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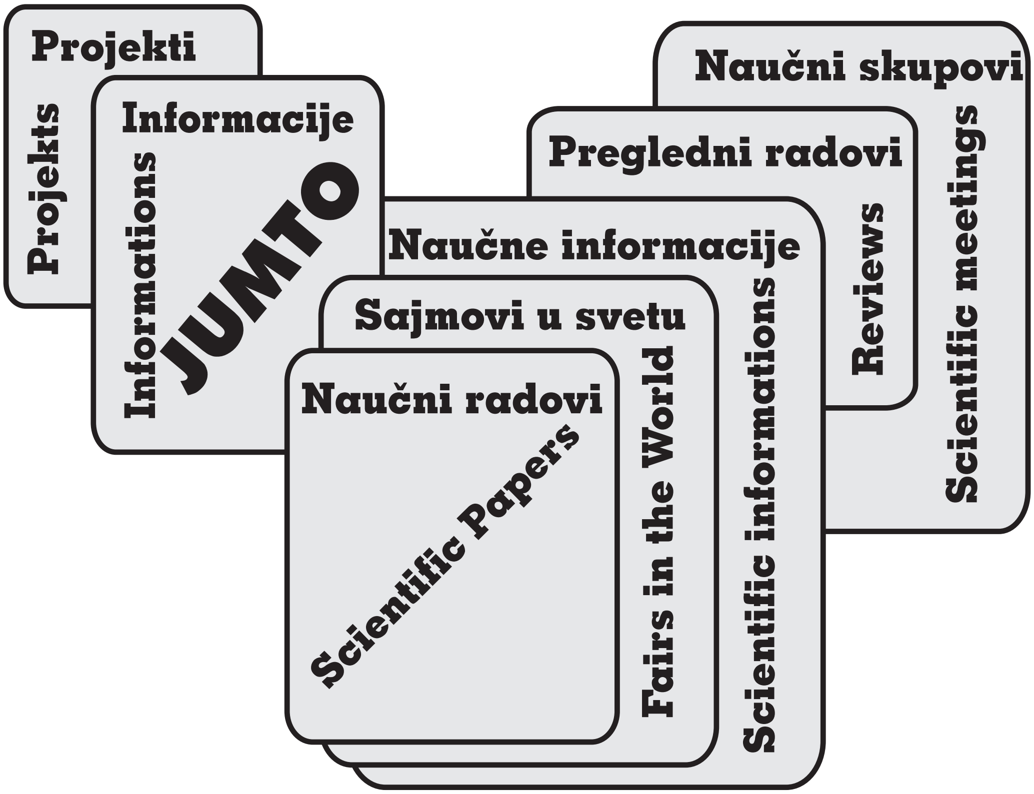

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Naučni rad
Scientific paper

RESEARCH METHODOLOGY AND DEVELOPMENT OF MODERN MEASURING EQUIPMENT FOR TESTING WATER HYDRAULIC COMPONENTS

METODOLOGIJA ISTRAŽIVANJA I RAZVOJ SAVREMENE MERNE OPREME ZA ISPITIVANJE KOMPONENTI VODNE HIDRAULIKE

Todić N.[1], Savić S.[1], Petrović R.[2], Jerković D.[3]

SUMMARY

Water hydraulics is a very old technology. It was the first fluid power technology used more than two centuries ago. Modern water hydraulics technology is a new application area which has been increasingly developing the last twenty years. Using water instead of oil in hydraulic systems brings numerous benefits such as environmental safety, fire safety, and explosion safety, easily available and low-cost fluid, etc. The Faculty of Engineering of the University of Kragujevac has systematically put effort into developing water hydraulic components during the new millennium. The research has been done in collaboration with the Research and Development Center PPT Namenska in Trstenik. This paper presents the research methodology and development of modern measuring equipment for testing water hydraulic components. The first part of the paper presents the test measuring equipment that was specially designed for this research. The second part of the paper gives an overview of the results obtained by testing the water hydraulic components.

Key words: axial piston pumps, measuring equipment, research, water hydraulic components

INTRODUCTION

There is a growing interest in application of water hydraulics technology among industrial sectors. The applied systems are becoming more and more sophisticated, which again calls for further development of components and special solutions, as well as a combination of several

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manufacturers components [1]. The development of water hydraulic components and systems has shown that this is a natural approach to solving many of the major environmental and industrial problems and an efficient way of dealing with contamination of products and fire and explosion risk issues [2].

