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FEATURES OF MANAGEMENT OF TECHNOLOGICAL PROCESSES IN MICRO-GRAVITATION AND MICRO-ACCELERATIONS CONDITIONS. 2. CATEGORIES OF THE MATHEMATICAL MODELS

Introduction

This article is extension of the performance [1]. Below levels of construction of mathematical models of technological processes as polyphysical dynamic systems with control of the basis of Tagrang-Hamilton formalisms are considered. Differential – topological and algebraic aspects of construction of technological process models are reflected.

Some Topological and Algebraic Models of the Polyphysical Control dynamic Systems

If we speak about the level of the construction of mathematical model, then it is necessary to consider the following basic circumstances:

1. Any precise physical theory must satisfy Lagrange's formalism;

2. With interaction of two subsystems the generalized function of Lagrange must take the form:

$$L = L_{\gamma}(q, \dot{q}) + L_{\gamma\hbar}(q, \hat{q}, \dot{q}, \dot{\hat{q}}), \tag{1}$$

where q – are generalized coordinates or functions of state of classical subsystem, $\hat{q}$ – observed by quantum subsystem, L_{γ} – classical Lagrangian, $L_{\gamma\hbar}$ – quantum and mixed Lagrangian;

3. If field structures are examined, then the functions $\varphi^{\sigma}(x)$ of field theory correspond to the generalized coordinates q of the discrete system, where σ – the discrete index, which transfers different fields, X - coordinate of three-dimensional space. Lagrangian L is represented in the form:

$$L = \int \alpha(\varphi, \partial_{\mu}\varphi)dx, \tag{2}$$

where α – the density of Lagrange's function, which depends on fields ϕ and $\partial_{\mu}\varphi$, taken at same point X.

4. Hessian matrices of the Lagrangian in (1) and (2) are reversible;

5. The principle of quantization is always carried out;

6. For the first subsystem classical equations can be used, for the second - quantum and the interaction of subsystems must be taken into account in functions $L_{\gamma\hbar}$. The solution by decomposition according to the degrees of Planck's constant $\hbar$ and passage to the limit $\hbar \to 0$ are unacceptable, since one of the subsystems must be quantum

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7. The possibility of passage to the Hamilton formalism and formulations. If Lagrangian degenerates, i.e., the determinant of Hess matrix becomes zero, then passage to the Hamiltonian form by the usual conversion of Legendre is impossible. In this case poly-physical system must satisfy some equations of relations of the quantum-mechanical content, which can make it possible to pass to the Hamiltonian formulations for the poly-physical system.

Thus, control of technological processes is reduced to the problem of control on the macro- and the micro-levels, based on the natural time-spatial hierarchy of physical chemistry structures and processes in the substance. It consists in the fact that in the space of the external and internal degrees of freedom of continuous medium are separated the subspaces of the states of two interacting and interpenetrating media, namely: controlling and controlled. Control must be realized via activization of the managing medium via excitation or extinction of micro-accelerations fields, wave processes, quantum transitions and so forth, and also administrations of boundary and initial conditions.

As a whole the structure of technological process as dynamic system with control, can be represented in the following general integral-differential form:

$$F_\alpha(t; h(q); C; \frac{d^{(\mu)}h}{dt^\mu}; \frac{\partial^{|\sigma|}h}{\partial q^\sigma}, q; \int dq; u(t, h(q), C)) = 0, \tag{3}$$

where

$$F_\alpha(\cdot) = uF_\alpha^{[i]}(\cdot) + (I - u)F_\alpha^{[j]}(\cdot), \tag{4}$$

$1 \leqslant \alpha \leqslant r$, indices $[i]$, $[j]$ determine the numbers of subsystems and independently pass values $1 \leqslant \{[i], [j]\} \leqslant n$. In the analytical understanding (3) $q = (q_1, \ldots, q_N)$ – the coordinates of space R^n, $h(q) = (h^1(q), \ldots, h^m(q))$, $C = (C_1, \ldots, C_\beta)$, $\mu \in [1, l]$ and determine the order of time derivative of the function h. $\sigma = (\sigma_1, \ldots, \sigma_s)$ – multiple indices and $|\sigma| = \sigma_1 + \sigma_1 + \ldots \sigma_s \leqslant k$, $u = (u_1, \ldots, u_p)$ – control and $p \leqslant \alpha$, $k \leqslant m$.

In the equations (3) variable q and t can be considered as the three-dimensional and time coordinates respectively, and the solutions from the vector- set h describe the state of system and they are the variables of the state, which were discussed above. It is assumed that the equations (3) depend on the parameters from the vector- set [C] (Reynolds number, structural constants, the strength of magnetic field, field of micro-accelerations and so forth) and it is natural to name their controlling parameters.

The mathematical special feature of equations (3) as the models of dynamic system with control is their irregularity in its content, induced by the physical chemistry special features of the described process. Hence follows the rigid need to use regular mathematical models in one or other sense or another.

