INVESTIGATIONS OF DYNAMIC PHENOMENA OF PRECISION LENGTH MEASUREMENT SYSTEM

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Abstract

The development of the automotive industry is conditioned by the application of production technologies, which directly depend on production volumes. Today's development of car production is possible only in conjunction with the volume of production, ensuring both the parameters of assembly and production quality. Their constant monitoring is related to the application of the verification tools and technologies used. Such is the length measurement process that needs to be precise in the automotive industry. The paper analyzes the precision length measurement system and its dynamic characteristics. The research is applied to solve the problems of dynamic processes of a precision length measuring system, and the obtained results can be used in the development of precision systems for other purposes. The obtained results describe the vibrations of the length measuring system housing and the measuring head, which show the weak points of the system at the respective frequencies. The paper analyzes the precision length measurement system and its dynamic characteristics. The obtained results describe the vibrations of the length measuring system housing and the measuring head, which show the weak points of the system at the respective frequencies.

Keywords: vibration; length measuring system; measuring head; dynamic phenomena; precision measurement; dynamic characteristics

1. Introduction

The use of high precision measurement methods is particularly relevant in the automotive industry. An important emphasis in the development of automotive power technology remains the precision of the production and assembly of their parts. Therefore, the use of length measurement system research is an integral part of the manufacturing industry,

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ensuring the constant development of production technologies and ensuring the requirement for quality. The incremental optical coding sensor is widely used to control movements to control rotor speed and position. The sensor output is a square signal, the frequency of which depends on the resolution of the encoder (number of nominally evenly distributed sections at the edge of the disc) and the motor speed [2, 8-9]. The quantitative nature of the coding results in a static error inherent in the measurement that can cause oscillations. The second type of error is also in the control feedback and measurement process: a consequence of the dynamic error caused by the phase delay. At low speeds, the implementation of a control scheme such as an observer has been shown to improve system performance. However, such an approach does not describe the nature of the lag inherent in the coding device.

Motor drives play a key role in modern industry, where the operation of an internal closed-circuit system is largely determined by the optional feedback sensor [6]. Incremental optical encoders are often found in computer numerical control machines, printers, papermaking, food and beverage automation, and problem assessment of rotating machines, where it is mainly used to obtain feedback speed loops [3-5].

The optical encoder module makes it much easier to control simple control methods such as proportional-integral (PI) or proportional-integral-differential (PID) at low speeds using low-resolution devices [1, 7].

2. Methodology of experimental study of the dynamic characteristics of a length measuring system

During the experimental studies (Figure 1), the accelerations of the measuring head and the sensor housing of the sensor with one-piece housing were measured. During the study, 6 signal measurements were performed (signals 1, 2 and 3 - accelerators of the sensor housing; signals 4, 5 and 6 - accelerations of the linear converter head). Respectively 1 signal - linear converter head Y direction; Signal 2 - linear converter head Z direction; Signal 3 - linear converter head X direction; Signal 4 - linear converter housing Y direction; Signal 5 - linear converter housing Z direction; Signal 6 - Linear converter housing X direction.

