**MINISTRY OF EDUCATION AND SCIENCE,
YOUTH AND SPORTS OF UKRAINE
STATE HIGHER EDUCATION INSTITUTION
"PRYAZOVSKYI STATE TECHNICAL UNIVERSITY"**

TECHNICAL PROPOSALS

Catalogue

Mariupol

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TABLE OF CONTENTS

TECHNICAL PROPOSALS

TECHNICAL PROPOSAL 1

1. Name.

"Iron smelting practice of injecting into the blast furnace the hot blast with subatmospheric oxygen content under the conditions of shrinkage or lack of natural gas".

2. Key words.

ENERGY-SAVING, BLAST-FURNACE AIR, AIR-BLAST TEMPERATURE, OXYGEN CONTENT IN THE BF AIR, INDUSTRIAL NITROGEN, BLAST ENGINE, COKE CONSUMPTION.

3. Purpose.

The reduction of the coke overconsumption and the decrease of the pig iron production costs.

4. Application field.

Ferrous metallurgy**,** BF production.

5. Description and basic technical and economic characteristics.

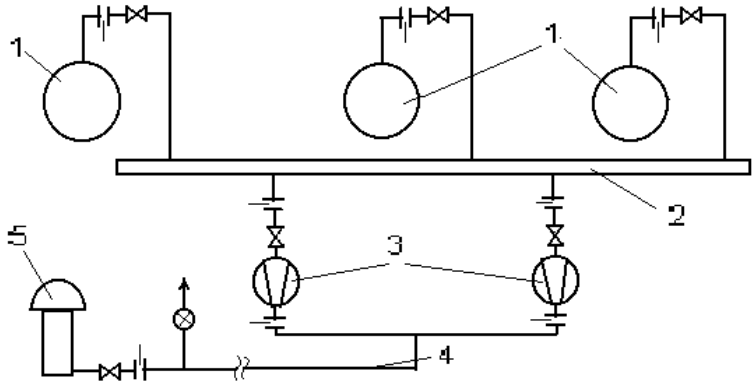
The largest natural gas consuming industry in Ukraine is ferrous metallurgy. A single iron and steel plant consumes 4-5 mln m^3 of natural gas per day. From 1/3 to 1/2 of the overall consumption is the share of the BF plants. The main consumption of natural gas in the BF plant is determined by the injection of the 100-120 m^3 of gas per each ton of pig iron produced. When the supply shortage of the gas occurs, the natural gas consumption is reduced in the BF plant in the first place, as the other energy consumers of the iron and steel works find natural gas their single energy source. Moreover, the gas is injected into the blast furnace under the pressure of 3 ATG and above. The reduction of the gas pressures makes its injection into the BF impossible. With no natural gas the BF smelting characteristics are to decrease: the air-blast temperature falls from 1000-1200 ^{0}C, the coke consumption increases from 480-500 to 700-760 kg/t of pig iron, the productivity decreases by 20%. This causes the pig iron cost price to increase by 20-25%. The sudden air-blast temperature drop results in the early breakdown of the stove, causing additional multi-million losses.

The best replacement of natural gas in the BF production is pulverized coal fuel that is widely used in European countries. However, the application of this fuel in Ukraine requires great capital costs and much time (3-4 years) for introduction and development.

Before the introduction of the pulverized coal fuel on the iron-and-steel works, iron smelting with injecting into the BF the hot blast with subatmospheric oxygen content turns out to be a temporary energy-saving method of iron smelting that provides an essential cost reduction. Due to the constant fuel combustion temperature in the tuyeres the method allows maintaining the air-blast temperature of 1,000 ^{0}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 m^3/hr. The nitrogen supply system includes (see the illustration) two standard air propellers and a pipeline that delivers nitrogen to the air inlets of the blast engine. The BF nitrogen supply system is assembled within three months on any ironwork having an oxygen plant. The daily cost saving due to the implementation of the suggested method in the BF shop with the capacity of 10,000 t pig iron/day amounts to UAH 500-800 thousand. The construction costs of the BF nitrogen supply system are repaid within a month.

6. Illustrations.



The scheme of delivering low-pressure nitrogen to the BF blast engines:

1 – scrubbers of the oxygen plant separation units; 2 – collector; 3 – air propeller; 4 – nitrogen pipeline; 5 – air inlet of the blast engine.

7. Comparison with analogues, advantages.

The conventional method to reduce BF-smelting costs with no natural gas available is blast humidification. Due to retaining the high air-blast temperature the coke overconsumption with no natural gas available is reduced by 30-35 kg/t of pig iron. Decreasing the oxygen content in the blast below 21% is more efficient, as it ensures reducing coke overconsumption by 60-89 kg/t of pig iron.

8. Consumers.

BF plants of iron and steel works, which have an oxygen plant.

9. Expectant market geography.

Iron and steel works of Ukraine.

10. Proposal validity period.

Unlimited.

11. Suggested conditions of the implementation of the technical proposal.

Compilation of the technological task for designing and technical and economic assessment, scientific supervision of the design and construction works, adopting technologies, design study and key ready construction of the system. Contractors – Pryazovskyi State Technical University and "Azov-Engineering" Ltd (Mariupol). R&D costs – UAH 300,000; the costs of the design, construction and installation works amount to UAH 8-16 mln.

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Appendix: the list of main scientific publications:

1. Тарасов В.П., Томаш А.А., Семакова В.Б. Изменение расхода кокса и производительности доменной печи при содержании кислорода в дутье менее 21 % // Труды международной научно-технической конференции «Теория и технология аглодоменного производства». – Днепропетровск, 1995. – С. 37 – 39.
2. Новые аспекты снижения содержания кислорода в дутье доменных печей в современных экономических условиях / А.А. Томаш, В.П. Русских, В.П. Тарасов, В.Б. Семакова, И.М. Пефтиев, Е.И. Хрущёв, А.А. Малимон, В.С. Чумаченко // Труды V международного конгресса доменщиков «Производство чугуна на рубеже столетий». Днепропетровск – Кривой Рог, 7 – 12 июня 1999 г. – Днепропетровск: Пороги, 1999. – С. 238 – 242.
3. Снижение энергетических затрат на выплавку чугуна в современных условиях Украины / В.П. Тарасов, В.П. Русских, А.А. Томаш, В.Б. Семакова // Металл и литьё Украины, 2000. - № 3 – 4. – С. 5 – 7.

TECHNICAL PROPOSAL 2

1. **Name.**
   "Blast-furnace air humidification through water-spraying in the tuyere region".

2. **Key words.**
   TUYERE STOCK, THERMAL STATE OF THE HEARTH, WATER-SPRAYING, INDIRECT REDUCTION, AIR-BLAST TEMPERATURE, REDUCTANT CONCENTRA-TION.

3. **Purpose.**
   Ensuring the high air-blast temperature under the conditions of shortage of natural gas and BF air humidification vapour, decreasing the specific coke consumption for iron smelting under the given conditions.

4. **Application field.**
   BF iron making.

5. **Description and basic technical and economic characteristics.**

The system makes it feasible to simultaneously feed several agents into the BF air: natural gas, fuel oil, vapour etc. Therewith, the theoretical combustion temperature in the hearth with the modified concentration of the listed blast elements. The suggested BF technology is supported by the specific air tuyere design that allows modifying the additive ration in the BF air.

The improvement of the BF smelting technical-and-economic performance after the development introduction is ensured by:

- maintaining the maximum hot-blast temperature under any changes of the parameters (oxygen enrichment, moisture alterations, changes of the hydrocarbon additives consumption etc.);
- increasing the concentration of the gaseous reductants in the hearth gases;
- improving the gas permeability of charge column through decreasing the furnace gases viscosity together with increasing the hydrogen concentration in the gases;
- employing the BF smelting thermal state automatic control system.

The production-scale implementation of the given technical proposal requires the following: agents supply and delivery control system for each air tuyere of the BF, tuyere region thermal state control system and thermal state regulation system. The introduction costs of the system at one BF amount to UAH 80-90 thousand, the economic effect from the coke saving depends upon its price and amount to several millions hryvnas.

6. **Illustrations.**
   No.

7. **Comparison with analogues, advantages.**

No steam production costs are required; no negative influence of the air blast humidification on the blast-furnace brickwork is present, as distinct from the developments of the Japanese metallurgists.

8. **Consumers.**
   Ironworks, which have a BF plant.

9. **Expectant market geography.**
   Pryazovya, Donetsk region, Ukraine, CIS.

10. Legal Protection.

Patent of Ukraine № 74297 A, IPC C21B5/00
"Спосіб доменної плавки" ("Blast-furnace smelting method").

Patent of Ukraine № 47026 A, IPC C21B7/16
"Дуттьова фурма доменної печі" ("Blast-furnace tuyere").

11. Proposal validity period.

Unlimited.

12. Suggested conditions of the implementation of the technical proposal.

On the terms of the agreement.

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TECHNICAL PROPOSAL 3

1. **Name.**
   "Control method of the charge and gases distribution in the blast furnace".

2. **Key words.**
   ORE MATERIAL, COKE, GAS FLOW, FURNACE TOP, BLAST FURNACE.

3. **Purpose.**
   The method is for introduction in BFs equipped with bell-type charging devices.

4. **Application field.**
   Ferrous metallurgy, iron-making.

5. **Description and basic technical and economic characteristics.**

The method includes feeding ore material and coke. In this regard increasing the ore burden and reducing the gas flow intensity at the walls of the top are conducted through charging ore materials at a higher burden level than that of the coke.

The gas flow distribution control is performed using different gas permeability degrees of the two BF burden components: ore materials and coke. The mechanically more stable coke possesses the higher gas permeability degree, and the fraction of 25 mm is screened from the coke before charging. The less solid ore materials are fractured in the BF, and only the 5 mm fracture is screed from them. The ore materials add the increased resistance to the gas flow. In the areas of the top, which are charged the larger quantity of ore materials and the lesser quantity of the coke, i.e. which have the higher ore burden, the intensity of the gas flow is reduced. In the areas of the top, which are charged with the larger quantity of the coke and the lesser quantity of the ore materials, i.e. which have the lower ore burden, the intensity of the gas flow is increased.

The control method of the charge and gases radial distribution in the BF is employed as follows. The initial charging system $\begin{cases} CCCC\downarrow \\ AAAA\downarrow \end{cases}$ – 1.50 m with the constant burden level of 1.50 m both for coke and agglomerate. The control of the CO_2 content in the top gas and the gas temperature at the walls is held. When the CO_2 content in the boundary area is decreasing lower that 10% or the top gas temperature at the wall is increasing more than 180 ^{0}C, the boundary area is to be charged with additional ore materials.

The next charging system is $\begin{cases} CCC\downarrow -1.50\ m \\ AAAA\downarrow -1.75\ m \end{cases}$ with the burden level of 1.50 m for coke and 1.75 m for the ore material – agglomerate. After four skips of coke are taken to the large bell, the charging control system is in the stand-by mode till the burden surface is descending by 1.50 m from the edge of the large bell in the descended state. When the target burden level is reached, the large bell is opened letting the coke dump on the top, thus making the column of coke. The large bell is then closed. The four skips of agglomerate are charged on its surface. The charging control system is in the stand-by mode till the load descends by the target level of 1.75 m. Afterwards the large bell moves down and the agglomerate is dumped on the top making the agglomerate column. Subsequently the cycles of charging four skips of coke and four skips of agglomerate is repeated. If the CO_2 concentration at the top walls exceeds 16% or the top gas temperature in the boundary are is lower that 140 ^{0}C with the hard burden yield, the core zone is to be discharged and the charging system $\begin{cases} CCC\downarrow = 1.75\ m \\ AAAA\downarrow = 1.50\ m \end{cases}$ is applied.

The production-scale test of the control method of the charge and gas radial distribution was conducted at the BF № 4 (with the working volume of 2,002 m^3) of a metallurgical iron and steel works of Mariupol. The BF was not equipped with the facilities for the top gas sampling and the gas temperature measurement at the top radius. The development of the peripheral gas flow was controlled according to its temperature under the stockline-wearing plates. After the initial charging system $\begin{cases} CCCC\downarrow \\ AAAA\downarrow \end{cases}$ – 1.50 m was changed by the system $\begin{cases} CCC\downarrow -1.50\ m \\ AAAA\downarrow -1.75\ m \end{cases}$, the average temperature under the stockline-wearing plates dropped from 566 to 474 ^{0}C, which testifies the substantial reduction of the gas flow at the walls. After changing to the charging system $\begin{cases} CCC\downarrow = 1.75\ m \\ AAAA\downarrow = 1.50\ m \end{cases}$, the average temperature under the stockline-wearing plates once more increased from 474 to 563 ^{0}C, i.e. the intensity of the peripheral gas flow has increased.

The BF operation experience demonstrates that improving the control of the charge and gas radial distribution ensures addition reduction of the coke consumption by 1.05-2.0 kg for 1 ton of cast iron and the productivity improvement at the same time. Due to the reduction of the specific coke consumption in the BF with the working volume of 2,002 m^3 the annual economic effect makes:

$$0.001 \times 1.5 \times 350 \times 1{,}200 = \text{UAH } 630{,}000$$

where 350 is the price of 1 ton of coke, UAH; 1,200 – the annual production, thousand ton, of the BF with the working volume of 2,002 m^3.

6. Illustrations.

No.

7. Comparison with analogues, advantages.

Among the similar methods of BF charging is the well-known method that includes separate charging of coke and ore materials *AA*↓ *CC*↓, *CC*↓ *AA*↓, including increased loads *CCCC*↓ *AAAA*↓ (Patent of Ukraine №51584A, IPC C21B7/00//Промышленная собственность (Industrial Property). – 2002. – №11).

The given method of the separate BF charging with the increased loads ensures more balanced ore materials distribution in the radius of the work space; the redistribution of the gas flow in the cross-section of the furnace in the coke columns and elimination of the gas flow alteration caused by the inefficient ore mixture distribution; improvement of the gas permeability of the softening area due to the more efficient shaping of the coke holes. This ensures the reduction of the specific coke consumption by 25-35 kg/t pig iron together with the improvement of the BF productivity. However, this method does not make it feasible to regulate the distribution of ore materials and coke in the BF.

The suggested control method of the radial distribution of charge and gases in the BF through modifying the ore materials charging conditions with the separate discharge ensures the targeted redistribution of the gas, thus increasing the reducing power degree of the gases and reducing the specific coke consumption for 1 ton of cast iron.

8. Consumers.

Ironworks.

9. Expectant market geography.

Ukraine, CIS, Germany, UK, Brazil etc.

10. Legal Protection.

Patent of Ukraine № 69655A, 11/11/2003.

11. Suggested conditions of the implementation of the technical proposal.
On the terms of the agreement.

12. Proposal validity period.
Unlimited.

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TECHNICAL PROPOSAL 4

1. **Name.**
   "The development and introduction of the natural gas supply method that ensures maintaining the high gas pressure at the BF tuyeres in wintertime".

2. **Key words.**
   NATURAL GAS (NG), TUYERE, BLAST FURNACE, THROTTLING, PILOT PLANT.

3. **Purpose.**
   Creating the technological circuit of NG supply to the BF tuyeres that excludes the influence of the seasonal reduction of the NG consumption for the gas pressure at the tuyeres.

4. **Application field.**
   BF plants of Iron and Steel Works in Ukraine.

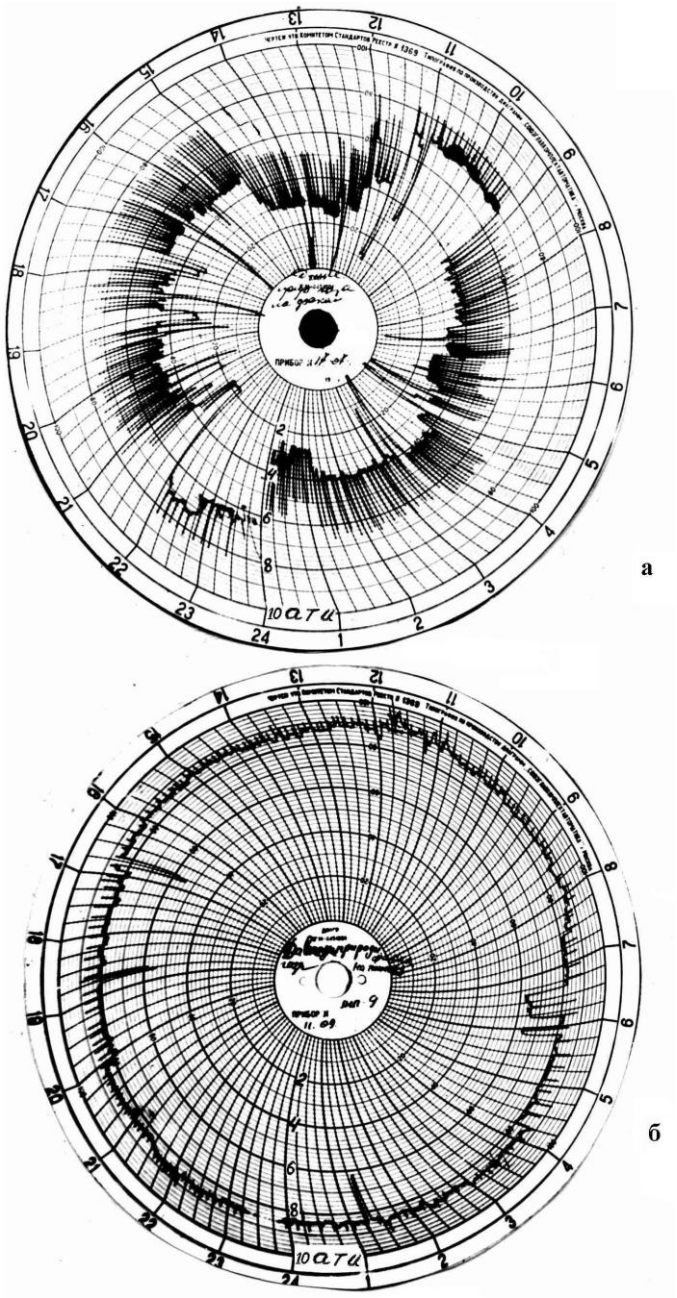
5. **Description and basic technical and economic characteristics.**

Annually in wintertime the ironworks in Ukraine suffer from the limitation of the gas supply. Among the ironworks is the OSC AZOVSTAL Iron and Steel Works. For the last few years the reduction of the NG consumption for this enterprise caused the gas pressure drop below (~ 2.5 ATG) the level of the injected air pressure (~ 2.7 ATG). Therewith, injecting the NG into the BF through the tuyeres is technologically impossible. The cast-iron production at the BF plant of the OSC AZOVSTAL Iron and Steel Works is substantially decreased during 5-10 day each year. Still, longer periods of the NG consumption limitation are possible to occur in the future. Unfortunately, the operating personnel got used to the present situation considering it inevitable. However, the reduction of the gas pressure due to the decrease of its consumption directly results from the inefficient consumption control rather than from the low network gas pressure. For example, during the complete cutting-off the NG feed to the BFs (January 19, 2006) the supply network pressure amounted to 17 ATG.

The present proposal is aimed at the creation of the technological circuit of the NG supply that ensures that the decrease of the NG consumption does not result in the reduction, but in the increase and stabilization of the NG pressure at the BF tuyeres.

6. **Comparison with analogues, advantages.**

The research work has been made at the open-hearth plants of the OSC AZOVSTAL Iron and Steel Works (picture 1) and the OSC ILYICH Iron and Steel Works of Mariupol on the methods of the wintertime increase of the gas pressure at the burner.



Picture 1. The diagram of the daily changing of the NG pressure at the burner of the open-heath furnace №9 of the OSC AZOVSTAL Iron and Steel Works as to the present (a) and suggested (b) circuits of the NG supply control

The burners with the new circuit of the NG supply control have effectively functioned for a long period of time.

The introduction of the suggested proposal at the BF plant of the OSC AZOVSTAL Iron and Steel Works will give the annual economic effect of ~ UAH 10 mln.

7. **Consumers.**
   BF plants of Iron and Steel Works in Ukraine (including the six BFs of the OSC AZOVSTAL Iron and Steel Works).

8. **Expectant market geography.**
   Near and far abroad countries.