Nowadays, water hydraulics is typically applied in the following industries:

- food processing (agitators, belt conveyors, saws, rotating knives)
- chemical
- nuclear power and treatment
- water-mist (firefighting, moistening, lumber drying)
- off-shore
- mobile (lorries, boats, hovercrafts, etc.)
- railway brakes

There are technological challenges that need to be overcome in order to make water hydraulic systems more competitive and reliable compared to oil hydraulics and pneumatics. Physical and chemical properties of water present the biggest problem in these systems. That is why water hydraulic components and systems need to be redesigned and adapted to water as a working fluid. There are different types of technologies within water hydraulics because pressure levels in the system can vary from low to very high [3]. Lower viscosity and a lower viscosity-pressure coefficient of water make lubrication more difficult compared to lubrication of mineral oil [4-6]. Since water hydraulic components, including pumps, require special design and materials, they are generally more expensive than oil hydraulic components. In addition, the amount of production is rather low, so costs are high [7-9].

An axial piston pump is the most important component of water hydraulic systems. It is widely used in the fluid power industry because of its robustness, controllability, wide operating range and compact size. In order to develop water hydraulic axial piston pumps and motors, as the basic constructional parts of water hydraulic systems, it is necessary to use new materials and optimal structures to overcome rust, leakage, and low lubrication ability inherent in water. To improve the efficiency and reliability of water hydraulic axial piston pumps and motors, the bearing/seal parts that significantly affect their performance and reliability, must be studied thoroughly [10-13].

EXPERIMENTAL RESEARCH INSTALLATION

For experimental research on water hydraulic components, a special test measuring installation was developed in the Research and Development Center PPT Namenska (RDC) in Trstenik. This installation was developed in collaboration with the Faculty of Engineering of the University of Kragujevac (FINK) and RDC. The test installation was designed to meet all the very stringent requirements prescribed by the methodology of exploration of water hydraulic components [14]. This experimental research is part of a very comprehensive research conducted at the FINK within an extremely important scientific field - water hydraulics. The test installation was formed to test water hydraulic components and systems of [15]. Fig.1 shows a schematic diagram of the experimental installation of the water hydraulic pump at RDC [16]. The installation consists of a water source, pressure transducers, flow transducer, torque transducer, flowmeter, tested axial piston pump, etc. The tested pump is driven by an electric motor via coupling.

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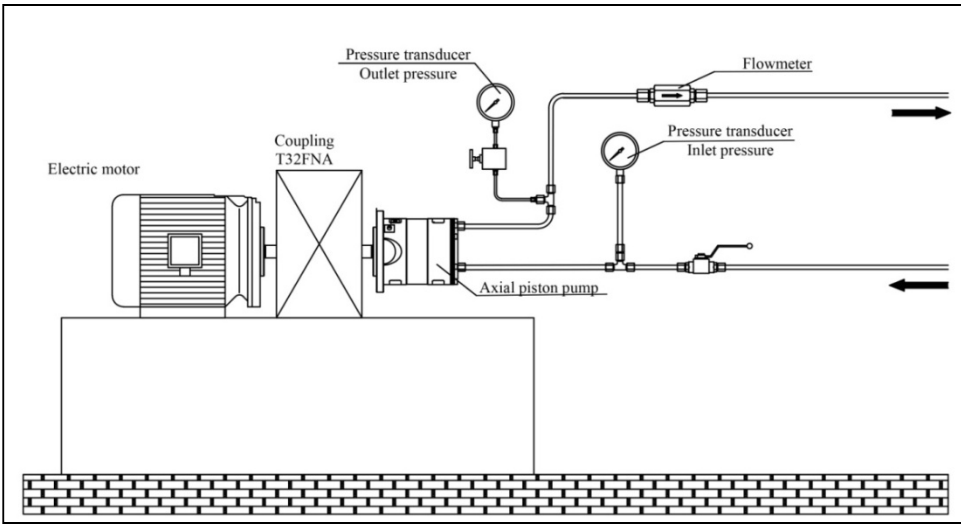

Fig.1. Experimental installation

The basic component of the test installation is the water hydraulic test stand BAC 2063 (Fig.2) The main features of the drive shaft with speed selection are:

- power of 37 kW at 7000 min-1
- speed selection from 100 ÷7000 min-1
- constant torque at the whole speed range
- it operates as a motor for pump testing in both directions

Fig.3 shows a water hydraulic axial piston pump installed on the test stand. The pump is connected to the drive shaft of the electric motor via a coupling. The electric motor is the basic driving element of the test stand. In addition to the test stand, the installation for experimental research is made up of measuring converters. The most important measuring converters are those for the pressure, flow and speed of the drive shaft.

