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INFLUENCE OF OPERATIONAL PARAMETERS ON CHARACTERISTICS OF PNEUMATIC HAMMERS

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The paper covers the results of experimental study in influence of temperature and compressed air pressure, pressing force on operational characteristics of puncher. It is shown that increasing the temperature of compressed air the less the initial degree of compression in the back chamber, the more the energy parameters are, but air consumption decreases unequally for different types of puncher. It is stated that increasing the pressing force the air consumption grows up to a definite limit which is the most significant factor in the case of plugger with spring-loaded valve.

Introduction

The main external operating parameters influencing the operation of punchers are pressure and temperature of compressed air, an operator's pressing power on puncher and properties of processed environment. Naturally, changes in power characteristics depending on operation conditions are due to changes in operation process. Regularities of this interconnection are conditioned by the puncher design of different functions.

Temperature of compressed air in air main has different value depending on weather conditions, season, field of device application, operating characteristics of compressor with subsequent condenser and remoteness of pneumatic energy receiver etc. Besides, one of the possible measures in energy saving at production and application of compressed air is its heating before pneumatic receivers using waste energy for this purpose [1]. Therefore, to establish the regularities of changes in puncher power performance and compressed air consumption depending on its temperature is of theoretical and practical interest.

It has been experimentally stated that the higher elasticity coefficient of the processes materials is, the more the rate of striker withdrawal from tool is. Increasing the withdrawal rate the stroke frequency grows and some increasing of impact power is observed. Character of influence of the processes environment properties on puncher energy parameters depends on its construction features and value of compressed air pressure. For the most effective operation punchers are designed for definite operation conditions.

Influence of pressing force on puncher operation is differentiated depending on their design features. As a rule, puncher power has less value at less pressing force, than at stronger pressing. The difference in power changes depending on pressing force amounts 2...20 % for most hammers [2]. Pressing force is one of the main factors influencing energy transfer from hammer to tool. The value of necessary minimal pressing force on hammer is defined mainly by the quantity of motion transferred from hammer to tool, stroke frequency and diameter of shank [2]. Regularities in influence of pressing force on external processes and parameters of pneumatic hammer are substantially stated [2], but in study of its influence on air consumption there is a definite gap.

In present work the results of experimental research in temperature influence of compressed air on operation parameters of hammer and dependence of air consumption on pressing force to hammer helve are presented.

Objects and means of investigation

The hand pneumatic hammers of different design and with various operating parameters have been tested: hammers MO-44, MO-39 and MO-9П with valve air distributor, chipper-riveters KE-22 with three-step slide and M-6, M-5 types having two groups of separately positioned microslides. Moreover, the value of stroke energy decreases in these hammers, but specific air consumption increases in the order of their listing.

To change and control compressed air parameters a special bench has been constructed. The bench consists sequentially of capacity with reducing valve and manometer, thermometer, flowmeter of variable differential pressure, compressed air heater with autotransformer PHO-250-5, chamber where manometer and thermocouple are installed and connected with electron recording potentiometer. Instead of thermocouple manometric thermometer of TC-100 type is applied.

Flowmeter consists of restriction device with a set of normal chamber diaphragms and tubular liquid differential manometer ДТ-150. Application of such flowmeter allows a more accurate determination of average compressed air consumption taking into account its temperature in comparison with widely used float meter of B-1 type. Volume of joint links, capacities and heater enables for smoothing air flow fluctuation.

Heater of compressed air is a heat-insulated and pressurized tube with flanges, in which tubular air heaters are built in.

Hammers are tested at air pressure 0,5 MPa on bench ERD-3 and manually at metal cutting. To register air pressure in plugger chamber strain pressure transducers with amplifier and light-beam oscillograph are used. Hammer energy parameters are defined by means of treatment of air pressure diagrams in plugger chamber.

Influence of compressed air temperature on hammer energy

As a result of investigations in hand pneumatic hammer drills it was stated that change in temperature of compressed air in air main influences significantly their operation. According to the experimental data the graph relative dependences of hammer energy parameters KE-22 (Fig. 1) and M-5 (Fig. 2) on temperature of compressed air before it were plotted. In this case plugger parameters at initial temperature of compressed air before heating were taken as standards. The common feature for hammers is growth of energy parameters at temperature increase of compressed air. Maximal, average in time and pre-exhaust pressure increased in the chamber back to the tool.

