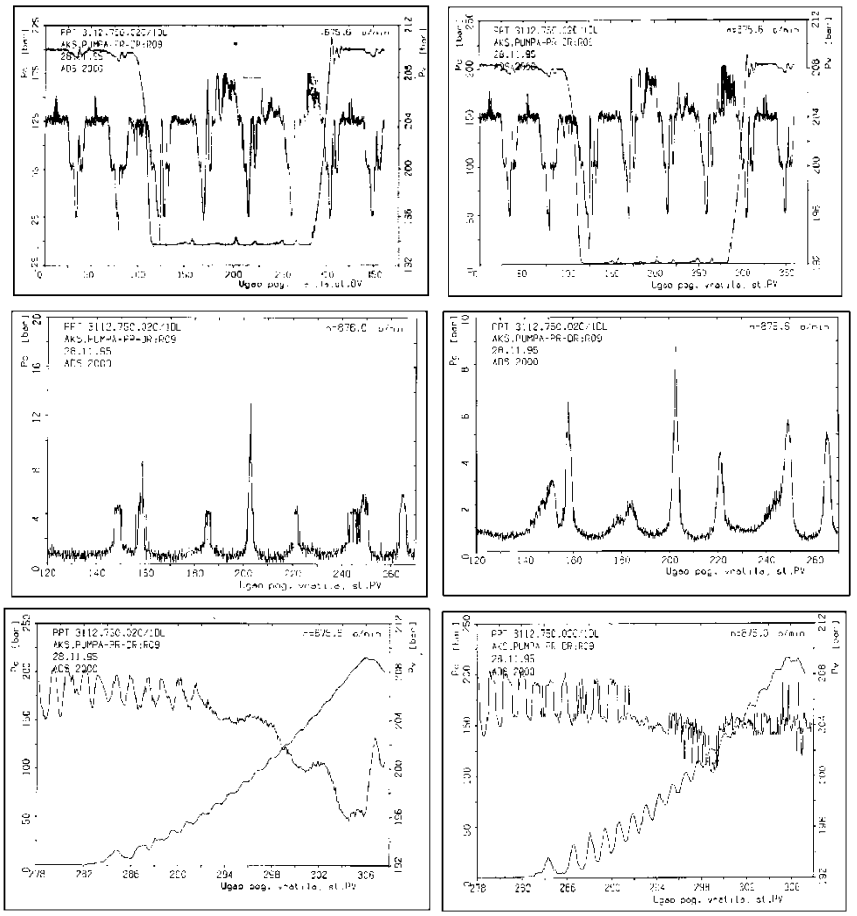

Figure 2: (a to f) Diagrams of the pressures measured in the operating mode n = 875. 6 min^{-1} and p_n = 200 bar.

Figure 2 (a and b) presents the pressure flow in the cylinder (p_c), measured for one, i. e. mid of the 10 successive cycles in the function of the angle φ of the drive shaft. From the diagram we can observe the pressure gradients in the phase of the compression and expansion, as well as the appearance of the "peaks" during the suction. The same Figures show the pressure flow in the discharge chamber (p_n) for one, i. e. mid of the 10 successive cycles in the function of the angle of the drive shaft.

Pressure pulsations in discharge chamber depend on the number of cylinders, which is obvious in this case, because it is about a pump with eight cylinders.

The appearance of the "peaks" in the suction phase for one, i. e. the mid of 10 successive cycles at the angle interval of the drive shaft of 120-270° is presented in Figure 2 (c and d).

Figure 2 (e and f) shows that pressure flow in the cylinder (p_c), measured for one, i. e. mid from 10 successive cycles in the angle interval of the drive shaft of 278 – 307°, with the aim to analyse the gradient of the pressure increase in the compression phase with more details. The same diagrams in the same interval also show the pulsations of the pressure in the discharge chamber.

3 Statistical and Fast Fourier Transform (FFT) analyses of the axial piston pump operating process parameters.

Quantities of the vibration amplitudes of the pump's housing measured for the mid of the ten successive cycles are presented in Figure 3. The applied decibel scale enables easier comparison of the absolute level of the amplitudes of the measured quantities per a recommended reference level.

