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Research of the influence of the operating parameters of a mobile lift on the oscillatory processes occurring during the work operations

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Abstract The article provides an analysis of the results of an experimental study of oscillatory processes occurring in mobile lifts with working platforms (MLWP) during the working operations. According to the developed research methodology, the results of measurements of acceleration along the horizontal and vertical axes of the machine at the point of articulation of the boom and at the point of attachment of the working platform to the boom were obtained and analysed. The analysis of the obtained oscillograms indicates that the greatest oscillations occur at the point of attachment of the working platform to the boom along the vertical axis. Accordingly, a detailed analysis of the influence of the operating parameters of the mobile lift on the oscillatory processes occurring during the operation of the machine at the point of attachment of the working platform to the boom along the vertical axis was carried out.

Keywords: • mobile lift • operating parameters • process • hoist • vibration •

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1 Introduction

The mobile lift market is developing dynamically, new types of lifts with excellent designs and better performance are emerging. An overview of popular mobile lifts in the Ukrainian and world markets shows that the most common are boom machines with a lifting capacity of up to 200 kg and a lifting height of up to 20 m [1]. It should be noted that during the operation of such lifts, oscillatory modes are observed during the operation of the machine and after the locking of the working platform. This phenomenon is unacceptable from the point of view of labor protection for the operator of a mobile lift, in addition, this fact is undesirable, since vibrations of the working platform lead to fatigue cracks in the metal structure of the lift boom. That is why this issue requires additional theoretical understanding and experimental research.

2 Analysis of recent research and publications

In [8], considerable attention is paid to the technology of experimental research of technical systems, the results of an experimental study of the parameters of the motion of an auto-hydraulic lift with a rotary joint are given in [9]. However, insufficient attention is paid to the experimental study of oscillatory processes occurring in the MPP in modern works. This is due to the high cost and complexity of testing.

A large number of studies considering the load simulation modes of mobility lifts with working platforms [6], [7], the theoretical development of the working platform motion control systems hydraulic lift [2], [3], besides a large number of works devoted to the study of the processes occurring in the volume hydraulic drive machines [4-5]. However, a comprehensive study regarding the appearance of oscillatory modes during operation and stopping of the machine is currently lacking.

3 The purpose of the research

The purpose of the research is the experimental study of the influence of the operating parameters of a mobile lift, such as the mass of the load and the angles of inclination of the upper and lower sections of the boom, on the oscillatory processes occurring during operation.

To achieve this goal, the following tasks have been identified:
- to carry out a comparative analysis of the results of the experimental study;
- to determine the degree of influence of the MLWP operating parameters on the oscillatory processes occurring during the work operations;
- based on the obtained data, draw conclusions and make recommendations.

4 Presentation of the main material

According to the developed experimental technique [10], the measurement results were recorded in digital form on an electronic carrier. Then they were presented in the form of oscillograms, on which the accelerations were recorded at the point of attachment of the working platform to the boom and at the point of articulation of the MLWP boom along the x and y axes (Figure 1).

Figure 1: Points of installation of two-dimensional accelerometers.

Figure 2 shows the characteristic oscillograms of the oscillatory processes observed in the hoist during the working operations.

