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SIMULATION OF DRIVE SYSTEMS USING MULTIPOLE MODELLING

Summary. Physical modelling of drive and other systems can be based on subsystems models in the form of multipoles respecting continuity and compatibility postulates which apply to all physical energy domains. Multipoles correspond directly to those subsystem locations in which the actual energetic interactions between the subsystems take place (gear boxes, shafts, electrical terminals, etc).

A versatile software SADYS had been developed for modelling, simulation an analysis of general linear as well as nonlinear dynamic systems. SADYS admits system specifications in the form of a set of equations, of a block diagram, of a multipole diagram, or in a form combining the above approaches.

This article describes the results of study of motion and dynamic behaviour of real driving systems with gears - drive off-the-road vehicle, obtained by means of the multipole modelling.

SYMULACJA UKŁADÓW NAPĘDOWYCH PRZY ZASTOSOWANIU MODELOWANIA MULTIPOLARNEGO

Streszczenie. Fizyczne modelowanie układów napedowychi innych może być oparte na modelach podukładów w formie multipoli uwzględniających postulaty ciągłości i zgodności, które znajdują zastosowanie we wszystkich fizycznych dziedzinach energetycznych. Multipola odpowiadają bezpośrednio takim usytuowaniom podukładów, w których zachodzą rzeczywiste wzajemne oddziaływania energetyczne (skrzynie przekładniowe, wały, zaciski elektryczne itp).

Dla celów modelowania, symulowania i analizy ogólnych układów dynamicznych zarówno liniowych jak i nieliniowych opracowano uniwersalne oprogramowanie SADYS. Oprogramowanie SADYS dopuszcza charakterystykę układu podaną w formie układu równań, schematu blokowego, schematu multipola bądź w formie łączącej powyższe ujęcia problemu.

Artykuł opisuje wyniki badania ruchu i zachowania dynamicznego rzeczywis-tych układów napędowych z przekładniami w pojazdach specjalnych uzyskane za pomocą modelowania multipolowego.

СИМУЛЯЦИЯ СИСТЕМЫ ДВИЖЕНИЯ ПРИ ИСПОЛЬЗОВАНИИ МОДЕЛИРОВАНИЯ

Резюме. В работе представлено физическую модель динамической системы которая может быть основана на модели субсистемы. Для этой цели использовано програму SADYS которая моделирует и делит анализ линейных и нелинийных дунамических сустем. Её применено для анализа дорожных пойездов.

1. INTRODUCTION

The aim of this paper is to reveal application of the multipole modelling on the solution of problems of dynamics of driving system with gears. The gears and first of all gearboxes, constitute one of the basic structural parts of driving systems. Due to their dynamic properties, given most of all by their constructional arrangement and dimensioning, they may influence significantly the behaviour of drives. The epicyclic gearboxes used in off-the -road vehicle, have many steps (5 or 7), contain two or more planet units and many spur gears, couplings and brakes. The control of coupling and brakes is hydraulic. Most of such systems are of mixed energy - domain nature. Phenomena in liquid are exploited in them in combination with phenomena coming from other energy domains (like mechanical, electrical, etc). Also thermal phenomena affect the behaviour of these systems. The available control design procedures are based on a rather high degree of system abstraction and idealization. Most of the procedures assume that the controlled systems, controllers, sensor and other components are linear and simple. In practice, however, they are mostly nonlinear, complex and subjected to many constraints.

When dynamic behaviour of these systems is investigated, the system is usually decomposed into a number of mutually interacting modules. These system modules may be real components from which the system is actually assembled on aggregates of such components. But they may also be just some nonseparable parts of the components exhibiting certain dynamic phenomena (fiction, clearance, flexibility of individual gearteeth, etc). In general, to investigate energetic interactions between a system module and the rest of the system, we have to integrate all the infinitesimal energy flows through a module energetic boundary - a geometrical surface enclosing the module.

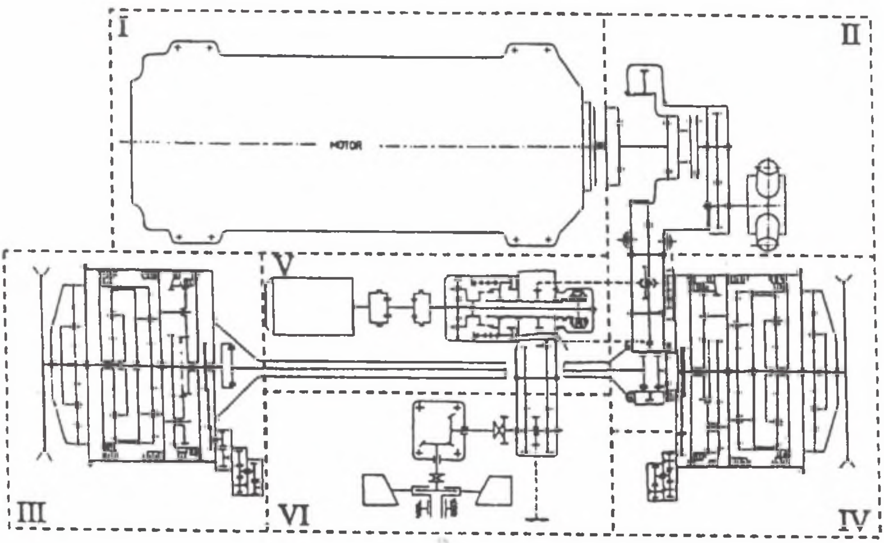

Fig. 1.