Vibrations level is defined by the relation of the amplitudes in the following manner:

$$N, in\ decibels = 20\ log_{10} \frac{A}{A_{ref}} \tag{1}$$

where:
N – is the number of decibels,
A – measured level of amplitudes,
$A_{ref}=10^{Kref}$ – recommended reference level.

Reference level is marked by the exponent K_{ref} on the appropriate diagrams.
From the presented diagrams of the harmonic analysis of pressures in the discharge chamber, a dominant order for maximum pressure amplitudes was observed, which contains a module that equals the number of cylinders (2).

$$\sigma = z \cdot n \tag{2}$$

Where:
z is the number of cylinders,
n= 1,2,3...is the number of cycles.

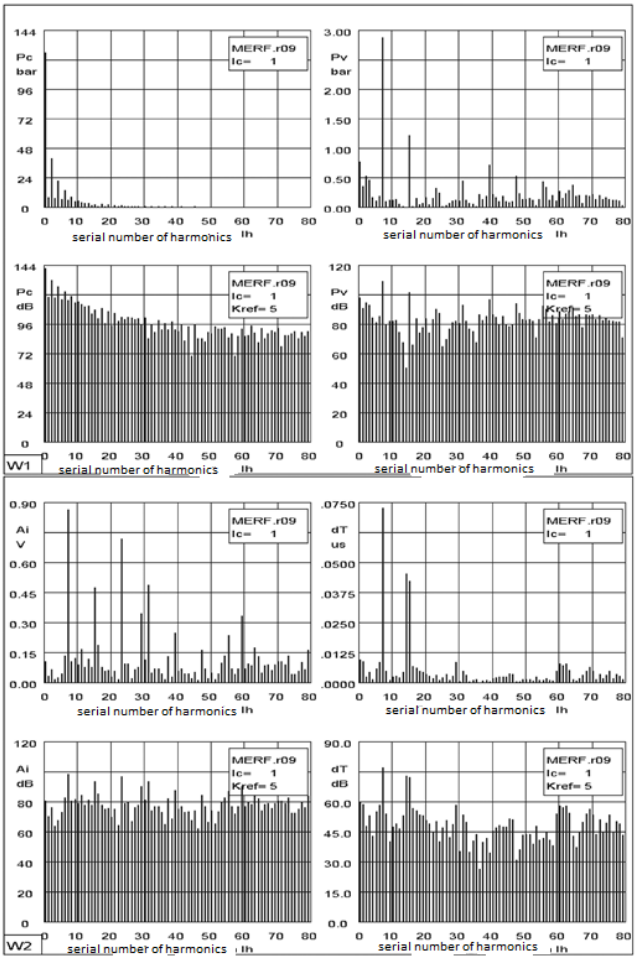

Figure 3: Results of the harmonic analysis of the measured pressures, vibrations and time intervals for one cycle in case of n = 875.6 min^{-1}and p = 200 bar with graphical presentation of 80 harmonics.

Figure 3 also shows us the appearance of the peaks of amplitudes in case of the harmonics. General conclusions about the results of measurement and analysis are principally valid for all the examined operating modes of the axial piston pump.

4 Conclusion

Within the performed experimental studies, the measurement of pressure was performed in the cylinder, discharge space and discharge pipeline, as well as the vibration amplitude of the pump's housing, depending on the angle of the drive shaft. All the pressures and vibrations are measured parallel at each cca 0,09° of the drive shaft of the pump (exactly 4096 times per one revolution of the shaft). As an incremental angle encoder, the optical encoder with 1024 impulses per a revolution was used. The impulses of the angle encoder were doubled with the help of an interface for angle encoders in an ultra-rapid measuring system ADS 2000-CADEX, so that we obtain 4096 impulses per a revolution of the shaft.

In order to observe the repeatability of the successive cycles in the unaltered operating mode, 10 successive cycles were measured. At the same time, the time interval from angle to angle was measured in order to determine the equality of angular velocity of the drive shaft and the control of the operation of incremental angle encoder. All the analogue signals (of the pressure, vibrations) are parallel converted into cyphers with the help of four ultra-rapid converters that work simultaneously (parallel).

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