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“PRYAZOVSKYI STATE TECHNICAL UNIVERSITY”



EFFECTIVE SCIENTIFIC DEVELOPMENTS

Catalogue

Mariupol

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1. BELL-LESS TYPE BLAST FURNACE CHARGING DEVICE ensures efficient control of radial blend distribution and gas flow by decreasing the iron ore load in the zone of maximum concentration of sinter and pellets. It results in predominant development of iron recovery reactions by gases and decreasing of endothermic reactions of iron recovery by solid carbon and hence decreasing of the specific coke consumption by 5-8 kg/t hot metal. In testing of this method at BFs 3 and 4 of AZOVSTAL Iron and Steel Works, Mariupol, the specific coke consumption reduced by 10 kg/t hm, the monthly profit amounted to UAH 320 thousand. The estimated annual profit for the average size blast furnace is at least UAH 1.5 mln. Implementation of this method does not involve any capital investment or adaptation in production. All the units in this method are protected by patents.

2. BELL-TYPE BLAST FURNACE CHARGING DEVICE is similar to bell-less type in technological parameters, however, it is 10-12 times more cost-effective in terms of capital investments and operation cost. In addition, application of this device produces at least UAH 4 mln annual profit due reduced specific consumption of coke by 15-25 kg/t hm (data from Zaporozhstal Iron and Steel Works). Such coke saving can be attributed to a specific structural feature – technological centerline opening in the bigger bell through which part of the coke is fed directly to the BF top center that makes it possible to:

- Form a centerline coke column of a given form and size, including a continuous one up the height of the furnace;
- Maintain a distributed centerline gas flow thus eliminating the reasons for clogging the hearth;
- Form efficient Λ -type softening zone;
- Increase degree of application of recouping capability of the blast furnace gas by 2-4%;
- Ensure stability in blast furnace operation.

Optimal radial gas distribution is characterized with the following circumference CO_2 concentration in the BF top gas: 14-18% at the walls, 20-22% in the top, 4-6% in the centerline zone. Different modifications of charging devices – with quick rotating burden distribution devices, with movable plates in inter-cone space – considerably expand technical possibilities of control of radial and circumference distribution of burden and gases and additionally reduce coke consumption by 3-5kg/t iron. All modifications are protected with patents. Operation period is 3-3.5 years, installation costs are paid back after half a year.

3. CHARGING SYSTEM FOR BLAST FURNACE WITH TRAY-TYPE CHARGING DEVICE is used at BFs 3 and 4 at AZOVSTAL Iron and Steel Works. It ensures feeding of coke both to the center of the furnace mouth and to the ore ridge. Intensifying the gas flow in this area allows reducing coke consumption by 16kg/t iron and enhancing the furnace productivity by 60 t per day.

4. DECREASING OF NATURAL GAS CONSUMPTION THROUGH THE INSTALLATION OF THE NEW CHARGING DEVICE AND THE USE OF THE ORIGINAL BLAST FURNACE CHARGING SYSTEM – the use of the new charging device together with the operational opening in the lower bell at the three of the BFs on the Zaporozhstal Iron and Steel Works allows reducing the coke consumption by 20-25 kg/t iron, or to reduce the natural gas consumption by $30 \text{ m}^3/\text{t}$ iron if the coke consumption is fixed.

The use of such charging devices on the BFs of the Donets Basin allows saving natural gas:
 $30 * 10^7 = 300 \text{ mln m}^3$ per year

30 – natural gas saving for 1 t iron, m³;

10⁷ – the annual iron production in the BFs (t), on which new charging devices with the operational opening in the lower bell can be installed within 5 years.

The newly designed charged material loading systems, which were tested on the BFs, reduce the coke consumption by 10-15 kg/t iron. The coke consumption unchanged, the natural gas saving of 15-20 m³/t iron can be reached. The annual saving makes:

$17.5 * 18 * 10^6 = 315$ mln m³ of natural gas.

If the charging devices with the operational opening in the lower bell are employed together with the new BF charging systems, the annual natural gas saving makes up:

$300 + 315 = 615$ Mln m³.

5. BLAST FURNACE MELTING OPERATION WITH WATER SPRAYING IN THE HOT BLAST FLOW under the conditions of shrinkage or lack of natural gas – the methods of feeding hydrocarbon addings allow changing the iron casting process essentially, adding into the blast several reagents simultaneously or only one at a time, as well as delivering into the furnace only heated atmosphere air. The pilot melts with a changing concentration of additives in the hot blast of the BFs were conducted. The results show that the suggested method ensures considerable raise (by 100-150 °C) of the hot blast, the run of the BF being stable.

The implementation of this method ensures improving the quality of the cast iron due to the stabilization of its chemical composition, changing the operation heat storage in the blast-furnace hearth on the chance of the unexpected fall of temperature in the BF. On the basis of the results the BF thermal condition automatic control system is under development. The blast moistening allows maintaining its temperature on the same or higher level, which ensures improving the furnace productivity by 8-10% and the reducing the coke consumption by 20-26 kg/t iron. The payback period of the blast moistening system is 3-4 months; the implementation of the method gives the saving rate of UAH 12 mln per year for a blast furnace with 1,033 m³ capacity due to the reduction of the specific coke consumption.

6. IRON SMELTING PRACTICE WITH INJECTING INTO THE BF THE HOT BLAST WITH SUBATMOSPHERIC OXYGEN CONTENT under the conditions of shrinkage or lack of natural gas – this is a temporary energy-saving method that provides an essential cost reduction (before the introduction of the pulverized-coal fuel on the iron-and-steel works). It allows maintaining the air-blast temperature of 1,000 °C in case of lack of the natural gas; reducing the coke overconsumption by 60-80 kg/t iron without decreasing the BF productivity.

The reduction of the oxygen content below 21% is achieved through injecting industrial nitrogen into the blast, nitrogen being an unused by-product of the oxygen production that is emitted into the atmosphere. The nitrogen consumption necessary for one BF with the pressure of 500 mm of water is 30-35 thousand m³/hr.