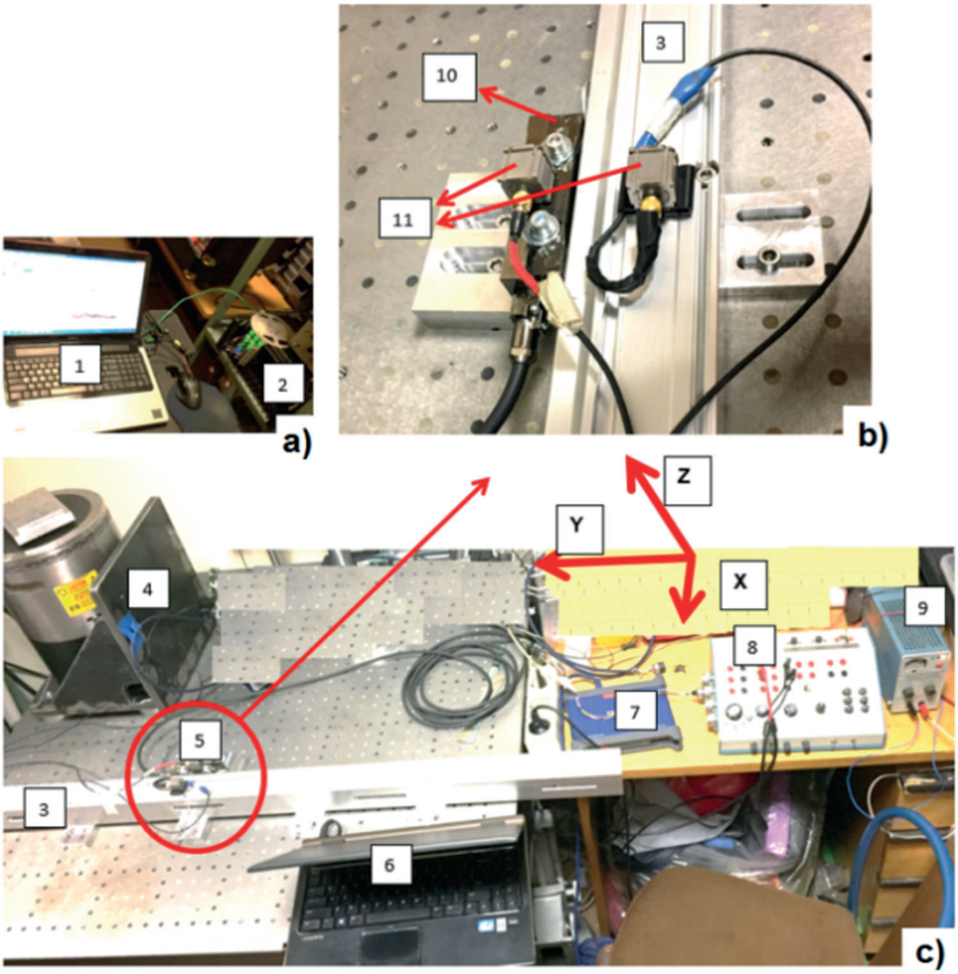


Fig. 1. Length measuring systems with one-piece housing and with elements of the bench for determining the dynamic characteristics of the fastening structure system: mobile measurement result processing equipment "3660-D" with computers DELL (positions 1 and 2); Excitation vibrator (Brüel & Kjaer 4811) with control and amplifier (position 4); linear converter with one-piece housing together with mounting structure (position 3); the measuring head of the linear transducer (position 10) and the mounting location of the three-axis accelerometers (position 11) (position 5); computer system for reading electrical signals from a converter (positions 6, 7, 8 and 9)

A block diagram of the bench for determining the dynamic characteristics of the linear transducer system together with the mounting structure is given in Figure 2.

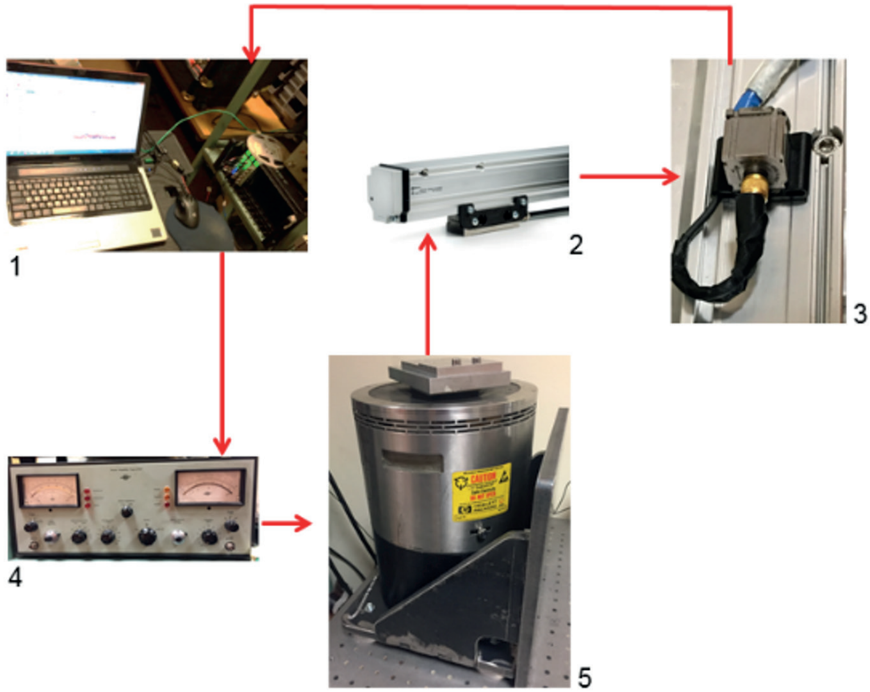


Fig. 2. Length measuring system together with the mounting structure and block diagram of the bench for determining the dynamic characteristics of the system

3. Research results

During the measurements, the length measurement system was excited in two ways: shock and harmonic excitations. The purpose of the measurements of the shock excitation (Figures 3-5) for the structure is to investigate the dynamic characteristics of the investigated system with a solid body.

