UNIVERSAL TECHNOLOGY

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The development of new technologies for the manufacture of various products from powder materials has been and remains in the focus of experts' attention in this and other countries. In recent time, however, specialists have been increasingly attracted by studies of the mechanisms and processes of what they call the self-organization of such materials– the emergence of orderly structures from chaos. The main feature of such processes in abstract and theoretical terms consists in the fact that they are non-equilibrial and occur in open systems which differ from the closed ones by the fact that one can input not only energy, but also substances. The latter then reenter the sphere of their utilization but with an already orderly structure.

Shore with a belt of compacted sand.

Today scientists are tracing such processes of what they call self-organization in both the living and the non-living, or material, nature. The German physicist G. Khaken developed a whole theory of synergy, or correlated action, and the number of its followers continues to grow in view of the fact that it not only explains certain neutral phenomena, but makes it possible to introduce new principles of processing of loose or bulk materials—much more effective than the conventional ones. An impressive example of this potential is offered by what we here call the universal, or versatile, technology with a fancy name of RUSSKIYE KACHELY (Russian Swing).

MYSTERIES OF NATURE

The term of loose, or bulk materials usually applies to all kinds of mixtures of crushed hard particles (powders) with air and moisture. In their free fall upon a hard horizontal surface they form a cone-shaped heap with a slope angle within a range of 25 to 50 degrees. The range of such materials includes ground, rubble, sand, sawdust, coal and ore chippings, concrete, asphalt-concrete, ceramic, refractory and metal powders and materials, etc.

According to the established opinion of specialists in the field, practically most, if not all of the listed materials requires its own specific processing technology. And the thing of principle, or basic importance is that no matter what material we are dealing with its processing should be conducted according to the following sequence—dozing, pouring the friable powder into a mold or a working panel and its compression. What one gets as a result are building panels and slabs, pipes, briquets, automobile roads, etc. And one should note this point that the central point for the traditional technologies is the aforesaid sequence of operations and its main objective is obtaining a product of the exact shape and the required density all along its height and volume.

And one more thing. Man has been dealing with loose or bulk materials for hundreds of years. Starting from some of the most primitive tools and passing on to more and more complicated machinery and equipment, people have invariably followed the basic sequence of the process. As a result even today 90 percent of the required energy is simply wasted on such things as friction between grains of material, its friction with the walls of the mold, compression of the trapped air, activation of batchers or dosing devices and controls and also on the making of heavy and strong molds of a much greater mass than the end products.

Summing it up, one can say that the commonly accepted processing techniques of friable materials have reached their limit. Any attempts at improving the traditional technologies push up production costs at no appreciable technological effect. And the obvious conclusion is that the only way to improve the situation is to move away from the established stereotypes. In doing that it could pay to take a closer look at the way Mother Nature handles such problems.

And Nature resolves all of these things at one single stroke which combines dosing or batching, feeding or loading and compaction. It is like a surf wave forming a densely compact border on a sandy beach. One can walk and even ride a bike upon it. Or take another example: due to some mysterious mechanisms rather dense geological structures are formed from sedimentary rocks in the upper layers of the Earth without any large pressures being involved. Geologists call such processes diagenesis or catagenesis, which does nothing to improve the situation so that the nature of this phenomenon remains a puzzle.

Having said all that, where can we look for the answers to these seemingly simple, but also very difficult questions?

"FLOWING EDGE" EFFECT

It was some 30 years ago that one of the authors of this article—Nikolai Korolev—made some interesting observations. He was intrigued by a constantly repeated fact: when a rigid stamp or die is pressed into some friable material its particles do not move in some chaotic manner, not just scatter under the pressure in some random way, as living beings would probably do under the circumstances, but "act" in a just the opposite manner, moving in and concentrating within this active surface, producing, like a swarm of bees, a cone-shaped, or edge-shaped, nucleus. And this "piling up" is the denser the greater is the resistance of the friable material. The formation of this nucleus offers a vivid example of what we call a closed equilibrium system—a cyclic technological process of formation of a dense structure.

To produce the effect of a kind of diagenesis (like the one in nature) it is necessary to maintain an uninterrupted, or stationary, process of regeneration of a compact nucleus, pumping in from without both energy and matter and also evacuating the orderly structures into the environment. As for our scientists, they tried to produce a nucleus of this kind not by impressing a die into powder, but acting in the opposite way. They impressed powder constantly supplied from without into powder of the same kind, located under the die, or stamp, which is oscillating up and down within some fixed limits. And the attempt turned out to be a success.