The nitrogen supply system includes 2-3 standard air propellers and a pipeline that delivers nitrogen to the air inlets of the blast engine. In the simpler construction when the oxygen supply line is used to deliver nitrogen, only air propellers are installed.

The BF nitrogen supply system is assembled within 1-3 months on any ironwork having an oxygen plant.

Depending on the conditions and the chosen variant, the cost of the system amounts to UAH 1-5 mln. The system is assembled without any outer assistance, or a contracting organization is involved into project execution and assembly.

The daily cost saving due to the implementation of the suggested method in the BF shop with the capacity of 10,000 t iron/day amounts to UAH 500-800 thousand.

In case of the lack of natural gas the construction costs of the BF nitrogen supply system are repaid within 6-15 days.

7. ENERGY-SAVING METHODS OF HEATING THE BF BLAST IN STOVES WITHOUT USING NATURAL GAS – is realized through air and BF gas preheating before delivering into the stove primary furnace and through the reduction of combustion gas emission. Here are the stove heating methods used:

1. Preliminary heating of the combustion air to 150-250 °C by the heat of the exit gases in the recuperative heat exchanger. The use of this method has given beneficial results at OSC Zaporozhstal Iron and Steel Works.

2. Oxygenation of the combustion air.

3. Delivering a part of the hot blast into the combustion chamber of the stove.

4. Preliminary heating of the combustion air to 400-450 °C in two sample action regenerative heaters by means of flaring additional quantity of the BF gas.

5. Preliminary heating of the combustion air to 400-450 °C in the continuously working recuperative heater by means of flaring additional quantity of the BF gas.

6. Using for combustion the cold furnace blast oxygenated with lowering the pressure before the combustion chamber of the stove to 1.0-1.2 atm. The combustion gas is presented by BF gas released from the high-pressure scrubber units (semiclean gas) with the pressure of 1.2-1.4 atm. The stove during the head heating mode is transferred to the work under pressure.

7. Using for the combustion a mixture of cold and hot blast of 350-400 °C with decrease pressure of 1.0-1.2 atmosphere for combustion and using semiclean gas for the heating of the stove head.

Each of the suggested methods allows complete exclusion of the natural gas consumption in stoves and ensures the necessary head heating temperature and the preset BF hot blast temperature. The daily saving due to the exclusion of the natural gas in blast heating amounts to more than UAH 30 thousand for one BF. The costs are repaid within a year.

8. METHODS OF SINTERING ORES AND CONCENTRATES USING FINE-DISPERSED SLIME – Fine-dispersed cake-formed slime is fed into the sintering mixture, upon which it is granulated into fractions of 1.6-8 mm. Gas permeability increases due to the introduction of the slime granules acting as palletizing centres (minor particles roll on them), thus increasing air seeping and caking rate. This procedure raises the sintering plant productivity and palletized blend quality.

The method makes it feasible to exceed present slime use limit to 190 kg/t (in the real production this limit is even lower). The given method solves this problem, therewith it is ecologically clean and unlike pellets its cost price is lower. Compared to the world analogs, the suggested method increases the gas permeability of the sintering mixture enhancing the productivity of the sintering mixture and the quality of the sinter. It also ensures a substantial raise in the slime quantity. The use of the slime in the form of free-flowing mixture results in the productivity slowdown and the sinter quality loss. On the contrary, the use of slime granules, though increasing the overall slime consumption, enhances both the productivity from 0.72 up to 1.52 t/hr*m² and sinter strength properties.

The introduction of 66.9 kg of granulated cakes for a ton of sinter and the reduction of the overall slime consumption by approximately 190 kg/t cause the tumbler-test sample probe to increase from 55.5 to 68.55%. At the same time the increase of the waste gas temperature from 500 to 630 °C indicates the fact that the cake strengthening results from the fuel efficiency and the temperature rise in the combustion zone. The cleaner solid fuel burning in the sintered layer is caused by the increase in the oxygen supply by the improved blend gas permeability. The annual saving rate of the implementation of the given method on two sintering machines with a zone of 62.5 m² amounts to

UAH 10.9 mln or 5.9 UAH/t sinter. The pay-back period of the unit for converting slime into granules by means of homemade equipment is less than a year.

9. THE TECHNOLOGY PACKAGE FOR BLAST AND SLUG ADJUSTMENT IMPROVEMENT, THERMAL BALANCE REFINEMENT, AND BASIC OXYGEN PROCESS ENHANCEMENTS – includes:

1. The newly-designed oxygen lance with supersonic nozzles that ensures the maximum usage of the oxygen flow potential energy into the vessel bath agitation, extended adjustment rate (of the optimal oxygen consumption rates), and advanced erosive wear resistance of the outlet part of the nozzles. The use of the lance in the converter plant of the OSC Ilyich Metal and Steel Works of Mariupol made it feasible to improve the slag-making process, to increase the slag assimilation of the lime, to enhance the melting process thermal balance and control, and as the result to increase the metal dephosphorization and desulphurization rate in the vessel, to raise the resistance of the copper heads (1.7 times) and the lances to “metallization” (1.5 times), to decrease the discharge intensity of cast iron (by 1.0 kg/t), metal stock (by 0.7 kg/t), lime (by 1.5 kg/t), fluorite (by 20%).

2. The new vessel bath lancing methods with the regulated (altering) rate of oxygen input by cast lancing periods, and the optimization of the oxygen operation consumption and the lancing mode in accordance with the initial conditions of the melting (chemical composition and the temperature of the cast iron, the share of scrap metal in the metal stock, the quality of the lime, the condition of the vessel lining etc). The implementation of the given methods at the converter plant of the OSC Ilyich Iron and Steel Works made it feasible to stabilize the blast, slag and temperature melting modes, the melt decarburizing rate, to improve the service conditions of OQG, lances and vessel lining, particularly under changing charge and operational melting conditions (the change of the Mn content in iron to 0.15-0.75%, Si – 0.40-1.5% etc). Herein the dephosphorization and desulphurization rates of the metal in vessel have increased by 5.5% and 8% respectively. The specific consumption of iron has reduced by 2 kg/t, metal stock by 0.8 kg/t, fluorspar by 0.3 kg/t. The number of further blows for slag, phosphor and sulphur has decreased.