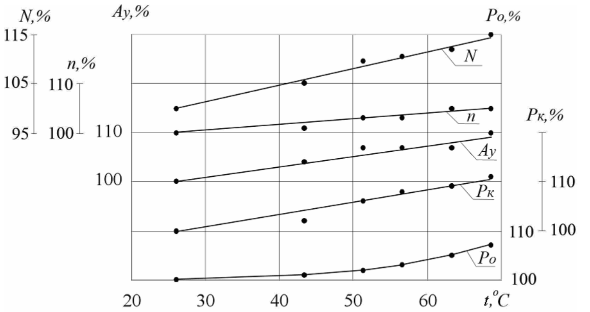

Fig. 1. *Dependence of changes in KE-22 puncher energy and power parameters on temperature t of compressed air: A_y is the stroke energy; n is the stroke frequency; N is the stroke power; P_0 is the maximal air pressure; $P_к$ is the pre-exhaust air pressure*

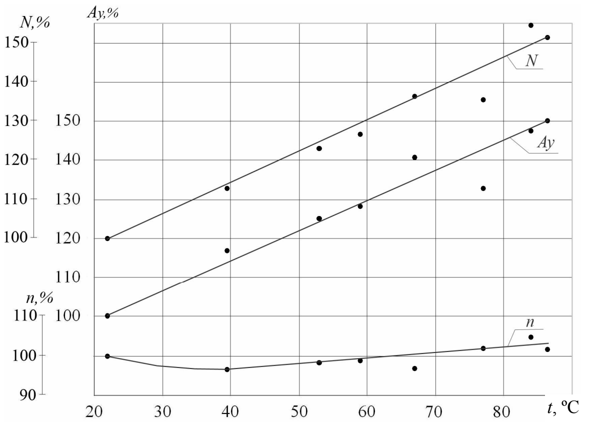

Fig. 2. *Dependence of changes in energy parameters of M-5 hammers on temperature of compressed air t*

In pluggers and KE-22 maximal pressure in the back chamber is higher than in the air main, the volume of noxious space being relatively small. Hammers of M type differ from most of the analogues by the fact that in the back chamber the compression rate is low, maximal air pressure is significantly lower than that in the air main and rate of pressure growth is low due to increased volume of clearance space owing to introduction of additional chamber and air flow along command channel into the atmosphere during its compression. Therefore, when heating energy carrier, the stroke energy (Fig. 2) and travel of hammer striker of M type increase more significantly, than those of KE-22 riveter. Pluggers in comparison with riveter possess high values of air compression degree in the back chamber, that is why heating compressed air a less significant growth of stroke energy and higher growth of stroke frequency should be expected to have.

Practical application of compressed air heat at temperature close to that of the environment does not work well, i. e. pneumatic percussion tools operate mostly due to potential energy of compressed air. When heating the gas the working capacity per its mass unit increases. The supplied heat has to go into change of air internal energy, external mechanical work and heat transfer. But in fact, taking into account relatively low increase in temperature of compressed air, growth of heat loss through the wall of cylinder and, first of all, essential decrease in gravimetric flow of energy carrier, working capacity of air mass in hammer because of its heat, in our opinion, does not increase significantly, though average gas temperature in working chambers become higher.

Striker surface is covered with thick oil resinous film. In increasing temperature of compressed air oil and dropping liquid viscosity decreases, therefore, friction coefficient decreases. The value of working medium energy loss for overcoming friction in piston couple is less, but the rate of hammer motion increases.

When heating the gas its leak quantity in pistol couple and in command channel of M-5 plugger decreases, therefore, decreasing its loss at the same values of compression rate the current value of air pressure becomes higher. Besides, as our experiments show, air compression in the back from the tool chamber starts at higher values of pressure and air temperature, which contributes to increasing the values of current and maximum gas pressure. In general, the rate of working chamber filling rises, which also make possible to increase energy parameters of pneumatic mechanisms, the more significant, the lower the initial rate of back chamber filling before heating like that of M-5 hummer.