In the graphs in Figures 3-6, the notations next to the numbers "m" and "u" correspond to the multipliers 10^{-3} and 10^{-6}, respectively (see Figures 3-6).

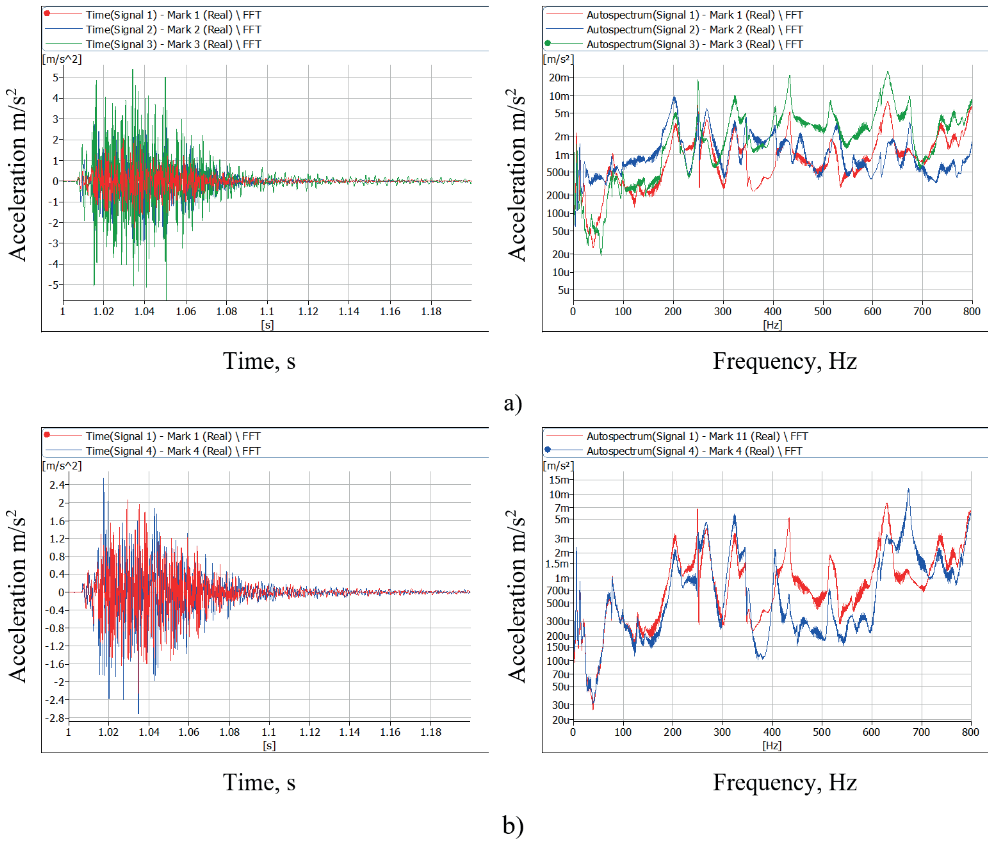
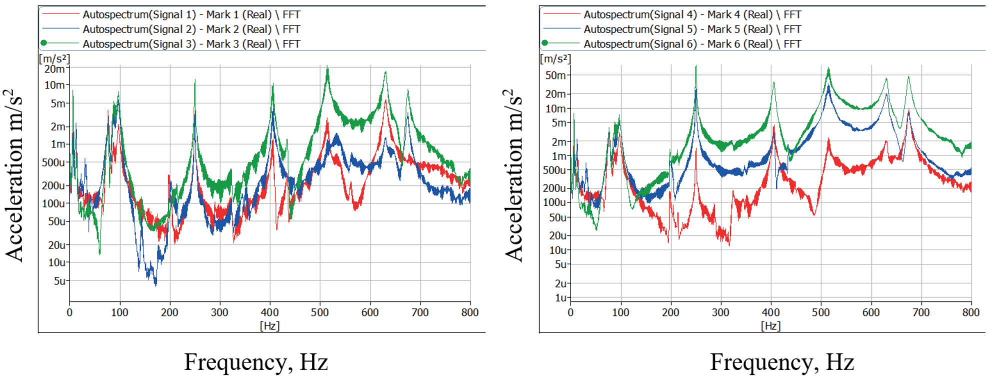
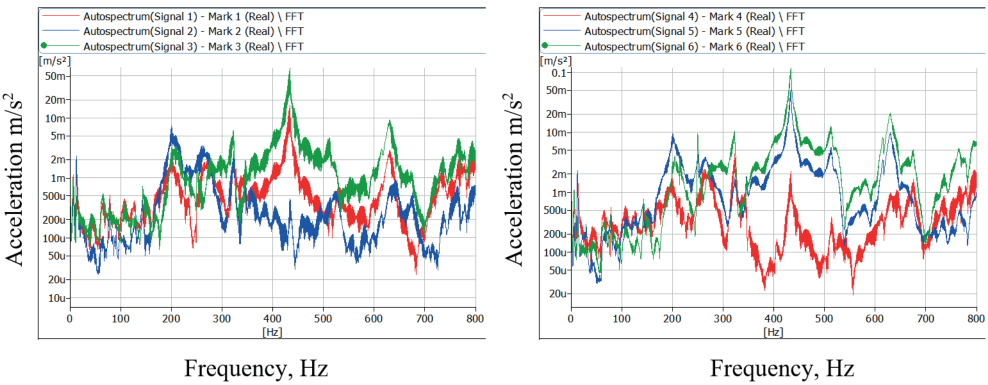