3. The new oxygen lance with central nozzle module for simultaneous melt blow by two different oxygen jets (supersonic for melt depuration and agitation; and central vortex ‘curtain’ for the intensification of the process of the discharged gas afterburning in the slag-gas-metallic emulsion) ensures melt thermal balance enhancement, the acceleration and stability of the slag-formation processes in the BO furnace. The introduction of the lance at the converter plant of the OSC Ilyich Iron and Steel Works ensured the increase of the heat supply into the vessel bath due to the implementation of the gas after-burning process equivalently to the reduction of the specific iron consumption by approximately 2 kg/t steel (with no harmful effect for the vessel lining); it also allowed reducing the slag adjustment period by 20% and decreasing the equipment metallizing intensity.

10. THE COMPLEX OF ENGINEERING SOLUTIONS ON THE IMPROVEMENT OF OPEN-HEARTH FURNACE HEAT PERFORMANCE AND STEELMAKING ENHANCEMENT – includes:

- **The nozzle module of the OHF oil-gas burner** with optimized design parameters, that ensures fuller use of the potential energy of the fuel oil nozzles, increase of the kinetic energy, and enhancement of the regulation of the oil-gas parameters. The introduction of the module at the open-hearth plant of the OSC Ilyich Iron and Steel Works of Mariupol made it feasible to enhance the open-hearth production, decrease the specific fuel (natural gas and fuel oil) consumption for steelmaking by 2.0 kg/t and save approximately UAH 2.3 mln annually.

- **The oil-gas burner for firing of the OHF** with optimized design parameters and the two-channel nozzle unit for the intensificator (oxygen) feeding, that ensures the amplification of the fuel oil spraying and the combustion efficiency rates, the intensification and enhancement of the heat-exchange process control in the “metal-slag-jet-gas phase” system. The introduction of the burner at

the open-hearth plant of the OSC Ilyich Iron and Steel Works of Mariupol made it feasible to decrease the specific fuel (natural gas and fuel oil) consumption for open-hearth steelmaking by 2.2 kg/t and save approximately UAH 2.5 mln annually.

- **The roof oxygen lance for the OHF lancing** with the optimal nozzle quantity depending on the oxygen lancing intensity, furnace charge and the quantity of the lances used simultaneously, that ensures stable OHF lancing in the wide range of the oxygen operating consumption, improvement of the intermixing in the “slag-metal” system, and the decrease of the iron melting loss and “smoke”. The introduction of the lance at the open-hearth plant of the OSC Ilyich Iron and Steel Works of Mariupol made it feasible to twice slow down the erosive wear of the exit part of the nozzles and to stabilize mold blast mode, to improve the durability of the lances by 10%, to decrease the specific fuel (natural gas and fuel oil) and metal stock consumption for open-hearth steelmaking by 0.3 kg/t and 0/8 kg/t respectively. The annual saving amounts to UAH 2.8 mln.

- **The method of the OPF bath lancing** with the regulated oxygen lancing intensity depending on the specific consumption of iron for steelmaking, that ensures synchronization of the heating rate and the decarburization of the metallic melt of the bath (as well as under the unstable share of the iron in the metal stock of the melts), improvement of the heat balance, reduction of the waste and oxidation of the metal. The introduction of the method at the open-hearth plant of the OSC Ilyich Iron and Steel Works of Mariupol made it feasible to decrease the specific consumption of fuel (natural gas and fuel oil) and metal stock for OHF steel production by 0.2 kg of s.f./t and 0.7 kg/t respectively. The annual saving amounts to UAH 2.4 Mln.

11. NEW ENERGY-SAVING METHODS OF HEATING OPEN-HEARTH FURNACES (OHF) are based on the use of the index (cyclic, impulse) feed of fuel (natural gas, fuel oil, oxygen) into the working area of the OHF, as well as on the realization of the ‘thermostatic break’, i.e. periodical isolation of the working area of the OHF and both regenerators from the smoke pipe by means of the simultaneous closing of the both smoke gates of the flame reversal system, together with the almost complete stop of fuel delivery into the OHF.

Engineering-and-economical performance:

The use of the cyclic heating

- the reduction of the specific fuel consumption by 4-8 kg of standard fuel (s.f.)/t steel, the melt duration not increased;
- the reduction of the specific consumption of oxygen by 0,8-1 m³/t steel, the melt duration not increased.

The use of the ‘thermostatic break’ mode

- the fuel saving by 2-5 kg of s.f./t steel and the service oxygen saving by 0,5-0,8 m³/t steel - in the automatic mode;
- the fuel saving up to 10 kg of s.f./t steel, and the oxygen and return air saving – in the manual mode;
- greater control possibilities of the technological process of steelmaking in OHF.

The simultaneous use of the cyclic heating and the ‘TM’ mode

- the reduction of the specific fuel consumption for more than 12 kg of s.f./t steel.

The method has been introduced at the 400-ton OHFs of the OSC AZOVSTAL Iron and Steel Works.

12. ENERGY-SAVING PULSE HEATING MODES OF STANDS FOR THE DRYING AND HEATING OF THE METALLURGICAL LADLE LINING – are based on the index (pulse, harmonic) fuel feed into the working area of the ladles.

Pulse heating together with the direct control of the heat flow delivered from the flame and the fuel combustion materials to the surface of the ladle lining (in line with the internal heat resistance of the latter) result in the increase of the temperature difference and heat-exchange surface, as well as in the increase of the convective heat-transfer coefficient. This way the fuel effectiveness and the efficiency output are improved. Furthermore, the zone of maximum temperatures of the flame is in continuous 'movement' relative to the lining, which increases the heating consistency and reduces the possibility of local overheat causing the impairment of the drying of the lining.

