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Book review

Application of Metrological Laser Methods in Machines and Systems

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[pp. 275, with 242 Figures and 2 Tables]

The book reviewed is one of the series edited under the common title *Physical Research*. The aim of this series is the promotion and quick transfer of information about the results of research carried out by physicists as well as relative specialists in different fields of science and technology. The content of the book as well as its structural arrangement seem to correspond entirely with the purposes mentioned above.

The book is edited as a set of rather extended papers discussing the application of the laser techniques to different fields of science and technology; emphasis being put on mechanical constructions and systems.

To be more specific the following elaborations are offered.

Chapter 1 – *Introduction*, by A. FRANKOWSKI and N. ABRAMSON. This chapter presents a methodological approach to the application of laser techniques in the analysis of different physical parameters in machine parts and systems. The applicability of laser metrology to the correct estimation of machine properties in the practice of both designing and exploitation is discussed. The main purpose of this chapter is to inform the reader on the possibilities of laser techniques and to define the fundamental values measured in connection with chosen parameters of the machine.

Chapter 2 – *Metrological Laser Methods for Application in Machines and Systems*, by G. FRANKOWSKI. The methods of laser metrology in the examination of machines and systems have been briefly presented. The minimized version of theoretical fundamentals of the laser techniques used has been shown from the point of view of application of the latter to the analysis of physical parameters of concrete problems concerning machine mechanics. The described methods of examination have been illustrated by concrete examples of application. A brief report on the relevant numerical programming and analysis while applying different computer configurations is worth emphasising.

Chapter 3 – *Applications of Double-Pulse Holography for the Investigations of Machines and Systems*, by Z. FÜZESSY. The double exposure method as applied to the 3D displacement of the object under test has been considered. Also, some basic relations enabling the parametric representation of the displacement vector field are given.

Prof. Z. Füzessy has indicated the technical possibilities of the displacement analysis for large mechanical objects. A holocamera (Pulsed Laser Holographic System) HIM-3 built at the Technical University of Budapest has been presented. A method of experimental analysis of 3D displacements of the mechanical objects loaded mechanically has been elaborated. The results of these rather difficult examinations are illustrated by concrete examples of applications. The results of examination of the following objects are given: hydraulic press model, radial drilling machine, lathe bed, milling machine, shearing machine. Another example, interesting from the viewpoint of engineer practice is the analysis of vibrations of some parts of the vehicles, such as the body or engine.

Chapter 4 – *Applications of Laser Metrological Methods to the Investigation of Automotive Parts*, by

A. FELSKE, W. HENTSCHEL, A. BEECK, B. STOFFREGEN. In this chapter the group of authors, coming mainly from the research centres of the motor industry, have shown the methodics of laser metrology and examples of its application in solving some motorization problems. Among the more interesting examples, the possibility of laser techniques used to visualize the working processes occurring in the combustion chamber of an engine may be mentioned. The Schlieren method allowing us to vizualize the development of the flame front has been presented. The laser-Doppler anemometry has been proposed as a tool used in estimation of the flow speed distribution in the upper part of the engine combustion chamber. A separate but very interesting problem is the application of laser techniques to the examination of aerodynamic properties of a vehicle and, in particular, the distribution of the air streams behind the vehicle as related to its shape geometry. Another example is the application of the laser as a gauge to measure the front projection of the car – an important factor in the estimation of the aerodynamic properties of the vehicle.

In the further part of the article, the scheme of the measuring setup has been described and results of the examination of the back mirror vibrations are given as a function of the engine rotation rate.

An interesting application of the laser techniques were the examinations of the displacement distributions in the brake disc. The displacement distributions of the brake disc when simulating various forcings such as heat load or vibrations, among others, have been presented.

Holographic real-time interferometry has been exemplified by the analysis of vibrations of a combustion engine block. A rather complex measuring system has been built including a stroboscopic illumination unit and a holographic recording with a video camera.

The ruby laser double-pulsed holography has been applied to the analysis of wall vibrations of the combustion engine block. The method of the laser-Doppler vibration measurements has been used, among others, to estimate the distribution of the car window vibrations and the engine head.

Chapter 5 – *Fundamentals of Time-Average Holographic Interferometry and its Applications to Vibration Measurements*, by K. ANTROPIUS. In this chapter the advantages and limitations of the time-average holographic interferometry are presented. Also, a number of examples of the application of this technique to the analysis of vibrations of mechanical constructions (vibrations of airplane engine, for example) as well as in biomedicine are given. The author fittingly observes that this technique offers great possibilities as is often underestimated. It is especially useful when difficulties occur while designing mathematical model of a complex structure. The author suggests that the hybride methods such as the proper connection of the time-average method and that of finite elements constitute an irreplaceable tool in estimation of the physical properties of the object.

Chapter 6 – *Principles and Limitations of Phase-Schifting Techniques in Holographic Interferometry*, by R. THALMANN, R. DÄNDLIKER. The authors indicate that often a development of either the measuring setup or complex analysis procedures is required because of the difficulties of quantitative analysis in holographic interferometry. They have suggested the phase shift techniques and heterodyning in holographic interferometry as tools assisting the analysis of optical effects. The fundamentals of theoretical analysis of this technique have been given while different methods of interpretation in holography are encountered.

