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AN ADDITION ON DEVELOPING A SYSTEM FOR AUTOMATIC DESIGN OF GEAR TRANSMISSION SYSTEM

SUMMARY. An engineer experience exhibits a great variety of possible assignments in the field of gear transmission system design. As a result a large number of programme modules for calculating vital transmission items has been developed. Developed items for developing gear transmission system are not relevant for user because each newly formed concept of gear transmission system demands a great system improvement. Due to this reason a programme system integrating a series of partial programmes and data files into unique calculating system has been developed.

This essay exposes the results of conducted examinations and also a description of the system for automatic design of gear transmission system has been presented. This system is developed to provide the usage for a wide range of gear transmission systems, independent on the number of inlet-outlet values and degree of transmission. Studies have been limited to the gear transmission system with fixed rotation axes.

1. INTRODUCTION

Having in mind their function and economic value, transmission gear systems are among the most important assembly blocks. Transmission gears make 80% of all installed gear transmission systems, in driving machines, technological and transport systems.

Much more severe demands concerning the quality and price of transmission gear system and shorter time for acquiring a new product, make design procedure a problem in this process.

A large number of programme modules has been developed for calculating vital items of transmission gear systems, for instance for calculating cogged pairs, shafts and bearings.

Developed systems for designing transmission gear systems are not flexible for used because for each newly formed concept of transmission gear system they demand enormous system

rebuilding. Adding necessary data or their transfer from one programme modul intoanother makes large difficulties while using these programme packages. For this reason, we have developed a programme system integrating a series of partial programmes and data files into unique calculating system. Researches have been limited to transmission gear system with fixed rotation axes.

The function of such a CAD system is to provided:

- design of transmission gear system for general and special use,
- a complete automatic and simultaneous design of transmission gear system,
- a partial usage of single modules and the application of unique control system for interconnecting programme modules mot depending on the selected transmission gear system concept,
- operation with minimum input data,
- optimisation with flexible usage of different target and limit functions.

In engineering practice exists a great variety of possible assignments in the field of designing transmission gear systems, so that an analyses of these assignments is necessary.

2. POSSIBLE ASSIGNMENTS IN THE FIELD OF DESIGNING TRANSMISSION GEAR SYSTEMS

The aim of analysing design-construction assignments is to state the rang of the problem which is to be solved in this process.

Design-construction assignments can be devided based on the following criteria:

- a complexity of designing object,
- a degree of knowledge about the object, regimes and conditions of exploitation and
- the range of eventual production of designed object.

According to the first criteria, it can be devided to design and construction process items, subsystems, i.e. elements, subassemblies, assemblies and etc. For the sake of making a much more defined possible design-construction assignments, transmission gear system as a complex system can be devided to the system intended for power transmission, based construction of the system (housing), and lubricating system and system for stating working capacities. At this stage the following assignments are possible:

- a complete design of transmission gear system,
- power transfer system design,

- base construction design (housing),
- cooling and lubricating system design,
- design of a system for stating working capacities.

Between these systems there is a corresponding correlation of parameters and hierarchical system stages. A simultaneous designing is necessary where parameters of system for power transfer make the starting point. For instance loading and overall dimensions of the system for power transfer make the basic data for housing design, while power losses, area and shape of the housing are used for cooling system design. Ven diagram, Fig.1, shows a further process of power transfer system dismantling based on the example of two-stage transmission gear.

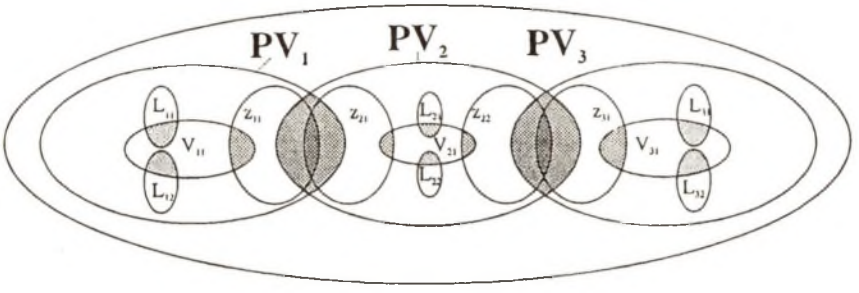

Fig.1. Ven diagram of two-stage transmission gear

This system consists of three subsystems connected to the shafts, while correlation's between these subsystems and their elements are presented with suitable cross hatched areas.