Engineering-and-economical performance:

- the reduction of the overall fuel consumption (natural gas) when drying tamped lining by 5-7% (by 12% for brick lining);
- the reduction of the overall fuel consumption (natural gas) during the intermelting heating of the lining by 10-12%;
- the enhancement of the ladle lining life by 5%.

The development has been introduced at the stands for the drying and heating of the 220-ton casting ladles of the open-hearth plant of the OSC AZOVSTAL Iron and Steel Works.

13. MICROALLOYING OF THE MELTS BY THE FLUX CORED WIRE WITH HIGHLY ACTIVE ELEMENTS – increases the efficiency of the ladle treatment of hot metal and steel. It is performed through the in-line treatment at various conversion stages, which ensures the reliability and mobility of feeding of reagents. The process is low-cost; it ensures 1.5-2 times saving of chemical reagents 3-4 times less heat loss. The environmental advantage includes three-fold reduction of the gas and dust emissions, and the technological advantage includes the prevention of clogging of steel casting nozzles. The microalloying process results in the increased cold resistance and 1.5-3 times higher through-thickness isotropic mechanical properties of the rolled plates. It is used for manufacture of the extra clean critical application steels for gas and oil big-diameter pipelines, floating oil-drilling platforms, shipbuilding.

14. PIPE STEEL was developed together with the OSC AZOVSTAL Iron and Steel Works. It possesses a higher level of plastic properties and impact strength at negative temperatures up to -60 °C.

The ultimate strength of the pipe steel is almost the same level than that of the steels of conventional grades (after being normalized). Furthermore, the developed steel surpasses them in the rate of yield strength and elongation; the impact strength values of the cross samples (at normal and negative up to -60 °C temperatures) is 1.6-2.2 times higher than those of the presently used pipe steel grades. The given result is reached due to the fact that the steel containing carbon, manganese, silicon, niobium, aluminium, and iron, also contains zirconium and yttrium.

The new steel is more cost-effective, as it does not contain expensive and scarce elements (such as molybdenum and vanadium), the upper limit of niobium is lowered fivefold, and the overall content of alloying elements is decreased 2-4 times.

Additional positive effect (due to the economical alloying) lies in the improvement of welding characteristics, as the carbon equivalent of this type of steel is 0.29-0.38 as against 0.41-0.43 of the standard steel 09Г2ФБ.

The overall influence of the improved mechanic and welding characteristics of the developed steel allows substantial increase of the service life of pipelines in the climatic conditions of low temperatures.

15. HIGH QUALITY DISKS for radio and electronic, machine building, automotive industries are manufactured using environmentally safe rotary rolling method using special disk rolling mill. Its design allows rolling of products of different materials and alloys of various grades and types with specified properties. The rolling conditions at various strain rates increase productivity by increasing rotary velocity of work rolls.

The method is unique in the opportunities it offers for controlling the high-speed rolling, optimizing its conditions, and manufacturing:

- magnetic disks from non-magnetic materials for memory storage devices;
- circular texture reducing anisotropic magnetic properties in reciprocal perpendicular directions;
- mirror-like surface of products that may be used as light decorating elements for lamps, chandeliers, panels, etc.

This method excludes:

- rough grinding using diamond tools;
- exit of internal defects onto the surface of the blank;
- metal loss in chip scrap.

The method was tested under the programs of industrial and military complexes and is protected by patents of Ukraine and Russia. Trial lots of disks may be manufactured in the university laboratories. DISKAPCHER-type mills are being designed for commercial production in the existing industries.

16. GREASE LUBRICANTS FOR HOT FORGING AND STEEL PRESSING – prepared water-based, are ecologically clean. The mechanized and automated machines for spraying lubrication of the die are developed. The use of the lubricants allows improving the economic characteristics of the hot forging due to increasing the die life by 25-30%, enhancing the quality of the work piece surface, raising the safety engineering level.

17. THE OVERALL INDUSTRIAL PRODUCTS HEAT TREATMENT TECHNOLOGIES – ensure significant enhancement of the industrial products and productive efficiency.

Heat treatment technology for the electroslag refining ingots manufactured of steels of groups III and IV by susceptibility to flaking – makes it feasible to produce ingots of high-quality macro- and microstructure through fuller steel recrystallization and higher metal dehydrogenization rate; it also increases the furnace capacity by at most 50%.

Heat treatment technology for high-strength weld steel roll stock up to 50 mm thick – ensures the creation of the consistent complex of mechanical properties. The attained impact strength values of the roll stock exceed the current steel specifications by at least 30%, the high strength characteristics retained.

Heat toughening technology for the roll stock more than 50 mm thick made of high-strength weld steels of groups III and IV by susceptibility to flaking – ensures the creation of the consistent complex of mechanical properties of roll stock and plates. The attained impact strength values of the roll stock exceed the current steel specifications by at least 25%, the high strength characteristics retained.

Heat toughening technology for boron-containing steels supplied in the form plate iron – ensures the creation of the steady complex of mechanical properties of plate iron boron-microalloyed steels, including chemical composition deviations, through the removal of the boron embrittlement effect. The introduction of the developed technology made it possible to reduce the volume of the roll stock reheat treatment by at least 35%.

Heat toughening technology for roll stock more than 50 mm thick, produced of high-nitrogen constructional irons – ensures both the increase and the stabilization of the roll stock mechanical properties due to the structure reduction and the neutralization of the adverse influence of the concentration-structure heterogeneity in the low-alloyed steels. After the introduction of the heat toughening technology, the feasible roll stock output increased by 30%.

Heat toughening technology for roll stock up to 50 mm thick inclusive, produced of high-nitrogen constructional irons – ensures the creation of the consistent complex of mechanical properties. The introduction of the developed technology made it possible to reduce the volume of the roll stock reheat treatment by 33%.