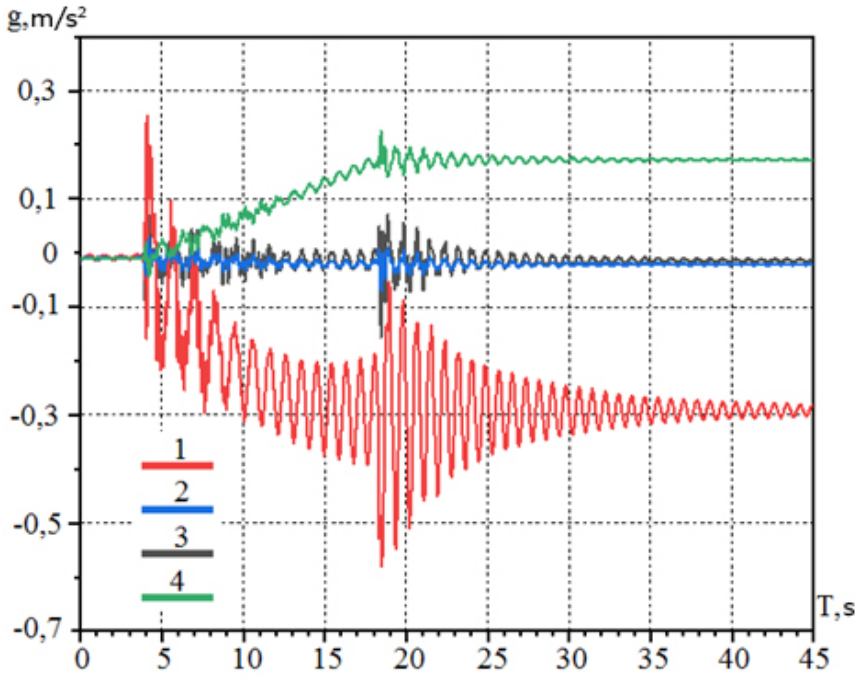

Figure 2: Typical oscillograms of oscillatory processes observed in the hoist during the working operations: 1- acceleration at the attachment point of the working platform to the boom along the Y axis; 2 - acceleration at the point of articulation of the MPC boom along the x axis; 3 - acceleration at the point of articulation of the MLWP boom along the Y axis; 4 - acceleration at the point of attachment of the working platform to the boom along the x axis.

Analysis of the obtained oscillograms of oscillatory processes observed in the hoist during working operations indicates that the greatest oscillations occur at the point of attachment of the working platform to the boom along the B axis. It should be noted that the acceleration at other points of the MLWP boom, in which the experimental data were recorded, is significantly less in amplitude of oscillations. It is advisable to consider the process of changing the accelerations at the attachment point of the working platform to the boom along the B axis in more detail. It is advisable to divide this process into the process of lowering (lifting) the working platform and the process of oscillating the working platform after stopping (Figure 3).

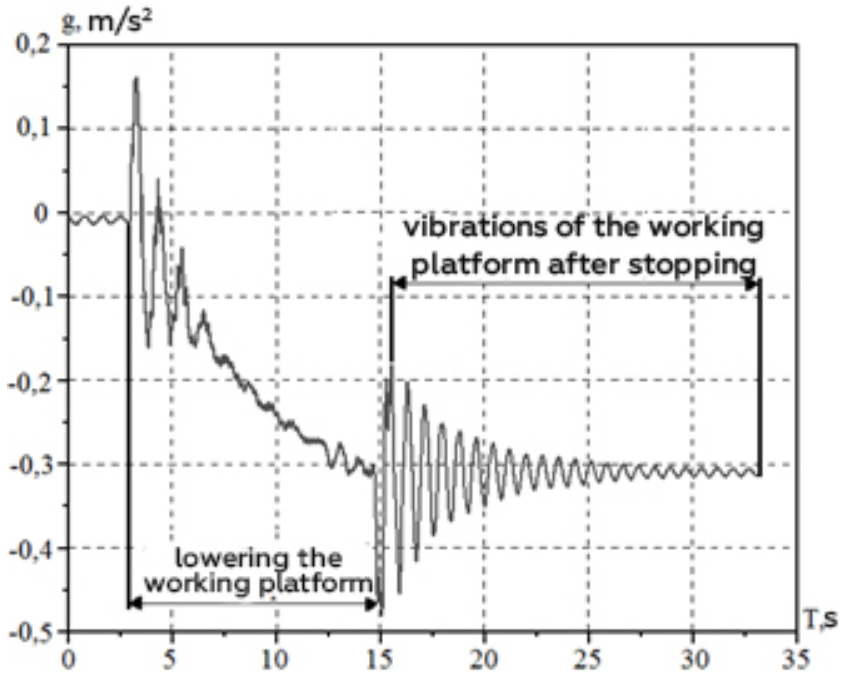

Figure 3: The process of changing accelerations at the attachment point of the working platform to the boom along the Y axis.

To determine the influence of the parameters that changed during the experimental study, on the oscillatory processes during the operation of the lift, let us consider the oscillograms of the change in accelerations at the point of attachment of the working platform to the boom along the B axis.