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P3MB (Fig. 4a) pressure transducers measure the pressure of liquids and gases exactly up to the accuracy class 0.1, which makes them suitable for both static and highly dynamic measurement tasks. They have already been proven in the most diverse fields of application, ranging from transmission test rigs and diesel injection pumps to oil pressure measurements and hydraulic applications. Using a proven strain gauge technology, the P3MB and P3MBP return exact and reliable measurement results, even for dynamic measurement tasks with high numbers of load cycles. The corrosion-resistant steel measuring body is made of a single piece, making the pressure transducer resistant even in aggressive environments. With the degree of protection IP67, it withstands moisture and dirt in industrial environments [20]. Pressure transducers are available in nine nominal (rated) pressure ranges, from 10 to 3000 bar.

The T32FNA (Fig.4b) torque transducer measures dynamic torques up to 25 kNm precisely and reliably with an excellent price-to-performance ratio. It features a rugged design for use in harsh conditions and is therefore ideally suited for production and test benches for large engines and transmissions. With its short design, large measuring range and various digital and analog interfaces, the T32FNA can be integrated into systems quickly.

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Fig.2. Test stand BAC 2063

Fig.3. Water hydraulic axial piston pump installed on the test stand

The flow measuring turbine RE 3-300 (Fig. 4c) is a flow rate meter. The turbine blade wheel is axially driven by the flow stream, rotating in proportion to the mean flow velocity. A non-contacting inductive pick-up generates a pulse each time its electromagnetic field is interrupted by the rotating blades of the turbine. These pulses are then directly converted into a flow measurement by the associated electronic instrumentation, in for example l/min [21]. An advantage of the RE flow measuring turbine are the integrated test points which enable additional measurements of pressure and temperature. Flow measuring range can be achieved from 9 to 300 l/min.

a) b) c)

Fig. 4. a) pressure transducer P3MB, b) torque transducer, c) flow measuring turbine

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The results obtained from measurements on the experimental installation were synthesized and analysed using the QuantumX MX840B system Fig.5a. This module is a universal measuring amplifier of the QuantumX series. This means that sensors and transducers based on 17 different sensor technologies can be connected to each of the 8 channels available on these amplifiers [20]. The universal measuring amplifier of the QuantumX family thus substantially minimizes the setup time in the test stand and is the ideal choice for frequently changing measuring tasks. As always with the QuantumX, the universal measuring amplifiers can be employed as stand-alone instruments or combined with other modules; this can be achieved in various topologies (centralized, distributed, hybrid) as well as by connecting them to a PC with HBM QuantumX Assistant software (Fig.5b). The universal modules provide a 24-bit analog-to-digital converter, sample rates of 40 kS/s per channel, and active low-pass filters and are

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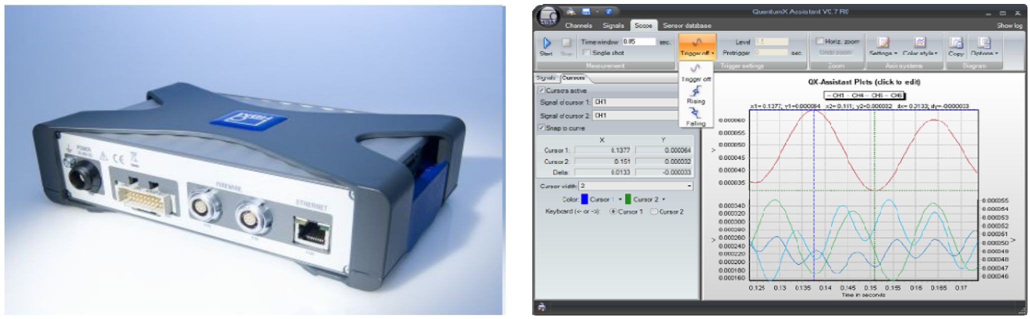
renowned for their high precision. Typical applications include test stands, service tasks, mobile data acquisition, and monitoring. Accuracy class is 0.05%. Sample rate per channel is 40 kS/s.



