COMPUTATION TECHNICAL PROBLEMS OF MECHANICAL DESIGNING SYSTEMS

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Summary

The authors have dealt for a long time with the computerized support of technical designing processes. The greatest trouble in every case was the comparatively small volume of available computer capacity. The above circumstances assumed that greater care was taken when searching for effective solution methods. The paper summarizes the methodological character experiences obtained when applying a computer in two concrete mechanical designing processes.

Introduction

Authors have worked on the computerized support of technical designing processes for a long time. In general—in every case— the greatest trouble was the comparatively small volume of available computer technique capacity. The worst bottlenecks arose in different points for the individual tasks: once it was the capacity of the operative memory of the applied computer, then the comparatively small size of the quick-access secondary storages was liable for the difficulties that could not be easily solved.

The above circumstances meant a lot of inconveniences in the course of solving each task, at the same time they assumed that greater care has been taken when searching for more efficient solution methods.

According to our experience, over and above the technical limitations of the computer, human problems i.e. difficulties of co-operation between the specialist of the field in question and the computer expert presented themselves with at least the same weight.

In the following we shall summarize our methodological-type experiences obtained when applying a computer for two concrete mechanical designing processes. Since that time we had the same experiences when testing, developing several other systems.

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We endeavoured to publish—first of all—the statements that can be generalized and described special local conditions and data only in order to give a more complete image.

At the end of the article we will outline the possibilities and development work—latter already partly under way—elaborated on ground of our experience above type tasks.

Short description of the design tasks

Both tasks to be described here are of industrial dimension, we dealt with them on the ground of a contractual commission by a production enterprise.

Since these tasks have already been published in another place [2], [3], here they will be described only briefly, omitting the mathematical modelling apparatus.

The problem packages prepared in the course of solving the single tasks were run on the IBM-compatible R-32 type computer of the Computer Technique Application Centre of the Budapest Technical University.

Designing and dimensioning of roller bearings of nose-suspended traction motors

In the course of the work a computing dimensioning method has been elaborated suitable to design the nose-suspended bearings (roller bearings) of electrical railway traction motors. A model had to be developed that describes—reliably—the original object, also regarding the dynamic loads. Since in the frame of the task a nose suspension construction roller bearing had to be elaborated, the co-operating team required the work of several specialists, also from a mechanical point of view.

The work was carried out in the following main steps:

— survey of the up-to-date technical literature,
— determination of the objective data (that can be measured or stated from the structure of the tracks) of the railway track that influence the load,
— elaboration of a calculation model, constructing the model of the purpose-oriented swinging system of the locomotive,
— analysis of the load of the nose suspension bearings, computer aided load test of the calculation model, model corrections on ground of the results,
— elaboration of the dimensioning procedure referring to the concrete task,
— development of the bearings of the nose-suspension construction.

It is obvious from the above, that the computer was applied in the course of the fourth phase: the load analysis.

A computer program package has been prepared for performing the task which is also generally suitable to test linear, dynamical systems of concentrated parameters and stochastic induction.

The program package is suitable to handle a computerized model of any mechanical system determined by its

— masses (inertia moments),
— topology,
— rigidity, attenuation data.

The variant for the given task could be used to determine the displacements and connection loads in any connection point of the model, in the knowledge of constraints and inductions acting in the model. This variant consisted of 30 mass points permitting 150 connections among these points.

In the following the most important computer technique principles are given used for designing the problem package that have proved successful when solving other tasks:

— the program package should be well structured in order to provide for a later extension in a simple way,
— indication and entry of the input data should be unambiguous (measurement units!), easy to handle and adequately checked,
— the modules requiring specially much calculation should be separated, they should not be re-run for all inductions,
— the output must be of variable depth and well surveyable.

The program package developed on ground of the previous standpoints consists of three main modules.

SOOO — reads in and checks the data describing the system; on the ground of this control checking it prepares the data characteristic for the system, and writes the necessary data for further calculations on magnetic data carriers.

TUVO — The system module realizing calculation intensive tasks, solves the complex own value tasks of the system. Referring to a given model the module has to be run only once, the resulting parameters get to a magnetic data carrier.

