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APPLICATION OF MARINE PREDATORS ALGORITHM IN DESIGN OF RAILWAY VEHICLES SUSPENSION MADE OF COIL SPRINGS

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ABSTRACT

The design and calculation of suspension system is one of the most important tasks in the development of railway vehicles. One of the most common concepts of suspension of railway vehicles, especially freight wagons, is based on a set of coil springs of different lengths, which are placed one inside the other. When the vehicle is empty, only the external spring is active, and when the vehicle is loaded above a certain limit, both springs are active. Thus, the suspension of such railway vehicles has a bilinear characteristic of stiffness. The design of such suspension systems is usually based on a conventional approach whose main goal is to design coil springs that will meet the all required conditions. These conditions can be satisfied by different combinations of parameters and dimensions of the external and internal spring. However, not enough attention is paid to achieving the optimal solution that could provide materials saving.

This was a motivation for the authors to explore the possibilities of applying biologically inspired algorithms in the design of suspension systems of railway vehicles. Accordingly, this paper presents the application of the Marine Predators Algorithm (MPA) in the design of suspension system of railway vehicles based on the coil springs. The main goal of optimization is to minimize the total mass of the set of coil springs, with simultaneously satisfaction all the required conditions related to the behavior of the suspension system of the considered railway vehicle. MPA is very successfully applied in solution of wide spectra of engineering problems. A key inspiration of this algorithm is the widespread food search strategy of ocean predators based on the Lévy and Brownian movements including the optimal encounter rate policy in biological interaction among predators and prey.

After considering the theoretical postulates of the suspension system of railway vehicles based on coil springs, a unique optimization model is developed. It consists of 6 parameters to be optimized (diameters of springs, diameters of wires and numbers of active threads of external and internal spring), target function and 14 constraints (7 for each coil spring). The established optimization model is applied in two specific examples of designing a suspension system of 4-axled freight wagons based on a sets of coil springs, the first for an axle-load of 200 kN and the second for an axle-load of 225 kN. In both cases, the application of the proposed optimization model and the MPA provided a significant reduction in the mass of the set of coil springs. Compared to the conventional design approach, the mass reduction in the first example is 18.2%

and in the second example 12.8%. More precisely, the total mass of 16 sets of coil springs of one 4-axled freight wagon in the first example is reduced by about 70 kg, while the mass reduction in the second example is about 50 kg. Considering the fact that commercial freight wagons are usually produced in large series of several thousand pieces and that their coil springs are made of special and expensive steel, it is obvious that the obtained results of this research have great practical significance and potential impact on improving profitability in the industry of railway vehicles.

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