Parameters and compressed air consumption

In the course of investigation the differential air pressure at restriction and the pressure with air temperature before its heating have been registered by differential manometer. According to these data the air consumption was calculated. In Fig. 3 the results of experiments on influence of compressed air heating on decrease in its consumption by pluggers of some types and sizes with different air distributors are presented, for comparison, theoretical dependencies of compressed air saving on its temperature at volume rate into cylinder and flow consumption are given [1]. Heating air from t_1 to t_2 consumption into cylinder decreases theoretically in the relationship [1]:

$$\Delta Q = \left(1 - \frac{t_1 + 273}{t_2 + 273}\right) 100\ \%,$$

but flow consumption in the relationship

$$\Delta Q = \left(1 - \sqrt{\frac{t_1 + 273}{t_2 + 273}}\right) 100\ \%.$$

It is obvious from experimental dependences that the nature of change in air consumption of pneumatic percussion tool is different from that of theoretical data. It is explained in the following way. Theoretical dependencies have been obtained by the assumption that stroke volume of cylinder chamber is constant, but outflow takes place constantly through a hole of the same square. In pneumatic percussion tools air is consumed not only for cylinder filling, but also for outflows. Besides, at temperature increase in compressed air the parameters of thermodynamic cycle change and energy characteristics of hammers increase to this or that extent. Naturally, at air temperature decrease energy parameters decrease and gas flow increases in air main.

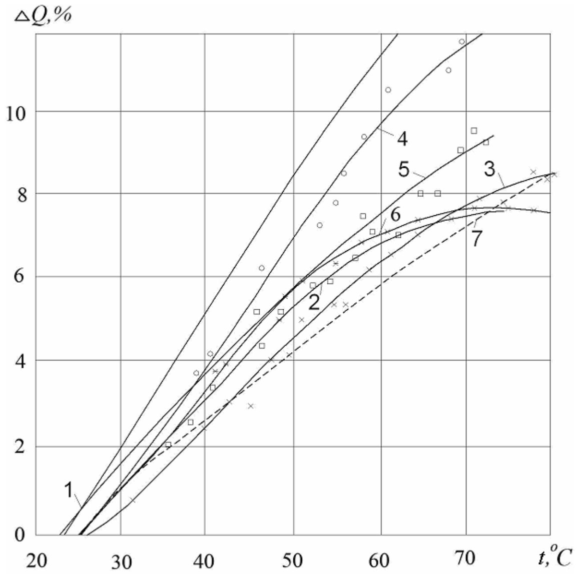

Fig. 3. *Dependence of compressed air saving on its temperature: 1, 7) at theoretical air consumption, into cylinder and flow, respectively; 2-6) hammers M-5, KE-22, MO-44, MO-9П, M-6 respectively*

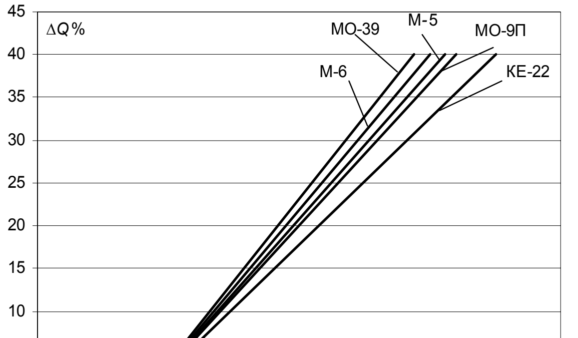

Fig. 4. *Dependence of change in air consumption on its pressure*

Degree of air saving is not the same for hammers of different type and size. Comparison of pluggers show that MO-44, possessing more significant stroke volume and less stroke frequency than MO-9П, has higher degree of air saving. The same is referred to M-6 and M-5 hammers. In comparison with pluggers, hammers of M series have significantly less stroke volume, more stroke frequency and nearly twice as higher specific air consumption, but their operation is characterised by long and relatively large air flows. Less percent of saving and change in decreasing air consumption of M hammers in comparison with pluggers is explained by the fact that essential increase in striker travel and energy parameters is accompanied by growth of air volume consumption. Time of compressed air outflow from the system through the front chamber into environment during back stroke of striker notably increases.

Increase of air pressure in the air main is known to result in growth of energy characteristics of the device. Experiment shows that compressed air consumption depends directly on its pressure in the system for all types of hammers under study (Fig. 4).

Influence of pressing force

According to the results of investigation experimental dependencies of change in compressed air consumption of hammers on pressing force are plotted, Fig. 5. Consumption at pressing force 170 H is taken as a standard. General regularity for all pneumatic percussion tools is increase in air consumption up to the definite level at raising pressing force.

