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# A MOBILE REAL-TIME SYSTEM FOR STRESS STATE DIAGNOSTICS AND RESIDUAL LIFE PREDICTION OF STRUCTURAL COMPONENTS

**Mykola Gerasymenko<sup>1</sup>**

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**1.** Ph.D. in Electronics, Associate professor of Department of Physical Fundamentals of Electronic Engineering

*«Kharkiv National University of Radio Electronics», UKRAINE*

**ORCID ID: 0000-0001-9428-163X**

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This paper presents a mobile real-time system for diagnostics of the stress state and prediction of the residual life of structural components operating under intensive dynamic loading conditions. The proposed approach is based on the use of operational data throughout the product life cycle and aligns with the Industry 4.0 paradigm, where information obtained during the operational phase is used to support technical inheritance and the structural evolution of engineering products [1, 2]. Such a system is particularly relevant for mechanical components in mechanical engineering, automotive, and aerospace industries, where reliability and durability requirements are critical.

The system operation relies on the use of strain gauge sensors mounted directly on structural components, followed by real-time acquisition and primary processing of measurement signals. Data processing is performed locally within the measurement module, enabling filtering, scaling, and stress calculation without transmitting raw data to external computing platforms. This architecture increases system autonomy and ensures stable operation under limited hardware resources, which is typical for mobile diagnostic solutions [3].

The algorithmic framework of the system is focused on the analysis of stresses caused by random dynamic loads characteristic of real operating conditions. Approaches based on operational strength and load spectrum analysis, widely applied in fatigue theory, are used to evaluate fatigue damage accumulation [4]. In contrast to deterministic computational schemes, statistical and probabilistic methods are employed, allowing the stochastic nature of loading processes to be taken into account and improving the reliability of technical condition assessment.

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Residual life estimation is performed on the basis of current stress state measurements, considering material properties and actual loading regimes. This approach corresponds to the concept of condition-based maintenance and enables residual life prediction without the need for a complete load history or long-term preliminary testing of structures [5]. The integration of diagnostic and prognostic functions within a single mobile solution creates prerequisites for prompt engineering decision-making regarding further operation of the components.

Experimental validation of the system performance was carried out using an automotive suspension component subjected to intensive random dynamic loading. The results confirmed the capability to identify stress concentration zones and to track trends in fatigue damage accumulation in real time. The obtained results are consistent with data on mobile automated stress state diagnostics and residual life prediction, as well as with approaches to dynamic load identification [6].

**Conclusions.** This paper presented the development and experimental validation of a mobile real-time system for stress state diagnostics and residual life prediction of structural components under random dynamic loading conditions. The system enables autonomous data acquisition and on-board processing of strain measurements, providing reliable assessment of stress state and fatigue damage trends under real operating conditions.

Further development of the system is associated with expanding the capabilities of operational data analysis directly during structural operation. In particular, the use of accumulated measurement data to refine parameters of load and fatigue strength models for specific structural components is considered promising, in line with product lifecycle information management approaches and the development of new product generations based on operational data [7]. This direction makes it possible to increase the accuracy of technical condition assessment without significant complication of the hardware architecture and while maintaining real-time performance requirements.

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