WOUT — The "analyzing" module of the program package that calculates the studied connection loads in the selected connection points on ground of given induction data. The module can be run several times in itself for the different inductions, it is not necessary to re-run the first two modules.

After the program package had been prepared (1977) and after its first real (successful) application, the developing team (a construction-manager mechanical engineer, two electrical engineers, system designing programmers) surveyed now to realize further development, in order to be able to utilize it for several purposes. (The further development suggestion is described here as the task introduced in the following paragraph has been solved already at this level.)

The suggested main steps of development thus were:

— the element set to be considered and creating the system should be stored on a data base,
— the derived data (e.g. the inertia moments) should be calculated by a computer,
— the data input should be reorganized in accordance with the above and be made interactive,
— at each possible point of the calculation algorithm checking points have to be inserted in order to monitor the performance of accuracy requirements,
— a wide range mathematic routine file should be formed (inverting, own value calculation, etc.) that is suitable to the different accuracy requirements (and computer possibilities),
— a library setup should be provided for the parameters of the system model, proved to be operable,
— in case the necessary means are available graphical possibilities should be utilized in the display of the results,
— the program package has to be completed taking educational standpoints into account.

Let us note that in the meantime the development of the program package has given more results than those figuring in the above, namely the data entry (SOOO) and the evaluating (WOUT) phases can be operated on professional microcomputers with a graphical option.

Elaboration of calculating procedures based on the method of finite elements suitable for statical and thermic modeling of the structure, section components of the supporting frame of machine tool trestles

In the course of our work models have been elaborated that are suitable for finite element examination and refer to the frame structure and box-type components of two machine tools (centre lathe and/or processing centre). The geometrical models directly suitable to create the finite element network have also been realized. These models facilitate creating a connection between the real structures and the finite element network assigned to them. The finite element networks built from macroelements have been drawn.

Models of mechanical and thermic loads and for boundary conditions have also been developed.

In order to determine the form variations caused by thermic and mechanical loads and by constant state temperature fields of the supporting frame structure and box-type elements of the tool machines—based on the finite element method—a program package called "VEMLIN" has been produced.

The result of experimental calculations with the VEMLIN program package was compared with the data measured on the original equipment and a condition system was elaborated that facilitates the dimensioning utilization of the developed procedure.

While preparing the VEMLIN program package experiences of similar nature, obtained with other studies were taken into consideration. More care than earlier has been taken to develop a well structured data system. In the following we give a short description of the program package construction.

The program system is built up of programs carrying out partial functions in accordance with the properties of the finite element method. It is characteristic of each program that it reads parameters and data from a card or the display screen, while it uses—as input—a file resident in the secondary storage, finally it provides as results lists and files developed on background storage for further processing purposes (Fig. 1).

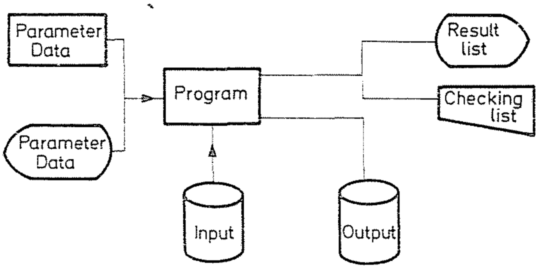

Fig. 1

The single programs can be connected to each other only through the files in the background storage. The programs can be run independently, the change (exchange) of the model to be tested is possible by copying the data referring to the actual model into the standard files.

The communication between the programs through the magnetic background storages is very reliable, the data protection standpoints can be well validated by an adequate structural development of the data files.

The VEMHALO program package operates in a similar way; it is suitable to display on a plotter the undeformed and/or deformed geometrical network of a given finite element model as well as the static temperature distribution prevailing in the single planes of the models.

(The program package was prepared in the International Computer Technique Training and Information Centre of the Central Statistical Office.)

The program package has a very big output:

the number of nodes can be	1200
the number of pieces of the elements	1500
the number of nodes per element	20
the number of physical parameters per node	21
maximum front dimension	400.

It is characteristic to the complexity of the modules described above that e.g. the PREM program consists of three phases and 48 subroutines.

