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ФОРМАЛАР КОШУНДУУЛАРЫНЫН ИМПУЛЬСТУУ НАГРУЗКАДАГЫ ТЫГЫЗДОО МЕХАНИЗМИ

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МЕХАНИЗМ УПЛОТНЕНИЯ ФОРМОВОЧНЫХ СМЕСЕЙ ПРИ ИМПУЛЬСНОМ НАГРУЖЕНИИ

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THE MECHANISM OF COMPACTING A MOLDING MIXTURE UNDER THE IMPULSIVE LOADING

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Формалар кошундууларыны кварц кумдан, байланыштыруучу зат жана көңдөйлөрдөн турат. Формалар кошундууларынын тыгыздоосу деп чоң (конгломераттардын ортосундагы) жана кичинекей (кумдардын ортосундагы) көңдөйлөр көлөмдөрунун кичиреиши деп тушунөбуз. Эксперименталдуу изилдөөлөр [1,2,3] формалар кошундууларлардын ичиндеги импульстуу нагрузка толкун турдөө тараганын тактайт. Ошол изидөөлөр жана практикалык маалыматтардын негизинде формалар кошундууларындагы импульстуу нагрузкада болгон процесстер төмөндө каралат.

Формовочная смесь представляет собой среду, состоящую из частиц кварцевого песка, связующего и пор. Уплотнение формовочной смеси рассматривается как процесс уменьшения объема крупных (между конгломератами) и мелких (между самими частицами) пор. Экспериментальными исследованиями [1,2,3] подтвержден волновой характер распространения нагрузок формовой смеси при импульсных методах уплотнения. На основе этих исследований и практических данных ниже рассмотрены процессы, происходящие в формовочной смеси при импульсном нагружении.

The molding mixture represents the medium consisting from quartz sand particles covered by thin stratum binder and pore. The compacting of molding mixture is considered as process of volume diminution of the pore between conglomerates and pore between particles themselves. By experimental research it [1, 2, 3] has been confirmed a wave character of load's distribution of the molding mixture under the impulse methods of compacting. Based on these researches and practical data the following paper is considered processes, which happen in molding mixture under the impulsive loading.

Experimental researches are carried out by the industrial molding machine of gas-pulse compacting (Gas-Impact process). On fig. 1 change of pressure of gases and a gradient of pressure of gases above a free surface of the compacted mould is presented. Characteristic duration of process for similar systems of compacting is accepted for considering in limits 0,03…0,05 s., that is the period of increase of a gradient of pressure of gases up to the maximal values and its reduction up to negative is considered (fig. 1). This period may be conditionally named the first or basic period of compacting processes.

Negative values of a gradient the pressure describing recession of pressure of gases up to atmospheric, operate during relative long time – 0,8…1,2 s. This period of process of the impulsive compacting, conditionally named by us as the second has not been investigated. However, as shown direct measurements of density at the end of process, additional compacting in this period may make up to 40 % from rated compacting in the basic period of process [3]. Characteristic diagrams of change accelerations, velocities and displacements of a molding mixtures layer and a pattern plate to the basic period of compacting are presented on fig. 2. The analysis of the received results from positions of propagation of the direct and reflected waves allows specifying the periods of action of the basic dynamic processes in a compacted molding mixture:

