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«Metrological Support of Innovative Technologies» ICMSIT-II 2021

«Model of object non-destructive technology of road surfaces compaction control»

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Problem statement

- **The digitalization and intellectualization of road construction processes.**
- Continuous non-destructive control of road surface compaction.
- In road construction, intelligent compaction, continuous compaction control, and neural network control system for road rollers have been used

Solution methods

Mathematical model in the state space

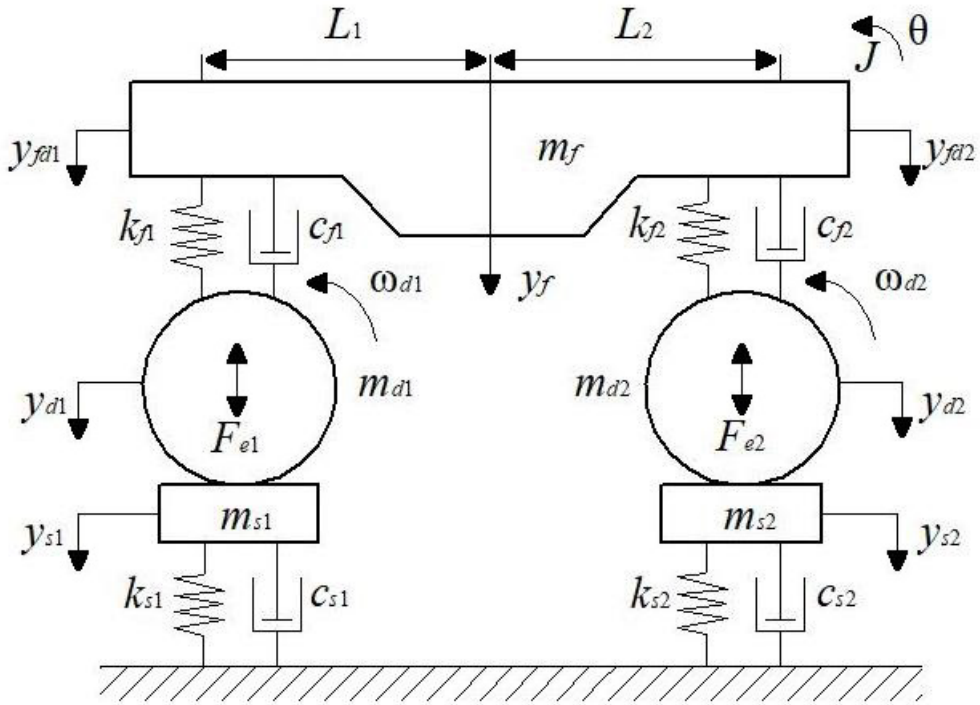

Figure. Design diagram of the dynamic system "vibrating roller-material".

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Solution methods

Mathematical model

$$(m_{d1}+m_{s1})\cdot\ddot{y}_{d1}+c_{f1}\cdot(\dot{y}_{d1}-\dot{y}_{f1})+c_{s1}\cdot\dot{y}_{d1}+k_{f1}\cdot(y_{d1}-y_{f1})+k_{s1}\cdot y_{d1}$$
$$=F_{e1}\cdot\sin(\omega_{e1}\cdot t)+(m_{d1}+m_{s1})\cdot g;$$
$$(m_{d2}+m_{s2})\cdot\ddot{y}_{d2}+c_{f2}\cdot(\dot{y}_{d2}-\dot{y}_{f2})+c_{s2}\cdot\dot{y}_{d2}+k_{f2}\cdot(y_{d2}-y_{f2})+k_{s1}\cdot y_{d1}$$
$$=F_{e2}\cdot\sin(\omega_{e2}\cdot t)+(m_{d2}+m_{s2})\cdot g;$$
$$m_f\cdot\ddot{y}_f+k_{f1}\cdot(y_{f1}-y_{d1})+c_{f1}\cdot(\dot{y}_{f1}-\dot{y}_{d1})+k_{f2}\cdot(y_{f2}-y_{d2})+c_{f2}\cdot(\dot{y}_{f2}-\dot{y}_{d2})=0;$$
$$J\cdot\ddot{\theta}+k_{f1}\cdot(y_{f1}-y_{d1})\cdot L_1+c_{f1}\cdot(\dot{y}_{f1}-\dot{y}_{d1})\cdot L_1+k_{f2}\cdot(y_{f2}-y_{d2})\cdot L_2+c_{f2}\cdot(\dot{y}_{f2}-\dot{y}_{d2})\cdot L_2=0;$$
$$\theta=\frac{y_{f1}-y_{f2}}{L_1+L_2};\ y_f=\frac{L_1\cdot y_{f1}+L_2\cdot y_{f2}}{L_1+L_2};$$
$$m_{s1}\cdot\ddot{y}_{s1}+c_{s1}\cdot\dot{y}_{s1}+k_{s1}\cdot y_{s1}-m_{s1}\cdot g-F_{c1}=0;\ m_{s2}\cdot\ddot{y}_{s2}+c_{s2}\cdot\dot{y}_{s2}+k_{s2}\cdot y_{s2}-m_{s2}\cdot g-F_{c2}=0;$$
$$F_{e1}=m_{e1}\cdot r_{e1}\cdot\omega_{e1}^{\ 2};\ \dot{y}_{s1}=\dot{y}_{d1};y_{s1}=y_{d1},\ F_{e2}=m_{e2}\cdot r_{e2}\cdot\omega_{e2}^{\ 2};\ \dot{y}_{s2}=\dot{y}_{d2};y_{s2}=y_{d2},$$