Figure 4 shows typical oscillograms of acceleration changes for the process of lifting and lowering the working platform. Analysis of the data obtained shows that the amplitude of oscillations of accelerations when lowering the working platform is 35 % greater than when lifting. This fact indicates that the lowering process of the working platform has high dynamic indicator.

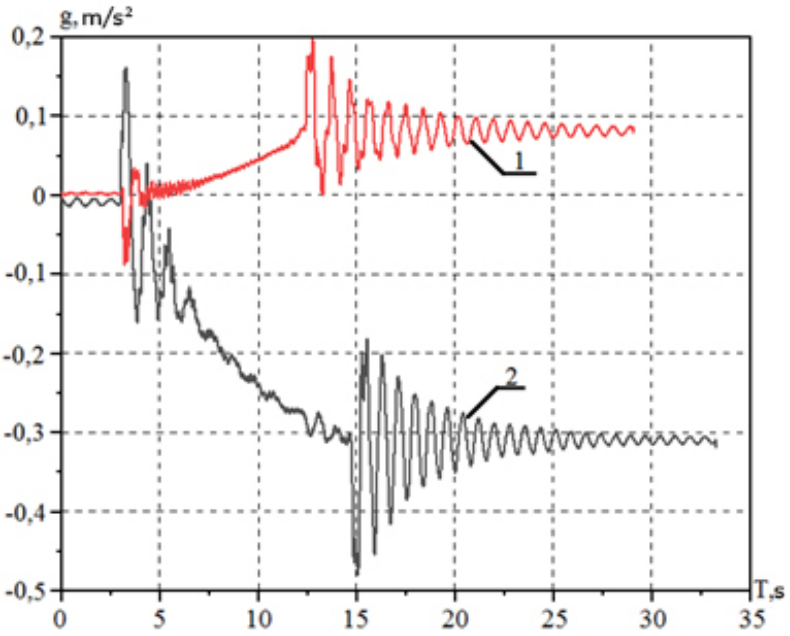

Figure 4: Change of accelerations for the process of lifting and lowering the working platform at the attachment point to the boom along the Y axis: 1- acceleration at the attachment point of the working platform to the boom during lifting; 2 - acceleration at the attachment point of the working platform to the boom when lowering.

After analysing the dynamic indicators of the processes of lifting and lowering, the influence of the mass in the working platform (Figure 5) and the tilt angles of the upper (Figure 6) and lower (Figure 7) boom sections on acceleration at the point of attachment of the working platform to the boom along the Y axis was analysed at lowering.

The result of the analysis of performance indicators for oscillatory processes indicates that with an increase in the working mass from 35 kg (analogous to lifting / lowering the working tool) to 105 kg (lifting / lowering the operator and the working tool), the amplitude of oscillations of the acceleration of the working platform increases by 38 % (Figure 5). At the same time, an increase in the decay time of oscillations after stopping the working platform by 13 seconds (52 %) should be noted.

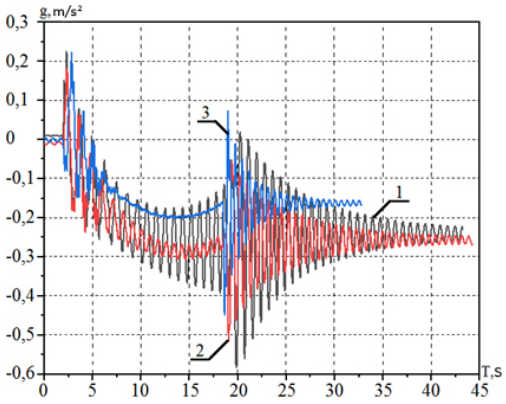

Figure 5: Changes in acceleration when lowering the working platform at the point of attachment to the boom along the Y axis: 1- operating weight 105 kg 2 - operating weight 70 kg 3 - operating weight 35 kg.

Changing the angle of inclination of the upper section of the boom from 45 ° to 15 ° (Fig. 6) with a working weight of 105 kg. leads to an increase in the amplitude of acceleration oscillations at the point of attachment of the working platform to the boom along the Y axis by 20 % and an increase in the decay time of the oscillation process after stopping the working platform by 7 seconds (31 %).

