VIBRO-IMPACT TECHNOLOGIES FOR ROAD CONSTRUCTION MACHINERY

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ABSTRACT

With development of technical means the application scope of vibro machines and technologies is expanding. Simultaneously, demand on reliability of devices and products, weight- size and cost indicators is increasing. The article presents a design scheme of universal impact machines, which through changing fixtures are adjustable to the specifics of overlapping operations. The synthesis of vibro-impact technologies for various industries is proposed, comprising technology for repairing of track and road construction machinery.

Keywords: hand-held electromagnetic impact machines, vibro-impact technologies, repair of transport and road construction machinery, processing of metallic and nonmetallic structures.

Background. *In the construction industry during the installation, special construction, operation and maintenance of construction and road machines, the technologies, based on the force action on the processed material, are widely used,.*

The main factors determining the feasibility of such technology in the operation of companies (hereinafter – OC), the low cost of their implementation and a relative simplicity, which best meet light, including manual, mechanized tools, primarily impact machines, capable of generating powerful force pulses.

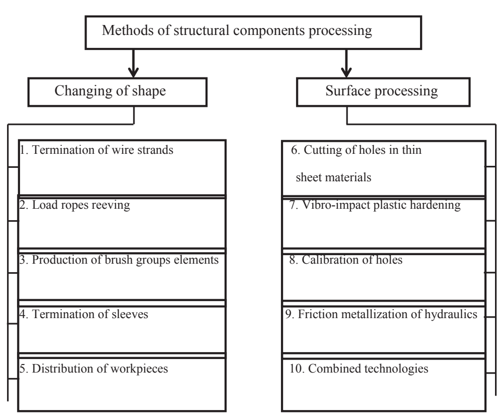
Objective. *The objective of the authors is to study vibro-impact technologies, applied for road construction machines, and to suggest some approaches to their development for their wider operation for various purposes.*

Methods. *The authors use general scientific and engineering methods, calculation, mathematical modeling, comparative method.*

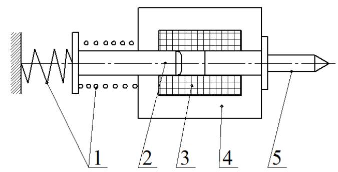
Results. *The research allowed to develop a number of vibro-impact technologies that meet the requirements under consideration, the main of which are shown in Pic. 1.*

In order to achieve maximum energy of a single impact with minimal weight and size parameters of a tool a size range of low-frequency hand-held impact machines with reciprocating linear electromagnetic motors (hereinafter – LEM) [1, 2] is developed. Pic. 2 is their schematic diagram, in which a spring scheme of a pane return is implemented.

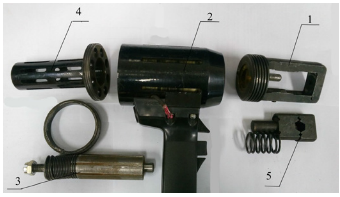
The driving of the pane is carried out by the magnetic force generated by the coil 3, origin return is performed by an elastic force of compression or tension spring 1. Forcing of LEM is achieved by increasing the current in the working half-period of



Pic. 1. Structure of process operations.



Pic. 2. Schematic diagram of a single-coil hammer: 1 – spring of tension or compression, 2 – pane, 3 – coil, 4 – housing, 5 – indenter.



Pic. 3. Components of a crimping tool of contact connections: 1 – die plate, 2 – housing with a coil, 3 – anchor – pane with return spring, 4 – body of return mechanism, 5 – matrix and punch.

sinusoidal voltage (220 V, 50 Hz) and passing 8–10 periods. Thus, the current value of the current drawn from the network does not exceed a permissible value.

Selection of a single impact energy is determined by technological requirements. For hand-held machines it can be 40–60 J at a frequency of impacts of 80–100 impacts / min. Assessment of the level of energy performance of LEM and their design features can be made when considering the specific implementations of machines and technologies.

The basic representative (prototype) of a size range of low-frequency electromagnetic impact machines is a crimping tool of contact connections, the general form of which is shown in Pic. 3 [3].