18. ECONOMICALLY ALLOYED STEELS, IRONS, SURFACING MATERIAL – with the in-service strengthening effect. The strengthening effect is as follows – in order to improve mechanical and service characteristics of the steels and irons a metastable structure is created (along with other constituents). This structure undergoes various deformation changes, which ensure the strengthening effect through the in-service self-hardening. The development of the changes is controlled through their optimization with regard to the loading conditions and the fact that much of the external action energy is applied to the in-service deformation changes, so that the lesser part of it is spent on the destruction. This causes the lessening of the internal strains in the microvolumes of the metals, which improves their operation capacity. On this basis the years of system tests resulted in the creation of the economically alloyed steels, irons of various structural groups and application (high-strength, corrosion- and wear-resistant), as well as the creation of the surfacing materials free of expensive elements (nickel, tungsten, copper, niobium etc). These materials are notable for the combination of the mechanical, technological and service properties, allowing them to exceed the similar more expensive industrially used materials.

The corrosion-resistant nickel-free chromo-manganese steels with structure similar to that of the steel 12X18H9T commonly used in industry were developed. In the level of the mechanical and service properties they almost twice exceed the steel currently used.

The newest high-strength steels, based on the principle of the strengthening through in-service self-hardening, are as good as the more expensive analogs.

Wear-resistant steels of various applications with lesser manganese content than in the steel 110Г13Л were created. Parts manufactured from the steels economically alloyed with manganese, surpass in durability in 1.2-1.5 times the steels parts from the high-manganese steel. Moreover, the manganese consumption, the heat treatment time and the spare parts production costs are decreased. The new steels are distinguished by the possibility to refine grain in the casts through special heat treatment processes, which substantially increases their mechanical properties. The latter was hardly realized with the steel 110Г13Л.

In consideration of the poor workability of the high-carbon manganese steels, the new low-carbon types of steel with the appropriate manganese content were created. They possess the high level of properties, meanwhile the wear resistance is ensured through the carburizing of the surface layer and the strengthening of the layer due to the stress-assisted self-hardening. This way manganese steels are disposable for components required to be of high strength properties, exact size and surface shock resistance.

Economically alloyed irons with the strengthening effect through the in-service self-hardening were developed. After the heat treatment process they surpass more expensive irons containing scarce elements.

The new surfacing materials developed on the basis of the economically alloyed steels and irons substantially increase the operation life of various machine components.

19. NONCLOGGING DEVICES FOR APPLICATION OF LOW-STABILITY SOLUTION (e.g. technological lubricants) on the working components of the machines, in which non-clogging of pipelines is achieved by the operation conditions during lubricant feeding or during pipeline purging when lubricant residues are removed. The suggested device makes unnecessary to use oversized high-cost and unreliable sine control systems for air and solution flows. Simplicity and high manufacturability of the device can be attributed to the absence of complicated small-section piping and presence of only one pipeline operating under successive feeding and purging conditions. The device was introduced at the Rail Fasteners Mill of the OSC AZOVSTAL Iron and Steel Works. It would be appropriate to make use of this device at industries incorporating hot and cold pressure forming. Patentability is confirmed by protective documents.

20. PULSE PUMP for explosion-free and lance-free demolition of concrete structures, rock drifting and breaking of metallurgical vessel lining is manufactured based on percussion-type universal hydraulic drive maintaining high efficiency independently of the selected intensifier ratio. Test operations performed on concrete "500", exceeding coal rock in hardness, demonstrate higher productivity of the explosion-free drifting. Improvement of concrete breaking efficiency compared to pneumatic method, explosive actuated rock breaking and pulse water-jet method is 100, 50 and 8 times higher, respectively, and is supplemented by high manufacturability of the pump due to three-fold shorter run of movable components. Use of hydraulic drive in place of pneumohydraulic drive makes feasible:

- simplification of pump design and control;
- safe pump operation due to initialization and acceleration of movable parts by liquid pressure only;
- employing natural seepage through seals for controlling the work run and the idle run of the pump.

The technological level is proved by the patents and by the successful operation over a few years in high-speed cutting of profiles during pressing at Stupinsky and Belokalitvinsky iron and steel works.

21. ENERGY-SAVING AND RELIABLE MACHINE DRIVES FOR VARIOUS APPLICATIONS - developed by optimization of the design using minimum mass criterion that reduces the mass of the machine and hence, the motor starting moment thus minimizing the specific power consumption of the motor. They are made with progressive fine-module high-capacity wave gears smaller in size and 1.7-2.5 times less in weight compared to similar non-wave gears. It results in their high kinematical precision and 35-40% lower dynamic load. Parts for such gears are manufactured from economically alloyed steels (30HGSA etc.). Reliability of the drives and their high technological and economical levels are substantiated by their application for construction of basic oxygen furnace, mobile 600-t mixer vessel, ore-crushing mills, rotor and single-bucket excavators. The technological solutions contained in 52 patents offer research-cost-free production of the new drives that ensure extended service life of metallurgical, transport, ore mining, lifting and other machine-types.

22. POLYURETHANE COMPENSATOR OF SLIDE RUN ERRORS FOR OPEN-TYPE PRESSES is manufactured in the form of an elastic plate having variable through-width toughness, due to which it has many-fold less thickness compared to similar devices, thus providing deformation of less than 30%. Having such deformation, it can withstand 7106 stress cycles thus increasing the

service life of certain structures. Through-width toughness variability of the compensation plate is achieved by the presence of a certain (calculated) number of holes with unequal pitch in the specified direction. It allows simplification of the design thus reducing the manufacture cost ten-fold. Errors caused by the frame opening are compensated by non-uniform compression of the plate, and inaccuracies of slide movement in the horizontal plane are compensated by polyurethane sliding against the support surfaces of the die and of the slide. The developed compensators are successfully applied in presses IPR1812 and KA1739 in the Rail Fasteners Mill of OSC AZOVSTAL Iron and Steel Works. Compensator designs are patented.

23. DEVICE FOR INFORMATION READ-OUT FROM MOVING COMPONENTS OF RAILWAY TRANSPORT is used in automated control systems in rail-way transport (and other types of transport). It retains the speed of operation and high credibility of the read-out information at any speed of movement.