There appeared in what we call this open system a stationary non-equilibrium state, which is known in synergetics as "flowing balance" and is characterized by a dense homogeneous structure. The effect achieved in this way was called a "flowing edge". In the subsequent studies and practical experiments it was established that it can be easily reproduced directly in a mold or without molds and in any given place. It can be used to "grow" from various powders and friable materials, slabs, sheets, pipes, and so on in horizontal, inclined or vertical positions.

A major feature of the above effect consists in the fact that a "flowing edge" is produced only when the compacted material is open at least on one side. And if it is closed on all sides the desirable effect will not occur no matter what we do or what amounts of energy are applied.

If one compares the suggested new technology of processing friable materials with the traditional methods, the

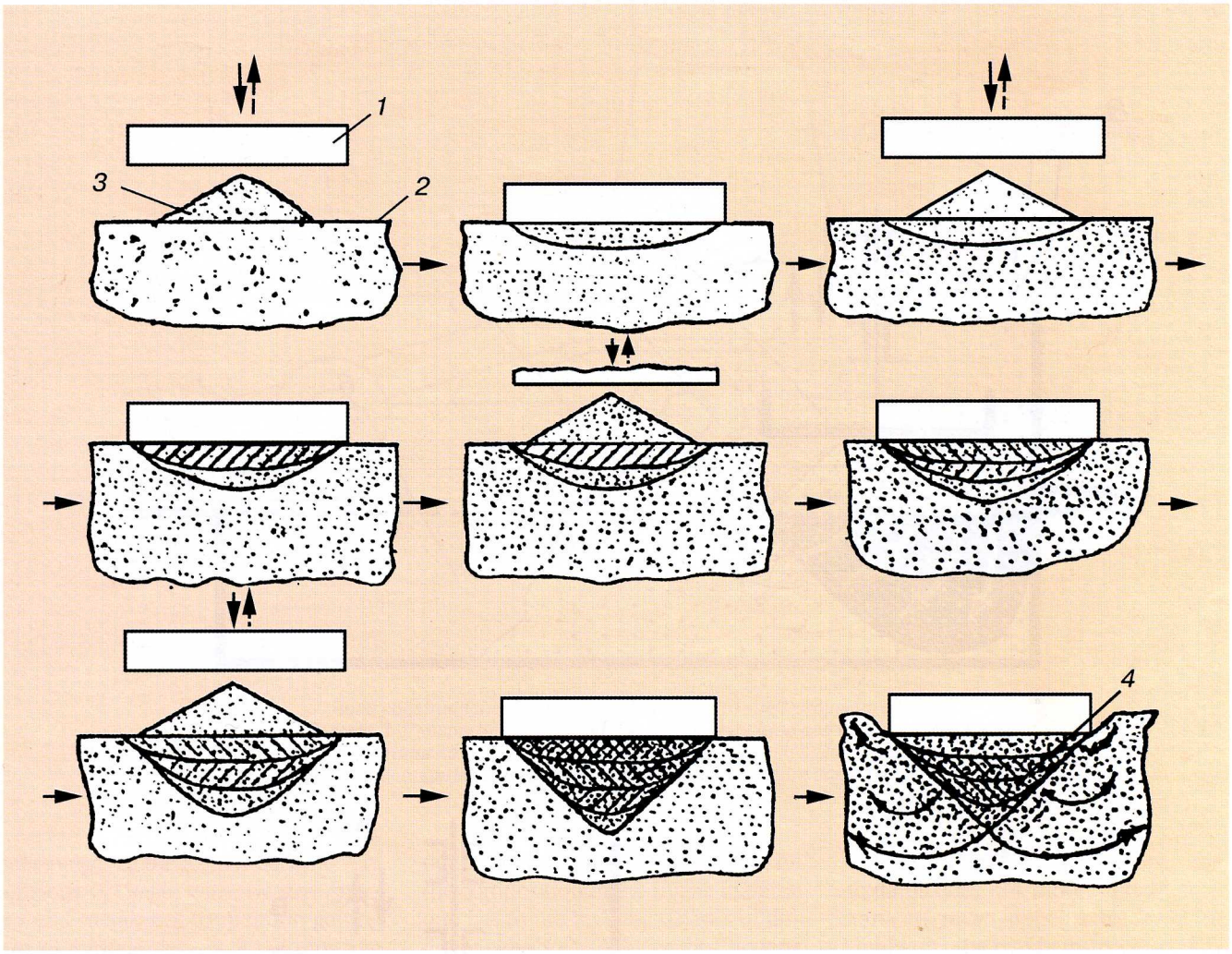
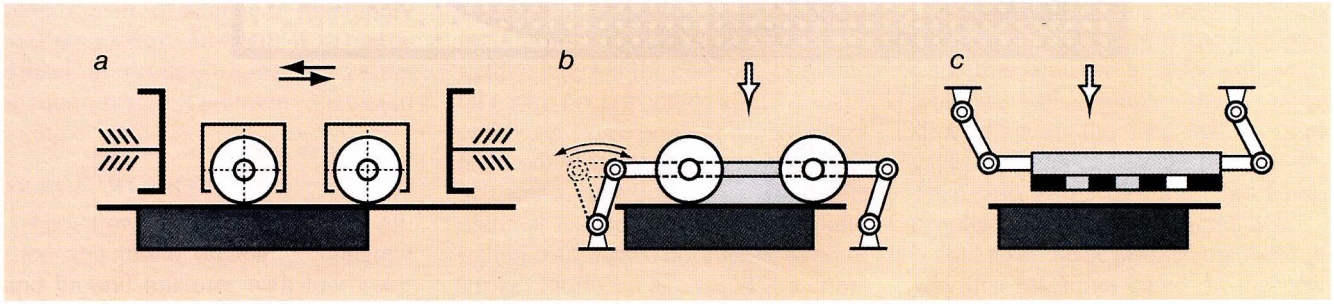
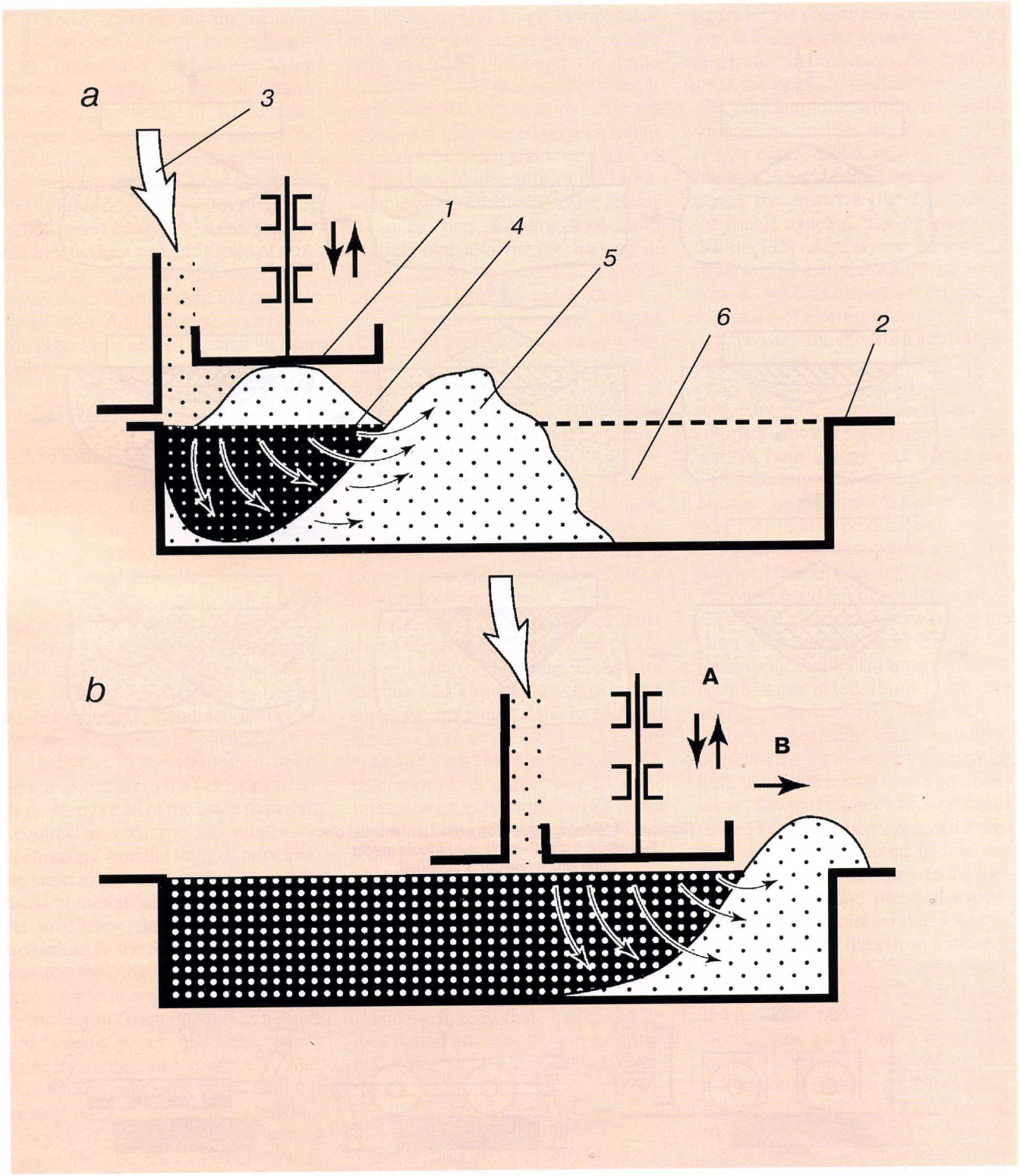