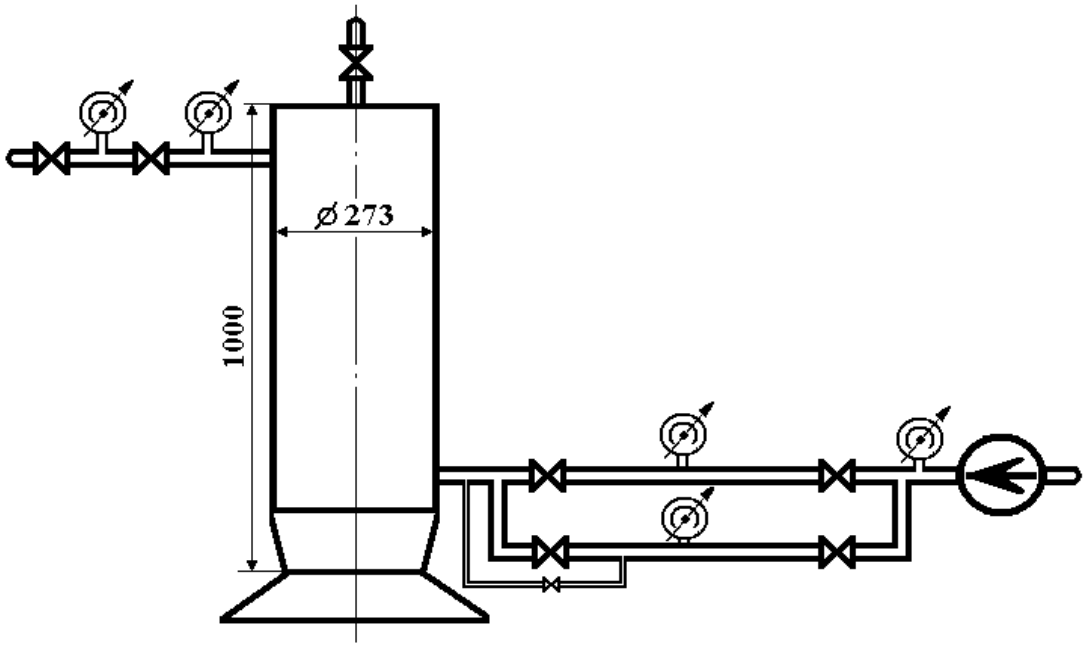
9. Legal Protection.

The technical proposal is patentable.

10. Suggested conditions of the implementation of the technical proposal.

The introduction of the technical proposal, on the OSC AZOVSTAL Iron and Steel Works in particular, requires the realization of the complex of research, design and implementation work:

1. Analysis study on the recount of the supply pipelines, the NG consumption for each tuyere (about 100 tuyeres) being reduced (contractor – Pryazovskyi state Technical University).
2. Manufacturing, assembling and conducting tests on the laboratory physical model (picture 2) with installation of the supply pipelines according to the new control circuit. The delivery pressure amounts to 10-12 ATG.
3. Carrying out the project (contractor – the Project Designing Department of the OSC AZOVSTAL Iron and Steel Works) of the installation of the additional (in wintertime) pipelines for each tuyere, preliminary calculations of the NG supply system included.
4. Designing the new circuit of the NG supply distribution on the enterprise from the gas-distribution station (contractor – UKRGIPROMEZ). The assembling of the new regulation system at the GDS (control equipment and flowmeter). Assembling the wintertime variant of the NG supply system on the each tuyere of the six BFs.



Picture 2. Trial plant pattern.

5. Signing the NG supply agreement to the OSC AZOVSTAL Iron and Steel Works. According to the agreement the gas consumption control is entrusted to the BF plant (not to the GDS).
6. Registration of the patent documentation for invention.
7. Tests and start-up of the new control system of NG supply to the six BFs.

The costs for the proposal introduction work amount to UAH 200,000; including UAH 90,000 for the R&D work. The term of the work performance is one year. Desired is the wider distribution of the new technological circuit of the NG supply to the BF tuyeres in the system of the PA "Metallurgprom".

11. Proposal validity period.

Unlimited.

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TECHNICAL PROPOSAL 5

1. **Name.**
   "Acoustic automation system of the basic-oxygen and arc-furnace steelmaking processes".

2. **Key words.**
   CONTROL, ACOUSTICS, BASIC-OXYGEN FURNACE, ELECTRIC ARC FURNACE, MELTING, HIGH-TEMPERATURE MEASUREMENTS, REAL-TIME, TEMPERATURE, CHEMICAL COMPOSITION, RECOURSE AND ENERGY SAVING.

3. **Purpose.**
   The system is designed for the real-time regulation and control of the BOF and arc-furnace steelmaking processes.

4. **Application field.**
   Ferrous metallurgy, steelmaking.

5. **Description and basic technical and economic characteristics.**

The acoustic system is assembled from the reliable technical components and based on the stable and robust algorithm. The visual indication ensures the real-time control of the basic melting parameters, including the melting-stop signal.

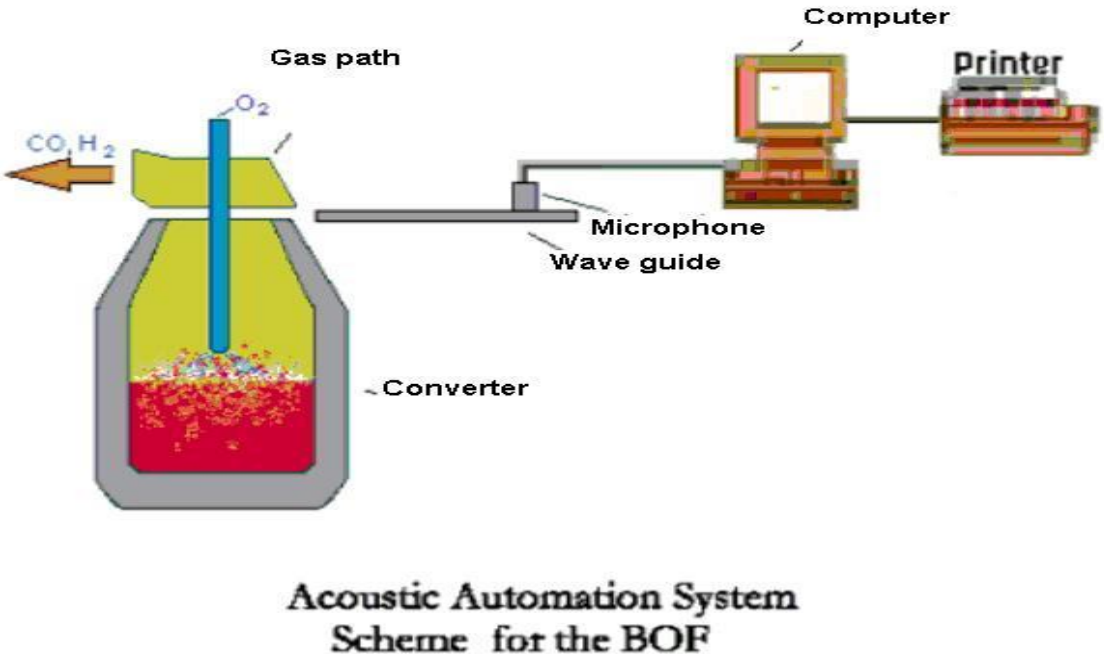
The components of the system are:

- initial acoustic data registration unit;
- acoustic data filtrating and processing unit. On the real-time basis the following parameters are defined: mass-averaged melt temperature, mass-averaged concentration of chemical elements in the melt, scrap melting pattern, pattern of the melt liquid slag phase formation;
- unit for the instrumentation complex and melting technological parameters control.

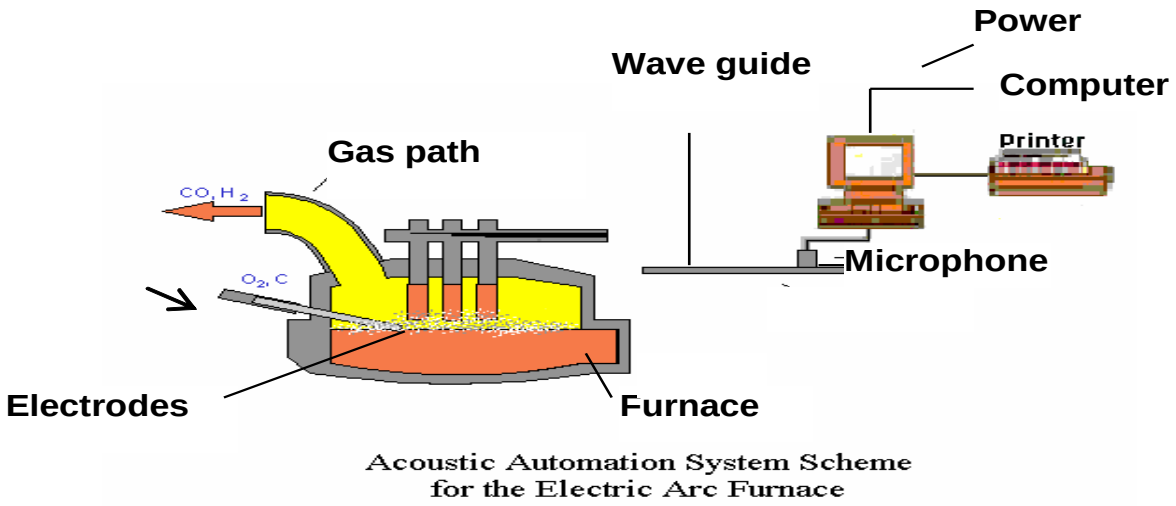
The acoustic system was tested on the BOFs with the capacity of 25, 180 and 400 t in Ukraine and China (1986-1995), on the alternating and direct current electric arc furnaces with the capacity of 15, 30, 50, 100, 150 and 250 t in Israel, Japan, Italy, Spain, and USA (1997-2005). The tests confirmed the high reliability and accuracy of the parameters defined by the system. The correlation coefficient of the parameter values, which are controlled by the system and are measured conventionally, reaches 0.95-0.97. The employment of the acoustic system made it feasible to observe the technological process, consequently ensuring the improvement of the steel made, reduction of the aluminum and ferroalloy consumption. Among the major results are: facilitation of the technological process, decrease of the mistakes of the operation personnel, finding the unpresentable samples and measurements.

The received operation data testify that the energy recourses saving reaches 5-30%, the furnace productivity is enhanced by 10-25% and the metal loss is reduced by 1.5-5%. The high reliability of the technological parameters ensures creating control systems of the basic-oxygen and arc-furnace steelmaking processes.

6. Illustrations.



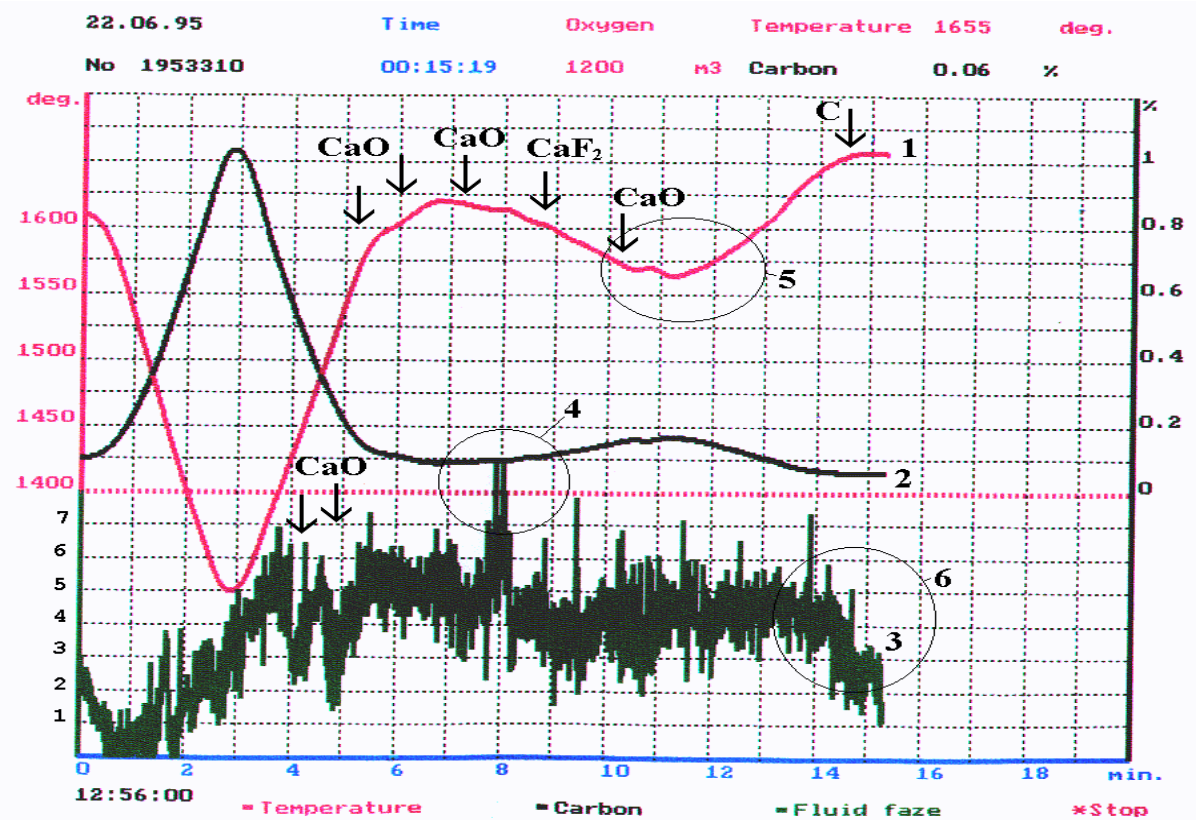
Picture 1. Acoustic Automation System Scheme for the BOF



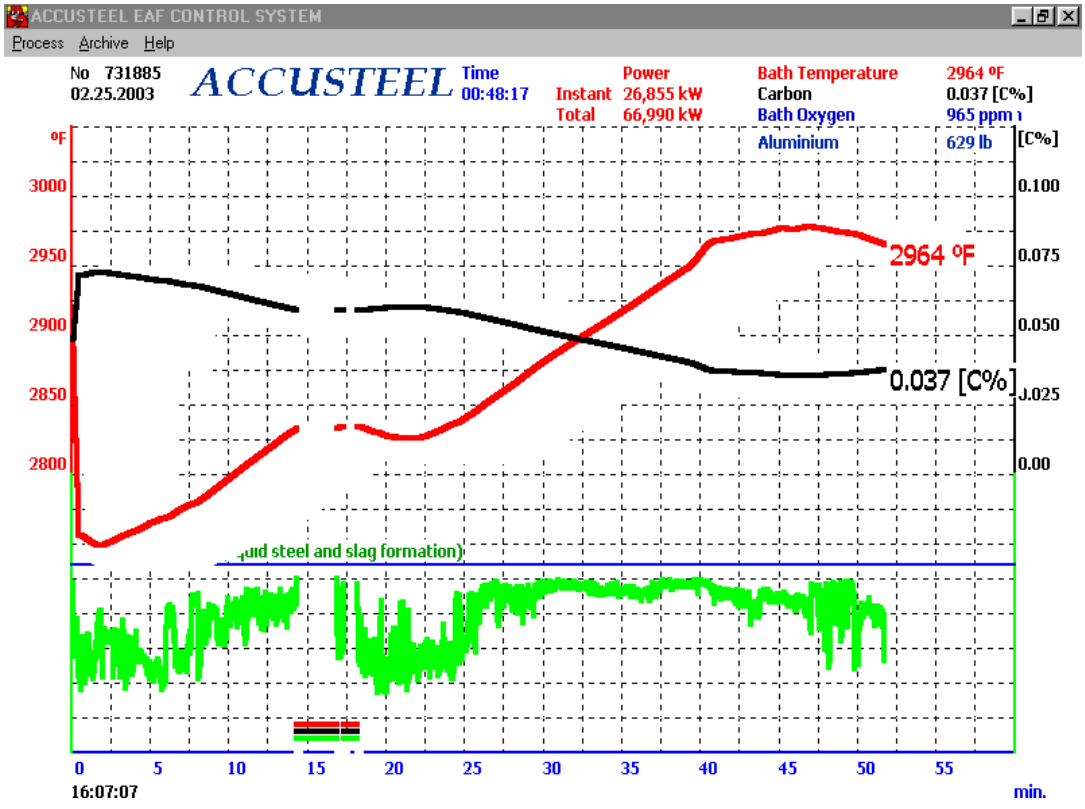
Picture 2. Acoustic Automation System Scheme for the Electric Arc Furnace

The pictures demonstrate the acoustic automation system schemes for the basic-oxygen and electric arc furnaces. The initial data source for the system is the operation melting noise that emerges BOF due to the interaction of the oxygen jet and the melt; in the electric arc furnace the noise is results from the interaction of the plasma jet and the melt. The noise traced by the microphone that is installed in the wave guide, is transformed into the electrical signal. The signal is then transferred to the analog-digital converter in the computer. The converted acoustic signal is then put into calculation. As the result, the following operation process data are received: 1) mass-average temperature; 2) chemical composition; 3) real-time statistics of the melt liquid slag phase formation. The received data appears in the computer display in digitalized and graphical forms.

Here are some of the examples of the system-controlled operation parameters visualization.



Picture 3. Basic-oxygen Conversion.



Picture 4. Electric Arc Conversion.

7. Comparison with analogues, advantages.

The analogues are presented by the computer systems designed for the regulation and control of the BOF and EAF steelmaking. The algorithm of the systems is based on the physical representation of the material and thermal balance of the melt. In order to make the calculations more dynamic, the following parameters are taken into account: the acoustic noise signal of melt or the off-gas gas composition data with the calculations corrected according to the results of the melt temperature measurements with the thermocouple in the end of the melt. The results of the calculation are the real-time data of the temperature and the chemical composition of the melt. However, among the disadvantages of the conventional algorithms are: a) the survey of the dynamics of the material component of the melt is impossible (in the calculation the statistical information is used); b) the low, within 0.2-0.5, correlation of the temperatures, which were calculated by the computer system and measured by the thermocouple in the end of the melt; c) the dissimilarity of the analysis results of the off gases, which were sampled in the gas path, and the in0operation gas composition in the steelmaking unit.

The nearest analogue of the developed system is the acoustic system of the slag0making process control in BOFs and EAFs.

The performance capabilities of the conventional systems are limited by their inability to convert the steelmaking process dynamics data into the reliable operation parameters.

The suggested acoustic computer system makes it feasible to trace the mass-average temperature of the melt, carbon content in the metal, and the dynamics of the melt liquid slag phase formation in real time.

8. Consumers (present and prospective).

Ironworks.

The modified acoustic system can be employed for the monitor and control of the:

- fuel combustion processes in the aircraft jet engines, electric plant burners, reheat furnaces;
- technological processes of cement, quicklime, copper, aluminum, nickel, magnesium production, oil cracking, production and sterilization of food;
- thermal control of nuclear and thermonuclear reactors.

The enterprises of the named fields are sure to be considered the consumers of the suggested acoustic system.

9. Expectant market geography.

Ukraine, CIS, Spain, China, Brazil, USA, Austria, Italy, Germany, France, UK, Japan etc.

10. Legal Protection.

Patent of the Russian Federation № 2006007 “Способ определения температуры жидкости” (“Method for measuring the temperature of the fluid”), 15.01.1992.

Patent of the USA № 6039472 “Method for measuring the temperature of a metallurgical furnace using an acoustic noise parameter and rate of electrical power”, 21.03.2000.

11. Suggested conditions of the implementation of the technical proposal.

On the terms of the agreement.

12. Proposal validity period.

Unlimited.

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TECHNICAL PROPOSAL 6

1. **Name.**
   "Process engineering of the automatic vacuum metal (AVM) ingot casting technique".

2. **Key words.**
   INGOT CASTING, AUTOMATIC VACUUM METAL, ELIMINATION OF THE CHEMICAL INHOMOGENEITY, CROP REDUCTION, ENERGY SAVING.

3. **Purpose.**
   Production of the high-quality steel ingots for rolling and forging production, ensuring the substantial increase of the metal yield and the enhancement of the metal homogeneity.

4. **Application field.**
   Ferrous metallurgy, mechanical engineering.

5. **Description and basic technical and economic characteristics.**

Nowadays a great number of ironworks introduce method of metal casting on the continuous-casting machine (CCM), which is not always efficient due to the great capital costs on the building of the CCM. The conventional ingots casting techniques from killed and alloyed steel grades inevitably cause the creation of the hot top of the ingot, in which the melt hardens the last. The top results from the development of liquation processes in the ingot causing its axial and extra-axial inhomogeneity to increase. The similar problems, though in a less degree, occur in the continuous cast billets. However, due to the less time needed for the metal freezing during the continuous casting, the liquation in such metal is less developed than in the ingots.

When casting the AVM ingots their upper parts are exposed to cooling, which decreases the freezing time of the melt and reduces the liquation. The employed methods make it feasible to get inside the ingot a hermetic shrinkage hole that is formed in vacuum (with no outer gases getting inside). During the following plastic strain the hole is completely melted, with no lamination occurred. The reduction of the liquation makes it feasible to enhance the metal quality, and the melting of the shrinkage hole walls ensures efficient ingot casting from killed and alloyed steel grades. During the plastic strain the top scrap of the produced billets lies within 0.5-8% depending on the requirements of the metal.