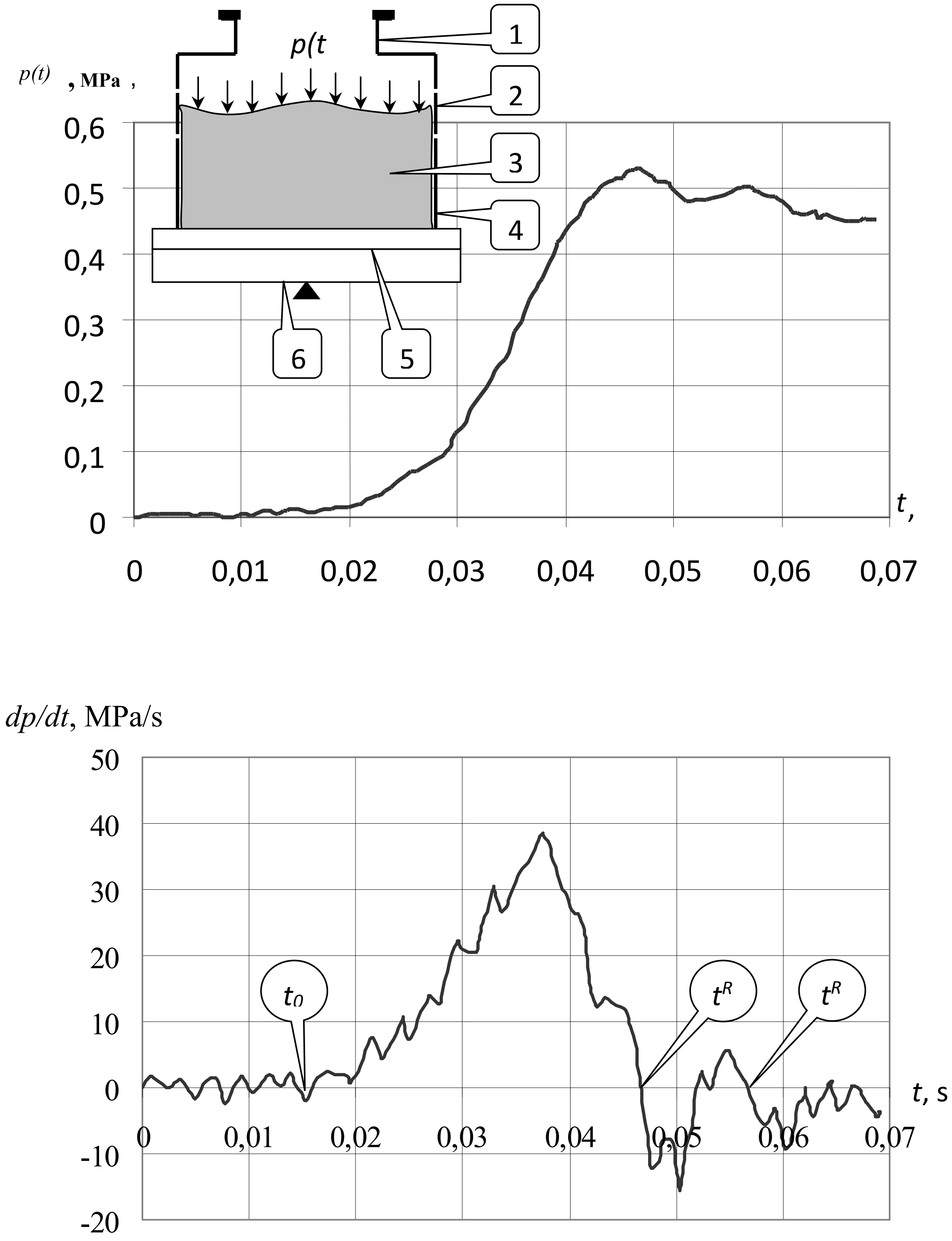

Fig. 1. Change of pressure *p(t)* and a gradient of pressure *dp/dt* above a free surface of a molding mixture at Gas-Impact process: 1 – combustor; 2 – framework; 3 – molding sand mixture; 4 – flask; 5 – pattern plate; 6 – table (basis) of the machine; revolutions of the fan of the gas-pulse machine n = 1750 rev/min.