The above mentioned shows possible assignments for designing, construction or controlled calculations:

- energy transformation items (cogged pairs, worm-type pairs,...)
- shafts,
- bearings,
- ties and connections.

Then next stage is dismantling the items on outer and inner structures where from the following assignments can come out. As for cogged pairs they are:

- selection of tools profile,
- selection of material and heat treatment,
- selection of quality and manufacturing process,
- selection of the shape of cogwheel body.

Based on the second criteria, i.e. on the knowledge about transmission gear system, its regimes and exploitation conditions, design-construction assignments can be basically classified to:

- reliability determination,
- max. loading determination,
- summarising, dimensioning and shaping.

Reliability determination is possible specific conditions and exploitation regimes, when all relevant gear transmission systems parameters are defined. Depending on the element for which the calculation is to be made, i.e. on the degradation process happening on the item, it is possible to define, for instance, the following calculations: cog base and side hard ness, tear and wear, heat stability, dynamic stability, elastic deformations and shaft elasticity and so on.

For determining possible transmission gear system loading it is necessary to define exploitation conditions and to set one minimum reliability values which should be provided by the transmission gear system.

In this case as well it is necessary to provide all relevant transmission gear system parameters.

The third assignment is the most complex one and for its solving a complete for partial knowledge of the function which should be achieved by the transmission gear system, conditions and regime of the exploitation, instalment conditions, technological possibilities, necessary reliability and transmission gear reliability.

The assignment should be solved in several stages stating with making a concept to determining all transmission gear system parameters. Based on the achieved researches a programme modul for defining design-construction assignment has been made. This modul is a part of pre-processor enabling efficient starting data input which depends on the selected conceptual variant of the transmission gear system and selected assignment type as well.

3. DESCRIPTION OF THE CAD SYSTEM

In order to solve the given task and use previously developed programme modules for power transmission elements calculation, a CAD system for simultaneous and automatic power transmission design has been developed. The CAD system consists of the following software units (fig.2)

PPR - according to the request list pre-processor makes selection of all possible solutions for adoption the most appropriate conception of power transmission. On the basis of the

adopted conception of power transmission pre-processor makes possible a quick entry and control of input data. In this way is provided very simple adoption of calculation and because of that entry of minimum necessary data.

PROR- programme comprising modules for power transmission elements calculation. In the scope of these modules, the optimisation is possible but for only parameters which don't effect the rest elements of system.

OPT - programme module for the analysis of obtained calculations, selections of possible solutions and optimisation. On user s request a complete or partial optimisation of power transmission elements for a given goal function and given boundaries is carried out. At the same time, permanent communication with the data base enables updating and completion of the existing data on power transmission after each calculation cycle.

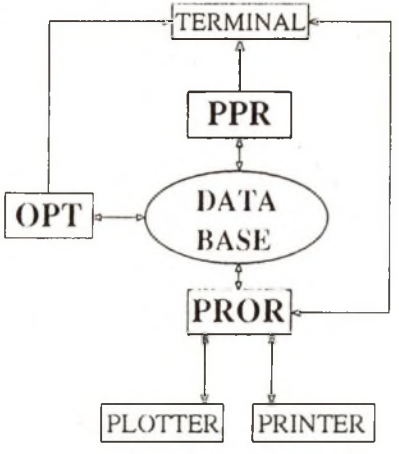

Fig.2. CAD system for design of gear drives

Starting with data on power transmission obtained in the first phase of the design process and, in communication with the data base, one or more power transmission types are selected. Final decision as to the power transmission concept is made by the user on the basis of the obtained relevant data in dialogue with the computer. The data on gear drive obtained in this phase a stored in the data base after being adequately checked and updated. Also, machining technology, materials and standard power transmission elements are selected depending on the available recourses of the user. These data mostly define further calculations.

