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APPLICATION OF COMPUTER SOFTWARES IN DESIGN AND WORK SIMULATION OF HYDRAULIC SYSTEMS

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ABSTRACT
Intensive development of computer technology in recent decades has contributed to the use of computers in all phases of technical systems design, including the design of hydraulic systems. Modern software solutions offer the possibility of numerical simulation of operating parameters and functions of the hydraulic system.
In this paper, the comparison of classical analytical methods and computer solutions is made, along with presentation of the methodology for design and simulation of hydraulic systems work by applying software solutions with an overview of currently available applications for the design and simulation of hydraulic systems.
Keywords: hydraulics, hydraulic system, design, simulation, software solutions

1. INTRODUCTION
Transformation of energy is one of the most important questions that preoccupies modern science and technical practice. The increasing need of industry for energy in the desired form and at the desired location with the least possible losses in transmission, determines the necessity of continuous development and improvements to systems and components for power transmission and conversion, as well as tools for their design and optimization.
The optimal response to a number of factors such as costs, energy transmission over long distances, regulation of speed, power and accuracy of displacement of working parts, makes hydraulic technical systems ever more widespread, and the demands that are placed in front of the same design are very complex, heterogeneous and dynamic.
To achieve compatibility with other forms of energy transfer (mechanical, electrical, pneumatic), numerous challenges are imposed to a hydraulic transmission and hydraulics, as a technical discipline, such as energy efficiency (reducing losses), environmental friendliness (control harmful leakage of working media), stability control of working fluid, the efficiency of maintenance, control of the purity of working media (affecting the service life of components), computer management and computer-aided engineering, [1].

The use of computers for the purpose of planning, design and manufacturing (CAD, CAM) of simple mechanical elements to complex systems goes from the first appearance of modern computers in 70s of the 20th century.

In the initial phase, the use of computers was reduced to drawing, but the development in hardware and software solutions enabled the use of computers in modeling, analysis, simulation, and complete design of technical systems.
Today, a phase of analysis and simulation is a very important stage for successful design of hydraulic systems from the standpoint of minimizing the time and cost of manufacture.

2. DESIGN OF HYDRAULIC SYSTEMS

Construction of the hydraulic system, which represents the designed and thought out functional hydraulic circuit, consists of calculating operating parameters, sizing and selection of the components of hydraulic systems and linking them into a functional unit.
Classical methods for hydraulic systems design implied manufacture of the system prototype after the phase of components selection and sizing. This means that it was necessary to purchase components and make a hydraulic system to test its functionality and adequacy in laboratory and exploitation environment. Moreover, any change in the pursuit of optimization led to new investments and expenditure of time to repeat the process (money and time-consuming process of purchasing new components and re-prototyping), while the success of the project relied on the experience and ability of the designer, [1]. On the other side, current dynamics and demands for various rapid adaptations and modifications, which are especially visible in the field of mobile hydraulics, require fast and efficient processing, optimization, and changes in which classical methods can not answer.