a) *b)*

Fig.5. a) Universal amplifier QuantumX MX840B; b) The user interface of QuantumX Assistant software

RESULTS

Test installation intended for experimental research of water hydraulic components allowed the acquisition of the most important working parameters. The diagram in Fig.6 shows the interdependence of the five operating parameters of the water hydraulic piston axial pump [22]. The most important parameters of the pump that allow further scientific research are the pressure on the inlet and outlet pumps, rotation speed, torque and pump flow.

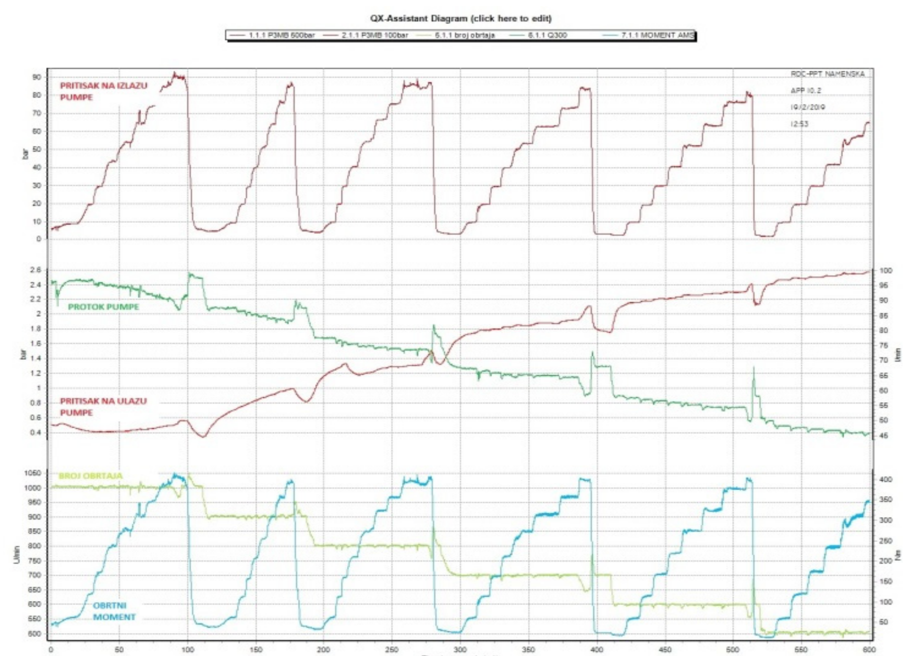


Fig. 6. Diagram of the pump operating parameters

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The diagrams were obtained using data the processing software QuantumX Assistant, specially developed for this type of research. The acquisition of the working parameters was done in the 600 s interval. The rotation speed was varied from 1000 rpm to 500 rpm. The value of the rotation speed was changed every 100 s. During this period, the value of the rotation speed was unchanged, and during this time the value of the outlet pressure was varied from the minimum setpoint to the maximum setpoint of the pressure at the outlet of the pump. This procedure was repeated for each new value of the rotation speed.

CONCLUSION

It is a great challenge to include design of water hydraulic systems and industrial solutions in education of engineers and researchers. FINK has recognized the importance of this field and through numerous dissertations, projects and studies, it has incorporated this extremely important branch of hydraulics into its education system.

Water hydraulic is an interesting technology area to research and develop. With water hydraulic systems, the first objective is to develop components using raw water as a pressure medium. Poor lubrication, wear and erosion are more likely to happen in water hydraulic components than in oil hydraulic ones. Therefore, material selection, optimal structures and manufacturing should be key issues in designing components and systems. The experience gained in this experimental study of water hydraulic components and systems will be a good ground for further development and design of new components. Modern water hydraulic technology is still a new field and there are a lot of problems to be solved in order to make its techniques for power transmission more widely available.

Technical challenges in possible applications create a need for continuous research in water hydraulics. Advantages of water hydraulics are mainly related to processes performed by end users, while challenges are directly related to water hydraulic systems and particularly to component design. Environmental safety has become a powerful global tendency, which guarantees that water hydraulics will have an important role in the future.

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