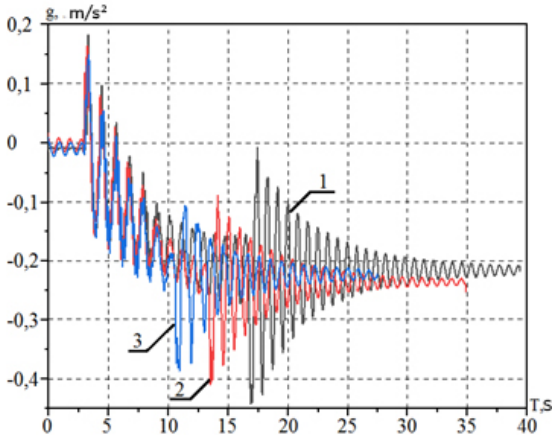

Figure 6: Change in acceleration when lowering the working platform at the point of attachment to the boom along the Y-axis: 1- tilt angle of the upper boom section 15°; 2 - the angle of inclination of the upper section of the boom is 30°; 3 - angle of inclination of the upper section of the boom 45°.

When the angle of inclination of the lower boom section is changed from 15° to 45° (Fig. 7) with a load weight of 105 kg. there is an increase in the amplitude of acceleration oscillations at the point of attachment of the working platform to the boom along the Y axis by 47 %, and the damping time of the oscillation process after stopping the working platform increases by 8 seconds (27 %).

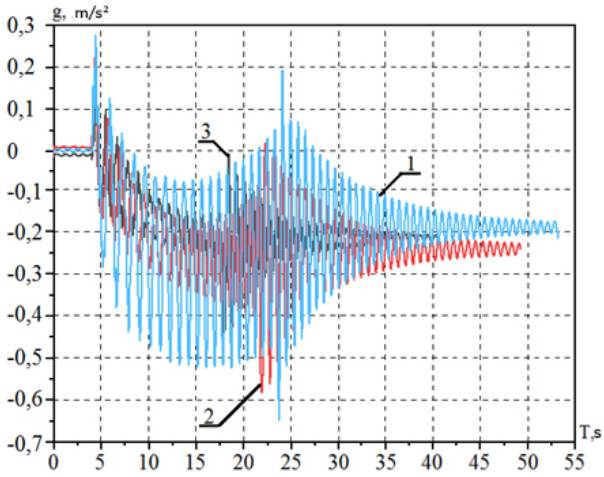

Figure 7: Change in acceleration when lowering the working platform at the point of attachment to the boom along the Y-axis: 1 - tilt angle of the lower boom section 45° 2 - tilt angle of the lower boom section 30°; 3 - the angle of inclination of the lower section of the boom is 15°.

In the process of lifting the lower section of the boom to an angle of inclination of 45° with a load weight of 105 kg (Fig. 7, oscillogram No. 3), unusual fluctuations in the acceleration of the working platform, which have a significant amplitude, are observed. This operating mode can be considered emergency and not recommended for MLWP operators.

The analysis of the oscillatory processes indicates that the greatest amplitude of acceleration oscillations at all modes of the MLWP load is observed at the moment of locking the working platform.

5 Conclusion

According to the specified purpose and objectives of the study, the following conclusions can be drawn:

1. Comparative analysis of the results of the experimental study indicates that the operating parameters of the mobile lift significantly affect the indicators of oscillatory processes, such as the amplitude, period and damping time of oscillations occurring in the machine during operation.

2. The amplitude of oscillations of accelerations when lowering the working platform is 35 % greater than when lifting, with an increase in the working mass from 35 kg to 105 kg, the amplitude of oscillations of the accelerations of the working platform increases by 38 %, the change in the angle of inclination of the upper section of the boom is from 45° to 15° leads to an increase in the amplitude of oscillations by 20%, when the angle of inclination of the lower section of the boom changes from 15° to 45°, the amplitude of oscillations increases by 47 %.

3. During the operation of the lower section, with the maximum working mass of the load, equivalent to the mass of the working and working tools, an emergency mode of operation is observed, which is not desirable.

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