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Solution methods

Simulation

Initial data:

$k_{s1} = 4 \cdot 10^7$ N/m; $k_{s2} = (4 \cdot 1.2) \cdot 10^7$ N/m; $c_{s1} = 210 \cdot 10^3$ N · s/m; $c_{s2} = (210 \cdot 1.2) \cdot 10^3$ N · s/m;

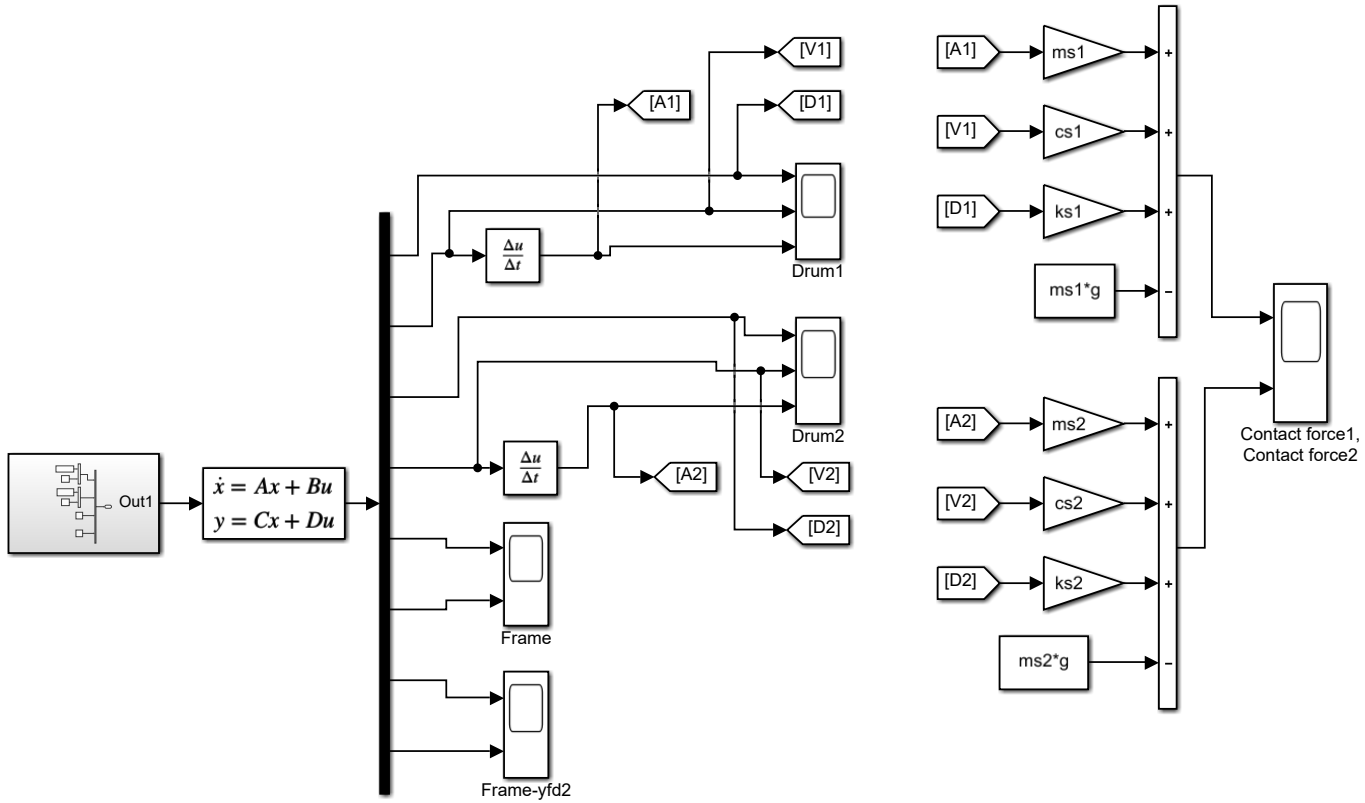
$k_{f1} = 140 \cdot 10^3$ N/m; $k_{f2} = 140 \cdot 10^3$ N/m; $f_{e1} = 48$ Hz; $f_{e2} = 48$ Hz; $F_{e1} = 95000$ N; $F_{e2} = 95000$ N;

$L_1 = 1.5$ m; $L_2 = 1.5$ m; $c_{f1} = k_{f1} \cdot \eta / \omega_{e1}$, N · s/m; $\eta = 0.16$; $c_{f2} = k_{f2} \cdot \eta / \omega_{e2}$, N · s/m; $m_{d1} = 2750$ kg;

$m_{d2} = 2750$ kg; $m_{s1} = 0.2 \cdot m_{d1}$, kg; $m_{s2} = 0.2 \cdot m_{d2}$, kg; $m_f = 6000 + 1500$ kg; $J = 12000$ kg · m^2.