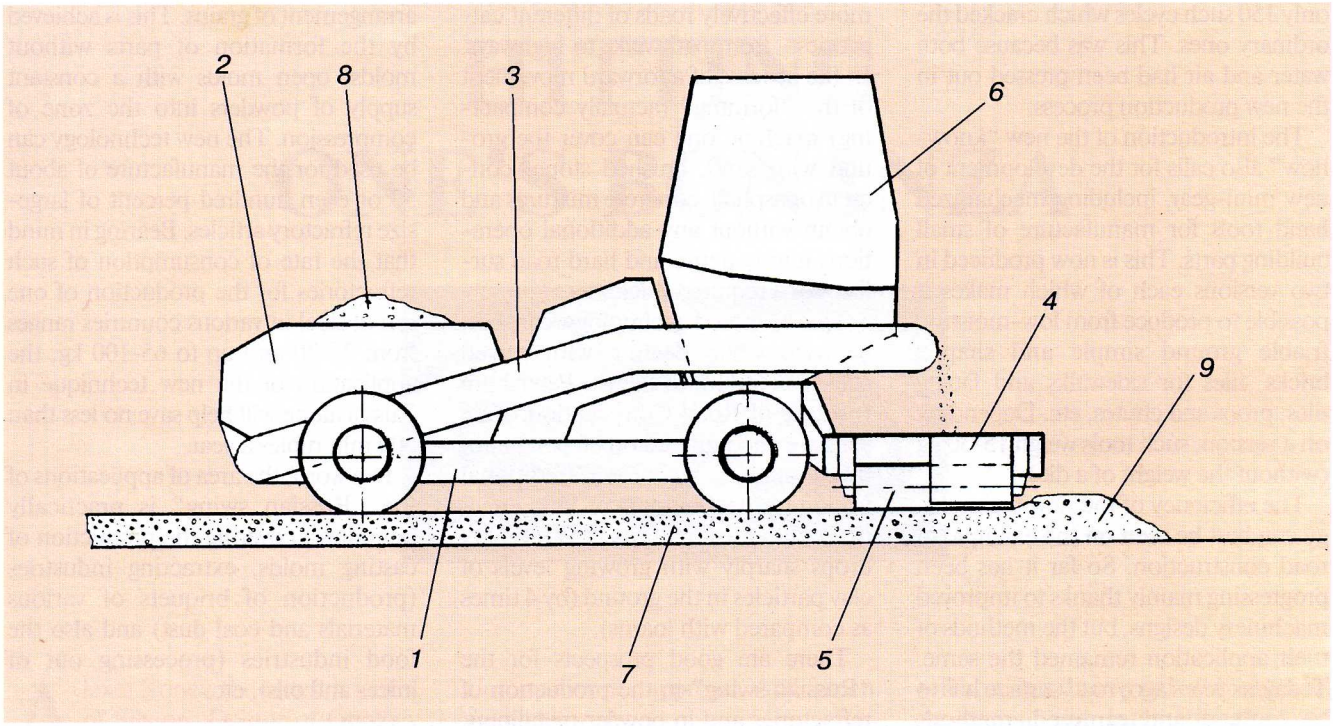
Diagram of "flowing edge" formation under a flat die:
1– swinging die; 2–surface of friable media
upon which powder is supplied;
3–supplied powder; 4–"flowing edge".



Actuator of "Russian swing":
a) with a roller stamp, moving from right to left;
b) with a roller stamp moving up and down
and from right to left;
c) with a meshed stamp moving
up and down and from right to left.



"Russian swing" in operation: a) beginning of casting;
b) middle of the process; 1–actuator; 2–mold; 3–feed of friable material;
4–compacted core or edge; 5–squeezing out of mass from under the actuator;
6–empty part of the mold; arrow A indicates the swing direction of the actuator;
arrow B–the movement of the actuator relative to the mold.
Portable tool for making building parts for house and home.



