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# RUSSIAN-MADE STEEL-CASTING SYSTEMS AND REFRACTORY PRODUCTION FACILITIES AT THE NPP "VULKAN-TM"[1]

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This article describes the latest advances at the "Vulkan-TM" Scientific-Industrial Association in the production of steel-casting systems and equipment for the secondary treatment of steel. It covers the main stages in the development of the company's innovative technologies, including a discussion of the advantages and design features of its state-of-the-art slide gates and equipment that protects steel from secondary oxidation. Special attention is given to the direction of its refractories business and the most recent progress in that area.

**Keywords:** new-generation steel-casting systems, slide gates, equipment and refractories for the secondary treatment of steel, pinch-roller system.

The "Vulkan-TM" Scientific-Industrial Association has been developing new-generation steel-casting systems and refractories to meet the needs the metallurgical and foundry industries for more than 17 years (Fig. 1).

Vulkan-TM occupies a strong position in the market for steel-casting equipment largely because it makes innovative, competitive products that are often unique and have been developed on a scientifically sound basis. Manufacturing operations at Vulkan-TM are focused mainly on the following:

– steel-casting systems for high-productivity casting;
– complementary refractory products encased in metal;
– equipment and refractories for the secondary treatment of steel, including bottom-injection systems
– unshaped refractories.

Throughout its existence, Vulkan-TM has been characterized by stable growth thanks to the implementation of innovative solutions to many of the problems encountered in design and manufacturing (Fig. 2).

Since its inception, the company has designed and built advanced systems for the stopperless casting of steel from ladles with capacities ranging from 2 to 300 tons. This includes the fabrication of slide gates and refractory products

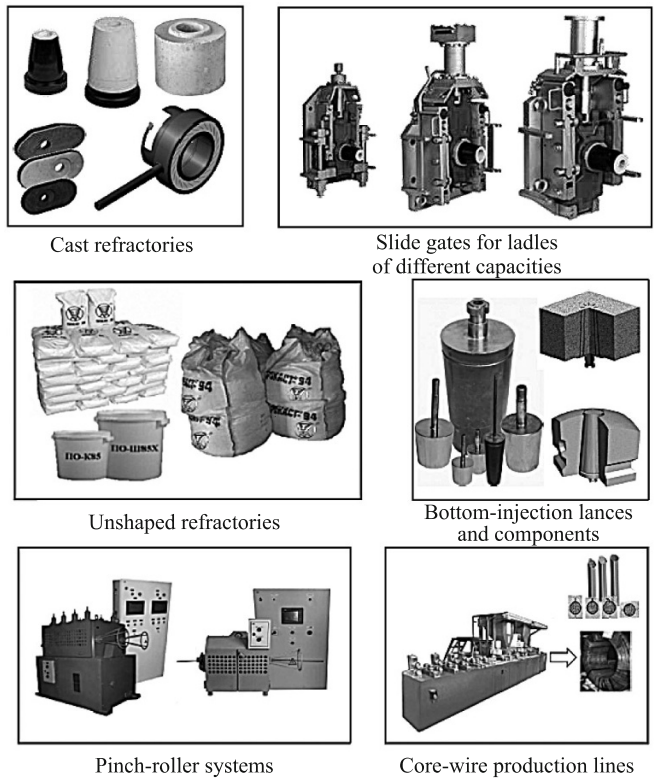


**Fig. 1.** Products of the NPP "Vulkan-TM."

[1] From materials of the International Conference of Refractory Specialists and Metallurgists (March 19 – 20, 2015, Moscow).