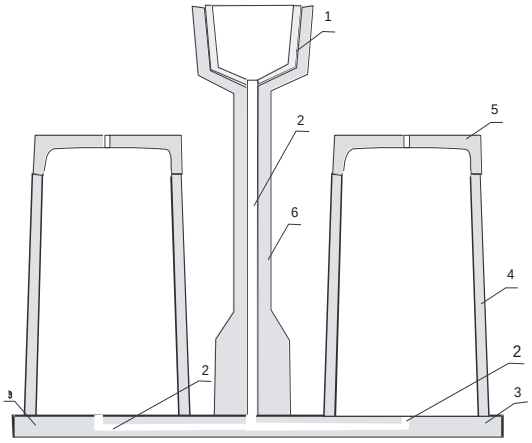
The stable and solid top of the ingot makes it possible to move the ingot to the soaking pit (or thermostat) till its complete freezing and at the same time without breaking the safety standards. This ensures substantial cost saving for the ingots heating for the plastic strain, and even further rejecting such heating method in favour of the temperature control for the temperature equalization in the cross-section of the ingot.

The basic technical and economic characteristics of the AVM ingots casting method:

- reduction of the top scrap of plate ingots from 18-20% to 3-3.5%;
- reduction of the top scrap of bar ingots by 5-15%;
- 0.5% reduction of the top scrap of semikilled steel ingots (the recovery amounts to 95%);
- reduction of the steel-casting train preparation costs by 10-15% due to the removal of the tuyere hot top manufacturing, service, and repair operations;
- 14-17% reduction of the energy carriers consumption for ingots heating in the soaking pit;
- reduction of the pollutant emission into the atmosphere by 15-29%;
- the economic effect of $ 20 mln for one ton of metal due to the recovery increase only.

6. Illustrations.

The structural scheme of the AVM ingots production method introduction device.



Фиг. 1

Picture 1.

1 – sectional top, 2 – gates, 3 – bottom plate, 4 – ingot mold, 5 – refrigerating cover, 6 - runner

7. Comparison with analogues, advantages.

The shrinkage hole hermetization method was suggested in France in 1967. The method is based on the plugging of the ingot head, cure of the melt fro a certain period of time, and turning the ingot mold around 180^0 on the horizontal axis. Thereafter the ingot is placed into the slow heat cell and hold there till the full crystallization across the section. Afterwards, the ingot is in its initial position taken to the flash heat cell. During the following 1971-1974 years a great number of similar shrinkage hole hermetization methods were put forward. Those methods differed only in the scheme of the ingot horizontal axial rotation. However, the desired degree of the metal homogeneity in non-metallic inclusions was not reached.

The suggested ingots casting method differs in the optimization of the thermo time control of the ingot solidification process. Due to the casting process of the ingots they were called pressurized or AVM (automatic vacuum metal); during the crystallization process the shrinkage hole inside the ingot undergoes hermetization, thus preventing the outer gases from penetrating the shrinkage hole and averting the oxidative processes in the freezing melt. The production-scale tests proved that the rolled products manufactured of the ingots (both plate and bar), which were cast according to the suggested method, had the top scrape of the killed steel ingot pieces of 3-8% instead of the usual 13-18%. The analysis of the results testified that the AVM ingots bloom possesses the higher quality of the metal and the lesser top scrape.

Among the most prominent advantages of the suggested method is the almost complete absence of the axial heterogeneity (both chemical and physical). In the top end of the piece the degree of the liquation square is substantially reduced or it is completely absent. This way the transfer of such products as rails to the lower quality degree is excluded.

On top of that, the introduction of the new technology does not require high capital costs. The present cost for the AVM ingots facilities do not surpass the present costs for the common ingots facilities.

The method allows rolling ingots with the increased enthalpy, which makes it feasible to considerably reduce the energy consumption and to increase the recovery and the quality of the metal.

8. Consumers.

Ironworks and mechanical engineering plants.

9. Expectant market geography.

Ukraine, near and far abroad countries.

10. Legal Protection.

The technical proposal is patentable. On the basis of the results of the preliminary work an application for the supposed invention was given and the patent of Ukraine was received. The process of the technical proposal introduction involves the development and commercial tests of the new technical solution that in a great measure differs from the conventional methods, which is supported by the appropriate legal protection.

11. Suggested conditions of the implementation of the technical proposal.

The TP introduction working costs (research and design work, tools production, experimental adjustment of the method under the present production conditions; contractors – Pryazovskyi State Technical University, "KAMIT" Ltd, Mariupol Branch of Urkgipromez) amount to UAH 500,000. The execution period is two years. The TP is allowed for replication, whereupon for each type of ingots the specific parameters of the freezing process are developed.

12. Proposal validity period.

Unlimited.

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TECHNICAL PROPOSAL 7

1. **Name.**
   "The theory and development of the energy and resource saving methods of injecting powder materials into the metallurgical melts and melting facilities".

2. **Key words.**
   DISPERSED FLOWS, POLYDISPERSE GAS SUSPENSIONS, PARTICLE ATTRITION, TWO-PHASE JETS, ADDED MASS.

3. **Purpose.**
   Improving the theory of the complex dispersed flows streams, the use of the theory for the creation and introduction of the competitive iron and steel production technologies.

4. **Application field.**
   Top-blown, side-blown, bottom-blown converters, electric furnaces, blast furnaces equipped with the pulverized coal fuel transfer and injection systems.

5. **Description and basic technical and economic characteristics.**

The systems of powder materials injection into the metallurgical melts and melting facilities are concerned with numerous theoretical and practical problems, which hinder the large-scale implementation of the advanced technologies. The introduction of the technical proposal (TP) gives the possibility to receive new information on the nature of the complex dispersed flows. On the basis of this information new calculation methods and technical solutions can be created in conformity to the following class of issues:

5.1 The high-density flow streams in the pneumatic conveying system:

- monodispersed uni- and multicomponent two-speed gas suspensions of constant composition; isothermal stream;
- monodispersed multicomponent gas suspensions with regard to the form of particles and their attrition;
- polydispersed multicomponent, multispeed gas suspensions of constant composition and with regard to the Magnus force;
- polydispersed multi-fraction gas suspensions with regard to the particle attrition, numerous resists and diversions;
- monodispersed multicomponent oil-fuel emulsion flows with regard to the particle attrition.

5.2 Streams in BOF and ladle tuyeres:

- monodispersed high-density gas suspensions of constant composition and intensive heat input; collisionless mixtures;
- monodispersed multicomponent gas suspensions with regard to the particle attrition and nonpermanent heat input;
- polydispersed multicomponent multispeed gas suspensions with intensive heat input, speed and temperature lag;
- polydispersed multicomponent gas suspensions with regard to the particle attrition and intensive unbalanced heat input;
- monodispersed multicomponent oil-fuel emulsion flows with regard to the alteration of the particles size and intensive heat input;
- design of the gun tuyere with the variable consumption of the gas suspension longwise (monodispersed stream, polydispersed flows, but with the heat input).

5.3 Stream in nozzles:

- monodispersed uni- and multicomponent gas suspensions of constant composition;
- monodispersed многокомпонентные gas suspensions with regard to the alteration of the particles size;
- polydispersed multicomponent gas suspensions of constant composition and with regard to the particle attrition;
- monodispersed multicomponent gas suspensions with regard to the particle attrition in the nozzle scarf;
- influence of the powder concentration on the diversion of the two-phase jet in the nozzle scarf.

5.4 Polydispersed flows in off-gas cleaning systems:

- isothermal stream;
- stream with heat input;
- dispersed flow with the absorption of foul gases.

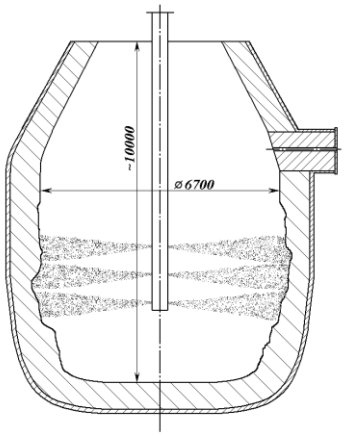
5.5 One- and two-phase stream in the high-power turbulent jets (~ 5 MW):

- structure of the supersonic non-design jet in the high-temperature cavity of the converter;
- structure of the supersonic non-design jet in the high-temperature cavity of the converter with regard to the carbon oxide (CO) combustion in oxygen (turbulent boundary layer);
- influence of the CO combustion in the oxygen jet on the added mass of the surrounding converter gas;
- supersonic one- and two-phase flows in the nozzle scarf;
- examination of the structure of the supersonic non-design jet in the high-temperature cavity of the converter with regard to the inclusion of slag-metallic emulsion the by the jet;
- structure of the polydispersed gas-dynamic flame during the spraying of the alloys with regard to the crystalline transformation and fluctuating velocities;
- lining gunning systems with regard to the dispersion of the powder particles in the converter cavity (as well as regarding the coke particle combustion in oxygen, heating and softening of the refractory particles);
- turbulent subsonic air jet in the BF combustion zone with regard to the inclusion of the gas-dispersion environment;
- turbulent subsonic two-phase jet in the BF combustion zone with regard to the inclusion of the high-temperature reactive gas-dispersion environment.

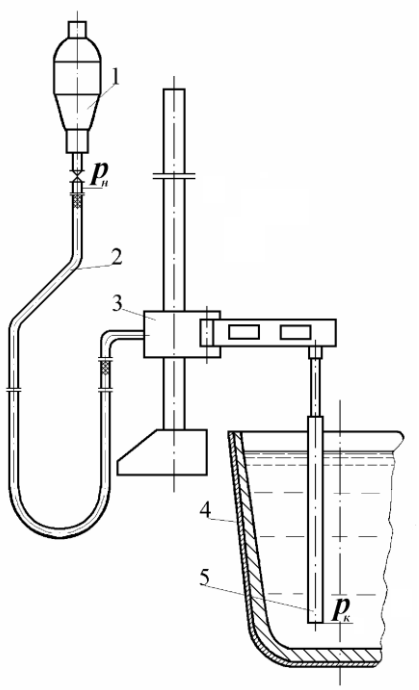
5.6 Method for slag skull spraying on the BOF hot lining:

- analysis of the motion of the various viscosity melted slag dripping during the direct and diagonal blows of the supersonic non-design unreactive jet.

6. Illustrations.

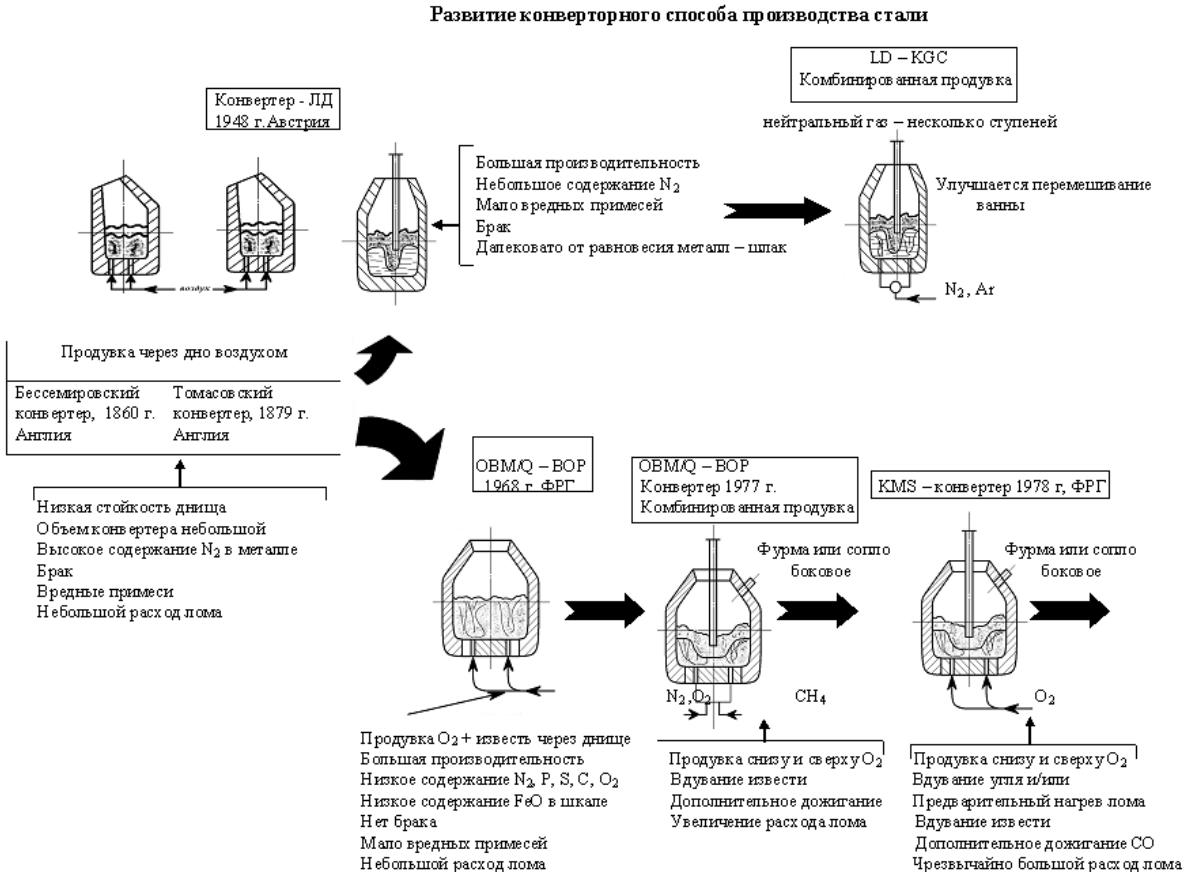


Examples of injecting dispersed flows into the melts and melting facilities.



Picture 1.
1 – ground bunker
2 – pneumatic transport system
3 – regulation gear
4 – ladle
5 – gas powder tuyere

Picture 2



Picture 3. The Development of the Basic-Oxygen Steelmaking Method

7. Comparison with analogues, advantages.

The existing analytical models commonly show the calculation of monodispersed streams only. Besides, the number of physical impacts on the stream is not more than 5-7. The number of physical impacts on the complex stream in the models created within the present technical proposal reaches 15. The new models are expected to fit more the actual stream of the dispersed structures. New methods of

injecting the high-density polydispersed flows into the melting facilities with minimal pneumotransportation energy costs are to be created in the future.

8. Consumers.

Nowadays the systems of injecting powder materials into the metallurgical melts and melting facilities are introduced at almost all ironworks in Ukraine, including the OSC AZOVSTAL Iron and Steel Works, Zaporizhstal JSC, Mittal Steel Kryvyi Rih, OSC Yenakiyevo Iron and Steel Works, OSC ILYICH Iron and Steel Works of Mariupol, OSC Dneprovskyi Metallurgical Works named after Dzerzhinsky and other.

9. Expectant market geography.

Ukraine, Russia, Belarus, Kazakhstan, Moldova.

10. Legal Protection.

The proposal is patentable. 20 practical articles have been written on the suggested subject, including:

- Куземко Р.Д., Наумов В.А., Поживанов М.А. и др. // Анализ режимов работы фурмы для интенсивной продувки стали в 160-т ковше: Сталь, № 2, 1997. С. 15-19.
- Куземко Р.Д. Теория и практика вдувания порошкообразных материалов в металлические расплавы: Вестник ПГТУ: Сб. науч. тр. Вып. 7. - Мариуполь, 1998. С. 189-205.
- Харлашин П.С. и др. Моделирование течения газовзвеси в фурме стальковша при различных теплофизических свойствах несущего газа: Металлургическая теплотехника: история, современное состояние, будущее. К столетию со дня рождения М.А. Глинкова: Тр. III Междунар. науч.-практ. конф. (1-3 февраля 2006 г., МИСиС). - М.: МИСиС, 2006. С. 480-483.
- Куземко Р.Д., Илющенко Д.В., Косолап Н.В. Влияние параметров газодисперсного потока на коэффициент аэродинамического сопротивления: Металлургическая теплотехника: история, современное состояние, будущее. К столетию со дня рождения М.А. Глинкова: Тр. III Междунар. науч.-практ. конф. (1-3 февраля 2006 г., МИСиС). - М.: МИСиС, 2006. С. 378-383.
- Климанчук В.В. Моделирование сопротивления при движении газовзвеси в ковшевой фурме: Металлургическая теплотехника: история, современное состояние, будущее. К столетию со дня рождения М.А. Глинкова: Тр. III Междунар. науч.-практ. конф. (1-3 февраля 2006 г., МИСиС). - М.: МИСиС, 2006. С. 325-328.
- Лукьяненко И.А. Предельная дальность транспортирования пылеугольного топлива в доменную печь при различной дисперсности потока: Тр. III Междунар. конф. по металлургической теплотехнике. - Днепропетровск, 2005. С. 78-81.

11. Suggested conditions of the implementation of the technical proposal.

The conduction of the research works requires the capital investment of UAH 300,000. The execution period is 3 years. The transfer and replication of the results is specified on the license basis in the “know-how” from (calculation methods), as well as in the form of new methods of injecting powder materials into the metallurgical melts and melting facilities. Moreover, the project organizations and ironworks have received practical recommendations on: a) more efficient stream of dispersed flows in the systems of pneumotransport, thus excluding the possibility of plug flow; b) ensuring the 2 times reduction of energy costs on transport; c) injecting the powder in melts securing the maximum impulse of the exhaust jets.

12. Proposal validity period.

Unlimited.

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TECHNICAL PROPOSAL 8

1. **Name.**
   "Practical gas dynamics and heat exchange in the iron and steel production processes. Volume 1. Homogeneous flows".

2. **Key words.**
   GAS DYNAMICS, BASIC-OXYGEN FURNACE, BLAST FURNACE, TUYERES, STREAMS.

3. **Description and basic technical and economic characteristics.**

The research team of Pryazovskyi State Technical University has prepared a unique reference book that consists of 16 chapters. The first chapter – the theoretical introduction – includes the brief theory reference on the gas dynamics of the metallurgical processes. The following chapters cover several hundreds of examples illustrating the iron and steel production problems.

The main theme of the reference book is the scientific-methodological coverage of the assimilation of the advanced technologies of steelmaking and new metallurgical equipment development. The engineering issues and problem situations are studies with specific examples. A great number of technical issues, which are often encountered by the metallurgical equipment designers, are provided with effective solutions and clear recommendations. The methods given in the reference book ere put on evaluation tests in the university laboratories and on the largest ironworks of Ukraine, Russia and Belarus. In its scientific level and fundamental approach the Volume 1 is of apparent practical interest for many specialists. The reference book is surely to be used during the design of the new equipment complex of iron and steel works.

4. **Purpose.**

The composed reference book is of great use for engineers and researchers of factory laboratories, research and development department workers, and operation and maintenance services. The information taken from the book can be used in the technological systems and units design, development and introduction of modern technologies, in the testing and self-preparation procedures, in the training of certified specialists – Candidates and Doctors of Science.

5. **Application field.**

The reference book is to be employed in the solving of following issues:

- designing the pipes for air supply to the hot-blast stoves and from the hot-blast stoves to the BF tuyeres;
- defining the air line dumping time in case of turbocompressor emergency shutdown;
- designing the one-phase oxygen nozzles (contracting, expanding, with/without account of friction, scarfed nozzles);
- designing the injection blowdown nozzles;
- designing the recipient pumping and dumping systems during the vessel lining pneumatic slagging;
- designing the oxygen and gun lance cooling systems;
- calculating the parameters of the combustion zone and the power characteristics of the jets running into the combustion zone;
- designing the mold cooling system for round, square, slotted openings, combination of round, square, slotted openings, for direct-flow, countercurrent and combined systems;
- studying the methods of receiving the extra power of dozen megawatt due to the efficient consumption of energy carriers;
- argumentation and exemplified proving that the compression of liquefied oxygen and nitrogen requires 150-300 times less energy than the compression of them in their gaseous state.

6. **Comparison with analogues, advantages.**
   No similar reference books are available.

7. **Consumers.**
   Iron and steel works and mechanical engineering plants, which manufacture metallurgical equipment.

8. **The offered transfer terms.**
   According to the contract.