Road construction using the "Russian swing": 1–self-propelled chassis; 2–tank; 3–transporter; 4–pressure feeder; 5–stabilizing and trimming device; 6–operator cabin; 7–compact layer installed; 8–road building material; 9–material squeezed out from under the pressure applicator.

advantages of the former become very obvious. To begin with, we save energy and metal, not to mention getting rid of various devices for dosing the friable material supplied. The number of various control devices is also reduced at no sacrifice to the product quality. And the latter is even considerably improved.

The introduction of the new technology, needless to say, called for the development of a range of machinery and equipment. In them it is reproduced by some original operating mechanisms nicknamed "Russian swing".

HOW IT WORKS?

The "flowing edge" effect has been tried and tested on loams, concrete and ground mixtures with low water contents, vitreous-ceramic and ceramic materials, foundry materials, coal dust and metal powders (aluminum, iron, cobalt, copper, etc.). In all of these cases the mechanism of formation of dense orderly structures turned out to be the same. But depending on the composition of the friable material one has to use pressing devices of different capacity to achieve the "flowing edge" state.

The "Russian swing" mechanism can be best illustrated by examples from the production of various building parts. The traditional materials, or mass, used are concrete mixtures, ground, etc. at moisture levels of 6 to 14 percent. What we call the "actuator" moved up and down and from right to left over the edge of a horizontal mold, open from to, until it touches the top of the product being manufactured. At every upward stroke of the actuator a new portion of the friable material is supplied under the die and is then compressed during a downward stroke. Produced as a result is a compact nucleus, or edge. The continued supply of the raw makes this edge "leak" which is demonstrated by the mix being pressed out from under the actuator when the limit of compaction is reached.

Before this "leak" develops, the actuator does not move, and when it starts to move it helps to form, or "build up" the part being produced by generating a "flowing edge" which takes place at the rate which is equal or lower than the rate of pressing out, or extrusion. We know from practical experience that building parts can be manufactured at rates of 0.5-3 running m/min.

To prevent the mix moving in the opposite direction from the required one, the actuator is fitted out with what we call a safety "sizing" slide shoe. Due to the fact that air and excessive water can escape through the open side of the die, the parts being produced do not expand and crack.

And it should be pointed out that the very first machines based on the new principle turned out parts twice as durable than those produced by traditional methods. Runway slabs, for example, (0.14×2×6 m) in size were not damaged when exposed to 500 "freeze-thaw" cycles as compared with

only 150 such cycles which cracked the ordinary ones. This was because both water and air had been pressed out in the new production process.

The introduction of the new "know-how" also calls for the development of new mini-gear, including mechanized hand tools for manufacture of small building parts. This is now produced in two versions each of which makes it possible to produce from low-moisture friable ground simple and shaped bricks, tiles for sidewalks and facing tiles, props and chutes, etc. Depending on a version, such tools weigh 15-30 kg (without the weight of a die).

The efficiency of the new technology can best be seen on the example of road construction. So far it has been progressing mainly thanks to improved machinery designs, but the methods of their application remained the same. Today, as years ago, road surface has to be tamped and rammed—methods long outdated which often fail to produce the expected results.

The introduction of the "Russian swing" makes it possible to build much more effectively roads of different categories— from pathwalks to highways. In the process of a forward movement of the "forming" (actually compacting) machine one can cover the ground with sand, crushed stone, concrete or asphalt-concrete mixtures and obtain without any additional operations utterly dense and hard road surfaces of a required thickness.

The proposed technology can best be used when dealing with mixed soils. According to the St. Petersburg Institute of Road Construction, such soils are encountered on 86 percent of this country's highways. Traditional imported machinery is of little effect in such cases and its productivity drops sharply with growing levels of clay particles in the ground (by 4 times as compared with loams).

There are good prospects for the "Russian swing" in the production of refractories and in powder metallurgy. This is, above all, due to the possibility of producing parts of large dimensions with a preset compact structure and also with a laminated (multilayer) arrangement of grains. This is achieved by the formation of parts without molds, open molds with a constant supply of powders into the zone of compression. The new technology can be used for the manufacture of about 50 or even hundred percent of large-size refractory articles. Bearing in mind that the rate of consumption of such refractories for the production of one ton of steel in various countries ranges from 25-30 and up to 65-100 kg, the application of the new technique in Russia alone will help save no less than 500 mln rubles a year.

In a word, the area of applications of the "Russian swing" is practically boundless, covering the production of casting molds, extracting industries (production of briquets of various materials and coal dust) and also the food industries (processing out of juices and oils), etc.

Illustrations provided by the authors