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METHODS EXPERIMENTAL RESEARCH WORKING CHARACTERISTICS OF THE ELECTROMAGNETIC SHOCK ABSORBER

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Abstract. *Description of the technique of experimental research and building of the working characteristics of the electromagnetic shock absorber based on the properties of the cylindrical linear machine. A mathematical model that describes the experimental study was built. The design of the experimental plant and the principle of experimental measurements was described.*

Keywords: *Electromagnetic shock absorber, cylindrical linear machine, experimental plant, electromotive force, Ampere force.*

МЕТОДИКА ЭКСПЕРИМЕНТАЛЬНЫХ ИССЛЕДОВАНИЙ РАБОЧИХ ХАРАКТЕРИСТИК ЭЛЕКТРОМАГНИТНОГО АМОРТИЗАТОРА

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Аннотация. *Описана методика экспериментальных исследований и построения рабочих характеристик электромагнитного амортизатора основанная на свойствах цилиндрической линейной машины. Построена математическая модель, описывающая экспериментальные исследования. Описано устройство экспериментального стенда и принцип проведения экспериментальных измерений.*

Ключевые слова: *Электромагнитный амортизатор, цилиндрическая линейная машина, экспериментальный стенд, электродвижущая сила, сила Ампера.*

МЕТОДИКА ЕКСПЕРИМЕНТАЛЬНИХ ДОСЛІДЖЕНЬ РОБОЧИХ ХАРАКТЕРИСТИК ЕЛЕКТРОМАГНІТНОГО АМОРТИЗАТОРА

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Анотація. *Описано методику експериментальних досліджень та побудови робочих характеристик електромагнітного амортизатора, заснована на властивостях лінійної циліндричної машини. Побудована математична модель, яка описує експериментальні дослідження. Описано устрій експериментального стенда та принцип проведення експериментальних вимірів.*

Ключові слова: *Електромагнітний амортизатор, циліндрична лінійна машина, експериментальний стенд, електрорушійна сила, сила Ампера.*

Introduction

Improving the energy efficiency of a car is one the most important tasks of the modern automotive industry. One way is to replace less efficient units of a car with those that are more energy-efficient. Thus, replacing the passive hydraulic shock absorber on the control electro-magnetic shock absorber with the possibility of fluctuations energy regeneration on-board network is an urgent task to improve the energy efficiency of a car.

Studies of electromagnetic shock absorber and construction of its performance requires the establishment of test procedures and test facility.

Analysis of publications

The classic way of experimental studies for passive hydraulic shock absorber described in [1]. A shock-absorber rod supplied harmonic disturbance of known frequency and amplitude. After that, the parameters are measured to determine movement of the rod in the compression and rebound damping. The resulting cyclic chart graphically converted in the performance damper. Modern shaker tests can check the status of suspension systems [2] without dismantling the shock absorbers. It can transfer all characteristics of the shock absorbers directly to the output device computer subsystem. In developing an EMSA at the Eindhoven University of Technology was established test stand [3] which using a linear motor simulated random road surface with a given spectral density.

Properties of the electromagnetic shock absorbers enables us to investigate the performance by a more simple method.

Purpose and task

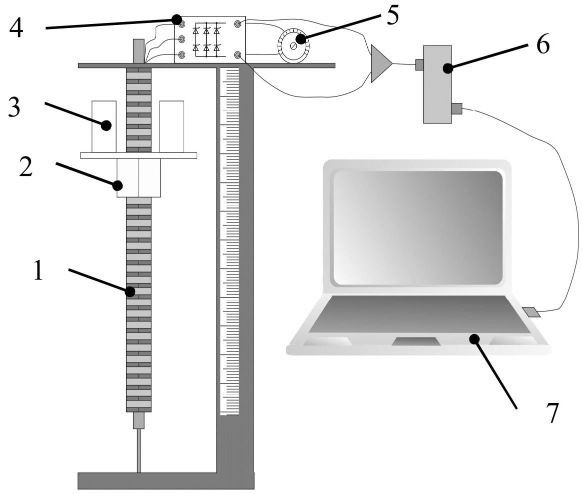
The purpose of experimental investigations is a performance characteristics building and finding of resistance coefficient for electromagnetic shock absorber (EMSA) in different working modes, sprung and unsprung weights, and movements mutual speed of an automobile.