9. **Volume 1 "Homogeneous Streams". Contents.**

Part 1. Theoretical Introduction

Chapter 1. Fundamental Equations of Aerohydrodynamics

- 1.1 Basic Terms and Definitions of Aerohydrodynamics
  - 1.1.1 Stream Line
  - 1.1.2 Stream Tube
  - 1.1.3 Unsteady Flow
  - 1.1.4 Swirling Motion
  - 1.1.5 Whirl Line, Stream Tube
  - 1.1.6 Speed Circulation
  - 1.1.7 Potential Motion
  - 1.1.8 Speed Potential
  - 1.1.9 Plane Motion
  - 1.1.10 Stream Function
  - 1.1.11 One-dimension Motion
- 1.2 Fundamental Equations of Aerohydrodynamics
  - 1.2.1 Continuity Equation
  - 1.2.2 Viscous Compressible Liquid Motion Equation
  - 1.2.3 Bernoulli's Equation
  - 1.2.4 Energy Equation
  - 1.2.5 Flow Equation of the 1^{st} Law of Thermodynamics
  - 1.2.6 Impact Reversion Equation
- 1.3
  - 1.3.1 Energy-conservation Equation
  - 1.3.2 Sound Speed, Maximum and Critical Speed
  - 1.3.3 Stagnation Parameters
  - 1.3.4 M and λ Dimensionless Speeds
  - 1.3.5 Gasdynamic Functions of Temperature, Density, Pressure and Expenditure
- 1.4 Viscous Fluid Motion and Boundary Layer
- 1.5 Fluid Flow Similitude and Simulation Criteria
- 1.6 Pipe motion
  - 1.6.1 Incompressible Fluid Flow
  - 1.6.2 Compressible Fluid Friction Flow in Pipes
- 1.7 Nozzle Gas Flow
  - 1.7.1 Supersonic Nozzle under Off-Design Conditions

Chapter 2. One-Dimension Flows Parameters Computations

- 2.1 Basic Terms and Definitions of Aerohydrodynamics
- 2.2 Fundamental Equations of Aerohydrodynamics
- 2.3 One-Dimension Fluid Motion

10.3.2 Non-Isoenthropic Flow
10.3.2.1 Convergent Nozzles
10.3.2.2 Supersonic Nozzles
10.4 Transient Mode Flow
10.4.1 Subsonic Pressure Drop
10.4.2 Supersonic Pressure Drop
10.4.3 Combined Mode

Chapter 11. Metal Jet Flow from the Ladle
11.1 Variable Level Flow
11.2 Flow with regard of the Slide Shutter

Chapter 12. Experimental Gas Dynamics
12.1 Pneumometric Parameter Determination Methods
12.2 Optical Methods
12.3 Nozzle Benchmark Tests

Chapter 13. Jet and Melt Interaction Simulating
13.1 Jet Momentum when Confronting the Melt
13.2 Defining the Jet Invasion Depth
13.3 Jet Interaction Zone Diameter
13.4 Mixing Power

Chapter 14. Study of the Cooling Processes in the Mold
14.1 Round Cooling Lines
14.2 Square Cooling Lines
14.3 Slotted Cooling Lines
14.4 Comparison of Consecutive and Combined Cooling Systems

Chapter 15. Aerodynamics of Heating Unit Burner Gases
15.1 Calculation of the Heating Furnace Burner Nozzle Diameter
15.2 Air-Jet Ejector
15.3 Using the Earth Cold for Creating Cool Air
15.4 Design of the Chimney Shaft

Chapter 16. Gas Dynamics of Water Vapour Flows in Industrial Power Units
16.1 Steampipes Design
16.2 Nozzle Operation in Subsonic, Sonic and Supersonic Pressure Drops
16.3 Design of Steam-Ejector Unit Nozzles
16.4 Scarfed Nozzle Flows

10. Proposal validity period.
Unlimited.

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TECHNICAL PROPOSAL 9

1. **Name.**
   "Practical gas dynamics and heat exchange in the iron and steel production processes. Volume 2. Dispersed flows".

2. **Key words.**
   GAS DYNAMICS, BASIC-OXYGEN FURNACE, BLAST FURNACE, PNEUMOLINE, INJECTION BLOWING,

3. **Description and basic technical and economic characteristics.**

The research team of Pryazovskyi State Technical University has prepared a unique reference book "Practical gas dynamics and heat exchange in the iron and steel production processes. Volume 2. Dispersed flows" consists of 9 chapters. The first chapter – the theoretical introduction – includes the systematic representation of one of the most complex scientific disciplines – the dynamics of dispersed flows. The following 8 chapters cover several hundreds of examples illustrating the iron and steel production problems.

The material given in the reference book is indispensable in designing and manufacturing new metallurgical equipment and new technologies of steelmaking. Following the example of the Volume 1, engineering issues and problem situations are studies with specific examples. The methods given in the reference book ere put on evaluation tests in the university laboratories and on the largest ironworks of Ukraine, Russia and Belarus. In its scientific level and fundamental approach the Volume 2 is of apparent practical interest for many specialists and is the scientific and technical support for designing new equipment complexes of iron and steel works.

4. **Purpose.**

The composed reference book is of great use for engineers and researchers of factory laboratories, research and development department workers, and operation and maintenance services. The information taken from the book can be used in the technological systems and units design, development and introduction of modern technologies, in the testing and self-preparation procedures, in the training of certified specialists – Candidates and Doctors of Science.

5. **Application field.**

The reference book is to be employed in the solving of following issues:

- Defining the bed resistance of:
  - sinter cake on the sintering belt;
  - gasdynamic charge resistance;
- Calculation of:
  - low-rate flows in the supply pulverized fuel pipe;
  - overloaded flows in the pipeline transportation system;
- Calculation of the pulverized coal fuel supply on the distance up to 3 km with account of any resists along the pneumoline;
- Design of the fine pulp and solid dispersed pieces supply pipelines;
- Design of two-phase nozzles in the upper blowing, including the pulverized coal fuel supply into the BFs:
  - single speed models;
  - two-speed models;
  - multispeed models;
  - with regard to the particle attrition in the flow;
  - with regard to the heat exchange;

- Design of two-phase oxygen jets:

- convergent, divergent, with/without regard to the friction;

- Design of injection blowing nozzles;
- Designing the tuyeres for the powder injection blowing of iron and steel;
- Designing the меде injection blowing bubbling systems;
- Designing the nozzles under transient flow mode;
- Calculation of the energy loss in shock waves of the supersonic two-phase non-design jet;
- Calculation of the reaction zone depth and diameter during the gas powder jet penetrating into the melt;
- Design of variable-delivery gun tuyeres;
- Design of the lining gunning system with regard to the particle dispersion during powder flight in the vessel cavity;
- Calculating the flight heating of particles during the flare gunning process;
- Calculation of the combustion zone parameters and power characteristics of two-phase jets leaking into the combustion zone;
- Calculation the particle fallout distance and time of particle fallout, which were in the smoke of the BOF chimney.

6. Comparison with analogues, advantages.

No similar reference books are available.

7. Consumers.

Iron and steel works and mechanical engineering plants, which manufacture metallurgical equipment. Enterprises designing and operating gas-cleaning units.

8. The offered transfer terms.

According to the contract.

9. Volume 2 "Dispersed Flows". Contents.

Chapter 6. Bottom-blowing converter

6.1 Powder material injection tuyeres
6.2 Gas-oxygen bottom blowing tuyeres

Chapter 7. Injection ladle blowing of melts

7.1 Pneumatic system of supplying powders for the out-of-furnace treatment of steel and iron
7.2 Ladle tuyere resistance
7.3 Inter phase interaction in the dispersed flow
7.4 Tuyere heat exchange
7.5 Complex dispersed flow stream in the tuyere

Chapter 8. The jet and melt interaction

8.1 Nozzle parameters supported by the measurement
8.2 Simulation of the gas-hydrodynamic melt and jet interaction processes
8.3 Jet penetration into the melt depth
8.4 Reaction zone parameters

Chapter 9. Hydrodynamic and heat-and-mass exchange processes of the melt bubbling in ladles, converters and other melting facilities

9.1 Air bubble diameter sizing
9.2 Bubbles removal speed
9.3 Rise rate during bubbling
9.4 Air bubble acceleration in the melt
9.5 Bubble sizes on the top
9.6 Bubbling zone diameter

10. Proposal validity period.

Unlimited.

11. Contact information: tel.: +38 0 629 44 64 98; fax +38 0 629 34 52 94;
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TECHNICAL PROPOSAL 10

1. **Name.**
   "Automatic process control system design in ferrous metallurgy".

2. **Key words.**
   DESIGNING, TECHNOLOGICAL PROCESS, OPTIMIZATION, APCS, UPPER LEVEL, MODELLING, TASK DEFINITION.

3. **Purpose.**
   Production facility control in combination with the feedstock and energy optimization and saving.

4. **Application field.**
   Ferrous metallurgy units (heating furnace, basic-oxygen furnace, continuous casting machine, blast furnace etc), food processing equipment, energotechnological units etc.

5. **Description and basic technical and economic characteristics.**
   The creation of the automatic process control systems is supported by the development and statement of various issues, such as regulation, control, mathematical modelling, data acquisition and processing. The implementation of the technical proposal ensures qualitative study of the technology, energy and fuel saving – 2-15%, improvement of the product quality, elimination of the technology violations.

6. **Illustrations.**
   No.

7. **Comparison with analogues, advantages.**
   The process optimization, qualitative control of the technological process through the introduction of the APCS upper level tasks, which are nowadays not used.

8. **Consumers.**
   Non-automatic facilities and technological processes; facilities equipped with the automatic control systems without the upper level.

9. **Expectant market geography.**
   Ukraine, CIS, far abroad countries.

10. **Legal Protection.**
    The proposal is patentable.

11. **Suggested conditions of the implementation of the technical proposal.**
    On the terms of the agreement.

12. **Proposal validity period.**
    Unlimited.

13. **Contact information:** tel.: +38 0 629 44 64 98; fax +38 0 629 34 52 94;
    e-mail: omid@pstu.edu

TECHNICAL PROPOSAL 11

1. **Name.**
   "Design (reconstruction) of the control strategy and mathematical models for the metal heating technological process automatic control system of the heating units".

2. **Key words.**
   TEMPERATURE, THERMAL AND HYDRAULIC CONTROL, METAL HEATING MODELLING, CONTROL ALGORITHM, EXPERIMENTAL HEATING, ENERGY SAVING.

3. **Purpose.**
   The development of modern metal heating technological process automatic control systems aimed at the fuel saving, rejection reduction, decrease of the scale loss, heating optimization.

4. **Application field.**
   Rolling mill heating furnaces, including technical, thermal and soaking pits, refractory annealing furnaces, drying stoves etc.

5. **Description and basic technical and economic characteristics.**
   The reduction of the fuel consumption by 2-15%, rejection and metal scale loss reduction.

6. **Illustrations.**
   No.

7. **Comparison with analogues, advantages.**
   Cooperation with design organizations is possible; the costs for the design and introduction of the APCS are decreased as the work is partially executed by the customer.

8. **Consumers.**
   Ironworks and other enterprises.

9. **Expectant market geography.**
   Ukraine, CIS, far abroad countries.

10. **Legal Protection.**
    The proposal is patentable.

11. **Suggested conditions of the implementation of the technical proposal.**
    On the terms of the agreement.

12. **Proposal validity period.**
    Unlimited.

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TECHNICAL PROPOSAL 12

1. **Name.**
   "Design (reconstruction and optimization) of the metal heating method in the heating units on the basis of the experimental metal heating processes".

2. **Key words.**
   EXPERIMENTAL HEATING, HEATING MATHEMATICAL MODEL, TECHNOLOGICAL INSTRUCTION, RADIANT AND CONVECTIVE HEAT EXCHANGE, ENERGY SAVING.

3. **Purpose.**
   Adjustment of technological instruction aimed at the reduction of the heating time (i.e. enhancement of the furnace productivity), fuel saving, rejected metal and scale formation reduction.

4. **Application field.**
   Mill production heating units.

5. **Description and basic technical and economic characteristics.**
   The metal is put to experimental drifts with the thermocouples injected to it; on the basis of the drifts the adjustment of the heating method is held.

6. **Illustrations.**
   No.

7. **Comparison with analogues, advantages.**
   Swiftness, precision, practical recommendations.

8. **Consumers.**
   Ironworks.

9. **Expectant market geography.**
   Ukraine, CIS, far abroad countries.

10. **Legal Protection.**
    The proposal is patentable.

11. **Suggested conditions of the implementation of the technical proposal.**
    On the terms of the agreement.

12. **Proposal validity period.**
    Unlimited.

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TECHNICAL PROPOSAL 13

1. **Name.**
   "Two-ply steel production electromagnetic process".

2. **Key words.**
   QUANTUM PROCESS, ELECTROMAGNETIC ATTRACTION, TWO-PLY STEEL, ELECTROMAGNETIC PRESSURE.

3. **Purpose.**
   The reduction of energy consumption, productivity improvement, two-ply steel quality enhancement.

4. **Application field.**
   Ferrous metallurgy and mechanical engineering.

5. **Description and basic technical and economic characteristics.**

At present time the two-ply steel is produced by the arc deposition of the cladding layer on the carbon steel or by the weld of the cladding and carbon layers with subsequent rolling to specified size. However, the full adherence between the sheets over the whole surface and the high quality of the two-ply steel are difficult to ensure, as during the rolling process the effects of high specific pressures and various linear expansion coefficients result in the destruction of the adherence of the cladding and carbon layers. The intensive process of building-up with alloyed materials requires considerable energy costs and does not ensure the full adherence of the cladding and carbon layers due to the possible formation of hardening substances in the fusion zone.

The suggested method for two-ply steel production is based on the use of electromagnetic attraction of conductors conducting the same-direction current. The method ground on the electromagnetic nature of the interatomic bonding forces, which ensure the body uniformity and are fundamental for the welding process.

The electromagnetic process of two-ply steel production is held through passing the same-direction direct current through the cladding and carbon layers and applying mechanical pressure that is determined depending upon the process according the following expression:

$$P = (25 - 27) \cdot 10^5 \frac{\delta}{I} \text{ MPa}$$

δ – the cladding layer thickness, mm;
I – intensity of current passed through the metal, A.

The application of mechanical pressure in such dependence ensures the emergence of the new effect – increase of the electromagnetic field under the action of mechanical pressure – and the complex impact of the electromagnetic and mechanical pressure on the connecting surfaces of the cladding and carbon layers. The electromagnetic pressure is determined by the field induction in the quadratic dependence. Moreover, the electromagnetic field induction depends on the current intensity and the distance from the axis of the conductor. Initially, when the contacting surfaces of the cladding and carbon layers are situated at the distance over interatomic, the electromagnetic attraction forces and electromagnetic pressure are inferior to the mechanical pressure. Under the action of the mechanical pressure the contacting surfaces at the contact point are drawn together. Therewith, the electromagnetic attraction forces and electromagnetic pressure increase dramatically. The electromagnetic pressure is at first superior to the yield limit, thus initiating the plastic deformation process. This process causes the oxidation films to be forced out from the contacting surfaces of the

cladding and carbon layers. Next, as the atoms of the contacting surfaces are drawn together to the interatomic distance, the electromagnetic pressure surpasses the yield limit, thus ensuring the more rigid adherence of the cladding and carbon layers. The mechanical pressure is initially an impulse that dramatically raises the electromagnetic pressure and increases the interatomic forces. This ensures the rigid adherence of the, improved mechanical and corrosion characteristics under lesser values of the current intensity.

The existing methods for two-ply steel production are based on the drawing together of the atoms to the interatomic distance due to the mechanical impact, the fusion of the cladding and carbon layers.

The electromagnetic process grounds on the efficient method for drawing together the atoms due to the electromagnetic pressure that is reinforced through the application of the mechanical pressure depending on the cladding layer thickness and the intensity of the current being passed through the metal.

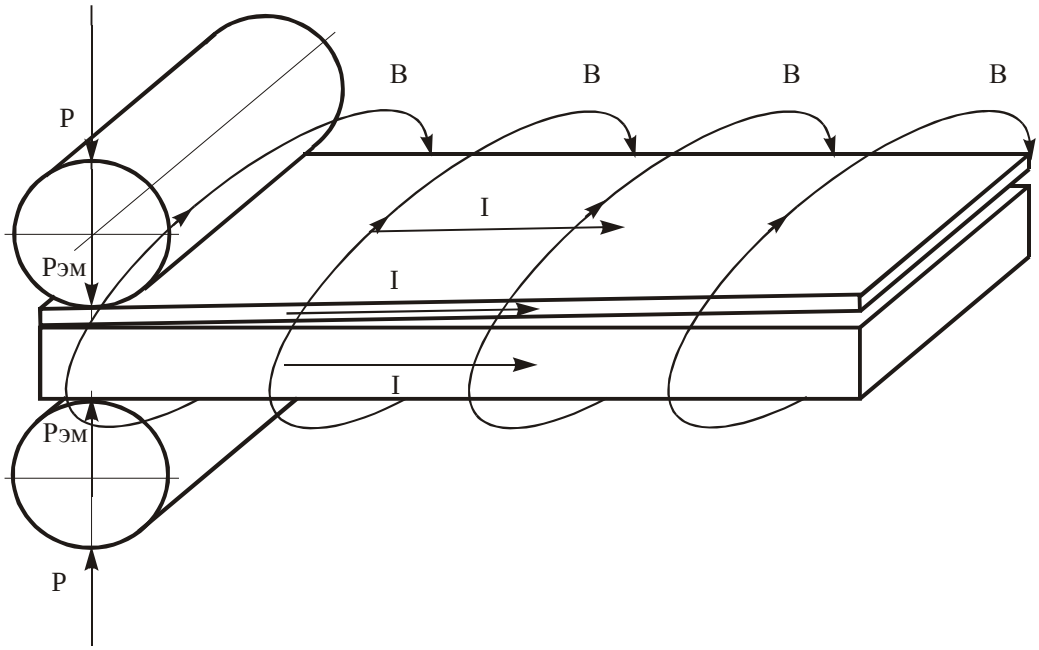
The electromagnetic method for two-ply steel production ensures:

- rigid adherence of the cladding and carbon layers due to the dramatic increase of the electromagnetic pressure, drawing together of the atoms to the interatomic distance and mutual penetration of the atoms from both layers;
- improvement of the two-ply steel strength and shearing resistance resulting from the increase of the contact area of the cladding and carbon layers under the effect of the electromagnetic pressure, which rises in the quadratic dependence upon the electromagnetic field induction;
- improvement of the inter-crystalline corrosion resistance due to the minor interfusion of the cladding and carbon layers;
- decrease of the energy volume of the process and the two-ply steel production cost price.

The production-scale implementation of the suggested method requires a rectifier welding set used in electric resistance welding, and an operating rolling mill.

The expected annual economic effect from the employment of the designed electromagnetic two-ply steel production due to the reduction of the energy consumption, contraction of the production circle, quality improvement and recovery increase, amounts to UAH 10-15 mln. The capital pay-off is 2 years.

6. Illustrations.



Scheme of the two-ply steel production electromagnetic process
I – direct current, P – mechanical pressure, Рем – electromagnetic pressure,
B – electromagnetic field force lines

7. **Comparison with analogues, advantages.**

Decreasing the energy volume of the process, two-ply steel productivity and quality improvement.

8. **Consumers.**

Ironworks and mechanical engineering enterprises.

9. **Expectant market geography.**

Ukraine, near and far abroad countries.

10. **Legal Protection.**

Patent of Ukraine № 20478, B 23 K 9/ 00 “Спосіб виготовлення двошарової сталі” (“Method for two-ply steel production”).

Patent of Ukraine № 65093 A, B 23K 9/00 “Спосіб виготовлення двошарової сталі” ((“Method for two-ply steel production”).

11. **Proposal validity period.**

Unlimited.

12. **Suggested conditions of the implementation of the technical proposal.**

On the terms of the contract. The development of the technological task, feasibility study, scientific project monitoring are stipulated.

The technical proposal realization costs amount to UAH 300,000; performance time is 2 years.

The finished design is allowed for license-based replication.

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TECHNICAL PROPOSAL 14

1. **Name.**
   "Energy-efficient process of the metallurgical equipment component reconditioning and hardening".

2. **Key words.**
   HIGH-SPEED BUILDING-UP, RATE OF ENERGY INPUT,
   COMPONENT, ELECTROMAGNETIC FIELD, METALLURGICAL EQUIPMENT.

3. **Purpose.**
   Reducing the energy volume of the process, increasing the productivity and wear-resistance of the metallurgical equipment components.

4. **Application field.**
   Ferrous metallurgy and mechanical engineering.

5. **Description and basic technical and economic characteristics.**

The rolling equipment components, which are exposed to high pressure during operation, are manufactures of high-carbon steel in order to improve their wear-resistance. After the building-up of those components, the crystal and cold cracks appear causing the peeling-off of the built-up components, as well as the reduction of their wear-resistance.

The majority of the existing methods for crack control are based on the raise of the rate of energy input, which results in the energy consumption increase and does not secure the wear-resistance improvement and performance of the built-up components.

The high-speed building-up of the metallurgical equipment components is conducted at the low rate of energy input at the increased speed, the speed being determined depending on the carbon content in the steel and the mode

$$V = (4-4{,}5)\cdot 10^{-3} CIU \text{, mph (meter per hour)}$$

C – carbon content in the steel, %;
I – arc welding current intensity, A;
U – arc voltage value, V.