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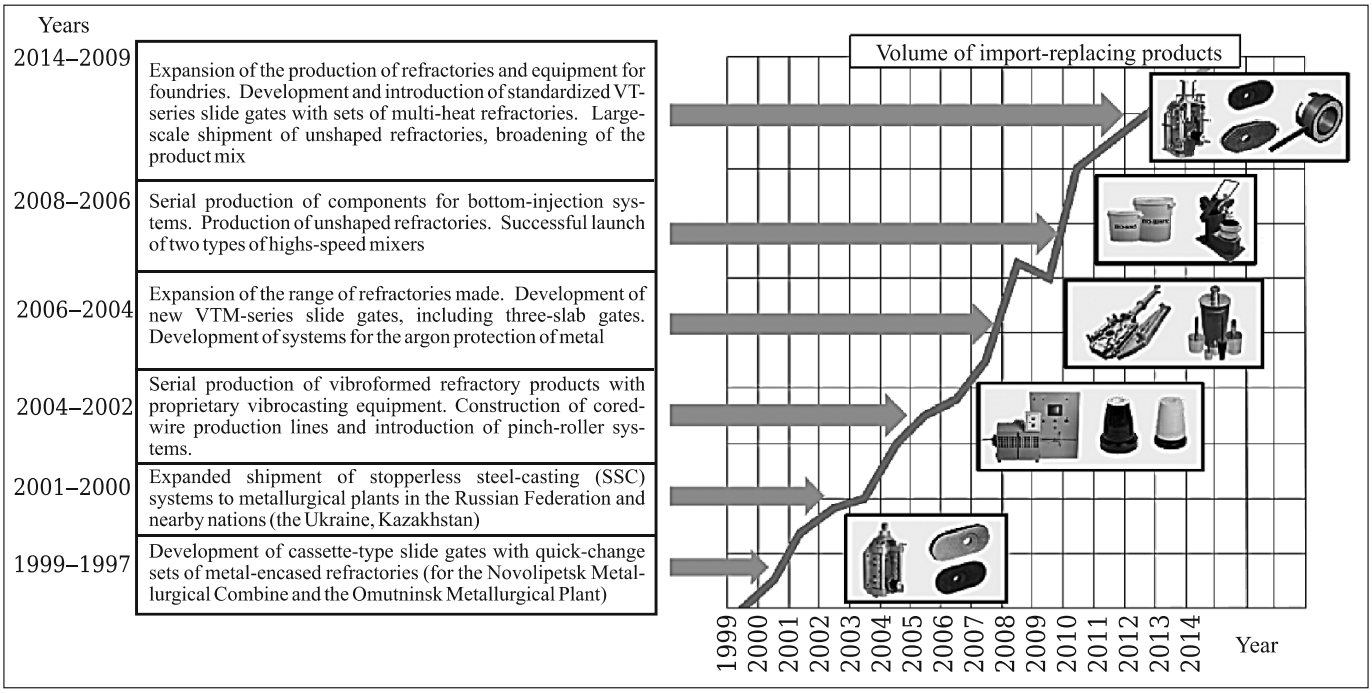


**Fig. 2.** Stages in the growth of the company.

for the gates, as well as on-site assembly. Parallel with work on the metal part of the gates, the company developed a standard set of metal-enshrouded and metal-encased refractories for the teeming assembly. During the same period, Vulkan-TM began successful use of the refractories on high-capacity continuous caster No. 6 in BOF shop No. 1 at the Novolipetsk Metallurgical Combine and in the open-hearth shop at the Omutninsk Metallurgical Plant. Since 2000, these products have also been used in the electric steelmaking shop at the Nizhneserginsky Metallurgical-Hardware Factory and other metallurgical plants in Russia and nearby countries (the Ukraine, Kazakhstan).

Since 2002, Vulkan-TM has serially produced vibroformed refractory products made from thixotropic low-cement mixes on vibrocasting equipment of the company's own design. Work has started on building automated complexes that produce cored wire and insert it into melts (the complexes include production lines and pinch-roller systems). Use of the complexes has made it possible to treat steel and cast iron outside the furnace and improve the quality of these products.

Components of different shapes and sizes for bottom-injection systems have been serially produced by the company since 2006. In 2008, Vulkan-TM mastered the production of unshaped refractories and now makes a number of refractory mixes, ramming mixes, concretes, and mortars for different service conditions. Two types of high-speed mixers were built and are now being used to make the refractory products.

Vulkan-TM also began making different lines of refractory products during the same period. Linings were made for one customer for use in factory and laboratory heating furnaces of different volumes. A three-slab gate and an argon protection system for metal were also among the products that were made.

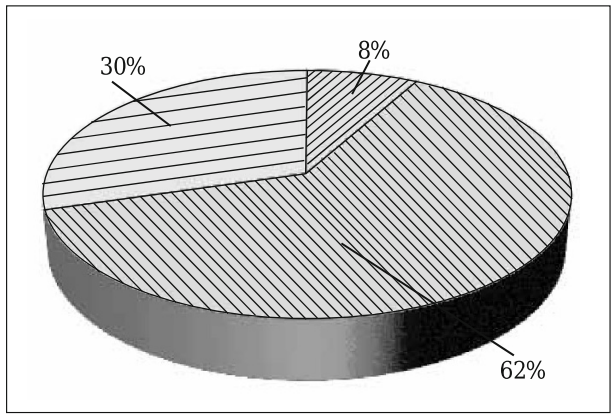


**Fig. 3.** Use of SSC systems in Russia: ▨) old-generation slide gates; ▧) imported slide gates; ▤) slide gates made by Vulkan-TM.

