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INVESTIGATING THE OPPORTUNITIES OF AUTOMATED TEST MACHINES USED FOR RESEARCH OF MECHANICAL SYSTEMS [10]

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Abstract: *The improvement of the strength and exploitation characteristics of mechanical transmissions and other components is a significant and interdisciplinary problem. The solution of this problem becomes possible through improving the methods in the area of machine design and the existing approaches in experimental investigations. The paper summarizes some of the most important existing methods of experimental research of mechanical components and systems with automated test machines. The objective of the research presented is to investigate the opportunities to increase the application of automated test machines for investigation of strength and dynamic characteristics of different mechanical components and systems. The authors' team also discusses the opportunities for data processing in an environment of professional software products. Conclusions are deduced.*

Keywords: *Automated Test Machines, Experimental Research, Mechanical Systems, Effectiveness, Efficiency.*

INTRODUCTION

The investigation problem concerning the opportunities of automated test machines used for research of mechanical systems is an important and a topical problem. Finding solutions to this problem is possible through applying some main principles of design theory and the systematic approach.

In order to investigate the research methods of mechanical systems using automated test machines it is necessary to analyse, compare and evaluate some important scientific achievements of renowned scientists working in this field.

The design theory and the systematic approach aim to explain in details the specific features of the procedure for creating a new product. Some of the well known scientists who have treated the engineering design in different aspect are: Pahl and Beitz (Pahl, G., Beitz, W., Feldhusen, J. & Grote, K. H., 2007), Pugh (Pugh, S., 1990), Roozenburgh & Eekels (Roozenburg, N. F. M. & Eekels, J., 1995) and Ullman (Ullman, D. G., 1997). They analyse the design process suggesting differents stages regarding their contents and their numbers (from 4 up to 9).

The authors' team Pahl and Beitz (Pahl, G., Beitz, W., Feldhusen, J. & Grote, K. H., 2007) described four main stages and designated them as:

- Clarification of the task (The design problem is analyzed; information is accumulated; requirements and constraints are established);

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- Conceptual design: (Essential problems are identified, function structures are determined, concept variants are developed and evaluated in order to determine the principle solution);

- Embodiment design: (Preliminary layouts are established; technical considerations are to be taken into account in order to evaluate the solution and to produce a layout documentation);

- Detail design: (Production documents are created with specifications of arrangement, dimensions, materials and tolerances of all the components in the new product).

The objective of the paper presented is to clarify the features of automated test systems for the study of mechanical systems, focusing on the first design stage formulated above: analysis of the state of art, gathering information, formulating requirements and limitations.

ANALYSIS OF LABORATORY EQUIPMENT AT THE UNIVERSITY OF RUSE

The author's team studied some successfully completed tasks in the field of designing experimental test machines for Machine Science and Machine Elements at the University of Ruse.

One of these products is the automated test machine for experimental research of energy efficiency in mechanical gear trains and reducers, described in details in the following publications: (Dobrev, V., Dimitrov, Y., Dobreva, A., Kamenov, K. & Ronkova, V., 2016), (Dobrev, V., Stoyanov, S. & Dobreva, A., 2015), (Dobreva, A., 2013), (Dobreva, A. & Dobrev, V., 1993), (Kosmanis, T. et al., 2011) and (Orzech, K., Khoshaba, S. & Dobreva, A., 2009).

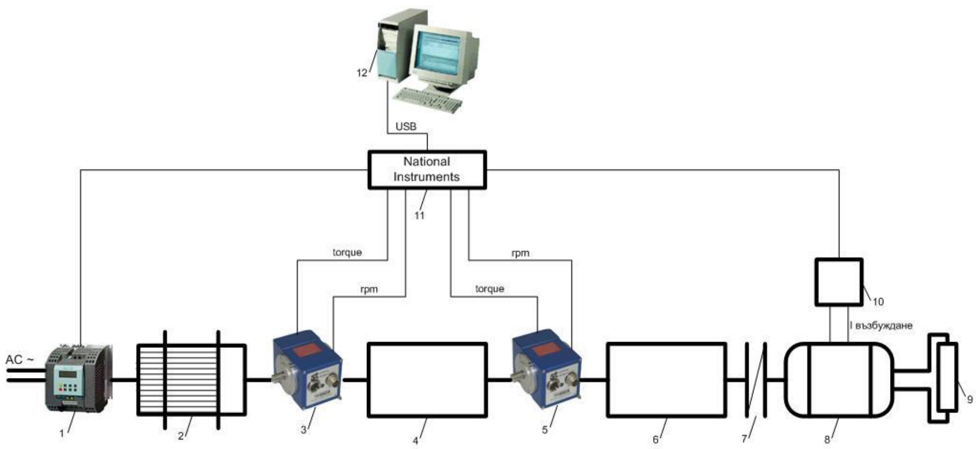

Fig. 1. Scheme of a test machine for experimental research of reducers

The scheme in Fig. 1 shows the components of the automated test machine for experimental research of energy efficiency of mechanical gear trains. It consists of the following items: 1 – frequency inverter Sinamics; 2 – asynchronous motor; 3 – sensor for input torque; 4 – reducer; 5 – sensor for output torque; 6 – multiplier; 7 – coupling; 8 – generator; 9 – load resistance; 10 – excitation control; 11 – unit of National instruments; 12 – PC.