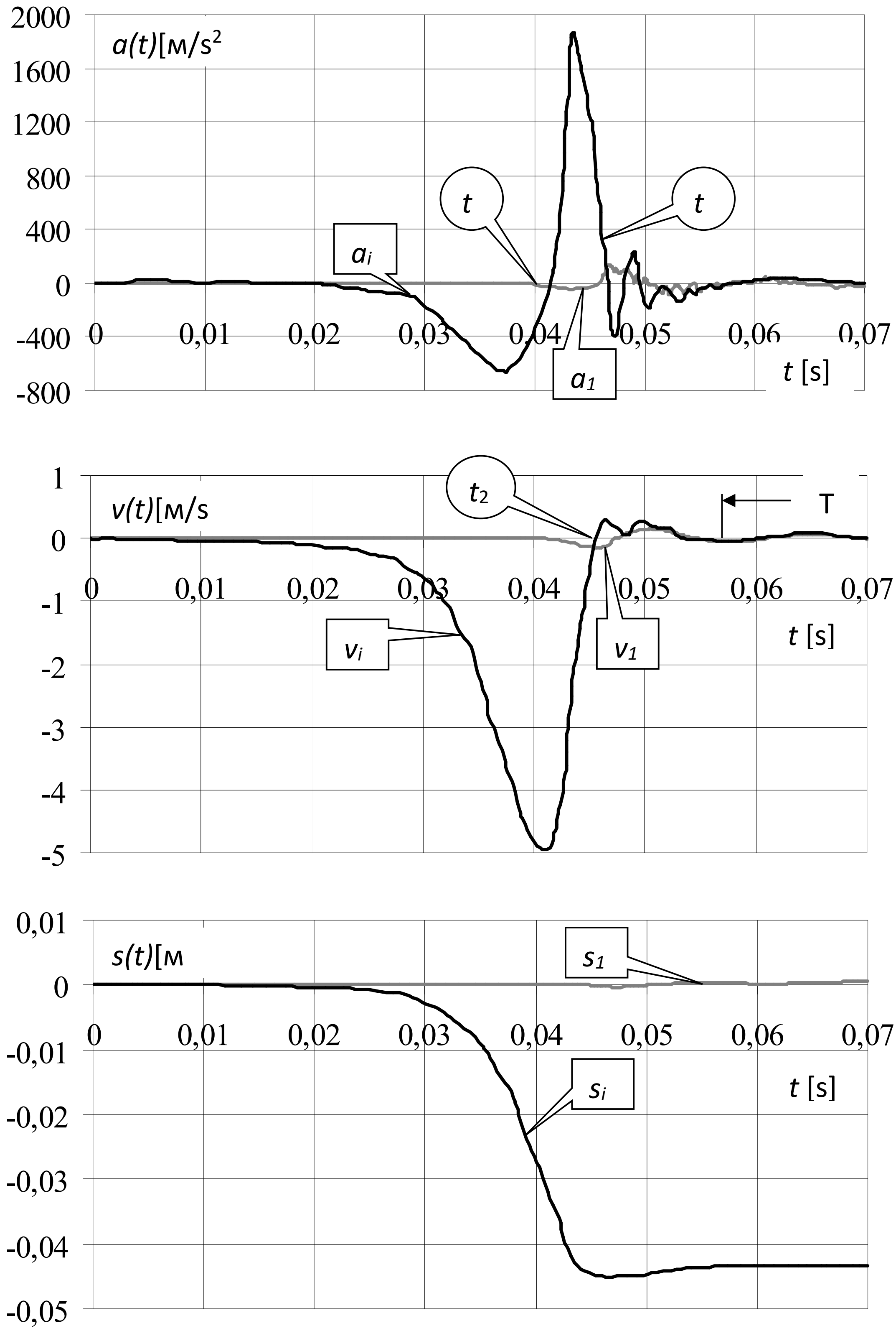

Fig. 2. Experimental data at Gas-Impact process: a_i, v_i, s_i and a_1, v_1, s_1- accelerations, velocities, displacements of a molding mixtures layer and a pattern plate.

– racing, braking and damped oscillation of layers, conglomerates and particles of a molding mixture. The periods of process of compacting may be submitted as:

- The period 1, $t_0 > t > 0$, where t_0 - time of achievement of front of an air – gas wave of a free surface of a molding mixture. Values t_0 are determined by time of the beginning of increase of values *dp / dt* (fig. 1).

- The period 2, $t_1 > t > t_0$, where t_1 - time of achievements of front of indignations (a wave of compression) pattern plate. It is the period of racing of layers of a molding mixture, which occurs from a free surface of the mold to a pattern plate. Value t_1 by the beginning of a pattern plate's acceleration is determined (fig. 2). Time-stamp t_1 may be accepted also as a time of the beginning of action of the wave reflected from a pattern plate.

- The period 3, $t_2 > t > t_1$, where t_2 - time of achievement of the reflected wave of a free surface of the mould and its reflection. Values t_2 it is determined by achievement of zero of velocity of a free layer during compacting (fig. 2). It is the period of braking of layers of a molding mixture, which occur from a pattern plate to a free surface of the mould.

