Damper for mobile installation of oil sludge pyrolysis

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Abstract. The article discusses the main types of dampers used in modern industry, their advantages and disadvantages. The reasons for their inefficient work on the mobile installation of pyrolysis of oil sludge. A new design of the collet elastomer type damper is proposed

1. Introduction
In modern engineering, the vibration that occurs during the operation of the units, lies in a narrow frequency range. The causes of vibration are moving parts and parts of the units. For each device, the frequency range of vibration will depend on the rotation speed of moving parts and can vary from 1 Hz to 100 kHz. The most popular way to overcome vibration is the use of vibration-proofing or vibration-absorbing devices. The basis of their work is the absorption of mechanical energy that occurs during the operation of the mechanism by converting it into heat due to friction. The most common of them are spring and elastomeric dampers, since they are the simplest and cheapest to manufacture. But these dampers have a number of significant drawbacks, the main of which is efficiency only in a narrow frequency range).

2. Formulation of the problem
At the same time, there are machines and units in which the frequency range is very wide and changes during the implementation of a certain technological process. Such a problem arose, in particular, during the implementation of a mobile low-temperature pyrolysis plant for oil sludge. The installation consists of several modules. The pyrolysis module is made in the form of a heat-transfer saddle-shaped bottom insulated from each other, a furnace space and a reactor with a mixing device, equipped with two rotors with blades, rotating in opposite directions with periodic reversing. The case of the pyrolysis module is box-shaped. Taking into account the fact that the modular unit for thermal processing of oil sludge should also be implemented in a mobile version, the following required characteristics of the basic model of the pyrolysis module are taken based on the condition that the module can be placed on high-traffic vehicles, which is extremely important for hard-to-reach areas:[1.2]
- overall dimensions: length 1.4 m, width 0.9 m, height 1.4 m;
- volume of raw materials processed 0.5 m3;
- capacity 1.5 - 2 m3 / day,
- rotor rotation speed of 30 rpm.

Steel 20X23H18 was adopted as the material for the manufacture of the pyrolysis module, which meets the performance requirements and the parameters of the pyrolysis module. The Young’s modulus of the material is $E = 2 \cdot 10^5$ MPa, Poisson's ratio $\mu = 0.3$, and the material density is $\rho = 7850$ kg / m$^3$. 
The density of oil sludge is $\rho = 830-1700$ kg/m$^3$. Consequently, the mass of the installation at full load will vary from 1500-2000 kg. With 4 supports for each damper there will be 500 kg of mass.[3]

The process of operation of the pyrolysis module can be divided into 3 stages. The first stage is the loading and mixing of the filler, and the fluctuations occurring during the installation will be constant. The second stage is the loading and crushing of the oil sludge. At this stage of work, multidirectional and variable shock loads arise due to the collision of sludge pieces between themselves and against the installation walls. The third step is the melting of oil sludge. At this stage, there is a transition from shock loads to permanent ones. Under these conditions, the use of spring or elastomeric dampers is not effective enough. Since the spring dampers are used at low vibration frequencies and have a linear dependence of the displacements on the load, which at large loads lead to significant displacements. Elastomeric dampers are used at high frequencies and at high loads lose their vibration-absorbing properties.

In this regard, the task was to develop a combined damper that will work effectively in a wider range. To identify analogs of the developed device, a patent analysis was conducted.
3. Solution of the boundary-value problem

In this regard, the task was to develop a combined damper that will work effectively in a wider range. To identify analogs of the developed device, a patent analysis was conducted. The closest in design of the device are presented in patents RU 2665108С2, RU 2643064С1.

Figure 3 shows the combined damper (patent RU 2665108С2). The device consists of two rings connected by elastic rods placed at an angle to the generator. In the center of the core structure is an elastomer array. The damper is designed for damping axial and torsional vibrations.

Figure 4 shows the combined damper (patent RU 2643064С1). The device consists of an elastomer array of toroidal shape, in the center of which a spring is placed. Vibration absorber is designed to dampen axial vibrations. When the damper is operating, the constancy of stiffness and damping characteristics is achieved.[4]

During the analysis of the presented devices, there were revealed the essential shortcomings of these structures: the complexity of the design, the linearity of the power characteristics, and the unregulated rigidity of the device. To eliminate these drawbacks, the authors have developed a design of a collet-elastomer type damper. The damper consists of a pressure disc 3, a support disc 1, along the perimeter of which collet spring rods 4 are located. In the center of the support disc an elastomer 2 is installed, which comes into contact with the spring rods.

The damper works as follows. When exposed to the axial force on the pressure plate 3, it transmits it to the elastic element (elastomer) 2. Under the influence of variable axial forces, static and dynamic elastomer deformed, acts on the collet spring rods 4. Under the action of the bursting force of the elastomer spring rods also begin to deform. As a result, the elastic properties of the elastomer and spring rods are summed.
To verify the performance of the proposed design the partial verification of the data was carried out. When conducting a compression test for a rubber specimen of the type IRP 17-01, a force diagram was obtained, which shows that when a load of 5 kN is applied, the axial displacements are 13 mm. The obtained data coincide with the result of modeling in the Ansis software environment. Test and simulation results are presented in figures 6.

![Force diagram](image1)

**Figure 6.** Force diagram

By applying a load of 5 kN to the modeled damper of the collet-elastomer type, the maximum axial displacement decreased to 6 mm, which proves the efficiency of the design.

![Collet-elastomer type damper](image2)

**Figure 7.** Collet-elastomer type damper

4. **Conclusion**

The simulation results suggest that the new design of the combined damper works in a wider frequency range. This is achieved by summation the damping characteristics of the elastomer and collet rods. The advantages of the proposed design are the ease of manufacturing, the ability to control stiffness, maintainability. The use of this damper will significantly reduce the transmitted amplitude of the inertial and vibration loads that occur during the operation of a mobile unit of oil sludge on the carrier platform.

5. **References**

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