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DO WE STILL NEED AN EXPERIMENT IN SOLID MECHANICS?

Contemplation about Position of Experiment at the End of the 20th Century

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The paper is continuing of discusion having been led before [1], [2]. The aim of the paper is to encourage the lowering in number family of experimantors, to think about the position of experiment in stress analysis and in reliability control and about the perspectives and future objectives of experiment [13].

Design, manufacturing and operation of structures of all kinds in a safe and economic way is not possible without assessment of the structure, its operation conditions and reliability [3]. The analysis is done by means of either computational and numerical methods or by experiment. Individual approach in the assesment was chosen according to the stage of knowledge.

Experiment, generally as a tool for knowledge, have been used as long as mankind has been existing. Even when formulation of the problem in mathematical ways was not known. More than four hundred years ago quantitative approach was given by Galileo Galilei (1564 - 1642) in one of his statements: „It is necessary to measure everything that can be measured, and to try making measurable what is not as yet". From the history we know that Galileo Galilei was better authority in the field of experiment than in application of numerical methods. Thus already in the past experiments have been used to observe the reality of the world. For our field of interest it means to analyse deformations and stability of structures. First In architecture and civil engineering, later in mechanical engineering. Later came problems of fatigue, fracture mechanics and residual stresses. Design, performance and reliability of structures have been were brought in reality on

the base of real experience [4]. We designate this period as the period of experiment.

Many experimental methods applying basic physical phenomenon have been found out or invented and practically used for model research. Experimental methods are still common and nonommitting methods to determine material behaviour in material testing as supposition for further analysis of structure, no matter whether the further analysis is performed in mathematic or experimental way or in combination of both.

Formulation of basic relation in solid mechanics were given in the last century, but solving was possible under some schematization [2] or very simple cases of real structures, mainly in shape and loading. Fast developments in computational techniques in hardware and especially in software completed by advanced numerical procedures (as finite element method or boundary element method) caused that experimental methods using assumptions for loading (photoelasticity) in the same way as numerical approach lost their dominated position and the numerical methods has gained step by step this position for themselves.

Classical two- or three- dimensional photoelasticity, in the past used very often not only for solving the technical problem, but also for finding optimal solution was wholly replaced by numerical procedures, even in nonlinear field [4]. New generation of computers having enormous capacity and operational velocity enables solving not only complex mechanical systems, but also simultaneously rapid processes. Since a few decades developments in computer techniques seemed to displace experimental approach in stress analysis [2]. But the reflexion modification of photoelasticity is still used as very helpful means as it is applied to the real structures [6], having imperfection in geometry and technology.

Parallel to the progress in computational techniques and procedure a rapid development in measurement techniques has been done. Increasing resolving power of modern measuring devices and recording systems, combined with automatic data acquisition and data evaluation methods of experimental analysis are of greater importance. Experimental methods are still used and are becoming more and more importance. Experiments are carried out not only to determine displacements, strain state and from it derived stress state as the base for judge behaviour , safety and reliability, shortly said quality of the examined structure [7]. Nowadays experimental mechanics has undertaken new function as to confirm theoretical and numerical analysis, that are strongly influenced and depending on the validity of assumptions [2]. Experimental methods are applied in identification procedures to analyse dynamic response of complex structures and systems [8] and to guarantee safety, to prevent failure and severe accidents and to receive permanent flow of information for expert systems. For developing these systems it is necessary to introduce „experience" that means to get

collections of data, obtained only by measurements to process them and later to use them in technology. Only in this way we can fulfil the statement of Lord Kelvin: „If you can measure what you are talking about and if you can express it numerically, then you know something about the examined object. But if you cannot express the result by figures, your knowledge about the object is very poor."