The reduction of the rate of heat input and increase of the solidification rate of the welding pool molten metal due to the increase of the building-up speed depending upon the carbon content and the mode, ensures the reduction of the crystal lattice microdeformations, microstresses, reduction of the grain size and dislocation density. The high-speed building-up increases the heating and chilling rates; as a result, after ferrite and pearlite have transformed into austenite, the grain growth is prevented. On cooling, the fine austenite changes on the upper subcritical temperature interval into the equilibrium structure – sorbite and troostite. Due to the high heating and chilling speed the time the welding pool is in the liquid from is reduced, the grain growth is prevented, the structure is granulated, which ensures the crack-resistance improvement of the metallurgical equipment components. Simultaneously with the reduction of the rate of energy input the welding stresses emerging during the building-up are decreased. The cracks appear when the welding stresses go beyond the strength limit. Accordingly, decreasing the welding stresses makes it feasible to improve the crack- and wear-resistance of the built-up components. The increased carbon content reduces the steel resistance against crystal and cold cracks. For that reason when building-up high-carbon steel, it is necessary to decrease the heat input through the reduction of it's rate and simultaneous increase in the building-up speed. As the building-up speed increases, the solidification rate increases accordingly causing the structure granulation, improvement of the built-up components crack- and wear-resistance. During the high-speed building-up the grain is additionally granulated due to the alteration in the heat input, current spreading, magneto-hydrodynamic reactions in the welding pool and the speed increase of pool melted metal

convection streams. Simultaneous structure granulation and melting stress reduction ensure improvement of crack- and wear-resistance and performance of the metallurgical equipment high-carbon steel components.

The employment of the high-speed building-up method makes it feasible to reduce the consumption of the energy and gas used for the component heating during the reconditioning and hardening process.

The energy-saving process of the metallurgical equipment component reconditioning and hardening ensures:

- reduction of the rate of heat input, increase of the melted metal solidification speed, decrease in the metal melted state time, and structure granulation;
- influence on the magneto-hydrodynamic reactions in the welding pool, increase of the convective streams, metal moving speed in the welding pool, and enhance of the structure dispersion;
- reduction of the crystal lattice microdefects, miscrostresses, dislocation density, improvement of the crystal and cold crack-resistance;
- improvement of the mechanical characteristics, wear-resistance and performance of the built-up high-carbon steel components;
- reduction of the gas used for the component heating during the reconditioning process due to the limitation of the build-up time.

The production-scale introduction of the suggested method requires appropriate building-up equipment.

The introduction of the designed high-speed reconditioning and hardening process including the energy and gas consumption reduction, shortening of the production circle, wear-resistance improvement and decrease of the costs for the metallurgical equipment component purchase makes the annual economic effect of UAH 5-10 mln. The pay-off is 1 year.

6. Illustrations.

No.

7. Comparison with analogues, advantages.

Energy and gas consumption reduction, wear-resistance improvement and decrease of the costs for the metallurgical equipment component purchase.

8. Consumers.

Ironworks and mechanical engineering enterprises.

9. Expectant market geography.

Ukraine, near and far abroad countries.

10. Legal Protection.

Patent 65092 A, Ukraine, B23K9/04 “Спосіб відновлення і зміцнення циліндричних деталей” (“Method for reconditioning and hardening of cylindrical components”).

Patent 65079 A, Ukraine B23B27/10 “Спосіб виготовлення деталей прокатного обладнання” (“Method for the production of the rolling-mill equipment components”).

Favourable decisions on the applications “Спосіб електродугового наплавлення” (“Arc jet building-up method”) and “Спосіб електродугового наплавлення чавуну” (“Arc jet iron building-up method”).

11. Proposal validity period.

Unlimited.

12. Suggested conditions of the implementation of the technical proposal.

On the terms of the contract. The development of the technological task, feasibility study, scientific project monitoring are stipulated. The finished design is allowed for license-based replication.

The technical proposal realization costs amount to UAH 200,000; performance time is 2 years.

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TECHNICAL PROPOSAL 15

1. **Name.**
   "Utilization of the pressurized gas potential energy in electric power production".

2. **Key words.**
   NATURAL GAS, POTENTIAL ENERGY, THROTTLING, GAS TURBINE, STARTING TURBINE.

3. **Purpose.**
   Replacement of the NG throttling procedure with the expansion of the NG in straight (strating) turbines for electric power production.

4. **Application field.**
   Industrial heavy energy-consuming regions of Ukraine. The electric power is used at the production site, line losses are minimized.

5. **Description and basic technical and economic characteristics.**

At present the annual NG consumption by the industrial complex of Ukraine approximates 35 billion m^3. The single-time compression from the pressure p_1 = 0.1 MPa to p_2 = 3 MPa consumes ~ 1,000 MW (which makes one third of the Zaporozhye Atomic Power Station). The NG pipeline transportation requires booster station installed every 100-150 km, the gas on each of them being pressurized to 3 MPa. The energy costs constitute up to 10 % of the NG cost price. The Mariupol Industrial Region consumes 11 mln m^3 of NG per day.

However, the enterprises do not utilize high pressure gas. As there are no technical methods of low pressure gas transportation, the electric power for the gas compression is wasted.

There are two pressure reduction methods. The most common is the bottle-neck throttling. The pressure drop due to the friction, but the enthalpy is recovered to its initial state. The process is isoenthalpic. When throttled, the gas temperature is usually decreased. Thermodynamically, throttling is an ultimately irreversible process, during which the pressure is reduced without any useful work done. The main advantage of the throttling method is the easy pressure and consumption regulation control.

The other pressure reduction method is the polytrophic expansion in the gas turbine. This method finds its application in cryoengineering and utilization of the excess blast furnace gas in power production. Ideally (frictionless expansion) all the electric power previously used for the gas compression can be recovered. However, in fact due to the friction and other irreversible losses (off-design outflow mode, stream shock losses, additional friction caused by the in-expansion gas humidification etc.) only 40-50% of initial energy for pressurizing can be recovered.

As in other industrial regions of Ukraine, the latter pressure reduction method is not used in the Mariupol region. Even at the new lines the inefficient consumption and pressure control method of gas throttling is employed. The gas distribution stations GDS-1 (Vostochnyi district) and GDS-2 (Mirnyi village) installed at the entrances of the Mariupol industrial region deal with gas throttling for the ironworks from 2.7-3 MPa to 0.6-0.8 MPa, and for the city community facilities – to 0.15 MPa. This way the larger amount of the given compression energy is irreversibly lost during the throttling.

The technical proposal involves designing a highly efficient energy-saving technology that is ensured through the replacement of existing throttling devices on the gas pipelines (supplying gas on the northern line from Volnovakha or Taganrog directions) with the expansion turbines. The implementation of the proposal does not require high capital investments or great operation costs. On the contrary, the electric power recovery, for instance in the Mariupol industrial region, will reach 12-15 MW. On the national scale 400-500 MW of power spent on the gas compression can be recovered.

The technical proposal is aimed at the 40-50% (depending upon the season – winter/summer) recovery of the electric power spent on the NG compression without any substantial capital

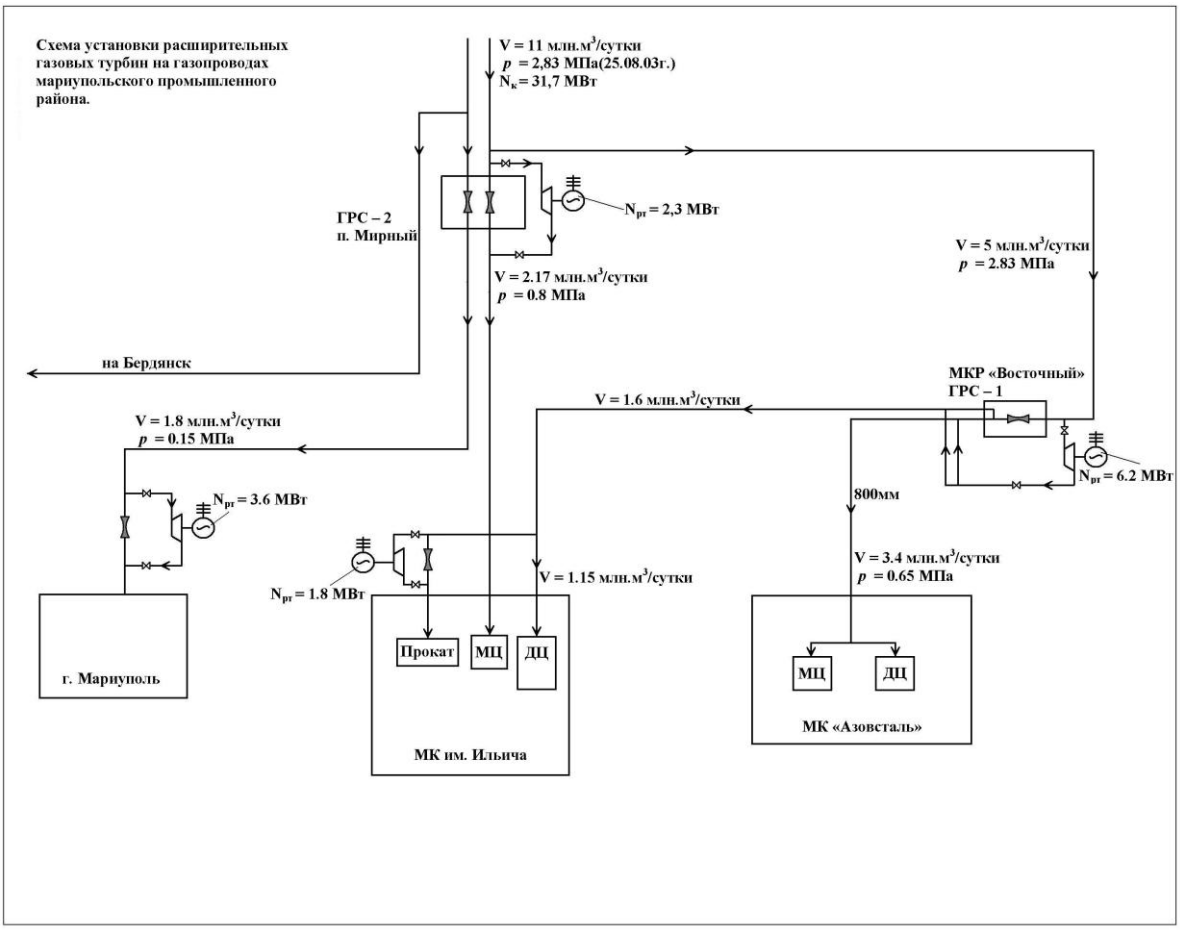
investments and employment of additional resources. The expansion turbines can be produced at the Poltava Turboengine Factory, Mykolaiv Shipbuilding Yard or Kharkiv Turbine Factory, which are nowadays not overloaded with orders (200-250 turbines are needed for industrial regions of Ukraine).

6. Illustrations.

The utilization of the NG potential energy can be illustrated with the design of the expansion gas turbine plant (Picture 1). If the GDS throttling devices are replaced with the expansion gas turbines, the same final result is reached, namely – the consumers receive the NG pressure they require. However, only by replacing the throttling procedure with the pressure reduction in the expansion turbine in the Mariupol industrial region only, out of ~31 MW of power spent for gas compression 15 MW is recovered into the electric power network.

The expansion turbines are technically quite unsophisticated; due to the gas high pressure they are metal-unintensive, they do not require cooling systems or any other special services (they can be completely automatic).

Expansion gas turbine plant design

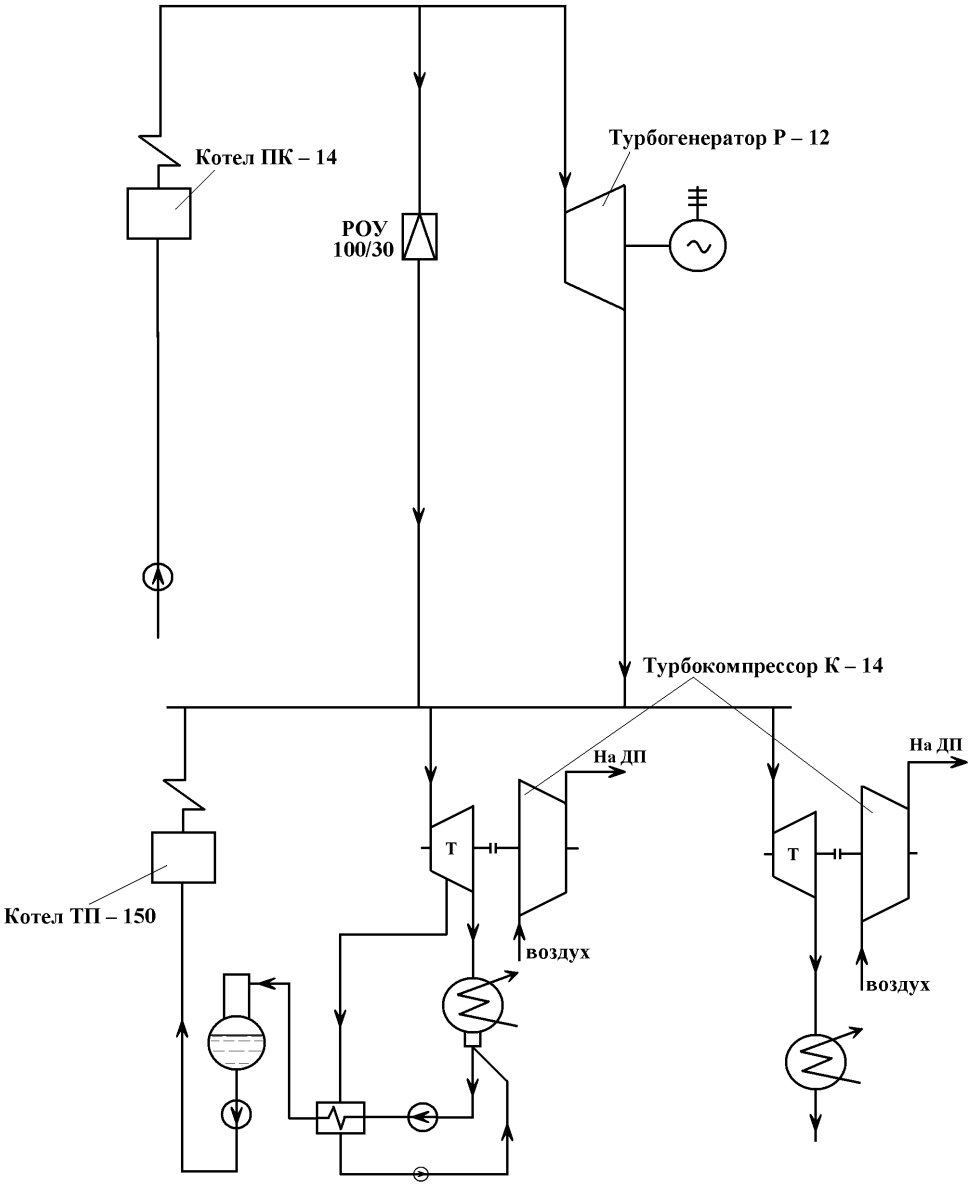


Picture 1.

7. Comparison with analogues, advantages.

In the electric power industry the installation of the so called top expansion turbines instead of throttling devices has become a rule (Picture 2). The top steam turbines with the capacity up to 50 MW have been developed. For instance, the P-12 type steam anti-pressure turbines with the electric capacity of 12 MW have been installed at OSC ILYICH Iron and Steel Works of Mariupol and OSC AZOVSTAL Iron and Steel Works. In case if the throttling devices were used, the irreversible power losses on the two of Mariupol enterprises would have amount to 24 MW.

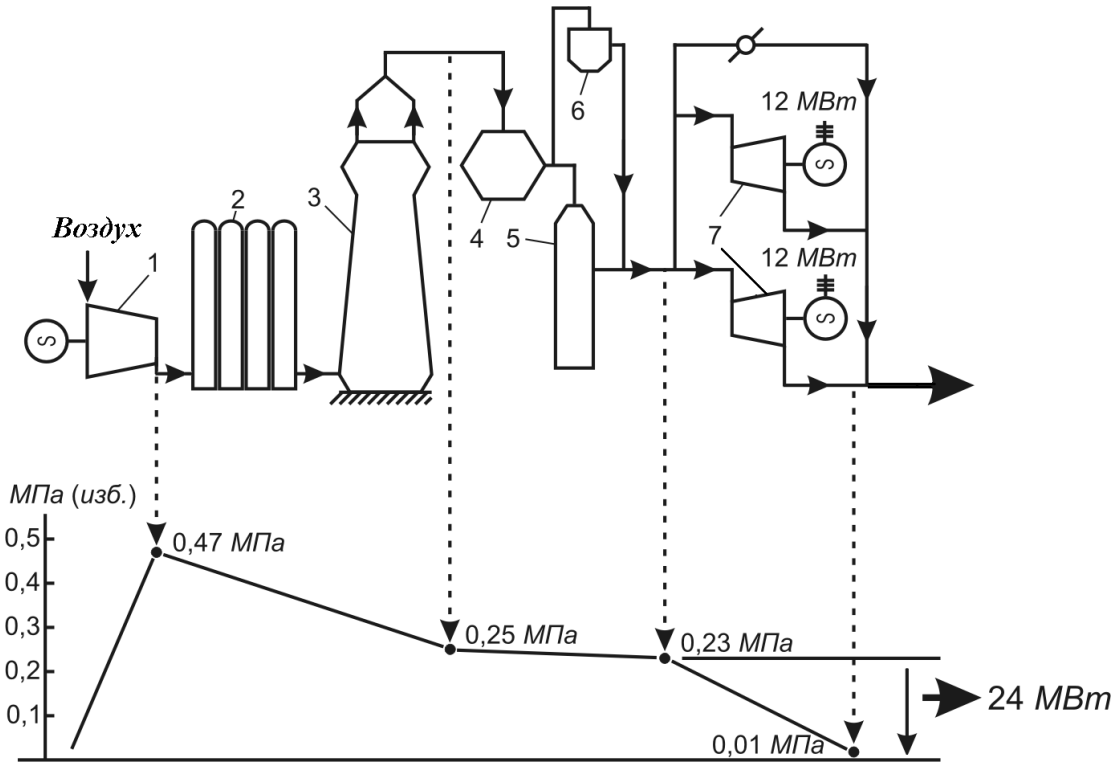
Installation design for the P-12-type steam anti-pressure expansion turbine on the TPP-1



Picture 2.

Another typical example of the high-efficient utilization of the NG potential energy is the gas-expansion turbine (top-pressure recovery type turbine) plant at the blast furnaces (Picture 3).

Design for the top-pressure recovery type turbine plant for blast furnace, Shiba Factory, Japan



Picture 3.
1 – turbocompressor; 2 – air heaters; 3 – blast furnace;
4 – scrubber; 5, 6 – blast-furnace gas good purification filters;
7 – expansion compressionless turbines

8. Consumers.

Industrial regions, ironworks and other NG consuming enterprises. The suggested designs for the NG expansion in compressionless turbines provide the production of additional electric power that can be utilized by the enterprises of the adjoining industrial area.

9. Expectant market geography.

Ukraine, near and far abroad countries.

10. Legal Protection.

The technical proposal is patentable. The method for the NG potential power utilization in the expansion turbines is well-known, but the suggested technical proposal with some substantial differences is patentable.

11. Suggested conditions of the implementation of the technical proposal.

The technical proposal introduction costs (contractors – Pryazovskyi State Technical University, Ukrgipromez, Promelektroproekt) amount to UAH 200,000. Execution period is 2 years. The technical proposal is allowed for replication: each industrial region requires its specific NG potential energy utilization scheme.

12. Proposal validity period.

Unlimited.

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TECHNICAL PROPOSAL 16

1. **Name.**
   "Development and exploitation of the methods for the express inspection of the thermal power plant turbine and compressor equipment, basic-oxygen plant compressors, and compressor plants".

2. **Key words.**
   TURBINE, CONDENSER, COMPRESSOR, AIR-COOLER, COOLING TOWER, PUMP, SPECIFIC FUEL CONSUMPTION.

3. **Purpose.**

The technical proposal is aimed at the rapid determination of the basic technical and economic parameters of each turbine and compressor through the express analysis of the current parameters of the pressurized air, oxygen, steam, condensate, feed and cooling water etc. The actual parameters acquired during the energy audit procedure experimentally or from the switchboard instruments in respect of each allow to work out:

- for turbocompressors – the driver turbine capacity, the share of the capacity spent on gas compression, as well as specific consumption of steam, heat and fuel;
- for electrically driven compressors – the actual gas compression energy in respect of the inner coefficient of performance, along with the per unit costs for the production of the blast furnace, oxygen and nitrogen blast.

The developed methods make it feasible to evaluate the technical condition and the degree of sophistication of the turbines, compressors and other units and their components, as well to detect the sources of waste during the unit tests. On the ground of the research done practical recommendations on the unit performance improvement are given.

4. **Application field.**
   Thermal power plants (TPP), high voltage power supply plants, technical water supply plants, oxygen plants and compression station on ironworks and other enterprises.

5. **Description and basic technical and economic characteristics.**

Ferrous metallurgy is one of the most energy-intensives fields of industry. The iron and steel works with the annual cast iron production of 5-6 mln ton have 300 MW of the total capacity of turbogenerators, air blower drive turbines, turbocompressors of the blast-furnace, oxygen, nitrogen blast. At the same time, the basic performance characteristics of such equipment – specific consumption of steam, heat and fuel – are available only fro electric power plants. Due to these unreasonably enlarged characteristics the performance of the single turbo units cannot be seen, large ironworks possessing about 60 of such units). Hence, due to such sophisticated energy equipment complex the performance of the individual units is difficult to be controlled, as well as the compilation and the execution of the plant energy saving plan are hindered.