Fig. 3. Length measurement systems, when the structure is excited by shock excitation in the Z direction (Figure 1), graphs of the acceleration of the housing in three directions and its spectral density: a) vibrations of the housing (red - Y direction; blue - Z direction; green - X direction); b) Y-direction oscillations of the linear converter housing (red) and head (blue)



a) b)

Fig. 4. Length measurement systems, when the structure is excited by shock excitation in the Y direction (Figure 1), graphs of the three-way acceleration spectral density of the housing and measuring head: a) housing (red - Y direction; blue - Z direction; green - X direction) oscillations; b) vibrations of the linear converter head (red - Y direction; blue - Z direction; green - X direction)



a) b)

Fig. 5. Length measurement systems, when the structure is excited by shock excitation in the X direction (Figure 1), graphs of the three-way acceleration spectral density of the housing and measuring head: a) housing (red - Y direction; blue - Z direction; green - X direction) oscillations; b) linear converter heads (red - Y direction; blue - Z direction; green - X

After determining the resonant frequencies of the transducer system, a harmonic excitation (Figure 6) was used to determine the acceleration amplitudes of significant points in the transducer housing and probe, which show the movements of system parts that affect system performance at the respective excitation frequencies.

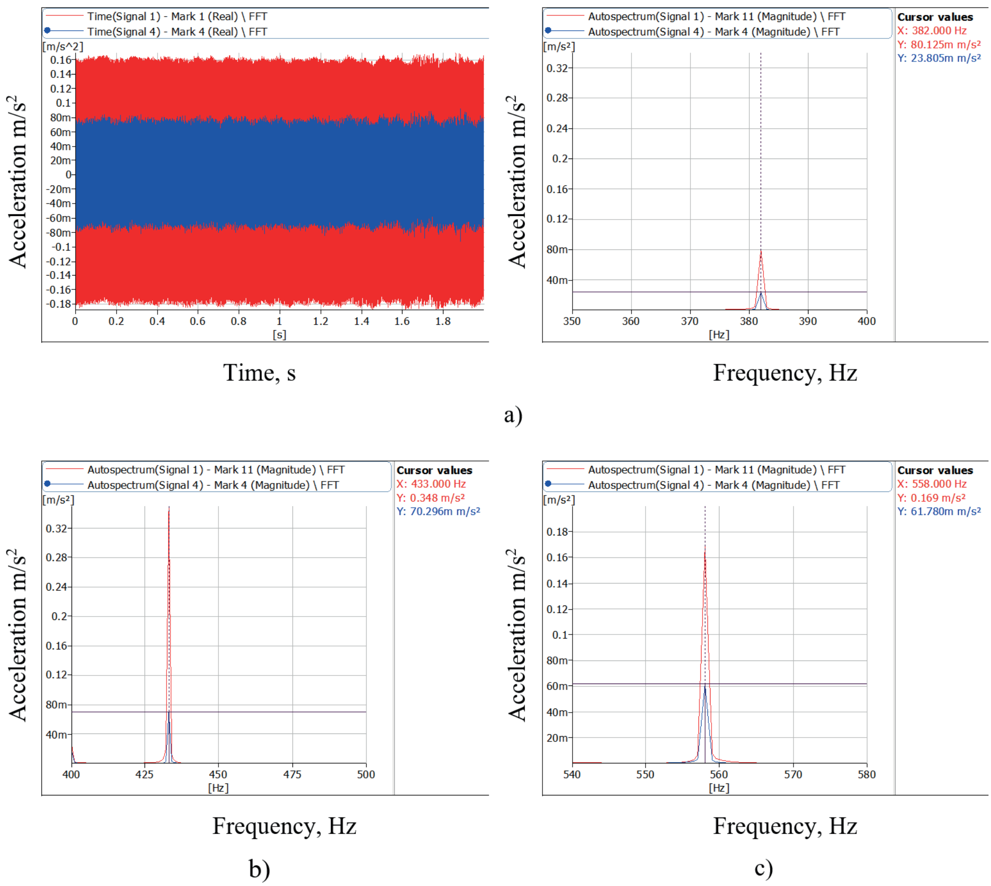


Fig. 6. Graphs of the three-way acceleration and spectral density of the housing and measuring head of a linear transducer with sinusoidal excitation (a - 382 Hz; b - 433 Hz; c - 558 Hz;) in the Z direction (Figure 1): a) housing and oscillations of the measuring heads (red - measuring heads; blue - housing); b) oscillations of the housing and measuring head (red - measuring heads; blue - housing); c) housing and measuring heads (red - measuring heads; blue - housing)

The analysis of the results shows the impact excitation on the test system (Figures 3-5), it was found that the resonant frequencies of the transducer measuring head are 382 Hz, 433 Hz, 534 Hz, 558 Hz, 629.5 Hz and 753 Hz.

The measurement results shown in Figure 6 show the acceleration results of the linear transducer housing and the measuring head when the system was excited by a harmonic effect at resonant frequencies and every 100 Hz from 100 Hz to 800 Hz. Analyzing the results of the harmonic effect on the test system (Figure 6), the response characteristics of the linear converter system, especially the measuring head, were determined. The analysis of the results shows the effect of harmonic excitation on the investigated system (Figure 6), it was found that the amplitudes of the acceleration of the transducer measuring head and the housing vary differently at the excited frequencies. The amplitudes of the converter probes and the housing acceleration at the respective excitation frequencies are given in Table 1.