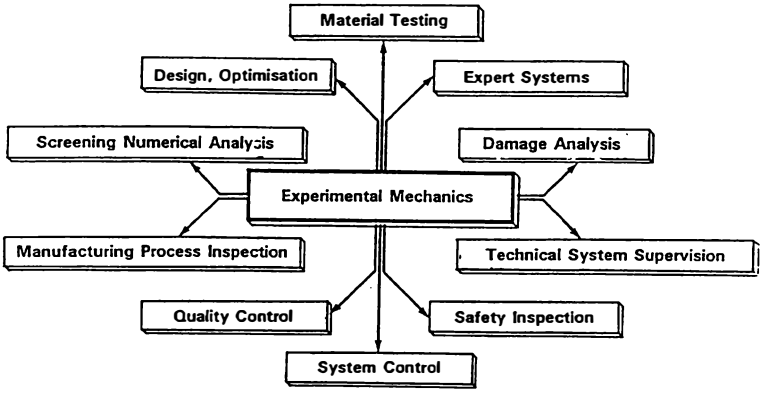

Fig. 1

Experimental mechanics influences many fields as it is seen in Fig.1. In technical speech it represents statically and/or dynamically loaded structures, impact loading and wave propagation, geometrically and physically non-linear problems, fatigue, fracture mechanics, as well as problems in elasto-plastic, viscoelastic region. Taking in service of new advanced materials with nonhomogenious and non isotropic architecture called more precise experiments. Their sensors have to influence very little or not at all the examined object. Similar situation is in examin ing of living structure - in biomechanics. At present mostly used measuring methods use electrical principles (strain gages, inductive and resitence gages,etc.). Most of these gages give quantityin reference points and distribution }gradients] must be evaluated from them, sometimes with high effort. Optical methods were used mainly for model investigation. As it was said above great progress is in experimental methods and devices. Experience from the previous and recent time has proved advantages of optical methods:

1. non-contact measuring;
2. whole field information enables to check the quantity in any point;
3. analysis of static or dynamic processes as well as vibration and inpact response;
4. relatively easy recording and processing optical data.

Beside clasic photoelastyicity in its all forms, in practical application we meet photogrametry, moiré- & grid techniques with concentration to conventional and shadow techniques [9], holographic moiré- and shearographic techniques, then hographic interferometry with its modifications. Special division is forming X-ray method as nondestructive method for evaluating the integrity of the object and measuring residual stresses.

Energetic approach quite usually used in theory is finding its application as well as in experiment in form of thermoelastic technique [10],[11]. I am afraid we have very limited possibility to come into contact with this prospective, but very expensive, method.

Integral part of activities in the field of experimental mechanics is assesment of failure probability. Intricity of experiments is growing up and beside methodologic knowledge of instrumentation one has to have knowledge in management of experiment [12].

Well designed and right produced component has a very low failure probability under scheduled operation. For providing the quality of structure its testing at normal conditions needs long time of testing and brings high expenses. At present competentive conditions are pressing down the time for research and verification of life-time of the product. Modern approach of testing is using accelerated tests [13], in which measuring devises and experimental methods are finding their application

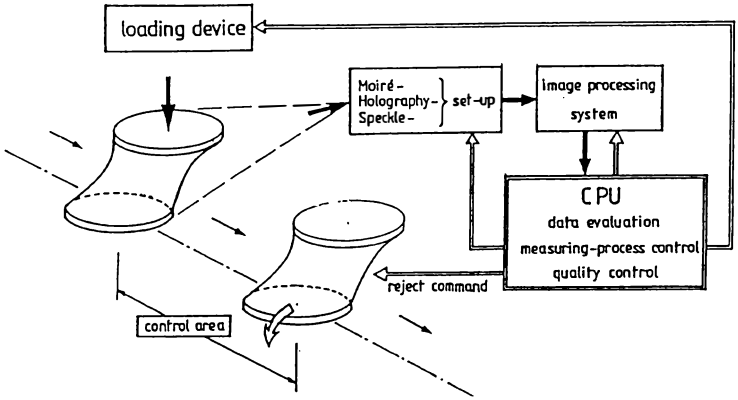

Fig.2

Application of experimental methods for noncontact determining of geometry are more and more used in quality control in industry. Time demanding control by a man is replaced by modern more accurate and quicker procedure. Pictorial information of examined part, loaded by the definite loading, is in computer compared with the pictorial information of

absolute perfect sample. Principle of automatic quality control by means of non-destructive testing using optical method is in Fig.2 .

Some people can be afraid from application of the experimental methods briefly above mentioned, particularly if the application and the transmission of the input signal to the output one is not traced carefully what can bring potentional uncontroled changes of informations. Therefore, everybody who is working in experiment cannot take it for one´s sake and has to cooperate closely with engineers and practitioners in industrial different fields, where methods of experimental mechanics will find their application [14].

I am convinced that experimental methods in mechanics, in solid one and in fluid dynamics as well will be the same importance as before. This was stated in the Seminar „Experiment in Solid Mechanics- Yesterday, Today and Tomorrow", organized in September 1995 in the Training Centre of the Faculty of Mechanical Engineering of CTU in Herbertov [13]. Next proof is this Conference having high number of papers and partcipants too.

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