- The period 4, $t_3 > t > t_2$, where t_3- the beginning of oscillation of layers of a molding mixture. It is the period of stabilization of agitation transmission when there are an averaging compressions and deformations after repeated passage of a wave of compression.

- The period 5, $t > t_3$, the period of oscillation of layers of molding mixture.

In timing characteristics it is necessary to note time-stamp t^R - the beginning of action of waves of nloading which may be determined by zero *dp/dt* (fig. 1).

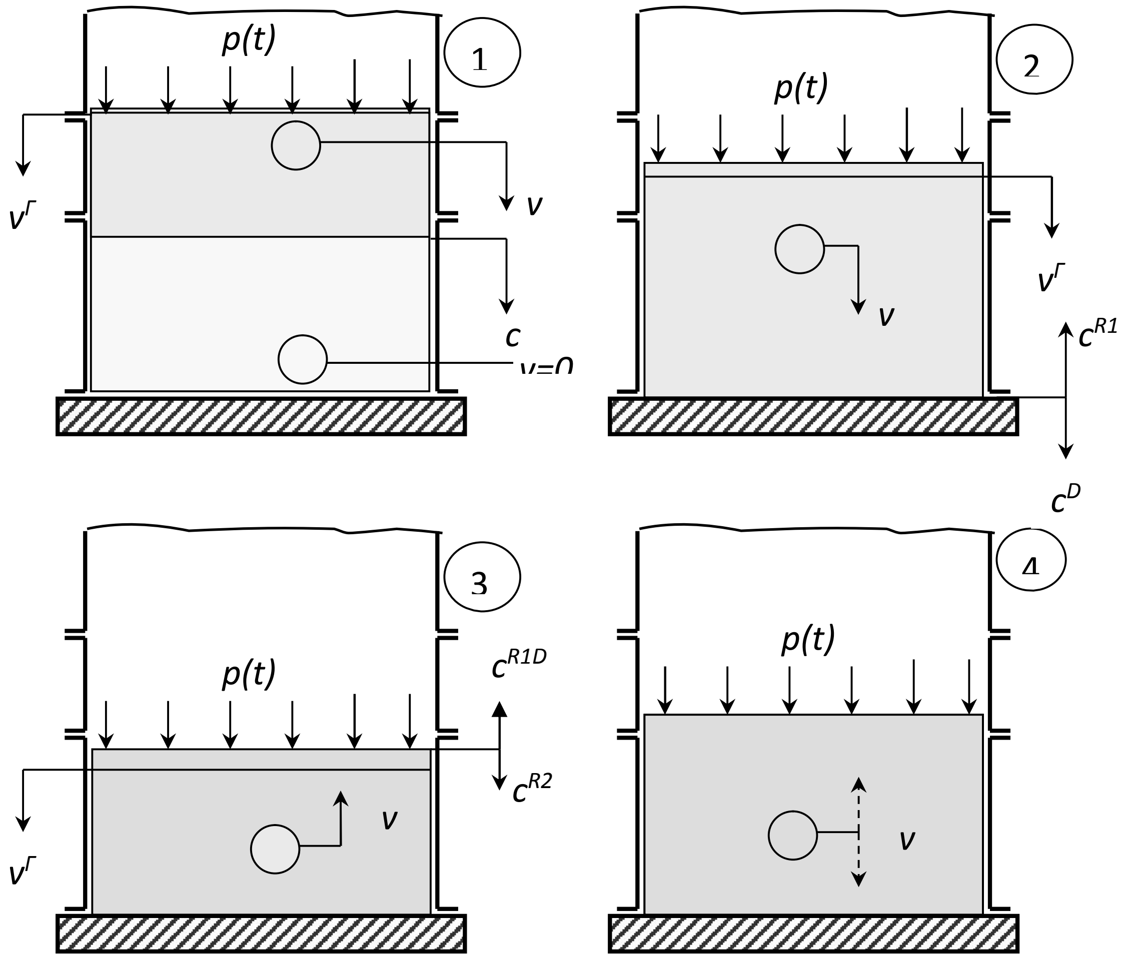

Fig. 3. The moments of passage 1 - 4 processes of impulsive compacting of a molding mixture:
1 – in the beginning of process; 2 – achievement by a wave of compression of a pattern plate; 3 - reflection waves from a free surface of the mould; 4 - at the end of the first period of compacting processes.