Compact and convenient in operation, reliable at various degrees of rolling-stock wear, dirt accumulation, icing, exposure to dust, snow, fog, steam, it does not depend on car fluctuations or temperature deviations within the range of -60...+125 degrees °C; allows to speed-up the wagon-turnover through reducing detention of cars, decrease the maintenance personnel.

The results from various testing sites are available, patents of Ukraine and Russia.

24. REINFORCED CONCRETE BASEPLATE FOR RAILWAY SWITCHES replaces wooden bars whose service life (6-8 years) implies expenses for deficit high-cost industrial wood. It is also more effective from technical and economical viewpoints:

- 2.5-3 times in terms of operation life;
- 5 times in terms of costs of one year of operation;
- 2- 2.2 times in terms of maintenance labor costs.

Cost-effectiveness of reinforced concrete baseplates increases with growing of traffic concentration and axial loads – profit from each set is UAH 24 thousand.

Use of baseplates makes feasible:

- laying the railway switch in L-H and R-H directions;
- using building cranes for this purpose and for unit-wise erection;
- replacing without removing the reinforcement concrete plates, insulation of rail lines;
- reliable operating of the track switch.

Three sets of baseplates for R65 railway switches are successfully operating at AZOVSTAL Iron and Steel Works.

25. BUILDING-UP METHOD is employed for jointed parts, tools, assemblies of equipment and safety devices, in which fixation of conjugating components is achieved by straining under the effect of a local heat source: welding arc, plasma jet, laser beam etc.

The new principle of connection of elements excludes labor and power costs on heat treatment and machining required for achieving the specified tightening conditions for the components and for assembling, making possible to avoid:

- using of high-precision machining equipment;
- oxidation of the connecting surfaces at high temperatures.

Use of the thermotension effect during local heating for modification of the tensioning conditions of the enclosed rod or shaft allows manufacturing of:

- built-up mill rolls, wheels and other parts having different requirements to service properties of individual components, as well as alternative requirements in certain cases;
- safety couplings and other safety devices that protect machines and units from failure under overload conditions.

Fixation of model built-up unit components using local heat source was performed successfully testifying to the reliability of the proposed method. The patent of Ukraine was received.

26. TECHNOLOGY AND MATERIALS FOR WEAR-RESISTANT SURFACING OF HOT-ROLLED MILL ROLLERS are used in metallurgy, heavy and power-engineering machine-building. They are intended for:

- Sheet-rolling rollers made of steel grades 75XM, 90 XΦ, etc. (HIIIC-1700; scalebreaker; working and back-up rolls of roughing and finishing stands);
- Primary mill rolls, 40-69 XH steel (blooming, slabing);
- Plate mill rolls, TJC 3000, TJC 3600 (back-up banded and one-piece)
- Pilger mill rolls;
- Continuous casting plant rollers;
- Rollers of the bed group, rollgangs (conical and cylindrical);
- Back-up rolls of straightening machines, etc.

The developments were introduced at the facilities of OSC Ilyich Iron and Steel Works of Mariupol, OSC AZOVSTAL Iron and Steel Works, and at several other enterprises.

27. BROAD-ZONED SURFACING OF THE WEAR-RESISTANT LAYER is used both for reconditioning and hardening of wearing parts of rolling mills, metallurgical and machine-building equipment, and for manufacturing of new components.

Surfacing is performed using cold rolled electrode tape, which improves the quality of the components' work surface enhancing their performance.

Application of a wide layer of metal on the work surface ensures the process productivity, thus reducing the cost of equipment reconditioning. Thus, surfacing of the worn components of rolling and metallurgical equipment at the OSC Ilyich Iron and Steel Works, Mariupol, using electrode tape expedited the process of reconditioning 1.5 times, and performance of the surfaced components improved by 20- 25% as a result of hardening.

The design is protected by the patents of Ukraine.

28. ROTARY BODY SURFACING AND MACHINING DEVICE – is designed for surfacing with wear-resistant materials and simultaneous machining of the external surfaces of the parts in the form of rotary bodies. The device is assembled on screw-cutting lathes with the center height above 200 mm. The surfacing is performed using flux cored wires. The cold hardness of the build-up layer amounts to NKS 50-55, which ensures the high wear resistance of the parts. The device is used at maintenance shop of metallurgical and metal mining enterprises, road-construction organizations etc. The device can provide surfacing and machining of rolls, wheels, brake pulleys of bridge cranes, half-couplings, binding band and other components of metallurgical equipment. The post-machining surface roughness amounts to the values $R_a = 12.5$ mcm, the accuracy is 10-12 accuracy degrees. The application of the device makes it feasible to significantly raise the labour productivity through combining the surfacing and machining processes and reducing the number of finish machining allowances.

29. LOW-VIBRATION HIGH-DUTY MULTIPOINT TOOLS – are used for high-performance processing of the vast engineering work mix during the milling operations of plain surfaces, figured, shaped and toothed bores, external and internal thread cutting etc. The designed free-cutting multipoint tools (milling tools, core drills, rymers, gear- and thread-cutters) possess such features:

- Regular alternation of the geometric and design parameters of the adjacent tandem cutter elements (teeth, leaves), which ensure the vibration damping directly during the multipoint cutting operation – the group of low-vibration tools;
- Structural elements of the machining attachments, which make the tooling system more vibration-resistant regardless of the design and geometry of the cutting part – the group of vibration-resistant tools;
- Enhanced stability during the production process, low rate of forced and self-excited oscillations, improved strength and wear resistance of the cutting part.

These features make it feasible

- to increase the production efficiency 2-3 times (the max. cutting speed exceeds 150 m/min);
- to enhance the quality of the processed surface, to use edge tools for high-efficiency machining;
- to improve the tools reliability and durability 3-3.5 times in comparison with standard prototypes;
- to employ modern hard metals, mineral ceramics and composites possessing limited cutting properties under repeated stress conditions, as the cutting part material.

