

TRANSDISCIPLINARY MODELS OF HYDRAULIC DRIVE

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An approach to the development of hydraulic drives of mobile equipment based on transdisciplinary models of instruments and control systems is proposed. An example of the application of this approach for the development of a three-dimensional hydraulic drive based on an axial-plunger hydraulic machine is given.

Keywords: transdisciplinarity; multiphysical analysis; CAD; CAE.

The creation of new generations of hydraulic drives requires an increase in the scientific and technical level of design and production. Increasing technical and operational characteristics of hydraulic drives determines the need to implement new development principles with a deeper theoretical analysis of the operation of hydraulic actuators.

The actual direction of development of modern production is based on multidisciplinary, multilevel and multistage research based on inter-, multi- and transdisciplinary computer technology [1].

Transdisciplinarity – a way to expand the scientific worldview, which consists in the consideration of a phenomenon outside the framework of any single scientific discipline. In this context, transdisciplinarity is treated as a meta-methodology, since it accepts as the object different methods of different disciplines for their transformation [2].

In relation to the development of the hydraulic actuators are realized by two main approaches: modeling at the macro and microlevel.

At the macrolevel, will use the discretization of space on a functional basis, which leads to the representation of models at this level in the form of systems of ordinary differential equations. In these equations the independent variable is time and the dependent variables constitute the vector of phase variables characterizing the state of the integrated elements of the sampled space. Such variables are force and velocity in mechanical systems, the voltage and current in electrical systems, pressure and flow of liquid and gas in hydraulic and pneumatic systems, etc. The system of ordinary differential equations are universal models at the macrolevel that is appropriate for analyzing both dynamic and steady-state objects.

Feature modeling at the microlevel is a reflection of the physical processes occurring in continuous space and time. The models at the microlevel are differential equations in partial derivatives. They independent variables are the spatial coordinates and time. Using these equations, mechanical stresses and deformations, pressure and temperature, etc.

Modeling at the microlevel problems of heat conduction and stress-strain state of the products is implemented through the finite element analysis for. For modeling of problems of dynamics of liquid and gas, fluid mechanics and heat and mass transfer uses finite-difference and finite-volume solution methods.

To ensure the concept of the product life cycle model of the hydraulic actuators should reflect not only current status but also the changes in process operation and design (climatic) performance.

Thus, for a comprehensive analysis of all work processes in hydraulic drives, as well as solving problems of modeling technological and production processes, it is necessary to perform analysis of problems of different physical nature by various mathematical and software tools- develop and use a transdisciplinary model of a hydraulic actuator and its elements. Models are designed to combine in a single information space mathematical tools of various physical nature: mechanics, kinematics, hydromechanics, electromagnetism, heat engineering, levels and methods of solution.

These models will reduce assumptions and reduce the safety factor as a measure of the imperfection of the scientific and technical view of the object.

Structural elaboration of the product is carried out on schematic level. At this stage, actively apply software tools for simulation and analysis of circuit decisions on the macrolevel (Matlab/Simulink or other similar, for example, SciLab/SciCos). These programs reflect the characteristics of the whole system and use the description of the test facility and get the results in a familiar user graph form.

As an example of the macrolevel-model, in figure 1 present the model and result of calculation of the indicator diagram of the hydraulic machine.

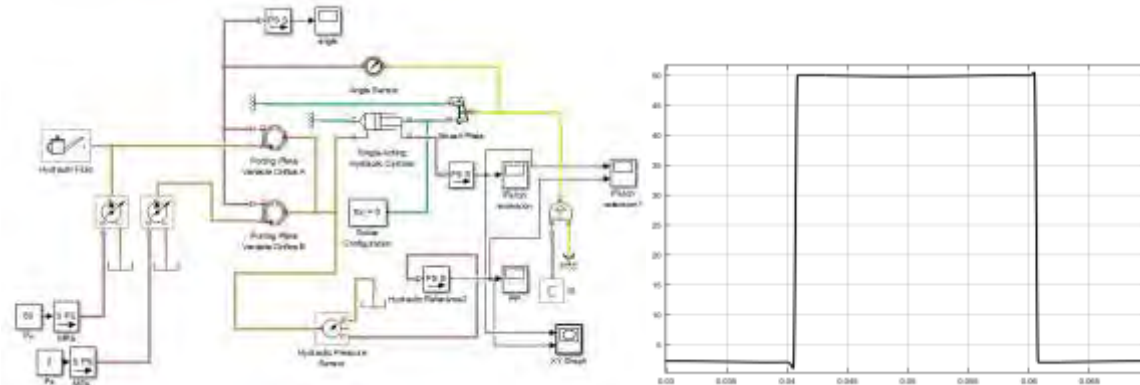


Figure 1 – Model and result of calculating the indicator diagram of the hydraulic machine

The macromodels is usually performed optimization of the system as a whole, traced the mutual influence of system components.

The disadvantages of macrolevel models are inherent in analytical and imitative approaches.

The next stage in the development of the product is a detailed study of its mechanisms and components. The initial data for this stage are the results of modeling at the macrolevel. The range of problems solved: kinematics, strength, fluid dynamics, electromagnetism, heat-mass transfer, etc., as well as their combination.

The task of calculating the indicator diagram at the microlevel, taking into account the geometric features and properties of materials, is solved by means of a complex of programs, including the tools CAD, CFD and CAE.