The left side of the equation (3) can be considered as set C^ν – mappings $F = \{F_\alpha\}$ and is assumed that there is a mapping

$$F : H \times I^* \to Y \subset R^r,\ I^* = [0, I] \tag{5}$$

Such that

$$F(h, 0) = F^{[j]}(h), \tag{6}$$

$$F(h, I) = F^{[i]}(h) \tag{7}$$

$\forall h \in H \subset R^m$ and $\forall u \in I^*$, $0 \leqslant u \leqslant I$. Mapping (5) is the family of mappings of the form

$$F_u : H \to Y, \tag{8}$$

Related to F with relation

$$F_u(h) = F(h, u),\ u \in I^*. \tag{9}$$

Mapping F in (5), that satisfies conditions (6)–(9), is a homotopy, which connects mappings $F^{[i]} = \{F_\alpha^{[i]}\}$ and $F^{[j]} = \{F_\alpha^{[j]}\}$ $\forall \alpha \in [1, r]$. The set F can be broken into disjunct classes of mappings, equivalent according to the relation homotopies. These classes of equivalence are homotopic classes $\pi(F^{[i]}, F^{[j]})$. The mappings, which belong to one and the same homotopic class π_i, have identical properties in a whole series of cases. It is possible to replace the studied mapping with simpler, that is homotopic to it. The conditions, which make it possible to stay in the homotopic class, thus guaranteeing equivalence relation of mappings, were examined in [2].

On the other hand, equations (3) can be considered as a topological space, allotted by the structure of variety, and so established different classes and equivalence relations, including the relation of homotopy of varieties. It should be noted that homotopic equivalence gives weak equivalence relation in comparison with the topological equivalence (homomorphisms) and to that differentiated (diffeomorphisms). From the existence of the differentiated equivalence follows topological, and from it - the homotopic, but reverse chain of equivalence relations may not hold. With the incomplete or badly defined model the relation of homotopy can play the role of comparative relative invariant and give information about the structure of many experimental data of process to, i.e., play the role of the crude estimate of the correspondence of physical and mathematical models and their supplement.

Conditions (6) and (7) and homotopy (5), related to the equations (3) as variety, make it possible to represent these equations in the form:

$$uF_\alpha^{[i]}(\cdot) + (I - u)F_\alpha^{[j]}(\cdot) = 0, \tag{10}$$

where $u \in [0, I]$. Here two systems $F_\alpha^{[i]}(\cdot) = 0$ and $F_\alpha^{[j]}(\cdot) = 0$ with substantially different properties, but with and $u \neq 0$ and $u \neq I (u \in (0, I))$ – the synthetic system, for which, for example, Lagrangian $L_{\gamma\hbar}$ in (1) is a characteristic function. With $u = u(t)$the set of equations (3) has functional power, moreover the properties of systems can sharply be distinguished both in the class of poly-aggregate and in the class poly-physical systems.

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The possibilities of study and realization of this type of dynamic systems with control must be based not on the differences between the systems, but exactly on the properties, which are inherent in all differential equations, obtained from the equations of the controlled system by the substitution in them of the permissible controls: general solutions, general invariant functionals, total symmetry groups, the united criteria of controllability and invariance, stability and adaptability and so forth. Another problem, the establishment of the criteria of isomorphism and adequacy of the model to real process, namely, the construction of equally adequate models and selection from this set of the model, that is convenient for solving the specific objectives. One of such the sets of models is the class of equivalence, which consists of the systems, connected with nonspecific, possibly nonlinear replacements of the variables of the state of process, mentioned above, and also the presence of mappings and conversions, which transfer one system of the class of equivalence into another or into another class of equivalence, which solves the task of decomposition in the classes of the poly – aggregate and poly-physical systems of some depth. Some aspects of the solution of the problems indicated are reflected in the works [3–8].

Thus, for the solution of the problems of control of technological processes under the specific conditions of micro-gravity and micro-accelerations, which are reduced to bringing of the initial states of process into a certain terminal with the given properties, it is necessary to create of controlled systems, which bear the distribution - concentrated nature as the interconnected systems for control and vibration shielding by the internal and external states of continuous medium. These systems must be with the hierarchic structure, adaptive, possessing the properties of poly-controllability and poly-invariance in the classes of associative and nonassociative algebras. It should be noted that a strict definition of the concept of adaptability and the criteria of adaptability are absent, but the theory of the controlled dynamic systems in the class of non associative algebras was not examined.

Summary

Thorough analysis and wide classification of objects that are different at first glance, methods of study and decided tasks of control and vibration shielding are the necessary and sufficient conditions of existence of the prerequisites for the creation of united axiomatic theory. This tendency represents its basic internal task. The need to construct new concepts and objects by this method appears immediately. This process of the accumulation of components is inevitable, if the problem of transforming initial many different concepts in different theories of control and vibration shielding into the united axiomatic theory is posed.

It is understandable that the united system cannot be realized without the united method. The method of the mutual classification of the varieties of states and motions of dynamic systems can become this method in the theory of control and vibration shielding. Three basic tasks are at hand:

- the introduction of different geometric structures and the propagation of classical results for these structures;
- the algebraization of the obtained structures;
- the extendability of the obtained local results to the global ones.

The research program, which includes these general formulations, must answer the following questions:

1. In which case each variety of the states of the system of a certain fixed class A can be represented to a certain variety of class B, which presents the purpose of control, by means of the mappings, which belong to class D?

2. By what intrinsic properties is the variety of states characterized, which belongs to class F, where F – is the image of variety from the class C during the mappings from the class E?

3. What are the properties of mappings from the class $N(A, B) \cap D$, where $N(A, B)$ – the class of the mappings, such that varieties from the class A serve as the domain of definition, and variety from classes B, D as range of values where B, D are another classes of mappings?

4. What structure of control and internal system characteristic solve the problem of bringing onto the assigned variety with the simultaneous compensation for external disturbances and what are the criteria of poly-controllability, poly-invariance, adaptability and so forth?

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