By analogy with the above mentioned systems, corresponding calculation software are developed; they are included in the block PROR (fig.2). This program block consists the next program's (fig.3):

PPS - programme for calculating system for power transmission;

SPH - programme for calculating thermal stability of power transmissions and lubricating systems;

DPP - programme for calculating dynamic behaviour of power transmissions;

DIJ - programme for designing systems for operability diagnostics.

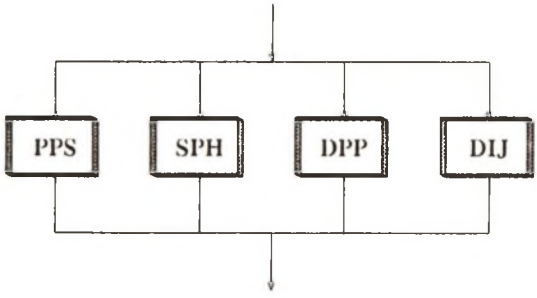

Fig.3. Programme block PROR

PPS programme includes calculation modules for power transmission elements in the system for power transmission.

This part of a CAD system includes the following calculations:

- *gear geometry calculation;*
- *determining the nominal loads for particular elements;*
- *calculating application factor through load distribution;*
- *calculation of load capacity of gears by various standards (DIN-3990, AGMA, Niemann) and various criteria (pitting resistance, tooth strength, wear);*
- *calculation of scuffing load capacity and determining transverse tip relief and root relief;*
- *calculating the longitudinal and tranverse load distribution factor $K_{H\beta}$, $K_{F\beta}$, $K_{H\alpha}$, $K_{F\alpha}$, and determining the end relief;*
- *calculating the shaft elastic deformation and strength;*
- *bearings calculation.*

Individual programme modules are interrelated so that the rezultats of one module calculations are used as input data for another module. Data on power transmission are constantly being updated and, by corresponding iterative steps brought to a higher level. Calculation and design process are by means of corresponding control functions, and user has permanent access to data and is in position to intervene trough a corresponding dialogue.

Thermal stability calculation of power transmission and lubricating systems is carried out by means of SPH programme. On the basis of this calculation operating temperature of power transmissions is determined using the data on energy flows in transmission, kinematics and geometrical parameters of power transmission elements, design parameters on positioning mode and tightness, lubricating agent characteristics and heat losses through casing, foundation and transmission elements.

If operating temperature surpasses the limit value, a calculation of cooling subsystems is done, alternatively for:

- pumps and corresponding systems for increasing oil circulation within casing (housing);
- fans on the inlet shaft of a power transmission,
- cooling systems with cooling outside the casing.

Lubricating oil is selected on the basis of data obtained trough calculation scuffing load capacity. In order to find adequate design solution with regard to critical and supercritical revolution number area it is necessary to determine the dynamic behaviour of power transmission in exploitation conditions. The effect of internal dynamic forces on power transmission load capacity is already considered via dynamic factor K_v in the system calculation for power transmission. However, in cases where majority of data were unknown or only so approximately, the calculation was done only by C method (DIN-3990). At this stage, data on power transmission design solution have been complete, so that factor K_v can be calculated by A method. The calculation is included in DPP programme where geometrical and design parameters obtained in the calculations so far, are used as input data. Should a change of the power transmission design parameters prove necessary at stage, an access to any programme module for the purposes of renewed calculations is possible.

DIJ programme includes the diagnostics system design for power transmission and corresponding safety devices operability.

4. CONCLUSION

The presented CAD system for power transmission design enables:

- *automatic and simultaneous design of complete power transmissions with fixed axes of rotation;*
- *selection of the optimum variant of multi-variant solution with flexible use of various goal functions and boundaries;*
- *operation with minimum number of input data and their constant control;*
- *work in dialogue with the computer and with an easy access to programme modules;*
- *application of unique control system functions for interrelating programme modules depending on calculation type;*
- *simple connection to the user s systems with the use of available user s programmes and data bases.*

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Revised by: Jan Kaźmierczak