The multipole modelling approach to simulation of dynamic system presented in this paper has been implemented in a software package SADYS/DYNAST [1]. Besides the physical - level simulations, SADYS/DYNAST is also capable of block - diagram based simulations useful for problems of a higher - abstraction level. SADYS/DYNAST can be also used as an equations solver for systems of implicit - form nonlinear algebro - differential and algebraic equations. Multipole, blocks and equations can be freely combinated to form models representations of the investigated dynamic systems [2].

2. EXAMPLE OF DRIVING SYSTEM

Fig.1. shows block diagram of the drive off-the-road vehicles. This drive system is decomposed into following interactive modules: I - motor, II - final drive, III, IV - epicyclic gear - cases; V - starter; VI - servosystems.

Table in the Fig. 2. gives examples of the basic mechanical subsystems (which are used in the scheme on Fig. 1) and their multipole representation.

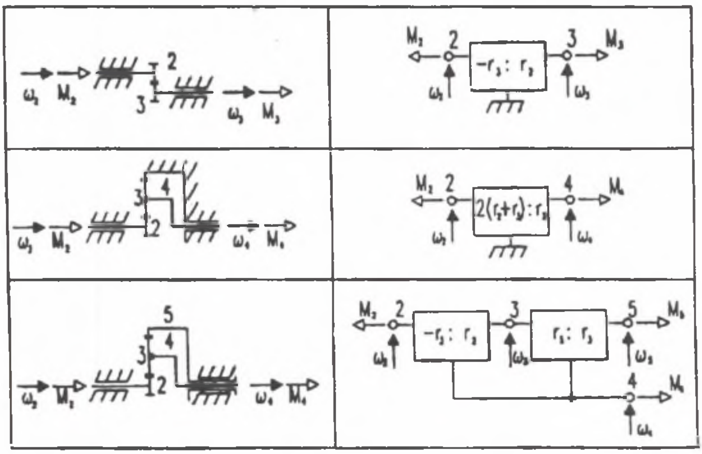

Fig. 2.

Fig. 3. shows a graphical representation of a multipole model of the complete drive systems.

Following fighters show some out put processes. Fig. 4. shows phase portrait in the model point A - see Fig. 3.

The changes of torque moments of the epicyclic gear shafts (modal points 1 and 2 - see Fig. 3) during the gear shifting are seen in Fig. 5.

In Fig. 6 the course of maximum and real moments in the fluid coupling S3 (see Fig. 3) are seen. Also, there is evident mutual coupling between the parameters of the mechanical and hydraulic subsystems [4].

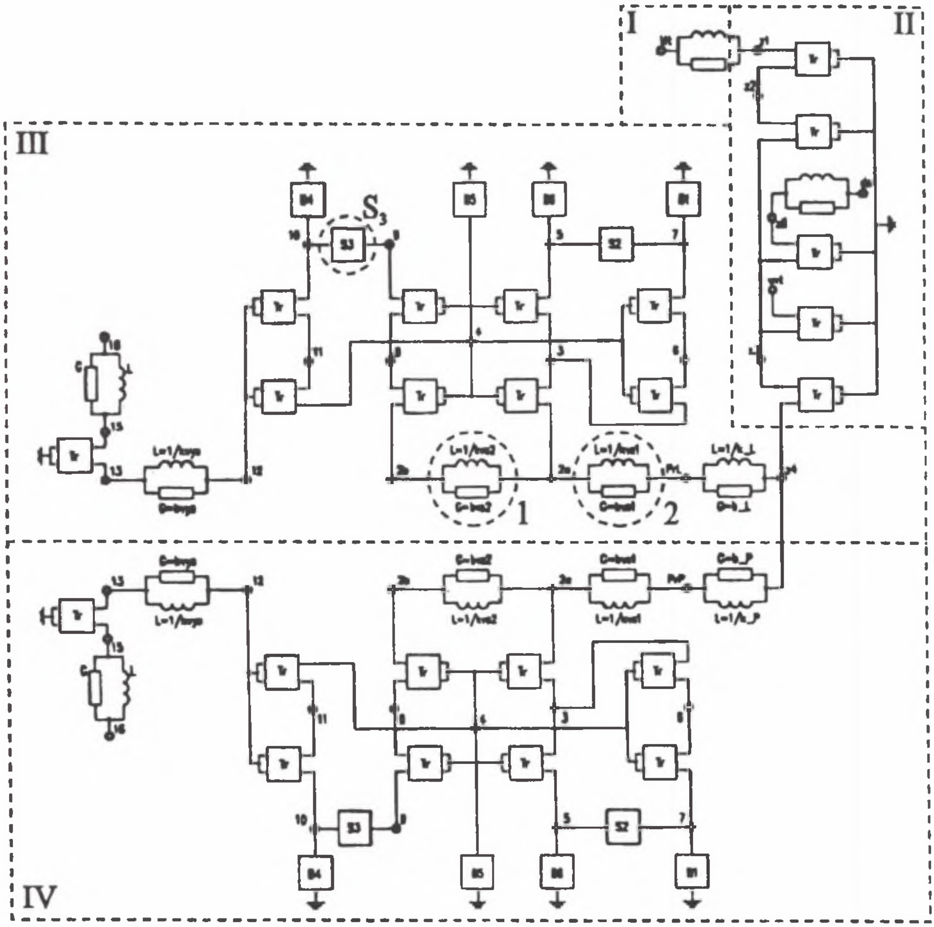

Fig. 3.