The main purpose of a crimping tool – termination of stranded wires and cables up to 240 mm² in tubular

Table 1

Features and winding data of LEM

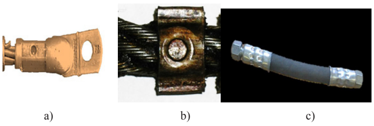
Impact energy, J	50
Pane weight, kg	0,8
Pane diameter, mm	30
Coil length, mm	70
Winding height, mm	16
Winding cross-section, mm²	2,32
Number of coils	300
Consumed power, kW	0,8
Motor weight, kg	3,8

Table 2

The coefficients of similarity and basic parameters of LEM of a size range

Operation	Vibro-impact surface hardening, calibration	Cutting of holes in panels	Crimping of contact tips	Crimping of steel ropes, distribution
Impact energy, J	10	20	40 original*	60
Similarity coefficient of:				
Impact energy	0,25	0,50	1,00	1,50
Linear dimensions	0,63	0,79	1,00	1,14
Cross-sections of copper and steel	0,40	0,62	1,00	1,30
Number of coils	1,59	1,26	1,00	0,88
Pane weight, kg	0,12	0,25	0,50	0,75
Pane diameter, mm	19	24	30	34
Coil length, mm	36	46	58	66

*parameters of the original (crimping tool OEM– 1) are shown in Table 1.



Pic. 4. Crimped machine elements: a) contact tip, b) brush element of a rotor – feeder, c) rubber steel sleeve of high pressure.

tags in their pressing from a round shape to a hexagon shape. Crimping tool, for example, UIM – 1, is an original design of a hand tool, protected by copyrights and patents, which has no analogues in Russia and abroad.

One of the main indicators of the effectiveness of impact machines is specific energy of individual impact, i.e. energy per mass unit, reaching 10 J / kg and above in a crimping tool, while the specific energy of the impact of other known machines and presses is less than 5 J / kg. Main specifications of a crimping tool are shown in Table 1.

Crimping tool is a multipurpose machine, readjusted by changing technological fixtures. For example, it can be used for performing operations similar in technology and energy costs for operations 1–4, shown in Pic. 1.

For reeving of steel wire ropes and cords bolsters are used made of aluminum tubes, pre-deformed into oval, with a wall thickness from 5 to 7,5 mm. Bolsters are mounted on strands of connected cables and crimped to a circular shape.

Likewise is performed termination of rope brush groups of track snow-removal, ballast cleaning, ballast compactors and electric ballasting machines. In the rotor drum – feeder of a snow-removal machine cassettes are installed, in which brushes are pressed. They are made of steel wire ropes of 40 mm diameter. Currently, in the repair of rotors feeders, ends of brushes, to prevent their stripping-down, are crimped in steel split sleeves. Depending on operating conditions, replacement of brushes for failure sleeves is made 1–2 times a month. Crimping with an impact allows to use for termination of brushes uncut sleeves, with which the quality of the repair is achieved, which is comparable to the quality of factory-built brushes.

In the vast majority of road construction and track machines hydraulic and pneumatic actuators are used, during operation of which it is necessary to repair the flexible connections – rubber hoses. This operation is also a type of considered technologies. Crimped machine elements are shown in Pic. 4.

In rail transport, pneumatic brakes are used, structurally executed in a form of a lever system consisting of rods and fingers with a diameter of 24–50 mm. During operation, there is an intensive wear of a middle part of a finger, which necessitates restoration of the worn surface.

Known methods of recovery with metal completion in places of wear require significant costs and cannot be implemented in road track repair workshops. In this case, the increase in the outer diameter of the finger in place of wear is reached with its distribution by driving the rod in a pre-drilled pilot hole with an impact energy of up to 60 J, and preheating of a finger.

Less energy is required for cutting of holes in the thin sheet elements and multi-layer panels, the performance of which is made by drilling with cone drill bits or cutting out with presses with relative movement of the matrix and the punch installed on opposite sides of the component.