Free-cutting multipoint tools provide the reduction of the deformation in the cutting area. The design of the suggested tools are easy to produce and can be easily manufactured at common toolroom machinery. The free-cutting multipoint tools are generally used for machines, machining centres, automated work cells, as well as for each case of edge cutting machining of parts made of difficult-to-cut materials.

30. TECHNOLOGICAL PROCESSES AND SPECILAIZED AUXILIARIES FOR PLASMA SURFACE HARDENING OF METAL-WORKING TOOLS allow achieving a qualitatively new, higher level of operational properties of structural materials through:

- using of high-productivity, economical, easy-in-operation and available equipment;
- increase of area of the hardened zone;
- using of plasma hardening methods in combinations with volumetric thermal treatment, induction tempering and surfacing.

The developed technologies of hardening provide means for obtaining composite many-layer structural materials possessing both high degree of hardness of the surface layer and high degree of crack resistance of the entire composition. During plasma hardening, economically-alloyed structural materials acquire properties of high-alloy materials.

Specialized auxiliaries have been developed, i.e. a series of plasmatrons of indirect effect, using inert gas (argon) which are compatible with conventional equipment manufactured for plasma cutting, welding, surfacing and spraying.

Overall economic effect is achieved due to decreasing labour-output ratio and increasing processing productivity, reducing tool consumption, saving expensive high-alloy materials and energy resources. Plasma hardening technologies have been introduced at OSC Ilyich Metal and Steel Works of Mariupol, OSC Krivorozhstal Iron and Steel Works, Vitebsk Television Plant (Belarus) and other enterprises.

31. PLASMA SURFACE HARDENING OF TOOLS MANUFACTURED OF HARD METALS AND HIGH-SPEED STEELS – is used for hard-metal cutter plates, tinned-plate cutters and non-resharpened plates for clamped-on cutters. The best plasma treatment mode presupposes the implementation of the strengthening mechanism of no meltdown with transformations in carbides and connective. The plasma surface hardening is characterized by the large size of the reinforced zone – up to 2 mm deep and 10 mm wide, which allows using tools previously reground several times. Both hardness and crack growth resistance are improved, especially of the VK group alloys.

The results of the beta test of the hardened hard-metal cutting tool testify the increase of the durability 2-3 times, as well as the possibility to implement force cutting parameters with retained specified basic durability.

The post-solid-machining plasma hardening of high-speed steel results in the almost complete dissolution of the carbide phase, additional saturation of the solid solution with carbon and alloying elements, substantial increase of structural dispersion and dislocation density, with in consequence causes the simultaneous increase of the service properties complex – hardness, heat resistance, fracture strength. The additional considerable hardening is realized through the cyclic (multiple) plasma treatment.

The technological processes for complex volume-plasma hardening of cutters, drills, mills, thread taps and other high-speed steel tools have been developed. The operating experience confirms the feasibility to increase the tool durability by at least 2 times compared to the conventional solid heat treatment.

32. PROTECTION OF HEAVY-DUTY MACHINERY AGAINST BREAKDOWN including various types of rolling mills, presses, cranes etc., by means of buffer and shock-absorbing devices based on polyurethane elastomers and using safety devices with consumable elements as well as automated. They include buffers, damping devices, shock absorbers, spring couplings, expansion clutches reducing non-technological stresses, and overload controls. Technologically effective, self-contained, safe and reliable, they increase the service life of equipment 2-5 times. They can be employed in mining, transport and other heavy-duty machinery.

Positive results from the production-scale use are available; certain devices have been in operation in steel industries for 8-10 years. Supplies of finished products may be organized.

Novelty of the devices is protected by 15 patents of Ukraine and Russia.

33. MODERN REPAIR TECHNIQUES USING METAL-POLYMERIC MATERIALS – are intended for:

- hermetization of basic parts (cylinder blocks, reduction gears);
- reconditioning of the worn-out surfaces of various parts (clutch shafts, bearing sets, mill housing base surfaces);
- recondition of the sliding pair surfaces (machine slideways, bearing sleeves, work surfaces of hydraulic cylinders);
- refacing and corrosion, erosion, abrasion and cavitation wear protection of the mechanism components.

The new technologies make it feasible to increase more than 1.8-2 times the service life of part and machine components operating under the dynamic load conditions, compared to the conventional retailing technique with consequent machining. The introduction of the developed techniques involves minimum of labour costs, but the improved durability effect of the parts and components proves to be of great significance. This way, the reconstruction costs for one stand of the sheet rolling mill 3000 according to the common technique amounts to \$ 225 thousand, whereas he suggested

technique presupposes only \$ 66 thousand for reconstruction. The performance of the reconstructed machines is guaranteed by ten years of operation. They are successfully operating at the OSC Ilyich Iron and Steel Works, OSC AZOVSTAL Iron and Steel Works, Nikopol Pipe Plant and other Ukrainian enterprises. The new repair techniques are protected by patents of Ukraine. The PSTU regularly organizes instructive seminars for the employees of local enterprises in order to transmit the 'know-how'.

34. FUEL COMBUSTION PROCESS AUTOMOTIVE CONTROL AND REGULATION SYSTEM – is based on the principle of the adjustment of the ratio 'fuel – air' according to the content of oxygen and carbon monoxide in combustion gases. The given principle removes the negative influence of the fuel composition alterations on the combustion. Herewith no continuous analysis of the composition and the temperature of combustion of the fuel burned are needed.

The system includes a gas analyzer for oxygen and carbon monoxide in fume gases, a regulatory controller, and an operation unit. The developed control algorithm ensures the optimization of the fuel combustion process (chemical under-firing and exhaust gas loss minimization); this way the content of carbon monoxide does not exceed the maximum allowed values. The post-introduction fuel saving amounts to 2-4%.

35. NEMTSOV'S FILTERS of the Φ H-A (alpha) group are used for the purification of

- dust emission into the atmosphere;
- dust-loaded air supplied into the rooms and control facilities, compressors and engines;
- machine oil in engines and compressors.