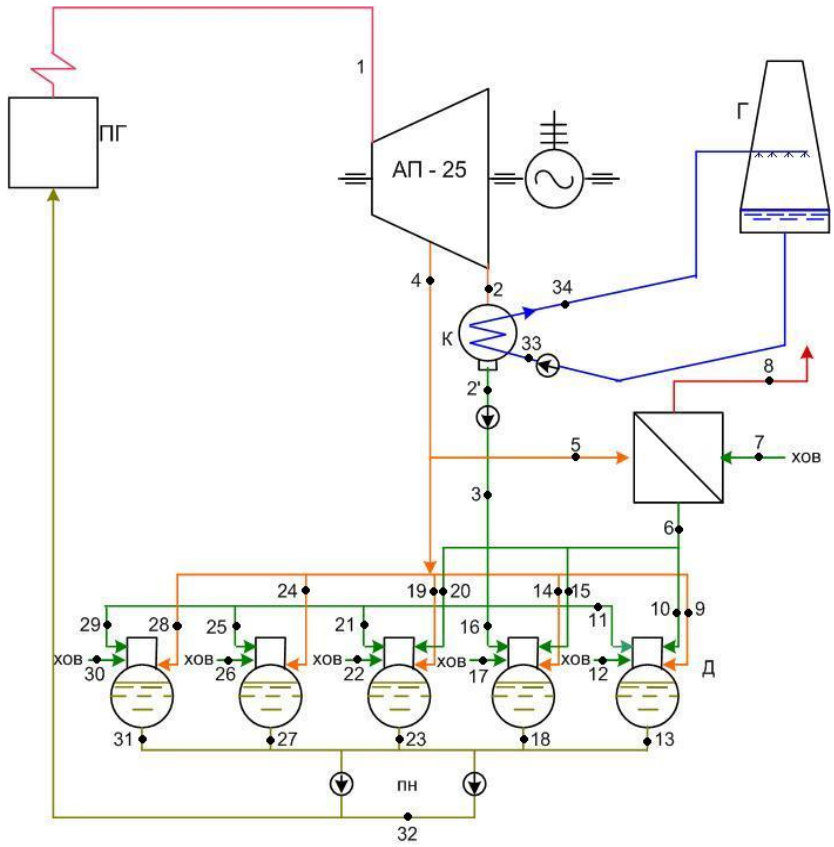
The technical proposal involves conducting tests and registering the parameters, which determine the technical state of turbines, compressors and service equipment. The enthalpy method, suitable for use due to the invention of the laser pyrometer, is employed. Technical condition evaluation procedure of the turbocompressor equipment according to the parameters registered at the measuring is now being developed and adapted in respect to the currently operating equipment. The introduction of the new methods for energy audit makes it feasible to elaborate within a short period of time (no more than 10 days) the recommendations on the reduction of the electric power consumption for the production of pressurized air, oxygen and nitrogen, along with fuel saving for the steam production. Moreover, any irreversible losses – resistance in the intermediate or final coolers, pressure losses in pipelines, low water cooling in cooling towers, deficiently high vacuum in the turbine condenser, gas pressure losses on the viscous fluid filter screens etc. – are illustrated with the methods for

recalculation into the kilowatts of unproduced (turbine) or overconsumed (compressor) power. The suggested methods are experimentally revised through comparing the obtained estimated results of the actual cost for gas compression with the electric power costs compression (with the help of the wattmeter installed on the electric engine) and the nominal performance coefficient of the turbine or compressor.

The introduction of the technical proposal on a Ukrainian iron and steel works indicated the following: the detected irreversible losses in the individual elements of the complex thermal scheme of the TPP result in the unreasonably excessive specific fuel consumption for electric power production – 0.75 kg/kWh. Meanwhile, the specific consumption on the thermal power stations in Ukraine is 0.27-0.4 kg/kWh. The general TPP energy waste on the ironworks has amounted to ~20 MW, the fuel overconsumption 75,800 ton of standard fuel per year (~1,378 cars in coal equivalent).

The introduction (without any capital investment) of only one of the suggested proposals on the alteration of the thermal scheme of the turbocompressor drive turbine ensured the annual saving of 7,500 t of coal.

6. Illustrations.



Picture 1.
The location of control points for parameter measurement

The picture 1 shows as an example the schemes of the location of the control points 1-32 during the test of the АП-25-type turbogenerator and the location of the corresponding points 1-35 during the inspection of the ВКВ-18-type turbocompressor.

7. Comparison with analogues, advantages.

The present time energy audit procedures involve unmanageable heat calculations of the whole units such as steam turbine, compressor, air cooler etc. These procedures require several weeks of work (for each unit), and the accuracy of calculation remains low. The named technical proposal is aimed at the employment of the enthalpy method – simple and convenient – in calculations. The

processing of the results of the unit express inspection with the given method does not require any special preparation. The employment of the developed method causes no serious errors as the calculations are made according to the actual energy carrier parameters. These parameters are registered with a high degree of accuracy, including with the help of the laser pyrometer. The calculations themselves are based on the fundamental principles of the theoretical thermology.

The technical proposal ensures the development and introduction of:

- the most convenient methods for the improvement of the technical and economical parameters of turbocompressors, turbogenerators and electrically driven compressors;
- suggestion for the full-scale retooling and modernization.

8. **Consumers.**
   Iron and steel works, other enterprises.

9. **Expectant market geography.**
   Ukraine, CIS.

10. **Legal Protection.**
    "Know-how" mode.

11. **Proposal validity period.**
    Unlimited.

12. **Suggested conditions of the implementation of the technical proposal.**
    On the terms of the agreement.

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TECHNICAL PROPOSAL 17

1. **Name.**
   "Technology of the iron-ore agglomerate production from the charge with the increased fine waste products concentration".

2. **Key words.**
   AGGLOMERATION, BLAST-FURNACE DUST, SLIME, BRIQUETTING, GRINDING, BRIQUETTING GRIT, PALLETIZING CENTERS.

3. **Purpose.**
   Sintering of the iron-ore agglomerate with the increased dust and slime concentration without reducing the productivity of sintering machines and agglomerate quality; increase of the degree of the metallurgical production waster product use.

4. **Application field.**
   Ferrous metallurgy, agglomerate production, utilization of the metallurgical production waste products.

5. **Description and basic technical and economic characteristics.**

The basic method for the utilization of the fine metallurgical production waster products, dusts and slimes, is the injection of these materials into the sintering mix after the minimal preliminary treatment. Therewith, the consumption of dusts and slimes is limited with 140-160kg/t of agglomerate. Further increase of the waste product concentration in the charge results in the degradation of the sintering layer gas permeability, which causes the reduction in the sintering machine productivity and agglomerate quality. This hinders the utilization of the metallurgical production waster product, especially at the enterprises with the insufficient agglomeration plant capacity, leads to the waste accumulation and deterioration of the ecological situation in metallurgical regions.

It is suggested to preliminarily briquette the fine waste products with the subsequent grinding to the size of 6-8 mm and injecting the obtained briquetting grit in to the sintering mix. The briquetting grit functions as the palletizing centers, on which the fine charge is rolled and forms the granules. With the briquetting grit injected, the gas permeability of the sintering mix increases. The laboratory tests showed that the preliminary briquetting of the blast-furnace dust and slime ensured enhancing the productivity of the sintering unit by 60%, the share of the utilized waste products being 260 kg/t of agglomerate. In the course of the pilot sintering of the agglomerate at the sinter plant of a metallurgical enterprise with the injection of the briquetting grit of the blast-furnace dust into the charge, the consumption of the dust and slimes increased from 120 to 190 kg/t of agglomerate, the sintering process parameters retained, under the capacity of the sinter machines of more than 2 t/m^2h and the agglomerate mechanical stability from M^{+10} = 67 to 69%.

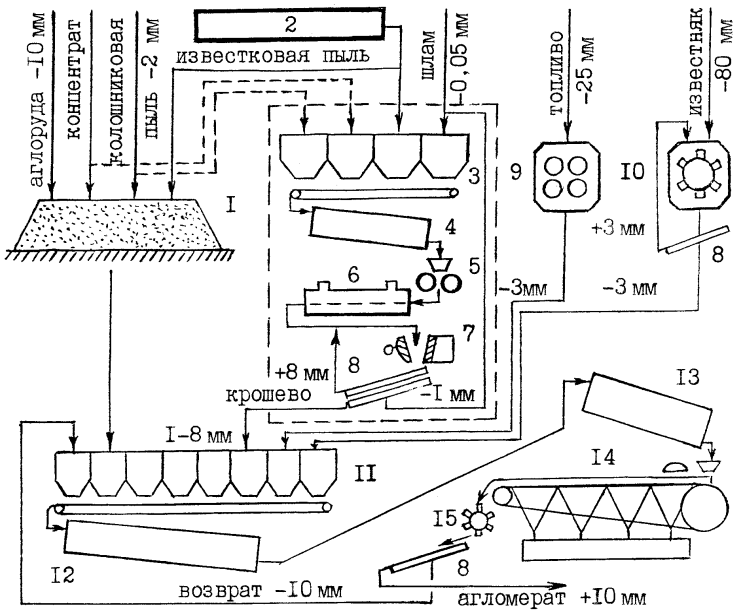
The new technology ensures:

- increasing the dust and slime consumption into the sintering ore up to 100% of the iron-ore material content without the deterioration of the sintering process parameters, i.e. sintering the agglomerate of the metallurgical production waste products only;
- increasing the sinter machines productivity by 20-30%;
- producing the agglomerate without the use of the sintering ore, increasing the ore content in the sintering ore;
- retaining the working efficiency of the sinter plant during the sintering ore supply setbacks through replacing it with the metallurgical waste products.

The production-scale introduction of the method requires creating a briquetting section within the sinter plant. The section includes storage bunkers, mixers, roller briquetting machine, feed-through stove, and alligator crusher. Lime and lime dust are supposed to be used as the binding substance.

There is also a possibility to press fine waste products with strew presses through the drawing-block for the production of the 8 mm grit without fracturing.
The expected annual economic effect of the introduction of the new technology of agglomeration through replacing the natural raw material with the cheaper recycled materials and increasing the share of the cheaper own-produced materials in the overall balance of the ironworks amounts to UAH 12-15 mln. The payback period is 2.5 years.

6. Illustrations.



Design of the sinter plant with the grit production department

1 – sinter plant charge storage; 2 – lime-burning production; 3 – storage bunkers of the grit production district; 4 – mixer; 5 – roller press; 6 – feedthrough (tunnel) stove; 7 – briquette crumbler; 8 – screen; 9 – fuel crumbler; 10 – limestone crumbler; 11- sinter plant storage bunkers; 12 – charge drum mixer; 13 – pelletizer; 14 – sinter machine; 15 – hot agglomerate crumbler.

7. Comparison with analogues, advantages.

The proposal ensures the maximum utilization of the recycled materials in agglomeration compared to the analogues.

8. Consumers.

Ironworks possessing a sinter plant of insufficient capacity.

9. Expectant market geography.

Pryazovya, Donetsk region, Ukraine, CIS.

10. Legal Protection.

The agglomeration technology is protected with the patent of Ukraine № 55955 A, IPC "Method for sintering ores and concentrates with the use of fine slimes".

11. Proposal validity period.

Unlimited.

12. Suggested conditions of the implementation of the technical proposal.

The license agreement, technological task development, technical and economic assessment, project and construction scientific monitoring, technology elaboration. Contractors: Pryazovskyi State Technical University, Azovengineering Ltd (Mariupol), Ferrous Metallurgy Institute (Dnipropetrovsk). Research and development work cost is UAH 200,000; project and construction work costs amount to approximately UAH 49 mln.

13. Contact information: tel.: +38 0 629 44 64 98; fax: +38 0 629 34 52 94;
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TECHNICAL PROPOSAL 18

1. **Name.**
   "Metallurgical production fine waste product briquetting department".

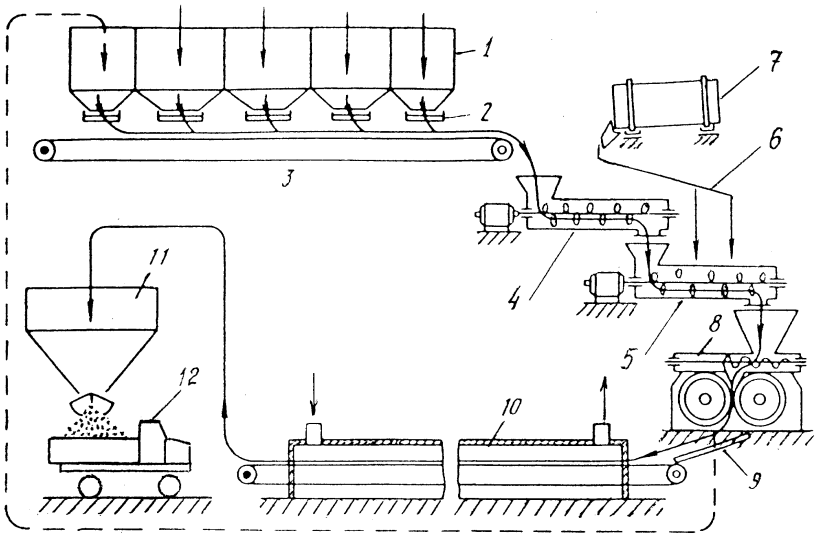
2. **Key words.**
   BLAST-FURNACE DUST, SLIME, BRIQUETTE, ROLLER PRESS, FEED-THROUGH STOVE.

3. **Purpose.**
   Utilization of iron-containing slimes and blast-furnace dust, production of iron-ore briquettes with adequate metallurgical characteristics, subsequent utilization in the agglomeration and steelmaking.

4. **Application field.**
   Utilization of secondary resources in metallurgy.

5. **Description and basic technical and economic characteristics.**
   The department includes the waste product input, mix and homogenization area, receiving bunkers, mix area, roller presses with the capacity of 30-50 tph, feedthrough stove, vibratory screen, alligator crusher, and the ready briquette unloading area. The working capacity of the department is 400,000 t of briquettes per year. The approximate department construction cost is UAH 100-120 mln. The cost price of 1 ton of briquettes is UAH 126. Department staff numbers 70 men. The expected annual economic effect amounts to UAH 25 mln. The cost payback period is 2,6 years.

6. **Illustrations.**



1 – consumable product bunkers; 2 – feeders; 3 – collecting conveyor; 4 – charge mixer; 5 – bonded mixer; 6 – bind supply; 7 – bind container; 8 – roller press; 9 – screen; 10 – tunnel stove; 11 – ready briquette bunker; 12 – discharge facilities.

7. **Comparison with analogues, advantages.**

Compared to the current development for the briquetting of the metallurgical production waster products the suggested proposal has its advantages:

- Production of briquettes and briquette grit of various applications: for use in the sintering mix, blast furnaces and steelmaking units;
- Future expansion of the department through the construction of the second briquette metallization line.

8. **Consumers.**

Ironworks having a blast-furnace plant but having no sinter plant, or the capacity of the latter is insufficient.

9. **Expectant market geography.**

Ironworks in CIS.

10. **Legal Protection.**

Patents of Ukraine № 70245 A, 74510.

11. **Proposal validity period.**

Unlimited.

12. **Suggested conditions of the implementation of the technical proposal.**

The agreement defines the development and exploitation of the technology, bind selection, equipment selection, technological task preparation and technical and economic assessment, design study, turnkey construction. The project is carried out in cooperation with Dontesk National Technical University and "Azovengineering" Ltd.

13. **Contact information:**

Pryazovskyi State Technical University, vul. Universytetska 7, Mariupol, Donetska Oblast, 87500, Ukraine, Department of Marketing and Innovation.

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Appendix

List of the publications of authors the technical proposal:

1. Брикетирование как полноправный метод окускования металлургического сырья/ В.В.Ожогин, А.А. Томаш, И.А. Ковалевский и др. // Металлургические процессы и оборудование, 2005. - № 2. – С. 54 – 58.
2. Возможности использования железорудных брикетов в аглодоменном производстве / В.В. Ожогин, А.А. Томаш, С.Г. Чернова и др. // Металлургические процессы и оборудование, 2005. - № 1. – С. 27 – 30.
3. Ожогин В.В. Оптимизация составов смесей для получения высокопрочных шламовых брикетов / В.В. Ожогин, А.А. Томаш, С.Г. Чернова // Металлургическая и горнорудная промышленность, 2003. - № 4. – С. 139 – 141.

TECHNICAL PROPOSAL 19

1. **Name.**
   "Development of the energy-saving method for the complex processing of the dispersed graphite waste into the commercial graphite".

2. **Key words.**
   ENERGY SAVING, GRAPHITE WASTE, PROCESSING, DRY METHODS, COMMERCIAL GRAPHITE.

3. **Purpose.**
   Processing of the metallurgical graphite waste into the marketable product for various fields of industry.

4. **Application field.**
   Ferrous metallurgy, mechanical engineering, chemical industry.

5. **Description and basic technical and economic characteristics.**

At the present time, the graphite waste products of the metallurgical production are partially recycled through the flotation method at the OSC "Markograf" (Mariupol). The employed equipment is highly energy intensive. The flotation results in the formation of the flotation concentrate with the up to 40% moisture content; the drying of the concentrate requires high energy costs. The use of the flotation tailings is impossible without the preliminary dehydration requiring additional facilities and energy.

The particles of the mixer department graphite waste (MDGW) contain graphite, iron compounds and slags. The rational use of the diversities in the physical characteristic of the substances serves as the basis for the efficient extraction of the graphite particles, which leads to the creation of the complex method (combining the magnetic, aerodynamic and mechanical influence) for the separation of the MDGW particles with the application of dry technology. It is possible to produce commercial graphite and dry powder materials, which widely used in various productions, without the employment of the flotation method.

The introduction of the technical proposal ensures efficient use of the named metallurgical waste for the manufacture of the highly liquid marketable products. The elimination of the labour-intesive and expensive water pumping and flotation product drying operations makes it feasible to reduce reduced the energy consumption. The current technology presupposes more than 400 kg of coal need for the drying of one ton of graphite.

The technical proposal does not require any high capital increments, the payback period is short.

6. **Illustrations.**
   No.

7. **Comparison with analogues, advantages.**

The new design for the complex enrichment of the MDGW employs energy-saving non-waste technologies, which allow establishing the commercial graphite production. One of the main advantages is the removal of water from the technological process and the increase of the production energy efficiency.

In addition, the MDGW graphite in contrast to the natural graphite is produced from the renewable resources; in its basic characteristics it competes in quality and even surpasses the natural analogue.

8. Consumers.

Ironworks and other enterprises producing cast iron and consuming graphite materials and mixtures.

In Mariupol the technical proposal and the result of its implementation find their application at OSC ILYICH Iron and Steel Works of Mariupol, OSC AZOVSTAL Iron and Steel Works, OSC "Markograf".

9. Expectant market geography.

Ukraine, near and far abroad countries.

10. Legal Protection.

The proposal is patentable. The application for a supposed invention is lodged; execution of the application for an international patent is reasonable.

11. Suggested conditions of the implementation of the technical proposal.

Preconception study cost (R&D contractors – Pryazovskyi State Technical University, OOO "KAMIT" Mariupol) is UAH 150,000; execution period is one year. The result of the R&D work is the creation of the manufacture scheme fro complex utilization of MDGW into the commercial graphite, development of the technical and economic assessment and technological task for designing the MDGW gathering, transportation and utilization equipment.

The production-scale introduction of the proposal is planned at the PA "Metallurgprom". The effect of the introduction of the developed technology lies in the improvement of the health and ecological situation and low-cost acquisition of the new types of marketable products from the available and renewable resources (metallurgical production waste products).

The technical proposal is allowed for the licensed replication; depending on the composition of the MDGW the utilization manufacture scheme is specified.

12. Proposal validity period.

Unlimited.

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TECHNICAL PROPOSAL 20

1. **Name.**
   "Technology for plasma surface hardening of tools and unit components".

2. **Key words.**
   PLASMA, PLASMOTRON, METAL-CUTTING TOOL, HARDENING, SURFACE, CRACK RESISTANCE, HEAT RESISTANCE, REHEATING SOURCE.

3. **Purpose.**
   Improvement of the operation characteristics of tools steels and alloys.

4. **Application field.**
   Ferrous metallurgy, mechanical engineering, tool production.

5. **Description and basic technical and economic characteristics.**

Nowadays, the tool performance is improved through the basic method for hardening – volumetric heat treatment. With the defined appropriate hardening and tempering modes, the desired (standard) value of the operation characteristic of tool steels and alloys are reached. However, the heat treatment for maximum hardness and wear resistance almost without exception results the drastic reduction of the metal viscosity and crack resistance, which in consequence lead to preliminary breakdown due to brittle fractures.

The operation characteristics of the tool materials are also improved through the surface hardening methods – induction hardening, surface impregnation, surfacing.