Main section

The EMSA is built on the base of cylindrical linear machine (CLM). Using CLM properties it becomes possible to make experimental investigations by methods for CLM [4].

The scheme of a test stand is shown in the fig. 1.

The magnetic part of EMSA is falling down along a three-phase winding. This is a simulation of sprung and unsprung weights mutual movement. The weights' different values will set the different speeds of falling. The experiment is based on the phenomenon of the current emergence in a conductor when it moves in permanent magnetic field. The electromotive force (emf) is inducted in the moving wires when they move through the magnetic field and cross the magnetic field lines.



1) winding part; 2) magnetic part; 3) weights; 4) 6-pulse rectifier; 5) variable resistor; 6) digital oscilloscope IRIS; 7) notebook

Fig. 1 – The test facility scheme

This happens in accordance with the law of electromagnetic induction [5]. This emf equation is

$$E = -k\frac{d\Phi}{dt}, \qquad (1)$$

where E – emf;
k – construction coefficient;
$\frac{d\Phi}{dt}$ – magnetic flux changing.

When the winding is picked up into load or closed onto fault, the current begins to flow through it. The current generates a force that counteracts the magnetic part of EMSA movement.

This force is proportional to the movement speed of the magnetic part, which occurs under gravity force, but directed opposite to the movement.

After some time, the gravity force, which acts on the magnetic part of EMSA with weights, and the opposite force, will be balanced and speed stabilized. The value of the stabilized speed depends on the magnetic part weight with added weights, the resistance coefficient of EMSA and dry friction force.

The resistance coefficient of EMSA depends on the emf value, own resistance of the winding and load in winding circuit. The dry friction force is generalized by the description of forces that have mechanic and magnetic character, directed opposite to movement and does not depend on movement speed. This force is determined experimentally and, as a rule, is considerably less than Ampere force.

For finding of the experimental stand main properties, we need to build the mathematical model of the magnetic part movement.

The movement differential equation is

$$m\frac{dv}{dt}+kv=mg-F\ , \qquad (2)$$

where m – mass of the EMSA magnetic part with added weight;
k – resistance coefficient of EMSA;
v – speed of the EMSA magnetic part with added weight;
g – gravitational acceleration;
F – dry friction force.

The solution of differential equasion is obtained in the form of

$$v=\frac{m}{k}\left(g-\frac{F}{m}-C\cdot e^{-\frac{k}{m}t}\right). \qquad (3)$$

For integration constant C determination, let's put initial conditions – $v=v_0$, $t=0$ into (3). At the end we'll get equation for current speed of EMSA magnetic part determination.

$$v=\frac{m}{k}\left(g-\frac{F}{m}-\left(g-\frac{F}{m}-\frac{v_0 k}{m}\right)e^{-\frac{k}{m}t}\right) \qquad (4)$$

From (4) we can see that speed changing process is the subject of exponential dependence. If $t\to\infty$ the speed is approached by asymptote to the value $\frac{1}{k}(mg-F)$. The process speed determined as a ratio of the EMSA magnetic part with added weight mass and resistance coefficient. Let's accept the moment and the coordinate of the entry speed into the 5% asymptotic corridor values as the origin. Thus, the ratio of the remaining path and the time of passage of magnetic part with the added weight of this path, would enable us to determine steady speed. The Ampere force will be equivalent to the gravity force, which acts on the EMSA magnetic part with added weights.

From (1) it is clear that inducted emf is directly proportional to the movement speed, thus the moment of the emf steady state beginning is the same as the moment of the speed steady state beginning. Measure the emf signal with help of digital oscilloscope and determine the moment of the emf steady state beginning, thus we determine the steady speed of magnetic part with added weight movement.

By changing added weight and phase winding ohmic resistance, we can build working characteristics of EMSA. Working characteristics of any EMSA will be the reflection of the origin, thus it is enough to make movement only in one direction.

Conclusion

The proposed test method EMSA uses the basic principles of CLM. Its use simplifies the preparation of the performance of EMSA. It eliminates the need to create complex devices because it simulates harmonic or accidental disturbance and avoids the need for adapting a standard test stand, hydraulic shock absorbers for the design and requirements of EMSA. Adequacy of the mathematical model leads to a high prediction accuracy of expected results.

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