Adaptive CAD model is required to generate the original geometry and its changes based on simulation results, as well as for subsequent CAM preparation and production [3].

As a result of CFD modeling, the following results were obtained. Figure 2 shows a picture of the distribution of pressure of the working fluid through the channels and gaps of the running gear of a hydraulic machine with flow velocity vectors and contact stresses on the cylindrical part of the plunger.

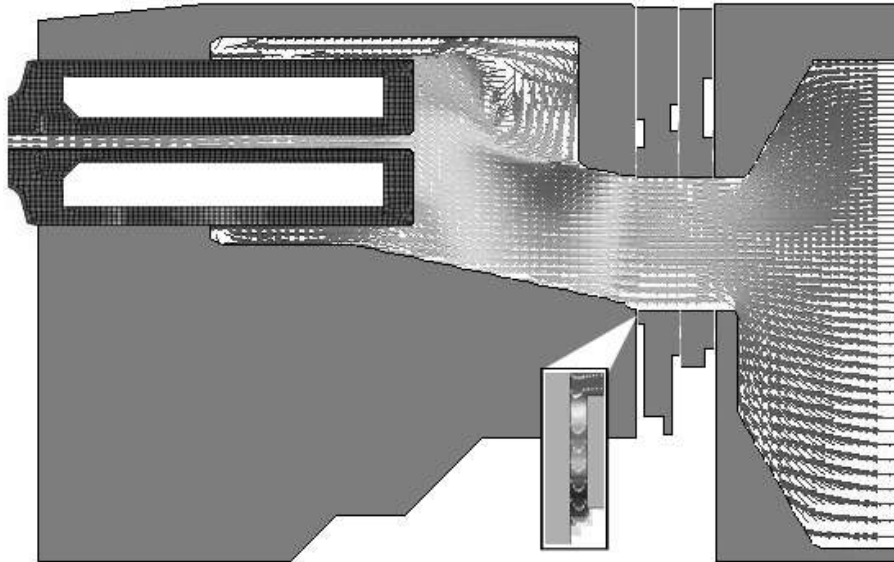


Figure 2 – Results of complex modeling of the running gear of a hydraulic machine: contact stresses on the piston and hydrodynamics in the chamber of a hydro machine

Figure 3 presents the generalized result of the simulation of the indicator diagram of one of the variants of the design of the distribution node (as an example of the effect of structural elements on the form of the graph) [4].

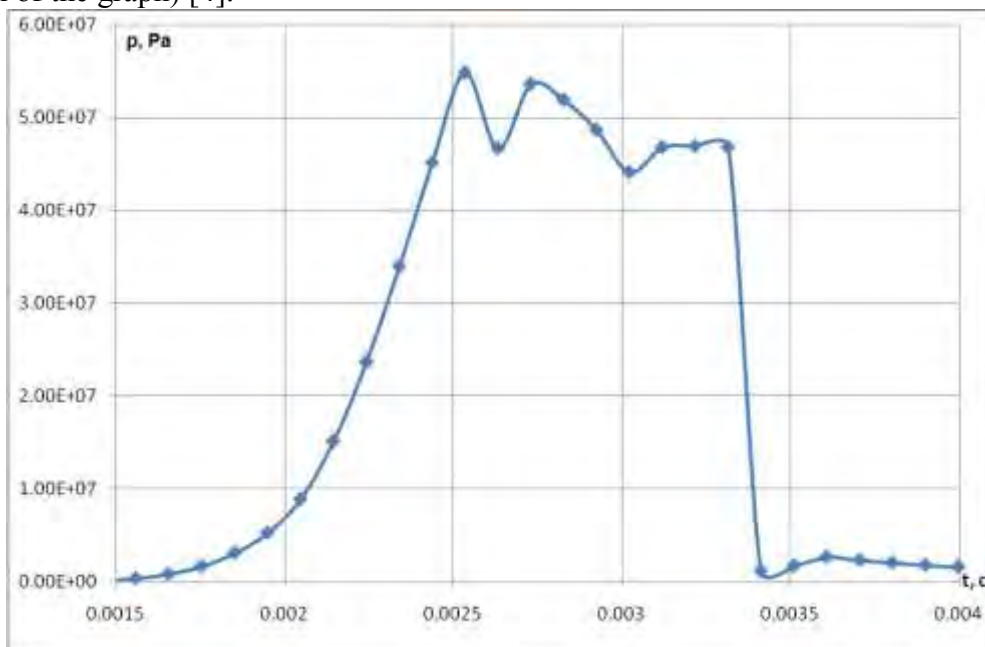


Figure 3 – Indicator diagram of the axial-plunger hydraulic machine

The figure reflects the influence of the parameters of the micro – structural features and the properties of the fluid, its gas saturation and pollution.

On the chart of the indicator diagram, positive results of the design work of the distribution center are seen: the smooth lines of entry into the injection zone.

The oscillatory process at the beginning of the injection zone reflects the content of dissolved gas in the working fluid and self-stabilization of the hydrostatic support of the plunger.

Conclusion

The transdisciplinary approach allows for a limited number of objects in more detail and to comprehensively study properties of the target object, as well as to explore the mutual influence of system and design parameters with the parameters of the environment.

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