Beginning in 2009, the company became active in the design and manufacture of products and equipment for an important new field of activity - small foundries that rapidly began to enter the market. Vulkan-TM successfully launched the production of series-VT slide gates during the five years since then, and the design of these gates is undergoing continual improvement to keep up with changes in production conditions. Thus, the process of developing new products that can replace imported goods is still continuing.

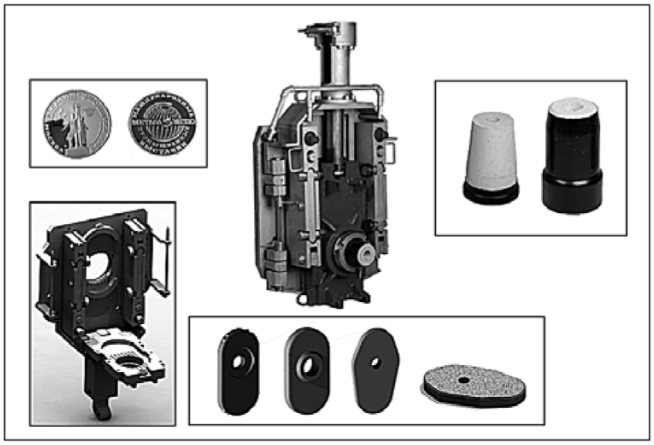

**Fig. 4.** Slide gate of the VT-60/80 series and the set of refractories used with it (TU 3138-306-43539424–2011).

An analysis of the performance of the main factories which use stopperless steel-casting (SSC) systems has shown that until now most integrated metallurgical plants have been using rigid-type (old-generation) slide gates made by the plants themselves. Upgrading of their casting facilities is often delayed by the lack of approved Russian-made equipment for ladles with a capacity greater than 300 tons, the high cost of imported gates, and the complexity of adapting those gates to the production conditions at Russian steel plants. More than 60% of the steel-casting systems that are currently in use in Russia have been imported (Fig. 3); most of these systems are installed at non-integrated plants which use ladles ranging in capacity from 30 to 160 tons. Many Russian metallurgical companies are presently having success with the use of the new steel-casting systems made by Vulkan-TM, and many of those systems have replaced imported equipment. Given the current adverse economic situation abroad and the fact that some deliveries of casting systems made in Europe have been suspended, it is important for Russian metallurgical companies to look for alternative sources of such equipment from Russian manufacturers (see Table 1).

Experience with the startup of new mini-mills has shown that most of these plants have initially shown a preference for foreign-made steel-casting systems. However, the extremely high production cost of a ton of steel usually compels mini-mills to look for alternative suppliers when the manufacturer's service warranty expires after a short period of use of the equipment.

Analytical estimates of business activity in the metallurgical industry to 2017 show that plans have been made for the construction of approximately 10 new metallurgical plants of different capacities by that year. Vulkan-TM has all of the necessary potential for successfully meeting the challenges encountered in equipping such facilities and upgrading existing plants based on the use of Russian-made products.

The history of development of slide gates and the refractories used for them here and abroad shows that there has been a natural and logical evolution toward the adoption of alternative technologies. The stopper — which was once thought to be the only means of tapping steel — came to be replaced by rigid-type slide gates.

The advent of spring-type slide gates brought new opportunities for alternative casting methods and the production of new refractories suited to those methods. The products of Vulkan-TM have significant advantages in this segment of the market for steel-casting equipment because of the company's previous successful efforts to optimize not only the design of its gates but also the production of the refractories that are used with them (Fig. 4).

**TABLE 1.** Comparative Characteristics of Slide Gates Made by Different Manufacturers

| Indices | Foreign company No. 1 | Foreign company No. 2 | NPP "Vulkan-TM" (model VT-60/80) |
|---|---|---|---|
| Slabs used in the gate | One type | One type and one manufacturer | Different types and different manufacturers (including a Russian analog of foreign-made gates) |
| Slab-locking mechanism | Slabs of one type secured on locking pins | Slabs of one type secured by a movable spring-opposed clamp | Universal, locking of slabs of different types without slide-gate replacement |
| Travel of the moving slab, mm: | | | |
| during operation | 160 | 200 | 160 |
| during servicing | 80 | 100 | 80 |
| Number of elastic elements | 4 separate springs | 10 separate springs | 2 spring blocks |
| Dimensions with the protective shield, mm: | | | |
| length | 863 | 1066 | 961 |
| width | 809 | 570 | 712 |
| height | 313 | 316 | 344 |