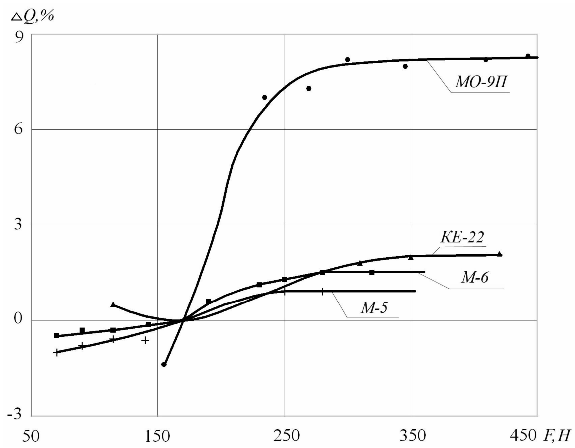

Fig. 5. *Changes in air consumption depending on pressing force F*

Changes in air consumption are explained by the fact that pressing force defines the behaviour of «tool – striker – case» system, i. e. energy parameters of pneumatic percussion devices. Hammer head makes complex oscillatory motion, consisting of vibration and cylinder withdrawal from tool restrictive bead. The greatest head withdrawal and maximal vibration amplitude is observed at low pressing force. General regularity for the hammers involved is decrease in value of hammer travel, stroke energy and increase in stroke frequency with rise of pressing force to definite level. At the value of pressing force definite for each type of hammer there is stabilization of energy parameters and air consumption. Quasi-stationary mode of M hammer operation appears earlier than that of KE-22 and MO-9П, since the latter internal shaking force is greater. Hammers of KE type have large diameter of tool shank, which is the main cause for higher required pressing force for standard operation than that of pluggers. On changing the value of air consumption one can quickly determine the beginning of stationary mode of pneumatic percussion device operation. Sharp change in air consumption of МО-9П hammer at pressing force less than 260 Н is explained by relative shift of helve, spring-loaded valve and case during operation. Decreasing pressing force helve and valve withdraw from hammer intermediate link, because of this efficient square of admission port reduces.

Conclusion

The regularities of changes in energy parameters and compressed air consumption of hand hammers at changing air parameters in the system and pressing force have been experimentally stated.

When increasing the temperature of compressed air, the energy characteristics, maximum and per-exhaust air pressure in the back chamber grow. The lower the pressing degree and maximum air pressure in the back chamber, the higher the growth of stroke energy and power. Among the types of hammers under study the most significant growth of energy power is observed in hammers of M types having relatively large volume of clearance space and low degree of air compression in the back chamber.

At heating the compressed air its consumption decreases sufficiently. The degree of saving in compressed air is not the same for different types of hammers, the more the payload volume and the less the stroke frequency, the higher the degree of saving in compressed air.

In production and operation of pneumatic percussion mechanisms of hammers and drills the influence of temperature of compressed air on its consumption and device operation should be taken into account.

Using hot compressed air or its special heating is characterized by high energy efficiency, for hammers of M type in particular.

Increase in pressing force on hammer helve is accompanied by the growth of compressed air consumption to the definite level. This level which corresponds to beginning of quasi-stationary operation mode is mainly determined by the value of shaking force in hammer. In hammers having valve intake in the helve, air consumption changes sharply and significantly at changes in pressing force up to limit value.

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DYNAMIC MODEL OF ELASTOPLASTIC CONTACT INTERACTION OF SMOOTH BODIES

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Dynamic model of introducing rigid smooth sphere into homogeneous elastoplastic hardenable solid body has been considered. On the basis of the model numerical-analytical dependencies describing the behaviour of solid body in elastoplastic region of contact interaction were suggested. The numerical-analytical dependencies allow us to take into consideration additional approach of contacting bodies owing to dynamic loading.

Demands of modern technology for construction design possessing mechanical reliability at low material consumption lead to development of optimal design in strength taking into account contact deformation. In terms of improvement of physical and mechanical concept on destruction mechanism of solid bodies the section of deformable body mechanics called fracture mechanics has been formed within the last three decades.

Creation of fracture mechanics made possible to interpret the processes of contact interaction from absolutely new point of view. Geometric localisation (in the contact region) of all forms of deformation (elastic and plastic) and destruction is known to be characteristics for contact interaction of solid bodies. Being at first local, destruction can then progress catastrophically and result in break of a sample or a detail. At present it is generally accepted that more than 80 % of failures in mechanisms, machines and devices are conditioned by the processes taking place in the contact zone of solid bodies. Investigations in this field as well as in strength tests are concerned with study of behaviour of material surface layers at impression of one body (indenter) into another. The strength tests provide information on mechanical properties of material and in study of this phenomenon significant success has been achieved. Investigations of fracture mechanics is wrongly paid little attention, which is obviously explained by complexity of formation and growth processes of surface fractures and absence of corresponding theoretical methods of analysis. However, study of contact destruction is of great scientific and practical importance.