As it can be seen by solving this task we made a big step forwards in computer technique; we succeeded to realize several phases assigned as further development purpose in the previous task, already in the basic system.

The most important ones are the following:

— entry of the data from a terminal can be carried out independently of the other modeling part-processes,
— the library setup of the single models, and/or their parts, has been solved,
— at a critical point of high calculation requirement of the program system an accuracy test can be performed,
— the results can be displayed graphically.

A more efficient utilization of the program system could be improved first of all by applying an interactive graphical work place. In this way the time of data preparation could be considerably decreased. It should be noted that this modification-further development assumes a work which—according to previous estimations can be compared, in size—to approximately the entire program system.

Standpoints for the development of computer-aided designing systems

The two computerized program packages outlined above supported only one phase of the work: checking calculations. This is a field where the application of the computer has begun in other branches, too. The other phases of the designing work—carried out by a computer—are very device intensive—they assume a CPU and secondary stores of very high capacities and interactive graphical devices. Even a seemingly simple work phase as collecting information necessary for the design can be supported by computer only with difficulties, on account of the high complexity and big range of data system types available. Fully interactive designing systems—that enable a development of the structure—are even now very rare according to our experiences, and can be used only for more simple constructions. The highly work intensive elaboration phase, however, can be automated well, thus—with computer aid—a high human designing capacity can be eliminated.

Till the mass appearance of complex computerized design systems, the computerized program packages supporting partial processes of the design work, as well as their application have a reason for existence.

Without endeavouring completeness, we will list some points of view which for such types of computerized development are very important, according to us:

— An accurate outline of the partial design process to be supported by computer, the definition of the expected output and the provided input are indispensable, in order to avoid later disputes,
— no time must be spared when developing the data system for the accurately specific task,
— special care must be taken regarding the primary input data,
— it should be separately tested whether there is an antagonistic contradiction or not between the dimensions of the given task and the available computer capacity,
— for the highly calculation intensive tasks it is reasonable to prepare a subroutine set of potentially differing accuracy, operating on the basis of different algorithms,
— according to our experience, the head of the elaborating team must be an engineer, a computer technique expert,
— the coding work of each program should be performed only after the availability of a very clear specification and the development of the complete data system,
— modularity should unconditionally be endeavoured, programs of big size should be avoided,
— the preparation of the test data as well as their editing should not be considered as a secondary task,
— the testing process is made much easier if the programs making up the program system communicate with each other through data files allocated on a magnetic background store.

Main development trends in the field of computer-aided construction design

In the following we give a very short survey of our most important research-development topic groups, the results of which raised the level of services of our computer-aided design systems.

There are basically three main topics:

— development of a technical data bank and its management system,

— development of a complete graphic display service,
— providing an interactive accessibility of the services belonging to the topic, to support the harmonization of the university development work by forming a network.

As far as the data bank is concerned:

— we have surveyed the expectations concerning the special purpose data base management system,
— we have surveyed the information to be stored as well as their characteristics,
— we have conceived the retrieval requirements,
— we have examined the necessary hardware-software conditions,
— we have taken the initial steps to develop a pattern system for the supervision of a general purpose data base management system (IDMS).

As far as the complete graphic display service is concerned:

— we have prepared the first version of a drawing subroutine set that is equally suitable for a high-power plotter (BENSON), a graphic display and a professional personal computer with a graphic option,
— we have built up an as far as possible online connection between the available graphic devices and the computer capacities,
— in order to meet the educational requirements we will also solve the integration of non-professional personal computers into the system.

As far as the provisions of the interactive accessibility and the development of the mains (network) method of operation are concerned:

— we have installed—on our central computer—the GUTS (Gothenburg University System) interactive program package that provides for the possibility of a remote job entry,
— by the modification and extension of the GUTS program package, we assure the accessibility to the majority of graphic devices, besides the IBM compatible alpha-numerical display screens,
— for the sake of getting to know the results of one another in an easier way, exchanging these results as well as utilizing the possibility of common usage of special peripherals, we provide for the connectibility of the Faculty's computer centres with the central university computer and with one another,
— the network formed in this way will be connected to the data network of the Post Administration, thus the possibility of data exchange among arbitrary research stations can be realized.

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