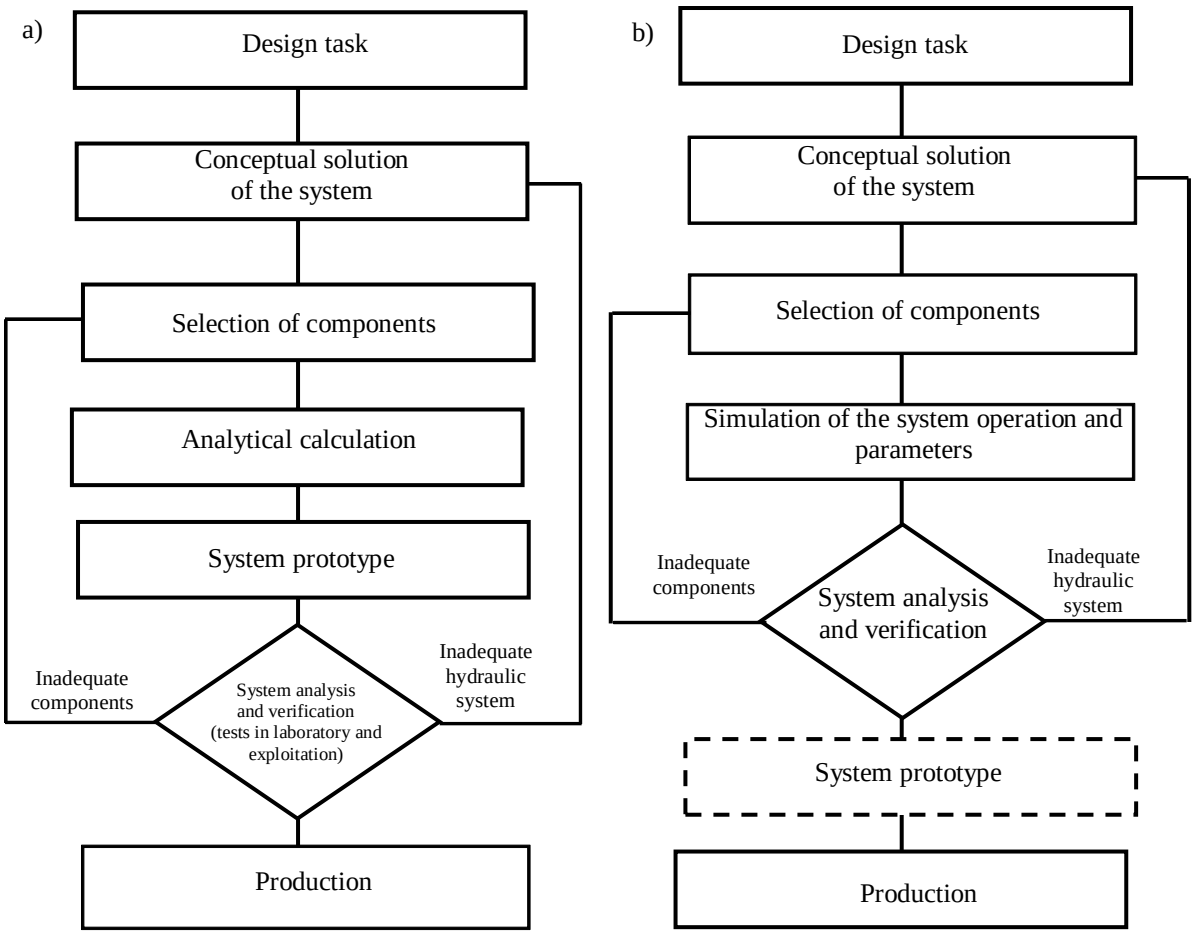

Figure 1. Flowchart in the design of hydraulic system:
a) classical method, b) computer aided design methods

The difference between the classical (Figure 1.a) and computer aided design (Figure 1.b) is reflected in the step of simulation of operation and system parameters, which takes place immediately after the selection of system components.

Along with the help in the design phase (system defined by software and elimination of complicated analytical calculation), modern computer aided hydraulic system design mainly offers the possibility of numerical simulation of functionality and system parameters, [2]. Computer simulation of the system requires no time nor significant material resources, and allows quick and „painless“ improvements in the components of conceptual design of the system using a very simple method of repeating steps after the changes, which leads to the optimization of functional hydraulic circuit and selecting the optimal system components.
Methods of numerical simulation do not eliminate the need for a system prototype completely, especially in case of larger production batches of the hydraulic system, but significantly shorten the path to get it and increase the optimality likelihood of the same in the first step.
We can conclude that the primary benefits of using computer software solutions in the design, planning and simulation of hydraulic systems work are as follows:

- saving time,
- fast and simple correction of mistakes,
- the possibility of optimization when selecting components and system parameters,
- the ability to use data and parts of previous projects,
- easier way to make documentation,
- simple presentation of the project,
- reducing the cost of corrections and optimization,
- calculation of parameters before making systems,
- the possibility of linking the designed system with other systems (e.g. PLC).

3. SOFTWARE SOLUTIONS FOR DESIGN AND SIMULATION OF HYDRAULIC SYSTEMS

The development of software solutions for the design of hydraulic systems can be divided into three phases:

- development of numerical methods for solving differential equations that describe the system,
- development of standard simulation applications for numerical analysis,
- development of specialized software solutions for the simulation of hydraulic systems and automation processes, [3].

Although all these steps require a high level of knowledge of mathematics, numerical methods, programming languages, and standardized system for analysis and simulation of the preformed numerical model, modern software solutions are user-friendly and graphically attractive, does not require knowledge of programming, allow visual modeling, and are synchronized with the market of hydraulic components.

The user synthesizes and combines various components that can be found in standardized libraries, and, if necessary, creates specialized components, chooses their characteristics and forms functional hydraulic circuits, or a mathematical model.
The most common popular software solutions integrate catalogs of manufacturers, so allow quick and easy selection of real, commercially available components, with all their technical performances and costs, thereby extending the use of software to complete project management, from procurement and optimization of components to the formation of a complete technical and commercial documentation.
Also, an important segment of the applicability of software solutions is the possibility of integration of computer aided control of the hydraulic system that goes beyond the stage of design and simulation and allows the stage of implementation in operation and maintenance of the system.

Integrated software solutions for the design and simulation of hydraulic systems are not as widespread or developed as, for example, solutions for 2D or 3D drawing or calculation of mechanical loads. The reason for this is the complexity and specificity of hydraulic system analysis, the isolation and specificity of hydraulics as a technical discipline, as well as the narrowness of the market versus the complexity of the software.

Some of the currently commercially available software packages, which are used for analysis and simulation of hydraulic systems, are:

- Automation Studio,
- Festo Fluidsim,
- FluidSIM- Hydraulics,
- HyDraw,
- Hydraforce i-Design,
- HyPneu,
- Hopsan,
- IRAI Automsim.

It is important to note that most of these software packages combine design and simulation processes, whether it is about systems and processes with hydraulic, pneumatic or electrical characteristics, that is, the possibility of designing hydraulic system is only one of several possible functions. Integration and the possibility of combining different features of the system contribute to the completeness and accuracy of the simulation project of real systems.

4. CONCLUSIONS

The analysis of hydraulic system can be very demanding and complex task depending on the degree of its complexity. This is further complicated by the fact that hydraulic components are specific and produced in a limited range of parameters, so the solution is partially approximated, which should be necessary to check by calculation and construction of the prototype.

Analytical calculation requires significant expenditure of time, and with increasing levels of complexity of the system, the possibility of making errors increases. Also, correction and optimization, if necessary, usually require repeating of calculation several times.

The construction of the prototype on the basis of analytical calculation needs a wide space for adjustment and optimization. All this increases the costs and ultimately the price of the end product - the hydraulic system.

Solution to these problems can be found in computer aided design, calculation and simulation of specifically designed products, which has been enabled by developments in numerical methods and computational techniques.

By simulating the operation of the designed system, we get the possibility to check the functionality and operation of the system, and the possibility of making rapid simple optimization, changes and corrections to the system.

As in other technical disciplines, the use of computer in hydraulics aims to facilitate the design, calculation and formation of documentation, as well as the simpler and cheaper way to perform verification of designed systems or elements before the manufacturing process.

It is important to emphasize that the use of software tools in hydraulics assumes a priori knowledge of the hydrodynamic theory and hydraulics as a technical discipline, and that the computer is just a tool to reduce time and make optimizations in the design.

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