Progressive motions of two-mass systems in resistive media

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It is well known that two-mass systems can move progressively in various resistive media, if the masses perform oscillations relative to each other. In the paper, simple mechanical models are considered that demonstrate this phenomenon.

The system under consideration consists of two rigid bodies with masses M and m that can move along a straight line. These bodies are called body M and body m, respectively. The main body M is subjected to the external resistance forces and contains the internal body m that performs specific periodic motions relative to body M. Periodic progressive motions of the two-mass system are obtained and analyzed for certain classes of the relative motions of the internal body m.

Various types of the resistance forces acting upon body M are considered including linear and quadratic resistance depending on the velocity of body M as well as Coulomb's dry friction forces. Both isotropic and anisotropic external resistance forces are examined.

Optimal periodic motions are obtained that correspond to the maximal average speed of the system as a whole.

The maximal average speed is evaluated explicitly for various cases. This speed is zero in the case of the isotropic linear resistance but is positive in the anisotropic linear case. Also, it is positive in the quadratic and dry friction cases, both isotropic and anisotropic.

The principle of motion based on the relative oscillations of internal masses does not require outward devices like wheels, legs, screws, oars, etc. That is why this principle is used for mobile robots and underwater vehicles equipped with moving internal parts. This kind of mobile robots seems especially prospective for robots moving inside tubes and in aggressive media.

In the paper, experimental models employing internal moving masses are presented including carts carrying inverted pendulum and rotating wheels, capsules and two-mass system moving inside tubes. Experiments confirm the realizability of the principle of motion described in the paper.

References

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