2021 DSTA
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16th INTERNATIONAL CONFERENCE
Dynamical Systems – Theory and Applications
December 6-9, 2021, On-line

A method to improve the accuracy of bridge cranes overload protection using the signal graph

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Abstract: Often during the bridge cranes operation, there occur the crane major components' breakdowns, due to overload. Therefore, to prevent these breakdowns, overhead cranes are equipped with safety devices to protect the mechanism from the overload. The system of bridge cranes protection against overload should expediently provide the crane securing against peak overloads as well as systematic overloads, another necessary requirement being to ensure such protection high accuracy, assessed using the accuracy coefficient. To determine the overhead crane overload protection accuracy coefficient, the "crane - limiter - load" system movement is presented in the form of a signal graph. Transfer functions' dependencies are found by determining the dynamic loads applied to on the hoisting ropes. A method has been developed to improve the accuracy of bridge cranes protection from systematic and peak overloads by the means of a quasi-zero stiffness load limiter designed. It is proposed to use in this load limiter design a roller transmission mechanism that allows to achieve the load limiter'squasi-zero stiffness.

Keywords: overload protection accuracy factor, systematic and peak overloads, transfer functions, quasi-zero stiffness, roller transmission mechanism

1. Introduction

In Figure 1 there is shown the signal graph of the overhead crane's lifting mechanism illustrating the change in force $S(t)$ at the hoisting ropes stepwise in accordance with the stages of "crane - limiter - load" system movement. In this figure, $W_1(t), W_2(t), W_3(t), W_5(t)$ are the transfer functions for each of these stages.

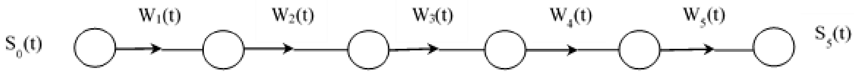

Fig 1. Overhead crane's lifting mechanism signal graph

Now having examined the "crane - limiter - load" system movement corresponding stages, we find the transfer functions' dependences determining the dynamic loads acting on the hoisting ropes, we consider the variance with load limiter installing in a hook suspension.

The calculated dynamic schemes of an overhead crane bearing a load limiter installed in a hook suspension, the pre-detachment and post-detachment movement stages, are shown in Fig. 2 and Fig. 3 respectively.

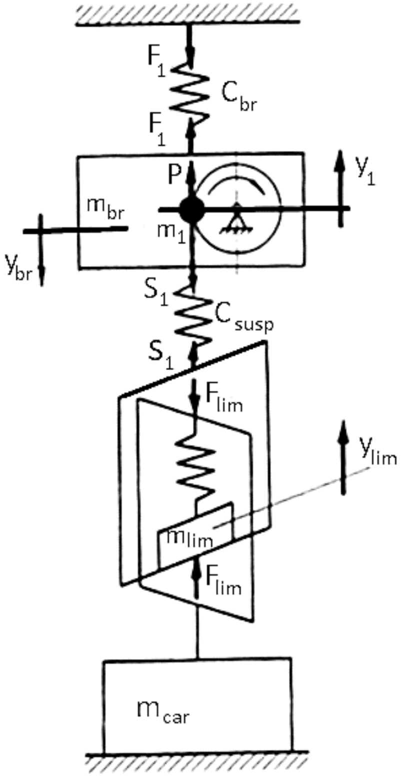

Fig. 2. Calculated dynamic scheme of an overhead crane bearing a load limiter installed in a hook suspension, pre-detachment movement stage

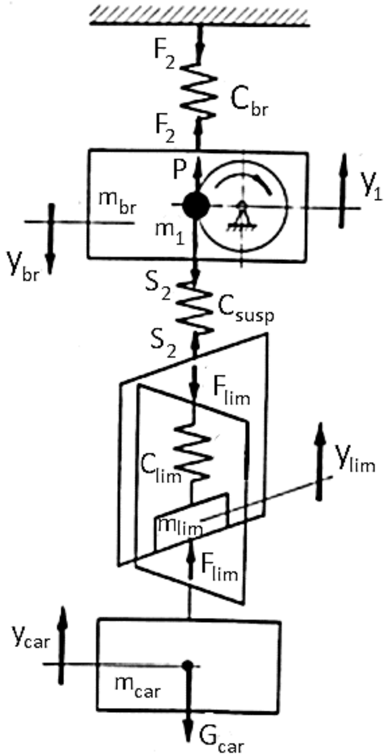

Fig. 3. Calculated dynamic scheme of an overhead crane bearing a load limiter installed in a hook suspension, post-detachment movement stage

2 Conclusions

Dividing the “crane – limiter – load” system movement process into characteristic stages and this process representation in the form of a signal graph allows us to determine ways to improve the accuracy of bridge cranes protection from overload.

An increase in the load limiter stiffness leads to a decrease in the accuracy of bridge cranes protection. The authors elaborated a method to improve the accuracy of bridge cranes protecting against systematic and peak overloads by creating a quasi-zero stiffness load limiter.

There was proposed to use in the new load limiter designa roller gear mechanism, allowing to provide quasi-zero stiffness of the load limiter due to the variable gear ratio.