3. CONCLUSION

While calculating the kinematic parameters of response and course of elasticity moment at particular points of the model, their mean or maximum values, and standard or extreme deviations, we can also calculate the course, the correlation and spectral density functions. These values, plotted in relation to the change in selected structure parameters of drive models, can then be used by engineers to give the dimensions of parts of the drives, and after further analysis to determine optimum variants of the structure. In solving a highly topical technical problem we have tried to demonstrate many advantages of the simulation method in dynamic analysis of machinery drive systems.

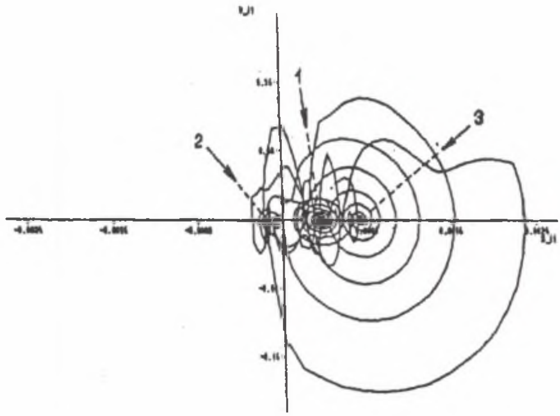

Fig. 4.

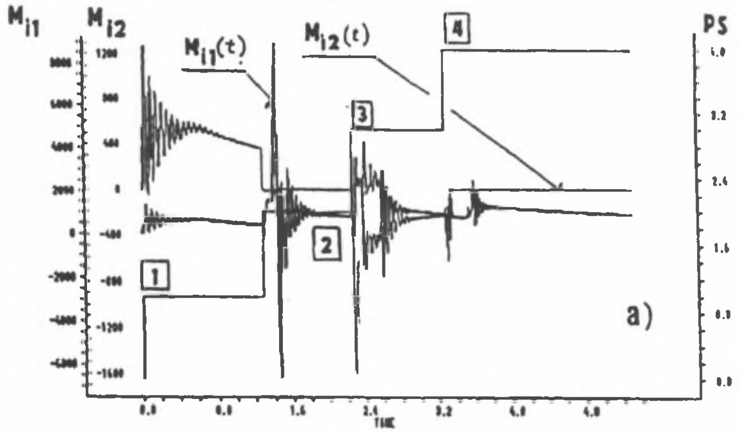

Fig. 5.

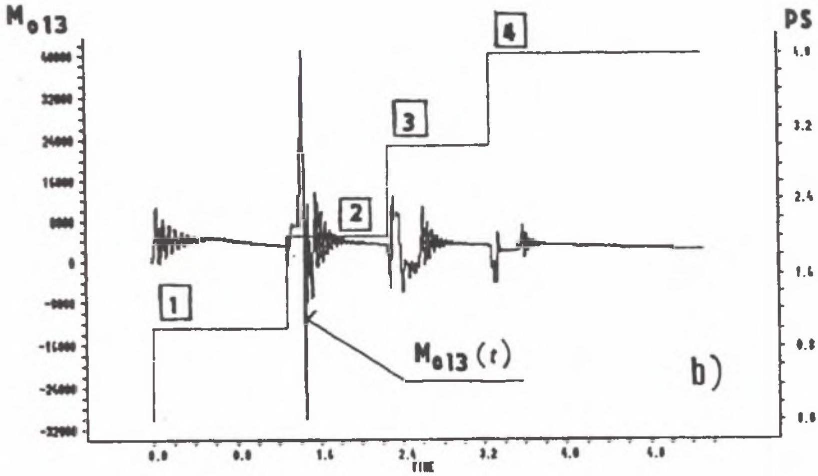

Fig. 6.

REFERENCES

[1] Mann H.: SADYS - program pro simulaci a analyzu dynamicych soustav, DT CS VTS, Praha 1986

[2] Havlicek J.,Styl P.: Seznam makromodelu pro programSADYS, zprava ZDAS c. 4-T 29561 - 29576; Zdar n. Saz. 1990

[3] Kratochvil C., Kotek V., Heriban P.: Analyza dynamiskyvh vlastnosti planetove prevodovky; vyzk. zprava UMT - FS VUT Brno 1992

[4] Heriban P., Kotek V., Kratochvil C.: Modelovani interaktivnivh pohonovyvh sonstav, sprava z re. projektu GACR cislo 101/93/0297, Brno 1993

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