The breakthrough level of the tool material operation characteristics is reached when the material is treated with a highly concentrated heat source – plasma jet.

The specialized technological equipment for plasma surface hardening is not produced in lost by any of the Ukrainian or CIS enterprises. However, the plasma surface hardening set can be constructed on the ground of the current plasma-jet welding sets of the UPS series, APR plasma arc cutting units, plasma-jet hard-facing and plasma spraying sets of the UPN, UPU, "Kiev-4", "Kiev-7" series. The design of the technological complex is presented on the Picture 1.

The technological process of the plasma surface hardening of tools generally includes the following operations:

1) Pre-hardening treatment of the tool: preliminary volumetric heat treatment (hardening, tempering), mechanical treatment (grinding, sharpening);
2) Plasma hardening;
3) Hardening quality inspection (hardness measures, mechanical tests, witness sample metallographical tests);
4) Final heat and mechanical treatment.

The exploitability and the economic effectiveness of the plasma hardening of tools stem from the possibility to obtain more advanced operation characteristics (hardness, heat resistance, crack resistance) for high-speed steel in comparison with the volumetric heat treatment and other surface hardening technologies. Furthermore, the plasma hardening is usable both for the tools operating at comparatively low cutting speeds (screw taps, threading dies, reamers, shaping cutters, broaches etc.), when high wear resistance is required in the first place, and for the tools operating at high cutting speeds (turning forming and parting-off cutters, disk and end milling cutters), which require high heat and crack resistance.

During the tool plasma treatment along the cutting edge both working faces, front and rear, are exposed to hardening due to the presence of the adiabatic boundary. The tool takes the shearing strength more efficiently and is able to undergo more resharpening procedures before prior the rehardening.

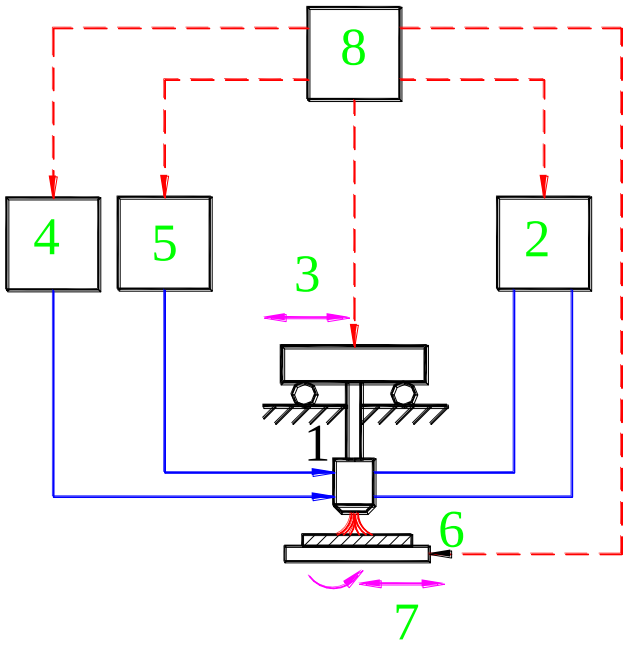
Apart from improving the strength of the cutting tools plasma treatment positively affects the variety of qualitative and economic characteristics of the mechanical treatment:

a) Standard tools manufactured of the high-speed steel after the work wear undergo the softening at the depth of 1 mm from the wear crater edge, which requires considerable resharpening metal inputs. Thanks to the higher heat resistance of the high-speed steel in the plasma hardening zone, the depth of the softened area does not surpass 0.2 mm after the cutter wear work occurs;
b) According to the data from enterprises, 30-40% of tools fail prematurely because of micro- and macrofractures: split-off, microchipping, breakdown. The plasma hardening facilitates the improvement of the crack resistance of the high-speed steel. With the complex mode hardening carried out, including the finishing volumetric tempering, the cases of the tool fracturing were not observed.
c) The hardened zone metal of highly refined structure and high fracture viscosity is indisposed to grinding cracks and sharpening and regrinding softening. This makes it feasible to reduce the grinding allowances and increase the saving of the high-speed steel;
d) During the mechanical treatment of sort malleable metals with the hardened tools the effect of galling of the processed material on the tool operation surfaces (overgrowth formation) takes place.

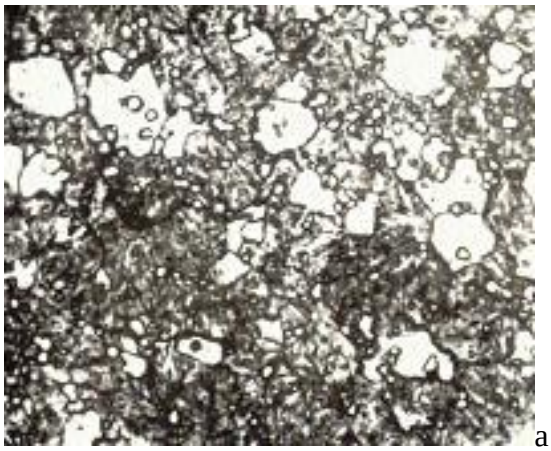
The plasma surface hardening is effective for improving the characteristic of not tool steels, but of sintered hard alloys as well.

Altogether, the improvement of the operation characteristics of the high-speed steels and sintered hard alloys and enhancement of the cutting process qualitative parameters aid to improve the hardened tool strength. Thus, according to the data from industrial enterprises, the basic cutter strength ranges within ± 50%, which results from deviations from the standard modes of tool volumetric heat treatment, violation of grinding requirements, improper cutting mode selection, unsatisfactory machinery condition. The employment of the plasma hardening ensures reducing the dispersal of the tool strength values to ± 20%.

6. Illustrations.



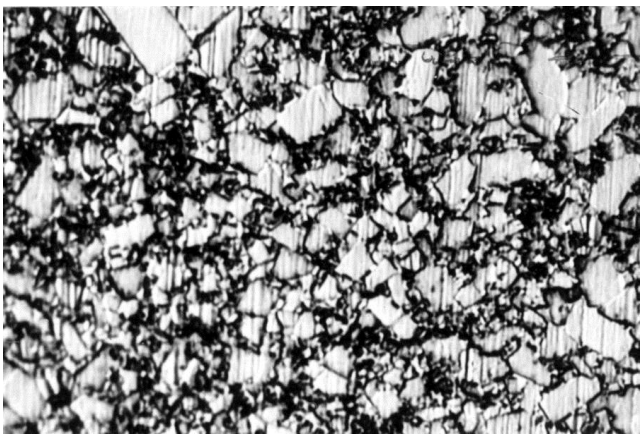
Picture 1 – Plasma technological complex design.
1 – plasmotron; 2 – power source; 3 – plasmotron traveling mechanism; 4 – plasma-supporting gas supply system; 5 – cooling system; 6 – work piece; 7 – plasmotron traveling mechanism; 8 – automatic control system.



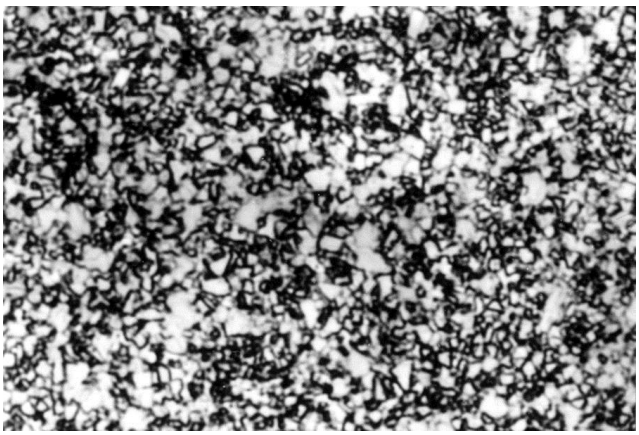
a

b

Picture 2 – High-speed steel P6M5 (x1000) microstructure:
a – after standard volumetric heat treatment; b – after plasma treatment.



a



b

Picture 3 – Microstructure of the sintered hard alloy BK6 (x3000);
a – in the initial condition; b – after plasma treatment.

7. Comparison with analogues, advantages.

According to the results of the research of thermal processes, phase and structural transformations, operation characteristics за steel and alloys (hardness, crack resistance, wear resistance, heat resistance), the method for the plasma surface hardening has several advantages over the known methods:

- It is feasible to obtain the hardened layer with up to 5 mm depth on the tool surface during the single and multiple treatments, both with and without the surface washing. This method is essentially superior to laser and electron-beam hardening, surface impregnation, vacuum and ionic coating deposition;
- It is possible to obtain within the hardened layer the cooling rate of 105 ^{0}C/s and finely dispersed tempering structures with the hardness up to HV 1100 fro steels and irons and up to HV 1700 for sintered hard alloys, which is on the level reached through the laser and electric-beam hardening, and surpasses the methods of high-frequency current hardening, volumetric furnace hardening;
- The 1.5-5 time improvement of the hardened material wear resistance depend on the chemical composition, friction parameters and treatment technology conditions;
- The suggested method can be easily employed together with the volumetric tempering or reduction weld facing by almost all operation combinations;
- It is possible to regulate the process over the wide range of the hardened tool crack resistance under various hardening technological variants, as well as under the employment together with the preliminary weld facing or furnace heat treatment;
- It is possible to locally harden the most wearing segment of the tool working area;
- The desired roughness level of the working area during the non-fusion hardening procedure is retained;
- High economic characteristics due to the low cost price, simplicity and accessibility of the equipment, high productivity of the process;
- The expensive tool materials can be replaced with the less alloyed and scarce ones;
- Advanced production standards, process automation.

8. **Consumers.**
   Ironworks, mechanical engineering, tool-making, food industry plants etc.

9. **Expectant market geography.**
   Ukraine, CIS, Spain, China, Brazil, USA, Austria, Italy, Germany, France, England, Japan.

10. **Legal Protection.**
    The Patent of the Russian Federation № 1815067 “Plasmotron”, 26/04/1993;
    The Patent of Ukraine № 20041109421 “Method for the hardening of the edge metal-cutting tools”, 16/05/2005.

11. **Suggested conditions of the implementation of the technical proposal.**
    On the terms of the agreement.

12. **Proposal validity period.**
    Unlimited.

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TECHNICAL PROPOSAL 21

1. **Name.**
   "Multipurpose economically alloyed steels, irons, surfacing materials with the increased level of mechanical characteristics and strengthening technologies with the use of the principle of self-hardening on cooling and/or stressing".

2. **Key words.**
   STEEL, IRON, SELF-HARDENING, OPERATION, HARDENING, RELAXATION.

3. **Purpose.**
   It is suggested to use manganese as the main alloying element instead of the expensive nickel, as well as to put into process the recourse of the materials through the obtainment of the metastable structure that is self-transformed during operation. This ensures the adaptation of the materials to the external load, and thereafter, the reliability and durability.

4. **Application field.**
   Metallurgy, mechanical engineering, repair equipment industry.

5. **Description and basic technical and economic characteristics.**

One of the main industrial tasks is the efficient use of resources that is caused by the escalating prices of iron ore raw materials, other resources and, as the result, of the metal. At the mechanical engineering and metallurgical plants a great variety of steel and iron grades are used for the manufacture of the replacement and spare parts, equipment and tools. Increasing their durability makes it feasible to substantially reduce the resource consumption. Generally, the issue is solved through the increased use of nickel, molybdenum, tungsten, chromium and other expensive and scarce elements, which results in the apparent increase of costs. However, an alternative solution can be implemented, which allows improving the mechanical and operation characteristics of steels and irons (in some cases even unalloyed) through the use of their internal reserves. This can be realized through the building-up the structure capable of adapting to the operation stresses.

The writing team has developed a new promising scientific field of the use of the principle of strengthening through the in-service self-hardening. 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 is 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.

On the basis of the developed concepts 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.

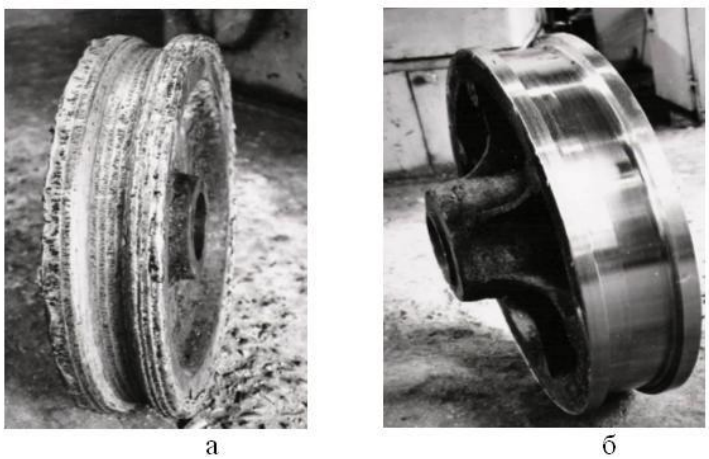
The new surfacing materials of various applications developed on the basis of the economically alloyed steels and irons substantially increase the operation life of various machine components.

Here are the examples of the use of the named developments:

1. Weld facing of crane wheels (see Picture) and steel-teeming ladle trunnions with the powder tape that ensures the effect of stress self-hardening in the weld metal. The service durability is almost 2 times increased. Weld facing of the Pilger mill rolls with the nickel-free wire ensures the 1.5 time increase in the service durability compared to the nickel-chromium wire widely used in industry.
2. the use of the steel with the stress self-hardening effect instead of 110Г13Л for the coke mill hammers and limestone breaking hammers ensured increasing their durability by 15-50% (depending on the operation conditions). The effect is also reached through the use of thee developed steels for the crushing equipment casing, iron-teeming ladle rollers and units and other fast wearing parts.
3. The developed nickel-free chromium-manganese steel used instead of 12Х18Н10Т in the manufacture of hydraulic pump blades increased their durability threefold. The steels of this grade after being hardened with hard phases obtain a high level of wear resistance under the conditions of the hydroabrasive wear.

The unconventional technologies of hardening of widely used in industry steels and irons through the realization of the in-service self-hardening effect have been developed. The technologies do not require any capital investments, they can be introduced on the currently operating equipment and ensure 15-20% increase in the mechanical characteristics. This can be illustrated by the durability improvement of various hydraulic valves manufactured of the (30-40)Х13 steel, part of low-alloyed steels (20Х, 4ХС, 6ХС, 65Г, 60С2) operating in the abrasive environment, e.g. for the production of the refractory production press mold lining plates etc.

6. Illustrations.



а б

Picture: crane wheel built-up with the powder tape (a), the same wheel after mechanical treatment (b).

7. **Comparison with analogues, advantages.**

The analogues (steels, irons and surfacing materials) used in industry contain such expensive alloying elements as nickel, tungsten etc, which under the current conditions of continuous price surge leads to high cost price of machine components and tools. Moreover, the currently used materials possess the lower level of mechanical characteristics and operation durability.

8. **Consumers.**

Ironworks and mechanical engineering plants.

9. **Expectant market geography.**

Ukraine, far abroad countries.

10. **Legal Protection.**

The economically alloyed steels, irons and surfacing materials and strengthening technologies are protected by patents of Ukraine.

11. **Suggested conditions of the implementation of the technical proposal.**

On the terms of the license agreement.

12. **Proposal validity period.**

Unlimited.

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TECHNICAL PROPOSAL 22

1. **Name.**
   “Economical metastable alloys (steels, irons) with the in-service self-hardening effect”.

2. **Key words.**
   STEEL, IRON, STRUCTURE, METASTABILITY, HETEROPHASENESS, AUSTENITE, WEAR RESISTANCE, CORROSION RESISTANCE.

3. **Purpose.**
   Economical metastable alloys (wear resistant irons, corrosion and heat resistant steels) are suggested as the replacement of the expensive high alloys in the manufacture of fast wearing components of metallurgical equipment, draw plates, blades, impellers, shotblast unit lining plate, shotblast machine nozzles, pump components, supporting heating and thermal elements, furnace fittings etc.

4. **Application field.**
   Metallurgy, mechanical engineering, maintenance machine building.

5. **Description and basic technical and economic characteristics.**

Improving the quality of the construction materials and saving the highly deficit alloying elements (nickel, vanadium, molybdenum, niobium) are the most important problems of Ukrainian metallurgy, though this problem exists in many other countries as well.

The essentially new economical alloys of various applications possess the metastable structure that undergoes deformation and thermo-deformation phase changes during operation: martensitic $\gamma \rightarrow \alpha'$ and $\gamma \rightarrow \varepsilon'$, dynamic strain ageing. These changes occur in inside or in the material surface layer under the influence of the wearing environment ensuring self-hardening and improving the wear resistance of components under specific operation conditions.

The developed scientific basis makes it feasible to produce highly efficient economic materials of new generation and create methods for the regulation of their properties. A number of new materials have been introduced on several enterprises in Ukraine and Russia.

At OSC ILYICH Iron and Steel Works of Mariupol the operation durability of the sinter machine lining plates of the designed wear resistant iron has increased in 2.5-3 times in comparison with the previously used steel 110Г13Л. The economic effect was UAH 14 mln.

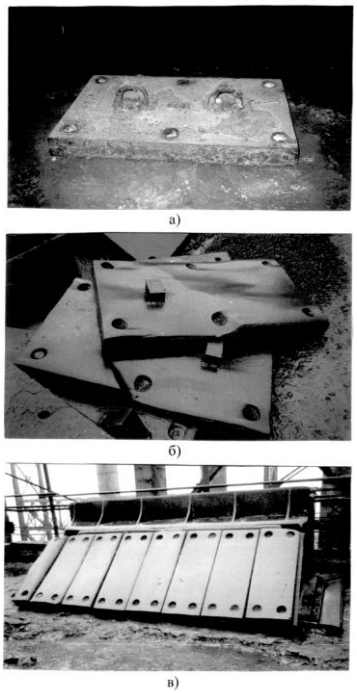
At OSC Commercial Finance Group “Interresurs” (Taganrog, Russia) the operation durability of the new iron draw plates of the *И*6122А automatic straightening and cutting machine has increased 2.5 times (compared to Р18 steel) and 1.4 times (compared to Х12М steel).

The new economically alloyed irons are recommended for the manufacture of nozzles, impellers, shotblast unit lining plate, shotblast machine nozzles. These irons came into use at OSC “Krasnyi Kotelschik” (Taganrog, Russia) and OSC “Azovmash” (Mariupol).

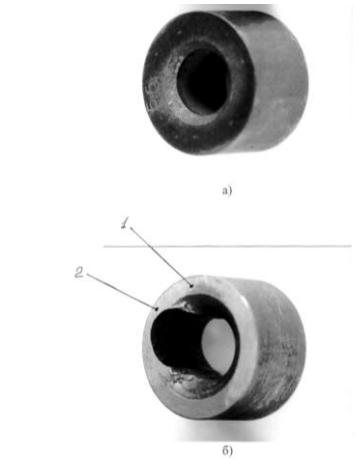
At OSC “Yuzhgirdromash Plant” (Berdyansk) the cost price of the new corrosion resistant nickel-free steel 12Х16Г10ДСТЛ suggested for the manufacture of the CSMI (centrifugal sectional multi-stage immersion) pump parts was approximately 700 $/t lower then the previously used steel 10Х18Н10Л. The annual post-introduction economic effect made UAH 250,000.

At OSC “Azovmash” the use of the new heat resistant 35Х23Г3СФЛ steel for the manufacture of heat-treatment furnace fasteners made it feasible to reduce the cost price of the products by ~ $ 3500-500 per ton in comparison with the previously used 35Х23Н7С and 40Х24Н12С steels.

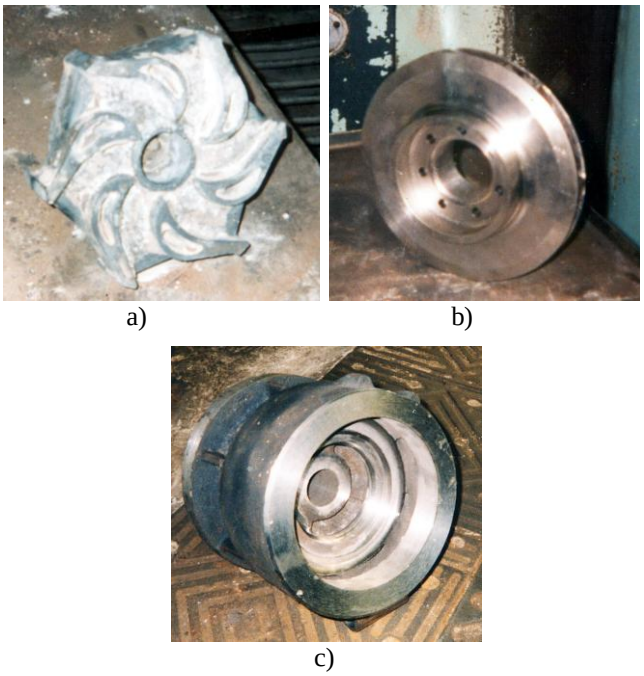
6. Illustrations.