Solution methods

Simulation model in MATLAB / Simulink



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Solution methods

Modeling

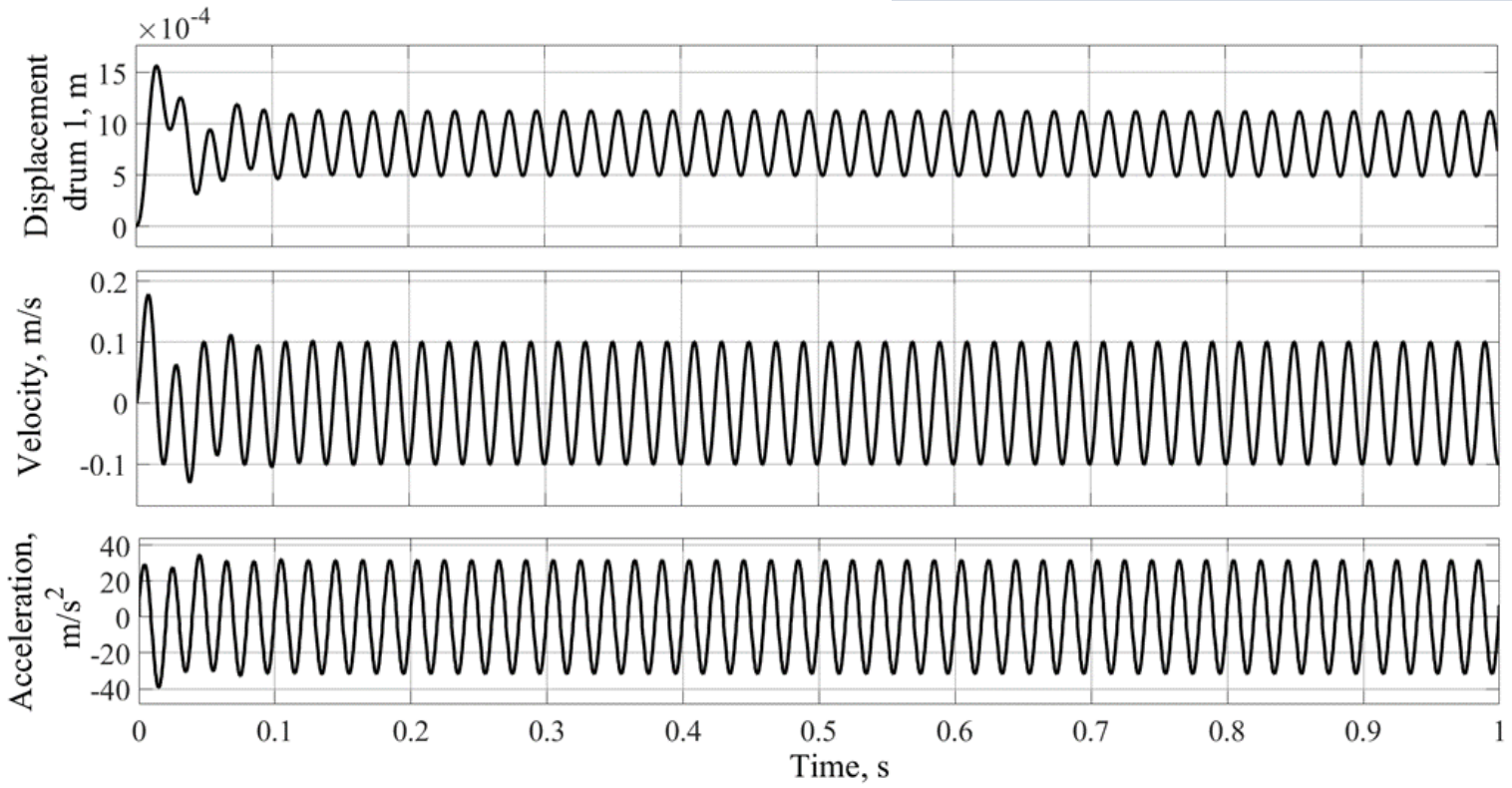

Figure. Time dependences of displacement, speed and acceleration of the screed paver.

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Conclusions

Results, implementation

- **A mathematical model of the object of non-destructive technologies for compaction of asphalt concrete mix by the method of state variables is obtained. A simulation model was developed in the MATLAB/Simulink software environment. The model is planned to be used for designing an intelligent (artificial neural network) system for continuous quality control of compaction of road materials (soils, asphalt concrete mixes).**
- **The mathematical and simulation model can be used to research and design cab suspension elements by adding additional elements of the dynamic system - shock absorbers, cab, operator's workplace.**
- **The results of the work are a stage of exploratory research in the field of automation of compaction processes with vibrating rollers.**

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