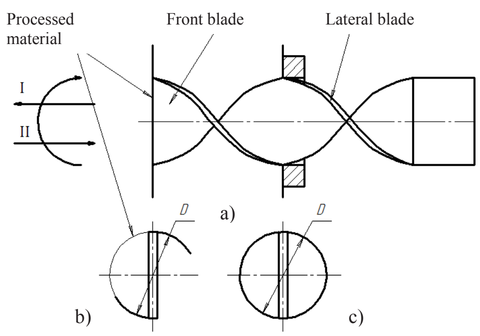
Cutting is inapplicable to process holes in volume elements of the closed loop, and a hole in the layered panels cannot be processed by drilling due to swelling of layers with chip scraps falling between them.

The alternative is a process that combines punching and cutting operation [4, 5], the circuit is shown in Pic. 5.

Hole processing is executed with screw (tape) drill, having a front and two lateral cutting blades. The technical process is divided into three series of operations I–III. When pane impact on the top (I) a leading hole breaks, which shape is shown in Pic. 5b), and then the drill is screwed into the processed element (II). Finishing sized hole processing is carried out with lateral blades of the drill when its return motion relative to the fixed matrix.

The scheme of the impact node of two-coil impact machine for holes processing is shown in Pic.6. The drill 1 is located in the ratchet-wheel 2, providing forced

Pic. 5. The scheme of hole processing: a) operating position of a drill and a matrix; b), c) – form of holes cutting.



rotation of the drill when the impact is transmitted through a shank end 3. The purpose of a shank end is to hold a drill at the end of the anchor – pane 4 when return stroke relative to the die plate 5. In the housing of LEM there are power (PC) and return (RC) coils.

The least labor-intensive processes are technologies to process surfaces in order to improve their operational properties, performed by surface plastic deformation – calibration and hardening with surface cold working.

The most effective is the impact deformation. Reducing the required impact energy as compared to the previously discussed operations is achieved by substantially smaller rods in the calibration (without distribution of a workpiece), or surface deformation without changing a shape of a workpiece. For these operations impact energy of 2–4 J is sufficient, which allows to increase the frequency of LEM impacts to 50 Hz.

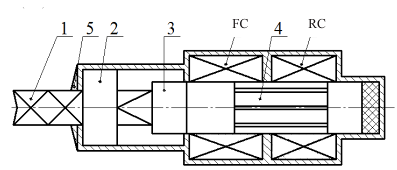
The study of vibro-impact plastic hardening (hereinafter – VPH) has shown that when processing of the shaft surface (steel 45) with a spherical indenter of 10 mm in diameter plastic deformation zone is formed around a footprint with a diameter of 3,1 mm, a depth of 2,2 mm. Analysis of the dependence between the amount of bearing surface and wear found that minimum wear is achieved with relative contact area of 30 to 60% and the depth of indentation to 0,02 mm, allowing to get the maximum oil absorption of a surface.

For all the above processes the required energy levels of single impacts are defined and, by the similarity method, the basic parameters of electromagnetic motors are calculated, shown in Table 2 [6].

Based on the results, a size range of geometrically similar hand-held electromagnetic machines with specific energy of a single impact, greater than 10 J / kg, is developed.

It is necessary to pay attention to an important fact. Processing of workpieces by impact opens up opportunities to create new, combined technologies. For example, to reduce fatigue damage occurring on the shafts under bearings pressed on them, clutches, gears or on axles and hubs of wheels of rolling stock due to fretting, wear frictional metallization (hereinafter – FM) of surface by copper and its alloys [7] is applied, creating a thick intermediate layer 4–6 microns, comparable to the height of the microroughness of protected surface. It reduces by one and a half – twice the coefficient of dry friction and reduces the possibility of jamming of connected elements in assembly – disassembly works. Since the quality of the copper layer is greatly influenced by in specific pressure in the contact area of the spare part and the indenter, it seems appropriate to create a pulse mode of loading, it with the applied load fluctuation under an electromagnetic force or impact.

There are also options for combining FM and VPH at diametrical location of friction and impact indenters or under impact onto the surface of the composite indenter.



Pic. 6. Scheme of a hand-held impact machine for holes processing.

Conclusion. *Thus, we can conclude the possibility of using a number of similar universal mobile hand-held electromagnetic machines to implement a wide range of technologies related to the impact effect on the material. These technologies are used in the repair of both track and road construction machinery, and in other industries.*

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