Tab. 1. Transducer measuring head and housing acceleration amplitudes at the corresponding excitation frequencies

Measuring point	Excitation frequency, Hz									
	100	200	300	382	400	433	500	534	558	600
	Acceleration mm/s^2									
Transducer measuring head	31.41	49.11	93.24	80.13	48.00	348.0	8.76	87.30	169.0	78.94
Converter housing	29.91	42.78	130.0	23,81	31.03	70.30	43.81	21.87	61.78	1.86

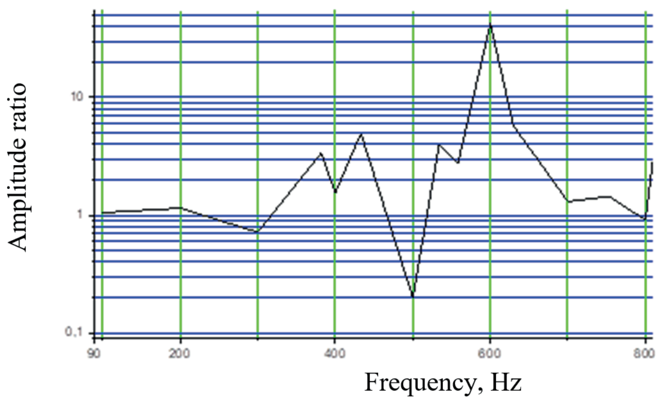


Fig. 7. The ratio of the amplitudes of the acceleration of the transducer measuring head and the housing to the corresponding excitation frequencies

Table 1 and Figure 7 results analysis shows that the ratio of the amplitudes of the acceleration of the measuring head and the housing of the transducer varies from 0.20 to 42.4. Accordingly, the lowest ratio of the amplitudes of the accelerator probe to the housing acceleration (0.20) was obtained at a frequency of 500 Hz, and the highest ratio (42.4) was obtained at a frequency of 600 Hz, respectively. Assessing the amplitudes of the converter probe and housing acceleration given in Table 1, it can be seen that the maximum transducer probe amplitudes were obtained at 433 Hz (348 mm/s^2) for the converter body at 300 Hz (130 mm/s^2), respectively.

4. Conclusions

The accuracy and stability indicators that directly affect the coding properties of a device are examined in this article. They are important in examining the performance of a high-resolution code-precision angle encoder and in evaluating its optimal configuration to avoid the effects of fluctuations and to increase its stability in the case of its dynamic mode of operation. The performed measurements allowed to evaluate the influence of various factors on the dynamic properties of the encoder and to determine the influence of the dynamic effects of the digital encoder output signals (analog and digital) on the stability of the reading signal.The article deals with the research of dynamic phenomena of the length measurement system, which determine the influence of vibrations of the environment and system elements on the dynamic processes of the system.

Analyzing the results of the impact excitation on the test system, it was found that the resonant frequencies of the length measurement system are 382 Hz, 433 Hz, 534 Hz, 558 Hz, 629.5 Hz and 753 Hz.

5. References

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