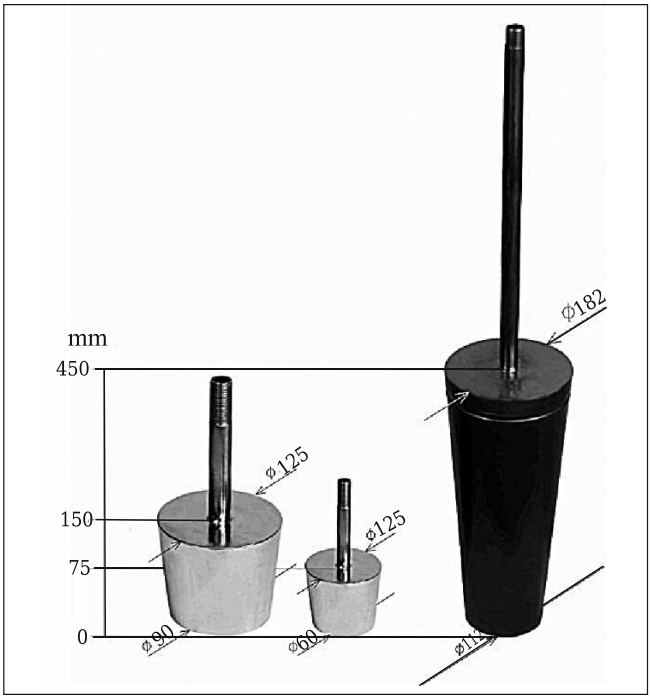


**Fig. 5.** Injection probes made by Vulkan-TM.

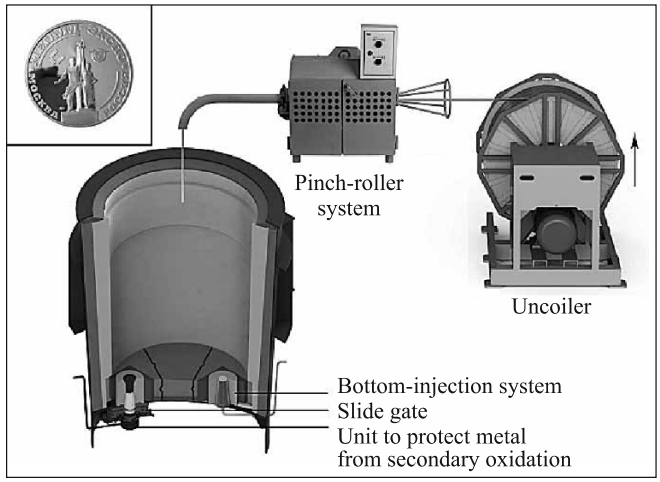


**Fig. 6.** Equipment complex for improving the quality of metal.

The series VT-60/80 slide gate made for ladles of up to 160 tons capacity is of a modular design with a "book"-type configuration. It is convenient to service, and the replacement of the previous structural elements by blocks reduces the amount of time needed to service the gate on the ladle. Its most distinctive feature is an original mechanism for locking the refractory slabs in position. This design feature makes it possible to use slabs of different sizes made by different manufacturers in the same slide gate, which is a clear advantage and will allow metallurgical plants to transition over time to the use of new designs of slabs with other service characteristics while not having to upgrade or modify the factory's existing supply of gates.

Two variants of slide gates have been developed for use under different conditions — gates that open vertically and gates that open laterally. The designs of both variants allow them to be installed in the existing seats and can easily be adapted so that the gates can be used with the drives that are already in use at the plant.

The clamping mechanism is an innovation that is unique to all of the gates of the VT series. The mechanism has two spring-opposed blocks equipped with heat-resistant disk springs positioned outside the high-temperature zone.

Slide gates of the VT series are an alternative not only to the generation of VTM-series gates but more importantly to all of the gates made by the leading foreign manufacturers. It can be seen from Table 1 that the VT-60/80-series gate is the equal of the latter in performance and has several other advantages as well, which makes it an alternative solution that is in demand. The gate successfully completed testing last year and is now being serially produced and shipped to customers.

In terms of its durability, the set of refractories of the VT-60/80 gate is comparable to the corresponding refractories produced by the foreign companies which make the imported slide gates that are already in use. The set can be used as an alternative variant in other similar gates. One of the most significant benefits of using steel-casting systems of the VT-60/80 series is the optimum combination of price and quality, which is reflected in their unit cost per ton of cast steel.

The original technologies developed by Vulkan-TM, the accompanying recommendations on their optimum use, and the technical support and consultation provided by leading manufacturers of refractory concretes (such as "Almatis") make it possible to come up with new solutions to improve the quality of vibroformed refractory products.

For the bottom injection of inert gases into steel just before or during casting, Vulkan-TM offers a broad assortment of different sizes of bottom-injection probes (lances) that are installed in the ladle's lining with or without a well block. If used, the well block can be square or circular in cross section (based on the customer's requirements).

