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About the vibration damping system for handles of pneumatic manual impact machines

Pneumatic manual impact machines, in accordance with their design, cause significant levels of vibration of the handles, which adversely affect operators. Vibration damping devices used to reduce vibration, which are various types of elastic shock absorbers installed between the vibrating hammer body and the handle, are not effective enough, since with high axial forces, the stiffness of the shock absorbers increases. In the developed vibration damping system of a pneumatic hammer, the overall stiffness of the shock absorbers and the vibration damping efficiency do not depend on the axial force within the required limits.

Keywords: pneumatic, manual, hammer, jackhammer, chopping, vibration, handle

Introduction

The principle of operation of pneumatic impact machines (manual chopping, jackhammers and stripping hammers, portable rotary hammers and others) is based on the conversion of compressed air energy into mechanical operation of the piston impactor, which produces reciprocating movements in the cylinder of the machine body and strikes at the end of its working stroke on the shank of the working tool.

All pneumatic manual machines must comply with current regulations on vibration, axial feed force, and a number of other parameters. However, so far these problems have only been partially solved, and the vibration of these machines significantly exceeds the permissible standards.

Some parameters of the Atlas Copco jackhammer (Sweden) and permissible vibration values are given below as

Characteristics of the Atlas Copco TEX 12PS Jackhammer

Impact frequency, 1/s	26.6
Weight, kg	10.5
Vibration level (3 axes ISO 28927-10), m/s^2	15.4
Directive 2002/44/EC, m/s^2	2.5

As can be seen from the table, the vibration of this hammer significantly exceeds the permissible level. It should be noted that when working with these hammers, the axial force of the operators usually exceeds the permissible 200 N.

The main reason for this situation is that the springs used to dampen vibration, installed between the handle and the hammer body, are effective with little effort, since with large forces their stiffness increases and vibration damping becomes ineffective.

Since different work requires different efforts from the operators, in some cases the vibration damping level becomes insufficient. For stripping and chopping hammers, these forces range from 0 to 200 N. For jackhammers, as a rule, from 200 N and above.

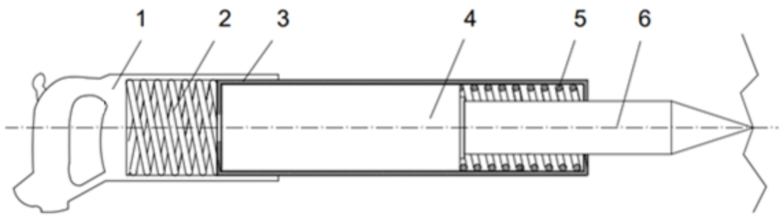
The object and purpose of the work

The purpose of this work was to develop a manual pneumatic hammer with an effective vibration damping system for the handle in the required range of axial forces.

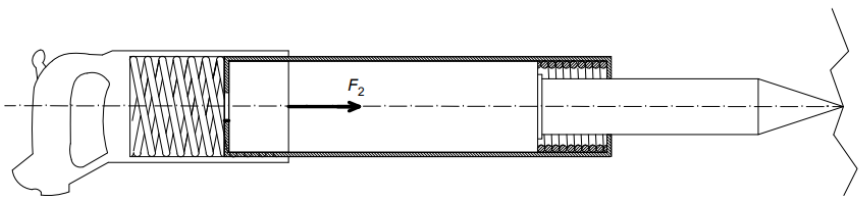
The results of the work

As a result of the analysis of various circuits and devices designed to dampen vibration, a system has been developed that provides effective vibration damping in the required range of axial forces.

The diagram of the developed hammer is shown in the figure 1.



a)



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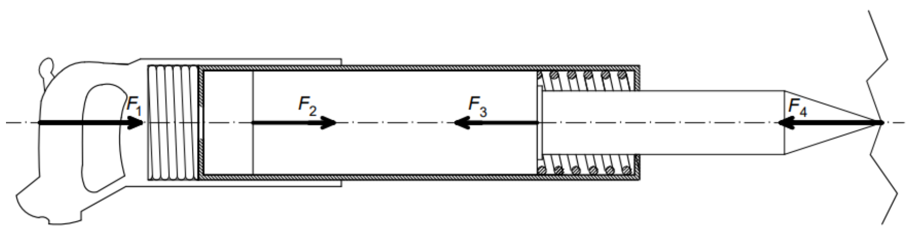

c)

Figure 1 - Diagram of a pneumatic hammer

As can be seen from Figure 1a), the hammer contains a handle 1, a handle spring 2, a housing 3, an impact mechanism 4, a housing spring 5, and a working tool 6.

The operation of the vibration damping system is as follows.

As can be seen from Figure 1a), in the initial state, the springs 2 and 5 are unclenched, and the impact mechanism 4 occupies the leftmost position in the body 3.

