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«Conference on Applied Physics, Information Technologies and Engineering» APITECH-2020

«Model-based approach to the design of a continuous soil compaction control facility»

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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

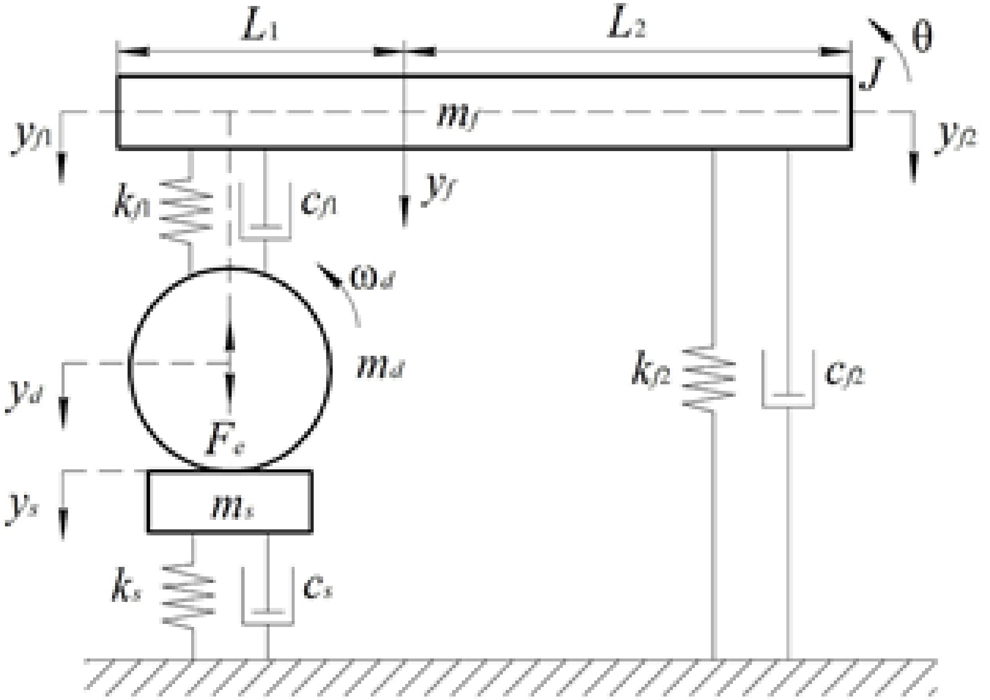

Figure. Design diagram of the dynamic system "vibrating roller-material".

Solution methods

The system of equations is reduced to a system of first-order differential equations in the Cauchy normal form:

$$\dot{z}_1 = z_2 ;\; \dot{z}_2 = \frac{1}{(m_d + m_s)} \cdot \begin{bmatrix} -k_{f1} \cdot (z_1 - (z_3 + L_1 \cdot z_5)) - c_{f1} \cdot (z_2 - (z_4 + L_1 \cdot z_6)) \\ -k_s \cdot z_1 - c_s \cdot z_2 + F_e \cdot \sin(\omega_e \cdot t) + (m_s + m_d) \cdot g \end{bmatrix};$$

$$\dot{z}_3 = z_4 ;\; \dot{z}_4 = \frac{1}{m_f} \cdot \begin{bmatrix} -k_{f1} \cdot (z_3 + L_1 \cdot z_5 - z_1) - c_{f1} \cdot (z_4 + L_1 \cdot z_6 - z_2) \\ -k_{f2} \cdot (z_3 - L_2 \cdot z_5) - c_{f2} \cdot (z_4 - L_2 \cdot z_6) \end{bmatrix};$$

$$\dot{z}_5 = z_6 ;\; \dot{z}_6 = \frac{1}{J} \cdot \begin{bmatrix} k_{f2} \cdot (z_3 - L_2 \cdot z_5) \cdot L_2 + c_{f2} \cdot (z_4 - L_2 \cdot z_6) \cdot L_2 \\ -k_{f1} \cdot (z_3 + L_1 \cdot z_5 - z_1) \cdot L_1 - c_{f1} \cdot (z_4 + L_1 \cdot z_6 - z_2) \cdot L_1 \end{bmatrix}.$$