In addition to the traditional variants which employ injection lances, Vulkan-TM can provide customers with monolithic injection blocks of a unique patented design. Having been approved for use by several leading metallurgical plants such as the OOO "Promtraktor-Promnlit" (in Cheboksary) and the ChPTZ Group (in Chelyabinsk), the injection lances made by Vulkan-TM have a maximum life of 65 heats performed with a blowing time of 30 – 60 min (Fig. 5). The service life of a specific lance depends on the conditions under which it is used and serviced at each given metallurgical plant.

The following reasons make the equipment that Vulkan-TM has proposed for the secondary treatment of steel a key element in solving the problem of improving the


**Fig. 7.** High-speed mixers made by Vulkan-TM: SID-90 – batch-operated hydraulically controlled mixer with a cover, batch container, and bottom-side scraper, unloaded by tipping, capacity 90 liters; S-02) top-unloading mixer with removable cover for batch charging, power of the pot drive 3 kW, dimensions 1235 × 580 × 1390 mm; SID-0) batch-operated bottom-loading mixer with stationary batch container, capacity 50 liters, batch size 10 – 40 kg.

service properties of finished products and the efficiency of production operations:

– the equipment serves to upgrade metallurgical plants and foundries based on the use of modern, competitive technologies;

– it introduces innovations to obtain high-quality steels having prescribed sets of properties.

For foundries and machine shops, Vulkan-TM has developed an equipment complex (Fig. 6) that improves the quality of metal and is unique to world metallurgy. The complex includes:

– a slide gate with an electromechanical or hydraulic drive (including an oil station), a set of refractories, and a system that protects metal from secondary oxidation;

– technically sophisticated refractory products that can be made in any shape or size, including products designed for use in the block lining of the critical parts of different types of furnaces;

– a lance for the bottom injection of inert gas into steel in steel-pouring ladles;

– a starter mix for filling the channel of the ladle nozzle prior to the beginning of the casting operation;

– cored wire with different fillers;

– a compact pinch-roller system for feeding cored wire into ladles.

Innovation is a key component not only of the products made by Vulkan-TM but of the equipment and technologies that are used to make them. The mixer “Vulkan-TM SID-50” has been designed and built to prepare refractory mixes. The mixer prepares aqueous solutions of thixotropic mixes or dry mixes in the high-speed regime (Fig. 7).

An analysis of the performance of the SID-50 mixer has shown that its design meets the requirements dictated by current manufacturing conditions and the thixotropic mixes obtained with it satisfy all existing quality standards. The mixer is convenient to service and helps significantly reduce the amount of manual labor that is needed in the mixing operation. It is a competitive counterpart to the mixers that are being procured from abroad.

One shortcoming of the methods that have traditionally been employed to protect metal from secondary oxidation based on the use of protective tubes and elastic inserts is that these pieces of equipment can only be used once and must be replaced after each heat. Protective tubes cannot be used at all in metallurgical and foundry operations when the steel is bottom-poured.

Vulkan-TM is proposing to use the principle of gas-dynamic protection as an alternative means of protecting metal from secondary oxidation. This principle has broad potential application and is not employed in competing equipment made abroad.

The new unit developed Vulkan-TM to protect metal from secondary oxidation is mounted on the slide gate by securing it with a bayonet nut during the servicing of the ladle between heats. Argon is injected into the metal throughout the casting operation. The protective system lasts seven heats. Its wear is caused by the build-up of metal in the injection channels and cracking of the refractory ring.

Foundries have recently shown increased interest in the products made by Vulkan-TM. Many of these plants are planning to reorganize their operations and are thus deciding that they need to begin to make use of slide gates and higher-quality linings. Vulkan-TM has developed compact slide gates of series VT-30 for mini-mills and foundries, as well as a mini rotary-type slide gate with a special set of refractories for mold casting from ladles having a capacity smaller than one ton. The design of this gate is radically different from all of the previous slide gates developed by the company. It is more accurate to refer to this as a “ceramic” gate, since most of it is comprised of a refractory material.

For foundry ladles, Vulkan-TM suggests the use of prefabricated linings of different compositions. After the parts of the lining are installed in the ladle, they are glued in place with the use of a refractory paste. Compared to the traditional technology of casting a new lining in the ladle, the use of prefabricated linings shortens lining operations, eliminates the need for lengthy (3 – 4 days) drying of cast linings in accordance with a complicated schedule, and makes the quality of the new lining significantly less dependent on the human factor because the parts are guaranteed by the manufacturer.