On the basis of the received results the below-mentioned picture of compacting process of molding mixture is offered at impulsive loading (fig. 3). At achievement of front of a shock wave of gases a free surface of the mould, in a molding mixture there is a wave of compression, which is transmitted on a molding mixture with velocity *c* (fig. 3 - 1). Examined process is characterized "smooth" loading, without jumps of parameters at the front waves of compression. Behind front of a wave of compression current of particles of the molding mixture, characterized by filling pore (repacking) and deformation binding begins. Deformation of particles of quartz sand at the greatest possible working pressure of gas equal 0,5…0,6 MPa, practically is absent. Current – averaged of particles of a molding mixture may be characterized velocity $v_i(t)$ (acceleration $a_i(t)$, displacement $s_i(t)$) a considered layer of the molding sand mixture, received of experimental data (fig. 2). Gas from a free surface of the mould will penetrate with velocity $v^Г$ on the certain depth. It's rather penetration is at a loss because of continuous reduction pore and the formed layer of sand particles with an air-gas mix moves at this stage with the top layer of the form. Air in pore goes also downwards and its average velocity in the beginning more, than sand particles. Then, as approaching a pattern plate and increase backpressure of pore air, velocity of moving of air in pore decreases and there may come the moment when it is equal to velocity current of particles of a molding sand mixture (presumably at achievement by velocities of particles of a maximum).

At achievement of front of a wave of compression of a pattern plate (fig. 3 - 2) are formed the reflected wave which is propagating from a pattern plate to a free surface with speed c^{R1} and taking place through a pattern plate and elements of the machine a wave with velocity c^{D}. In these period particles of all layers of a molding mixture have the growing velocity directed downwards. Acceleration of racing of layers of a molding sand mixture, since top, achieves approximately same level for the given loading. Achievement of a maximum of velocities of layers of a molding sand mixture and their reduction begins with the bottom layers. Thus the hypothesis according to which, the moment of achievement of zero of velocity of a layer of a molding sand mixture corresponds to achievement of front of the reflected wave of a considered layer is accepted. Change of velocity of layers of a molding sand mixture from the maximal values up to zero determinates the period of braking at which displacement of layers of a molding mixture, beginning from bottom, achieve a maximum.

At achievement of the reflected wave of a free surface (fig. 3 - 3) are formed the taking place wave extending in a gas cavity with velocity c^{R1D} and a reflected wave, extending with velocity c^{R2} which is imposed on the previous waves. Particles of all layers of a molding mixture at this moment have the velocity, directed to opposite initial direction. The displacement of particles directed in this connection back, is connected by elastic properties of a deformable layer of the molding mixture, determined elastic properties binding and height of a layer.

Changes of acceleration marks, connected with passage of waves, do not influence character of displacement, which are stabilized for the considered of timeslot on the certain values on which residual deformations and density are calculated. However in this period (fig. 3 - 4) as it was already marked above, occurs averaging of compressions, proceed action of external pressure of gases and deformations of repacking. It is supposed, that the reason of compacting of a molding mixture are the forced oscillation of particles of a molding mixture which have others amplitude-frequency characteristics, than at passage of waves of compression to the first period of compacting. Expected displacements of a layer of a molding mixture at the second stage are submitted on fig. 4.

From fig. 2 it is evident that the beginning of the second period of process of compacting of molding mixtures is characterized by occurrence of low-frequency oscillations, with period T (see also fig. 4). In researches [4, 5 etc.] it is marked that at the certain parameters of vibrating load occurs sharp reduction of internal friction of a molding mixture, i.e. substantial growth of mobility of a molding mixture takes place. If it is caused by sharp reduction of a corner of internal friction of a molding mixture and thus its kinematical parameters are kept, by analogy to the mechanism, it is possible to explain compacting of a molding mixture offered in work [6] as consequence of occurrence of instability of internal structure of the molding mixture resulting in its reorganization.

Other source of oscillations of particles of a molding mixture, maybe, transfers of vibrations of a pattern plate of the molding machine which are caused by passage of waves through elements of the machine. It is necessary to note that frequency of vibrations of a pattern plate a little bit differs from frequency of expected low-frequency oscillations of a molding mixture. However, these results demand realization of more detailed special researches.