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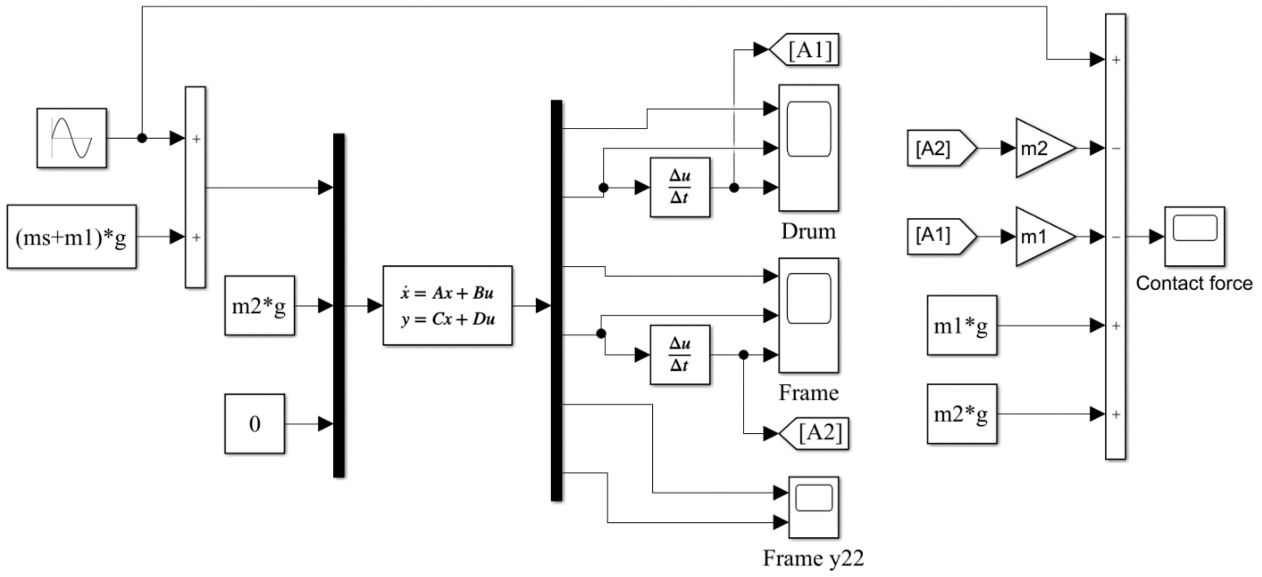
Solution methods

Simulation model in MATLAB / Simulink



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Solution methods

Modeling

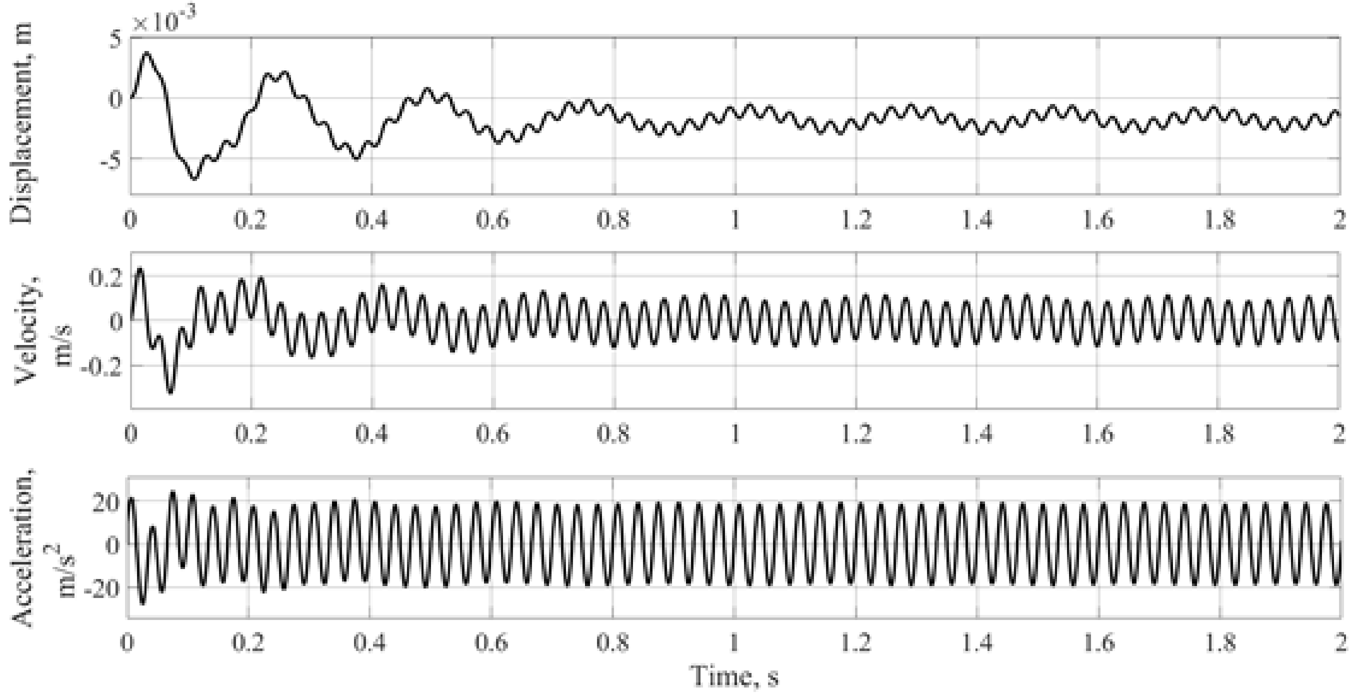

Figure. Time dependences of displacement, speed and acceleration of the roller.

Conclusions

Results, implementation

- Based on the method of variable states, a mathematical model of the vibration process of compaction of road material by a vibration roller is obtained. A model-based approach is implemented to automate the development of a simulation model in the MATLAB/Simulink software environment. The resulting models are planned to be used to design an intelligent (artificial neural network) quality control system for compaction of road materials (soils, asphalt concrete mixtures).
- 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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