When the hammer is enabled, compressed air is supplied the cavity between the left wall of the body 3 and the impact mechanism 4 through the handle 1.

In this case, under the action of the compressed air force F_2, the impact mechanism moves to the right and compresses the spring of the housing 5, as can be seen from Figure 1, b) and the impact mechanism 4 begins to work, inside of which a piston-impactor produces reciprocating movements, which produces impacts on the working tool 6.

These movements of the firing piston cause the body of the firing mechanism 4 to vibrate under the action of reactive forces.

The operation of the vibration damping system is shown in Figure 1 (c).

During operation, the operator presses the handle 1 with force F_1.

In this case, the spring 1 is compressed and transmits this force through the body 3, the impact mechanism 4 and the working tool 6 pressed against it through the spring 5 to the rock being destroyed.

The reaction force F_4 occurs in the rock being destroyed.

Springs 2 and 5 have different parameters.

The spring 2 is soft and dampens the vibration of the housing with a slight force F_1. Spring 5 is more rigid and is designed for greater force F_1.

With a large force F_1, the reaction force F_4, equal to F_2, also becomes large. This force acts through the working tool 6 on the body of the impact mechanism 4, which begins to move to the left.

In this case, the spring 5 begins to unclench, and its force F_3 acting on the body of the impact mechanism decreases.

At the same time, the compressed air force F_2 does not change.

The movement of the firing mechanism body stops when F_2 is equal to F_3.

Thus, regardless of the force F_1, equal forces of elastic elements always act on the body of the impact mechanism on the left and on the right: compressed air on the left and compressed spring on the right.

Since the mass of the impact mechanism is constant, the force F_2 is selected to ensure effective vibration damping in the required range of force F_1.

Figure 2 shows a general view of the prototype chopping hammer.

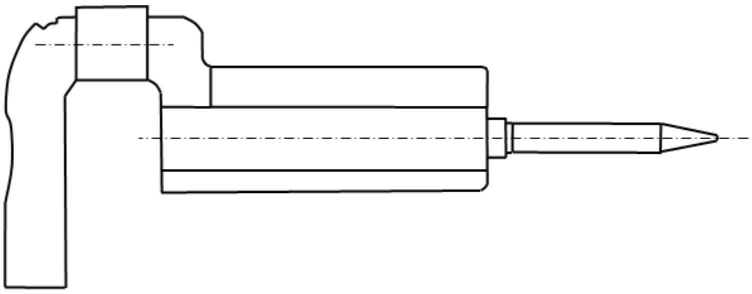

Figure 2 – General view of the prototype chopping hammer

Studies of experimental samples of chopping hammers when cutting metal blanks with a chisel have shown that the vibration level of the handle at axial forces from 0 to 200 N is close to 2.0 m/s^2, as can be seen from the approximate graph of changes in the vibration acceleration level of the hammer handle depending on the axial force shown in Figure 3.

The conducted studies have also shown that the vibration level of the handle largely depends on the working tool, the material being processed and the physical characteristics of the operator, which requires additional research. In this design, the vibration level of the handle can be reduced by adjusting the stiffness of the springs 2 and 5.

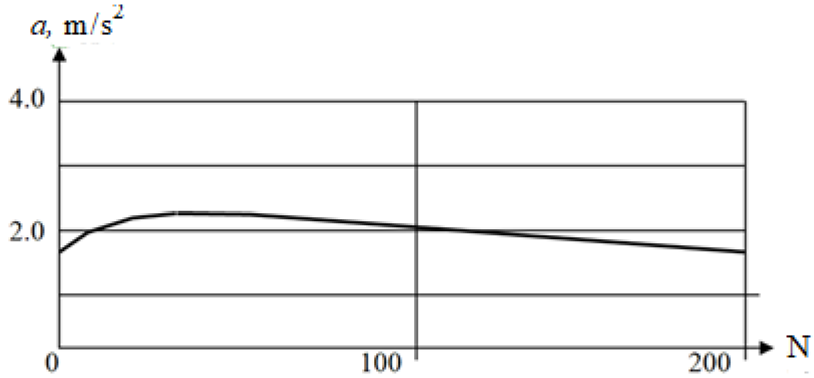

Figure 3 – Graph of the dependence of vibration acceleration on axial force

Conclusion

1. The developed vibration damping scheme of the pneumatic hammer handle ensures effective vibration reduction in a given range of axial forces.

2. The results of testing the prototypes of the chopping hammer have shown its fundamental operability, which makes it possible to ensure the vibration safety of this type of machine.

3. In order to determine statistically reliable data on the parameters of these machines in terms of vibration damping efficiency, it is necessary to produce experimental batches and conduct the full scope of necessary research.