The creating of this automated test machine is preceded by theoretical research presented in (Dobreva, A., 2013) and (Dobreva, A. & Stoyanov, S., 2012). Later on, the test macine is upgrated with software products for data processing and visualization of results, described in (Kamenov, K., Dobreva, A. & Ronkova, V., 2017), (Dobreva, A. & Dobrev, V., 2018) and (Stoyanov, S., Dobrev, V. & Dobreva, A., 2017).

Another test automated machine for experimental examination of cardan drives has been also produced at the University of Ruse, Fig. 2. The scales for immediate visualization of the rotational angles are assembled in a fixed way upon the driving and the driven shaft of the cardan drive tested.

The following feature characterizes this design solution: two rotations are used in order to achieve different angles of intersection of the axes of the shafts.

The angles' magnitude is controlled by the scales of both panels which rotate. The test machine is driven by a DC motor and a belt drive, (Dobrev, V., Dobreva, A., Ronkova, V., Dimitrov, Y. & Kamenov, K., 2016).

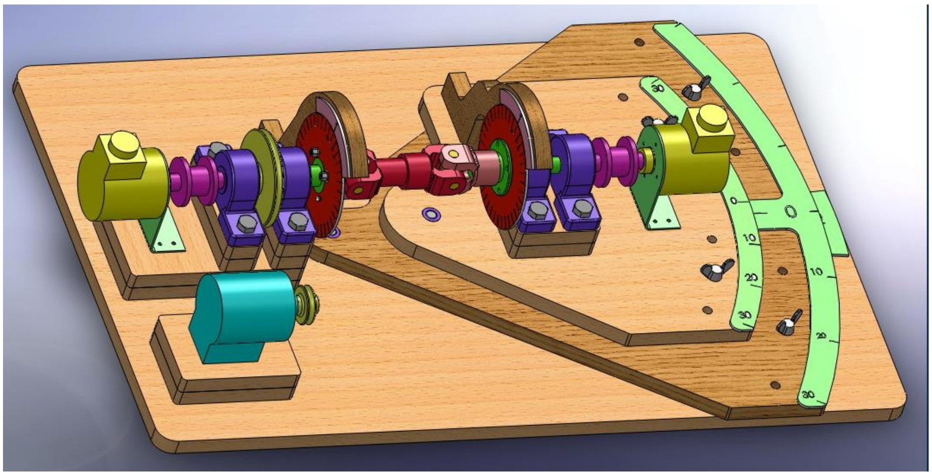

Fig. 2. CAD drawing of automated test machine for examining a cardan drive

This test machine is able to receive intermediate experimental results of both electronic and mechanical measuring devices. The values of the angle between the driving and the driven shaft of the cardan drive can vary in a significant range.

ANALYSIS OF OTHER AUTOMATED TEST MACHINES

The automated test machines used for mechanical systems described in (Michaelis, K., Höhn, B.-R. & Hinterstoißer, M., 2011) are quite similar to the design layout already discussed.

The researchers from (Mautner, E. M., Sigmund, W., Stemplinger, J. P. & Stahl, K., 2015) registered an increasing pitting damage (up to 45%) in mechanical gear drives. According to the authors mentioned, this pitting performance has no significant influence upon the efficiency of the wormgear tested.

Significant number of publications present opportunities for experimental investigation of mechanical gear trains. The application of some quite often used experimental methods on vibration detection is decribed in (Stoyanov, S., Dobrev, V. & Dobreva, A., 2019).

In many cases, the experimental vibration analysis is conducted with the help of ANSYS, (Wang, Z., Lin, T., He, Z. & Yang, X., 2015).

The authors of (Lin, T., He, Z. & Geng, F., 2013) focused mainly on radiation noise of gearboxes. Ericson and Parker in (Ericson, T. & Parker, R.G., 2013) have investigated vibration modes of mechanical gears drives. They applied experimental modal analysis procedures to analyse the dynamic behaviour of different mechanical gears.

The most commonly used devices for the experimental research of mechanical systems are sensors, controllers and accelerometers. The location of these measuring devices is especially important, because some gears create similar vibrations passing through a fixed sensor, (Feki, N., Karray, M., Khabou, M. T., Chaari, F. & Haddar, M., 2017).

CONCLUSIONS

An analysis of automated test systems used for the investigation of mechanical systems has been made. Such laboratory equipment is very often used in study process and in research implementation at universities. The investigation presented leads to the conclusion that the design process of such test machines is a complex, scientific and expensive process.

The theoretical analysis made shows, that the appropriate selection of specific experimental methods and measuring devices is facilitated by taking into account certain requirements: high accuracy, sufficient boundaries of measuring; minimal impact of sensors on the object investigated; resistance to environmental disturbing factors; receiving experimental results in explicit form; simple design layout, easy assembling and maintenance.

According to the author's team, it would be quite beneficial for the students and staff at the University of Ruse if similar automated experimental equipment could be purchased from the European Universities and institutions in which the cited above authors are working.

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