On the basis of the carried out analysis of the mechanism of compacting of molding mixtures are allocated characteristic processes in realization of various methods impulsive compacting. This current

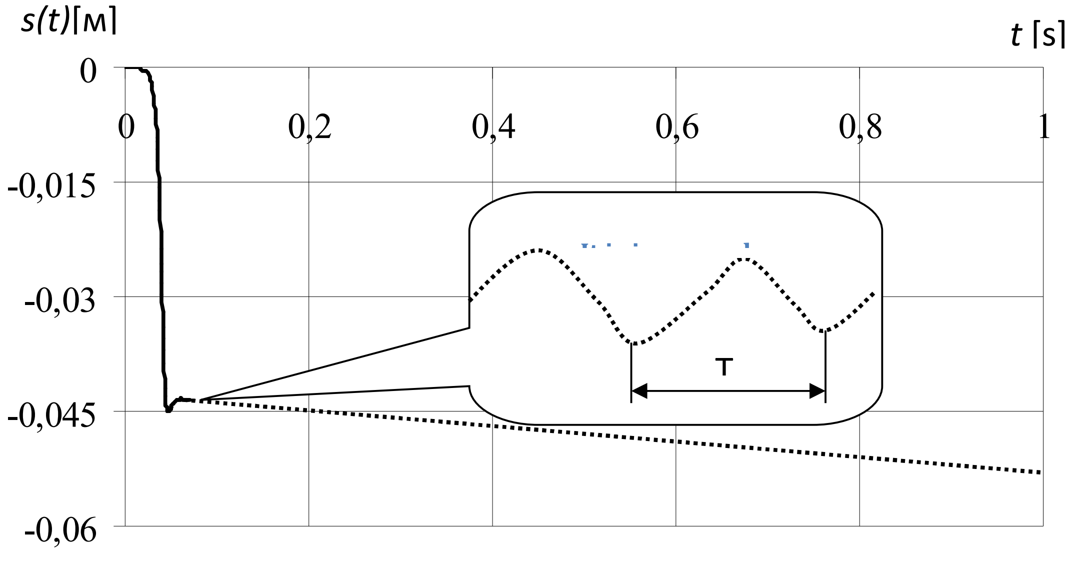

Fig. 4. Displacement of layer molding mixes during the process of impulsive compacting.

of the compacting caused by action of direct and reflected waves at the first stage and additional compacting, caused by the subsequent oscillations of particles of a molding mixture. The current characteristics of compacting of molding mixes are determined by a gradient of external pressure of gases *dp/dt*. So, at dp/dt_{max} > 30…35 MPa/s, characteristic for gas-pulse (GAS-IMPACT) and air-pulse (AIR-IMPACT) methods, transfer of forces to a wave of compression occurs due to contacts between particles and the through filtration of gas through the compacted mould at the first stage is limited. Filtration processes (including removal pore air) at these methods take place in the second, "longer" stage of compacting determined by internal structure of a molding mixture. Considered processes do not demand additional compacting a molding mixture by final squeezing, as against SEIATSU - process, where development of working pressure of gas above a free surface of a molding mixture *dp/dt* < 1… 2 MPa/s. In this case filtration processes proceed in both stages of compacting and the intense condition of a molding mixture resulting in its compacting, is determined as well by force of interaction sand particles and gas in a wave. At SEIATSU - process it is required additional compacting to a molding mixture by final squeezing.

The molding sand mixture is complex system with distributed in volume of the mould parameters, which vary during compacting. Rapidity of processes at impulse methods of compacting also complicates an exact establishment of the mechanism of deformations in volume of the compacted mould. It is one of the reasons of that developed systems of compacting are based more on results of the practical data, than the theory. At preservation of present trends of application of impulse methods (GAS-IMPACT, AIR-IMPACT, SEIATSU and their updating) for compacting of sand moulds, development of the theory of compacting becomes the major problem of creation the highly effective molding equipment. The technique of researches is based on the wave approach, which was not found while wide application by consideration of similar systems. The received results may become base for the further researches, including simulation the processes of impulsive compacting at various operations and parameters in system "molding machine - sand mixture".

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