The filters also can retain fines of powdered milk, cement, gypsum etc. from the air conditioning systems.

The filters are small in size, simple and reliable in design, easy regenerated. They possess high purification efficiency degree (96-99%), great dust holding capacity (approximately 10 kg/m³), and low hydraulic resistance (appr. 500 Pa). they do not require liquid supply, pressed air for regeneration and filtration processes. The filters have been introduced in many countries and were patented in Germany, Japan, France, Sweden, Austria, and other.

The filter is manufactured in the shape of cylindrical shell containing a headpiece made of fluffy grain-oriented threads, the ends of which are attached to the upper stationary grid and to the lower mobile one. During the filtration process the threads are compressed by the grids, so that a thick filter layer is created. Gases and liquids passing through the layer are cleared from admixtures. The upper part of the filter is equipped with the regeneration tool providing the headpiece cleanse, as well the lockup of the lower grid on the specified level during the filtration process. The dust captured by the hairs of the threads is delivered through the opening into the dust collector that is located between the rows of string-like threads. Afterwards the cleared threads are compressed by the grids, making the cycle repeat. The time spent on the regeneration of the threads equals 1 minute, the inter-regeneration period lasts for from few hours to few weeks. The filters function in automatic and manual modes. They are assembled according to the specific service conditions; the filter layer is composed in accordance with the type and concentration of the dust, temperature and humidity of the gases being purified etc.

36. DOMESTIC COMBINED PNEUMO-TRACK-MOUNTED SWITCHER BASED ON THE WHEELED TRACTOR is used for track-mounted transportation services at manufacturing entities with limited cargo traffic. The switcher shall still be used as a road-transport tractor. It was

designed on the basis of the wheeled tractor XT3-150K-09 in order to implement the energy-saving transportation technology. The switcher is at present used instead of high-powered diesel locomotives allowing the enterprises to reduce their transportation costs. The main advantage of the switcher is that, with the weight of 13.2 t and the specified engine power, it is capable to make the tractive effort enough to move 6-8 railcars on 8% slopes, and it still can be used for road transportation.

The combined pneumo-track-mounted switcher is characterized by the following features:

- It can make the tractive effort powerful enough to provide manufacture entities having the car traffic volume up to 35-40 railcars per day with complete transportation services.
- It can drive motor roads of the enterprise and quickly change to the rail tracks in order to perform maneuvering operations. Thus the maneuvering operations are accelerated, ensuring the flexibility of the transportation services. This also allows using the switchers in routine transportation operation as a wheeled tractor.

Among the perspective buyers of the designed switcher are enterprises of metallurgical, mechanical engineering, construction, power engineering, coal, chemical industries, agro-industrial complex, sea and river ports, warehouses, and grain elevators, minor and middle business of various fields.

The operation of the switcher is more efficient in coordination with the crane equipments during handling operations, railcar pull-ups, shifts and classification.

The estimated annual saving effect from the employment of the switcher amounts to UAH 200-250 thousand. The other part economical effect through energy saving (fuel saving for one mover is 20-35 t per year).

37. OBTAINING FROM METALLURGICAL SLAG S THE ECOLOGICALLY CLEAN BUILDING MATERIALS FOR HYDRAULIC ENGINEERING CONSTRUCTION – through surface treatment of metallurgical slag, preventing sulphur transition into the aquatic environment. Slags from the ferrous metallurgical plants is a solidified melt of oxides, which did not recovered in the furnaces and did not become metals during the iron-and steel making processes. For instance, BF slag (the by-product iron-smelting in BFs) is formed from the very same oxides, which are the components of various rocks and are used in construction. The building properties of the slag are well-known. Calcium silicate is they base for concrete. When treated with water, the slag receives cementing properties and within one month it becomes a solid monolithic mass.

The main source of water pollution after the immersion of slag into water is sulfur. The pollution is caused by the transition of the surface sulfur into the aquatic environment, encouraging the formation of hydrogen sulfide and acid medium. This results in the destruction of living organisms and the growth of anaerobic bacteria.

The problem of the sulfur neutralization is solved through the surface treatment of slag, which decreases the content of the surface sulfur 10-11 times to 0.1%. The surface treatment of slag not only prevents water pollutions, but it improves the building properties of slag, as it accelerates the process of the slag mass hardening.

Ways of using the new material for hydraulic engineering construction:

- dam filling;
- bank protection;
- berth construction and repair;
- artificial islands filling;
- bottom sediments improvements.

The building parameters of the cinder fill
One year after the finishing of the works

1. Processed BF slag cinder fill (0-400 mm) is homogeneous in mechanic and filtration characteristics, heterogeneity may occur because of the uneven stacking and ramming of the material.

2. The characteristics of the material one year after the dam filling:

- dry density 1.8 t/m^3 ;
- particle number density $2.5\text{-}2.8 \text{ t/m}^3$;
- porosity 40-45%;
- filtration coefficient $K_\phi = 1.32 \text{ m per day}$;
- modulus of deformation $E = 4000\text{-}9000 \text{ t/m}^2$;
- angle of internal friction $\phi = 41^\circ / 39^\circ$;
- angle of internal cohesion $C = 2.75 \text{ t/m}^2 / 2.5 \text{ t/m}^2$.

The stabilization of the stacked material takes place in 3 months, stiffening of the mass – in a year.

The price of 1 ton of processed slag amounts approximately UAH 25. The minimum price of natural breakstone is UAH 50-60. With the 0.5 ton of slag processed each year and using it instead of breakstone, the annual saving will amount to UAH 12.5. The costs are repaid within 6 months.

The perspective consumers of the processed slag are Chernomorneftegaz, merchant port of the Black and the Azov Seas, Olympiad objects (islands) in Sochi, Gazprom and Rosneft subsidiaries in Krasnodarsky Kray, local administrations of coastal regions.

Such forms of cooperation are appropriate: establishing a joint company, assignment of interest to the interested party (sale of license), preparing technical documentation of the slag processing method for the specific customer.