Chapter 7 – *Applications of Computer-Aided Methods for the Analysis of Fringe Pattern*, by B. BREUCKMANN. The author considers the possibilities of a computer-aided analysis of the fringe pattern. The basic measuring schemes used in laser techniques from the point of view of applicability of computers in the analysis of optical effects are presented. Some examples of block schemes of the systems for analysis of fringe patterns are given.

Chapter 8 – *Investigation of Surface Shapes by Means of a Spatial Heterodyne Interference Fringe Pattern Analysing System*, by G. FRANKOWSKI, F. SCHILLKE, I. STOBBE, W. TISCHER. In this chapter the application of laser techniques to the analysis of the surface structure of elements as well as the estimation of the surface irregularities are considered. The fundamental advantage offered by the methods discussed in this chapter is that they are non-destructive and very sensitive. The authors recommend the temporal heterodyne technique and image processing based on the phase tracing method. Also, the carrier frequency analysis is advised as being very convenient in practical measurements of the shape and irregularities of the object surface.

Chapter 9 – *Digital Holographic and Speckle Interferometry*, by W. OSTEN , R. HÖFLING. The authors have reviewed a series of different methods of interferogram estimation and made an attempt to

systematize the fundamental principles of elaborating the results. They suggest, as an effective implementation in the image processing techniques, a special configuration of the transducer system as well as a basic hardware for image processing to be applied in the analysis of both holographic interferograms and correlograms.

Chapter 10 – *Measurements of Vibrations of Dynamical Movements Using Electronic Speckle Pattern Inerferometry*, by O. J. LØKBERG. The author has described many ESPI (Electronic Speckle Pattern Interferometry) techniques with regard to their applicability to some examinations in the field of physics and technology. The operational possibilities of these techniques as well as their limitations have been discussed. At the end, a number of examples of application of the measuring technique discussed have been given as vehicle body vibrations or vibrations of a steel plate at higher temperatures. The author recommends the ESPI as a technique useful in practical measuring applications also outside optical laboratories.

Chapter 11 – *Dynamic Speckle Pattern Photography on Solid State Objects*, by D. VOGEL. The author has shown basic possibilities of determination of displacements, deformations (strains), rotations, and vibration amplitudes of a solid body subject to dynamic load using specklegrams produced by pulse laser. Limitations of the suggested measuring method have been discussed, especially where the necessary energy of the pulsed laser is concerned.

Proposals of the measuring systems have been illustrated by examples of concrete investigation results.

Chapter 12 – *Principles and Applications of Surface Roughness and Microprofile Measurement Using Optical Methods*, by R.-J. AHLERS. The author has shown the possibilities of optical measuring methods for contactless determination of irregularities and for exact imaging of the microprofile of the surface. In particular, the applications of two optical measuring methods are described:

- White Light Method (WLM),
- Dynamically Focusing Method (DFM).

These methods were applied to the examination of both fixed and moving samples. Theoretical fundamentals of the method, basic measuring schemes and results of the investigations are presented.

There is no doubt that this volume contains an excellent set of articles concerning the possibilities of experimental examinations oriented towards analysis of physical properties of mechanical constructions, multiphase phenomena, mechanics of flow, and the like. The quality of the book is all the more valuable at present, when whole groups of researchers seem to switch over to computer methods being tempted by a seeming easiness of interpretation of physical phenomena offered by these methods.

Examinations by laser methods offer valuable advantage in that they may be applied both to models and to real objects. In addition to high measuring sensitivities, these methods render possible both qualitative and quantitative analysis of the whole examined area, and they also allow distinguishing its more interesting regions or points. Another virtue of the book is a very convincing indication of the possibilities of both programming and analysis of the measurement results with application of numerical methods. I believe that this is an interesting example of correct exploitation of the computer in experimental investigations in the field of science and technology.

There exist some shortcomings such as: the description of theoretical fundamentals is repeated in many places, the same may be said about the application areas (similar objects). This is connected with the fact that the authors of particular chapters represent different research centres and different fields of application. This book offers a relatively great number of examples of application of the laser metrology in motor industry.

Perhaps, for the reader interested in selected fields of applications such a form of presentation renders a higher possibility of using given information without the necessity of studying the whole book.

An interesting approach, offered by the work under review, is the idea of presenting in one volume the examinations carried out in different countries and different research centres of diversified facilities offered by their equipment. However, the whole book is concentrated on similar measuring techniques and in particular on those using the lasers. I believe that this book refers, to a high degree, to the common heritage of European science and technology.

It should be also emphasized that the authors of particular chapters present their field of applications in an ordered way, thus enabling the reader his own interpretation of both the applied method and the

results of measurements and by the same means to evaluate the possibilities of the chosen technique of research.

The methods presented as well as the results of investigations are surely original achievements of the authors and the cooperating groups in the field of laser metrology.

A part of the material contained in this volume was earlier presented at the following conferences: *VDI – Volkswagen Symposium on Laser Metrology for Development and Quality Control of Automobiles, 1986*, and *Interferometry 89*, Warsaw.

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