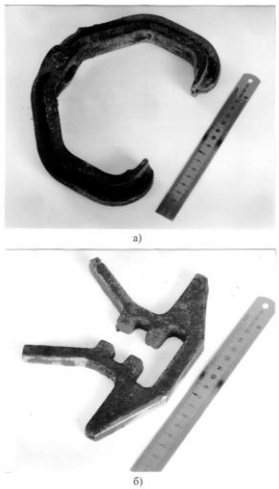
Picture 1. Refractory lining plates of sinter machine made of ЧХ15Г5ТЮ iron before operation (a), after operation (b) and



Picture 2. И6122А automatic straightening and cutting machine draw plates before (a) and after (b) operation: 1,2 – points of hardness measuring and microstructure examination.



Picture 4. CSMI-16-2000-1400 pump components:
a) casting for the grinding device;
b) working wheel; c) drain pipe.



Picture 3. Fasteners of thermal furnace of 35Х23Г3СФЛ steel:
a) suspension; b) bracket.

Comparative operation characteristics of the used and designed materials for fast wearing parts						
Material	Struc-ture	Hardness, HRC	Operation characteristics		Durability increase, time	Enterprise
			Description of the measurement	Absolute measure		
Automatic straightening and cutting machine draw plates						
Р18	М+С	63	Output, t	27,5	1	OSC CFG "Interresurs" (Russia)
Х12М	А+М+С	38		50	1,8	
ЧХ15Г5Т	А+М+С	50		69	2,5	
Plates of sinter machines						
110Г13Л	А+С	25	Durability, month	3-4	1	OSC ILYICH Iron and Steel Works of Mariupol
ЧХ15Г5Т	А+М+С	48		9-12	3,5	
Shotblast machine blades						
ЧХ16НМФ, «Амурлитмаш»	М+С	65	Durability, hour	264	1	OSC "Azovmash"
Fe-Cr-Mn-C	А+М+С	61		264	1	
Shotblast machine nozzles						
Р6М5	М+С	64	Processed, part	20	1	OSC "Azovmash"
Fe-Cr-Mn-C	А+М+С	61		140	7	
А – austenite; М – martensite; С – carbides.						

7. Comparison with analogues, advantages.

The designed materials are distinguished from the industrial analogues with the economical alloying – they do not contain expensive and highly deficit elements (nickel, molybdenum, vanadium, niobium), their price is lower by 320-350 $/t, and finally the new materials surpass the analogues in many other parameters.

8. Consumers.

Enterprises that have equipment with fast wearing changing parts, which suffer from wearing under high temperatures in particular and operate in corrosion active stress environments.

9. Expectant market geography.

Ukraine, CIS, far abroad countries.

10. Legal Protection.

Economical alloys and production technology are protected by patents.

11. Suggested conditions of the implementation of the technical proposal.

Contract. License agreement.

12. Proposal validity period.

Unlimited.

13. Contact information: tel.: +38 0 629 44 64 98; fax: +38 0 629 34 52 94;
e-mail: omid@pstu.edu

TECHNICAL PROPOSAL 23

1. **Name.**
   “Highly economic drives of various machines”.

2. **Key words.**
   WAVE TRANSMISSION GEAR, FLEXIBLE GEAR, RIGID GEAR, TEETH CONTACTING ELEMENTS, ROLLING ELEMENTS, ROLLED RACES.

3. **Purpose.**
   Transmission of rotation motion and rotary momentum from the input element to the output and executive elements.

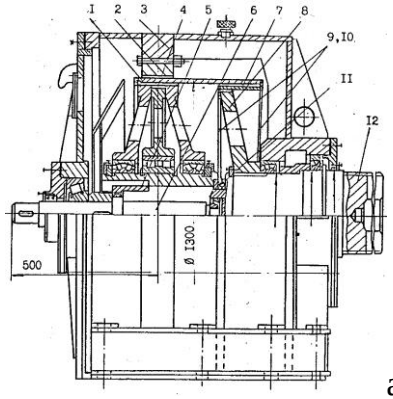
4. **Application field.**
   Metallurgical, hoisting, transport, mining equipment etc.

5. **Description and basic technical and economic characteristics.**

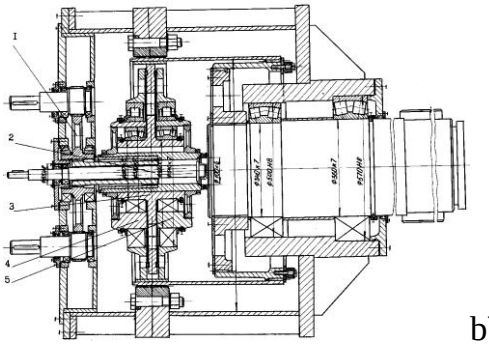
The specific arrangement of the developed drives is the wave gear equipped with teeth and intermediate rolling elements. It ensures the 1.5-3 times reduction of the mass and dimension characteristics. The basic assessment criterion of the transmission gears is the specific materials consumption. The harmonic drives value is 0.010-0.015 kg/Nm, while the value of conventional gears (planetary gears, which are the most similar to the harmonic one) makes 0.030-0.060 kg/Nm. Thus, the use of the new transmission gears in drives makes it feasible to substantially decrease the materials consumption, as they require bearers of less weight, and consequently the lower cost price and labour input for the manufacture of drive mechanisms and machines in general.

6. **Illustrations.**

The Picture 1 schematically shows the designs of the developed highly economic drives of various machines.

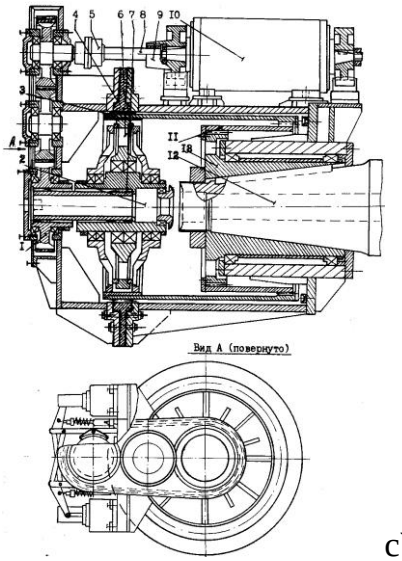


a)



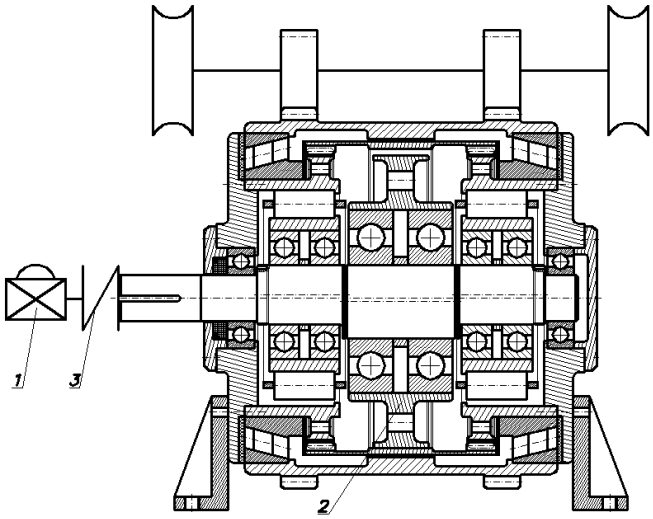
b)

Picture 1 – Design of the new highly economic drives with the wave gear for various machines:
a), b) – converters; c) – single bucket walking excavators ЭШ 10/70:
1 – engine; 2 – wave gear; 3 – joining link

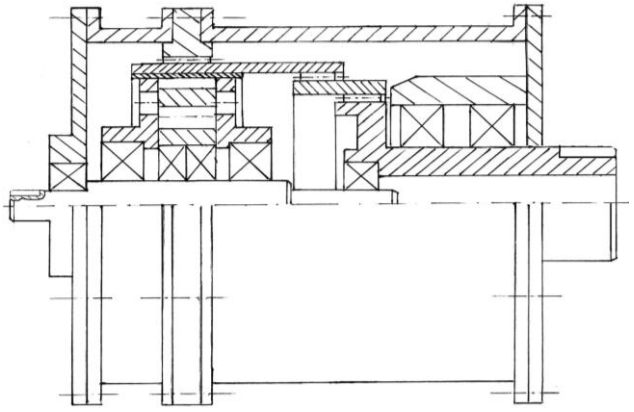


c)

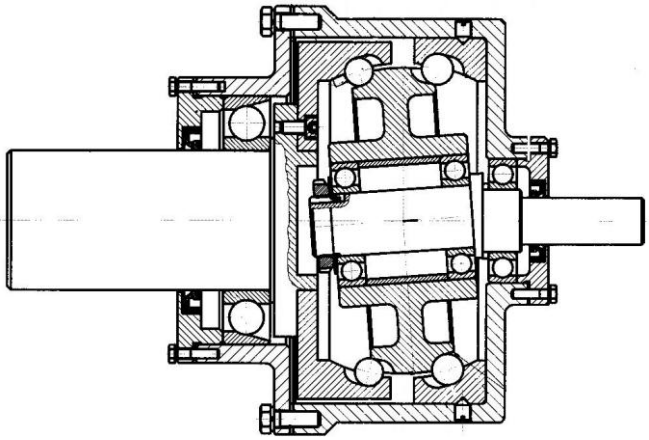
The new designs are presented by single-wave gear and two-wave gear for metallurgical equipment, ball transmission (Pictures 2, 3, 4).



Picture 2 – Single-wave gear drive for metallurgical rail-guided machines



Picture 3 – Two-wave gear transmission

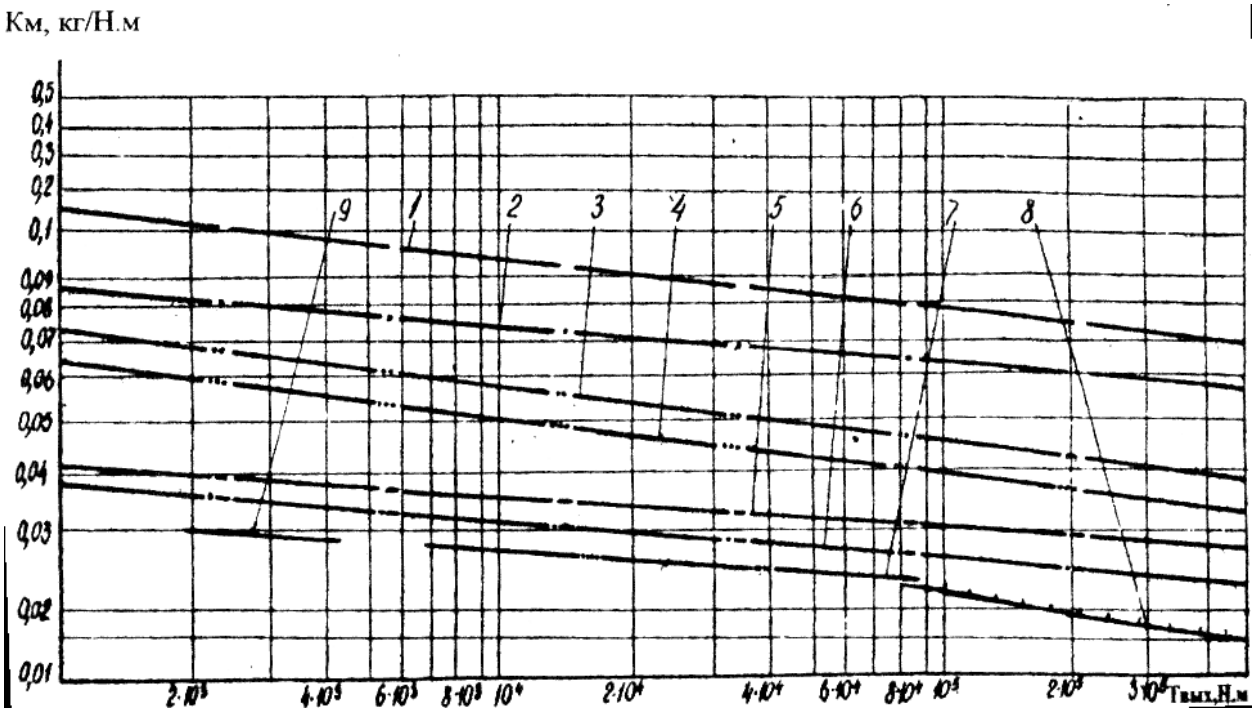


Picture 4 – Ball transmission

7. Comparison with analogues, advantages.

Advantages:

- Realization of high transmission ratios within the 40-500 range in a single stage with the two-wave wave generator.
- Advanced load capacity by relatively low mass and size.
- Minor backlash and high enduring accuracy.
- Transfer of the motion through the sealed bulkhead.
- Low inertia moment driven to the input shaft (for the machines with disk wave generators).
- The comparative analysis of the specific materials consumption of drives with various transmission gears is given on the Picture 5.



Picture 5 – Graph of behaviour of the specific materials consumption Km of various gears in relation to the torque output T_{out}:

1 – bevel-cylindrical gears; 2 – cylindrical gears; 3 – epicyclical gears; 4 – gear component type gearings; 5 – USM wave gears (USA); 6 – Haseg wave gears (Japan); 7 – wave gears designed by Moscow Institution of Civil Engineering and Moscow Higher School of Technology; 8 – wave gears of the designer's construction; 9 – interdigitated transducer and valve-jet drive of the designer's construction.

8. **Consumers (current and perspective).**
   The designed drives are currently introduced at the OSC AZOVMASH. Other perspective consumers are mechanical engineering enterprises.

9. **Expectant market geography.**
   Ukraine, far abroad countries.

10. **Legal Protection.**
    Patent of Ukraine: № 6060, patent date 15.04.2005; № 20258, patent date 15.01.2007; № 20259, patent date 15.04.2007; several certificates of authorship.

11. **Suggested conditions of the implementation of the technical proposal.**
    On the terms of the agreement – design of the drives in cooperation with the customer, including the instructions and production technology, industrial production.

12. **Proposal validity period.**
    Unlimited.

13. **Contact information:** tel.: +38 0 629 44 64 98; fax: +38 0 629 34 52 94;
    e-mail: omid@pstu.edu

TECHNICAL PROPOSAL 24

1. **Name.**
   “New synthetic secondary aluminum alloys and their application in metallurgy”.

2. **Key words.**
   UTILIZATION, FERROALUMINUM, UNIT SIZE, IRON-CARBON MELT, DEOXIDATION, ALLOYING, STEEL LADLE, STEEL QUALITY.

3. **Purpose.**
   Utilization of the secondary and ore materials containing aluminum, saving of aluminum during deoxidation and steel alloying, improving the steel quality.

4. **Application field.**
   Ferrous metallurgy: steel deoxidation and alloying processes.

5. **Description and basic technical and economic characteristics.**

The recent limited supply and appreciation of aluminum caused the intensive development of the utilization and recycling of secondary raw materials for the production of aluminous deoxidants in substitution of secondary aluminum ingots AB-87.

The efficiency of the aluminous deoxidants depends on their physicochemical and mechanical properties in solid and liquid form. These properties must meet the requirements of necessity and sufficiency. The necessity requirement lies in the obtainment of the desired alloy density that is brought to the density of the liquid metal and is always higher than the density of the furnace and ladle slag ($\rho \geq 3.5$ g/cm^3). The adherence to this requirement is necessary for preventing the secondary oxidation of aluminum due to the atmospheric oxygen. The oxidation inevitably occurs when using the aluminum ingots and melting the aluminum on the covering slag surface. The sufficiency requirement is determined by the structure-chemical state of the melt under the temperatures of liquid metal.

The analysis of the structure-chemical state of metallurgical phases through polygonal condition diagrams of binary and multi-component systems makes it feasible to estimate the thermal stability and chemical activity of the constituents, and therewith, the technological efficiency of the steel deoxidation and alloying processes. Moreover, the congruent melting alloys, the composition of which conform the intermetallic compounds in liquidus line singular values of the binary/quasibinary diagrams. These alloys are distinct in high stability (indisposed to autodecomposition on long standing and during transportation), which improves their operation properties and commercial values. Thus, the sufficiency property is reached under the conformance of the alloy chemical composition and the stoichiometric composition with the congruent melting point with the maximum thermal and structural stability in liquid form.

These two properties (necessity and sufficiency) are the basis of the production of new synthetic ferroaluminous alloys of the secondary raw material with a definite relation of basic components.

The nomenclature of the suggested ferroaluminous alloys includes the following grades: “feral” type ferroaluminum, “siferal” type ferrosilicoaluminum, type special alloys of the “carboferal”, “caferal”, “magferal”, “tiferal” and other types. These are produced under Technical Specifications ТУ У 27.3-13533123-001-2004. The product is delivered to the consumer in the form of ingots of the given unit size, briquettes, powder compact-material in the steel shell of the screenings of ferroalloys and hardeners, as well as granulated aluminum (flux cored wires in diameter 10-15 mm).

The proposal also suggests a through innovative technology of steel deoxidation and alloying that is based on the sequential ladle steel processing with various types of aluminous deoxidants. Upon this, at the first stage the aluminum feeding is given at the beginning of the steel tapping before solid slag-forming blends, at the second stage – during the steel tapping after SSFB, and at the last stage – into the ladle after the metal tapping. The major difference of the suggested technology is the batch

distribution of the aluminum according to the deoxidants types; thus the efficiency of deoxidation and alloying of steel with aluminum is improved.

The technical proposal makes it feasible to produce efficiently operating inexpensive non-self-destroying synthetic aluminum alloys of the secondary materials, to use them for industrial-scale steel deoxidation thus ensuring the reduction of the quality of rejected ingot, additional crops and the defective finished products.

6. Illustrations.

No.

7. Comparison with analogues, advantages.

The examination and industrial application of the new synthetic secondary aluminum alloys, FA-30 in particular, instead of the aluminum ingots AB-87 at the ironworks of the Donbass region showed the following advantages:

- Physical losses due to internal reasons "warehouse – steel ladle" are excluded.
- The application of the new alloys fit well into the mechanized methods for ferroalloy input and completely excludes hard manual labour that is applied during aluminum ingot feeding.
- The recovery of aluminum from FA-30 1.5-2.0 times exceeds the recovery of aluminum from AB-87 and amounts to 40-45% with the simultaneous improved recovery of manganese and silicon up to 10% each.
- The coefficient of the replacement of AB-87 aluminum ingots with FA-30 ferroaluminum (depending on the steelmaking process type and steel grade) makes no more than 1.2-1.6 in pure elements.

8. Consumers.

Ironworks, iron and steel works, mechanical engineering plants with metallurgical production.

9. Expectant market geography.

Ukraine, CIS, far abroad countries.

10. Legal Protection.

Certificate PA № 2825 "Methods for construction of polygonal diagrams of condition of binary metallurgical systems", 14.03.2000.

Patents for inventions:

№ 45937 7C22C35/00, C21C7/06. "Ferroaluminum" alloy for iron and steel deoxidation and alloying. 2004. – Bulletin № 3.

№ 75522 IPC (2006) C21C7/06, C21C1/00, C21C7/064. Method for obtaining the complex deoxidants of synthecoraferrosilicoaluminum for killed and open steels. 2006. - Bulletin № 4.

Declaration useful model patents:

№ 6198 C21C7/06. Method for obtaining the complex deoxidants of synthecora-ferrosilicoaluminum for killed and open steels. 2005. - Bulletin № 4.

№ 9593 C21C7/06. Ferroalloy of secondary aluminum "feral" for iron and steel deoxidation and alloying. 2005. - Bulletin № 10.

№ 9970 C21C7/06. Method for deoxidation of the open-hearth steel with aluminum. 2005. - Bulletin № 10.

№ 11857 C21C7/06. Method for deoxidation and alloying of converter steel with aluminum. 2006. - Bulletin № 1.

№ 16746 C21C7/06. Method for deoxidation of killed steel grades with aluminum. 2006. - Bulletin № 8.

№ 19470 C21D1/00. Method for secondary refining. 2006. Bulletin № 12.

№ 20644 IPC(2007) C22C21/00. Secondary aluminum alloy (ferosilicoaluminum) – "siferal". 2007. - Bulletin № 2.

11. Suggested conditions of the implementation of the technical proposal.
On the terms of the agreement.

12. Proposal validity period.
Unlimited.

13. Contact information: tel.: +38 0 629 44 64 98; fax: +38 0 629 34 52 94;
e-mail: omid@pstu.edu

TECHNICAL PROPOSAL 25

1. **Name.**
   “Installation for mechanized arc surfacing”.

2. **Key words.**
   INSTALLATION, SURFACING, SURFACING UNIT, THERMOSTATIC SHELL, TRESTLE, OPERATION PLATFORM, FLUX BUNKER.

3. **Purpose.**
   The installation (Picture 1) is designed for submerged mechanized arc surfacing of cylindrical and plain surfaces of various parts with the aim of restoring the size, improving the wear resistance.

4. **Application field.**
   Reconditioning and hardening of the parts of rolling, power, mechanical engineering and metallurgical production.

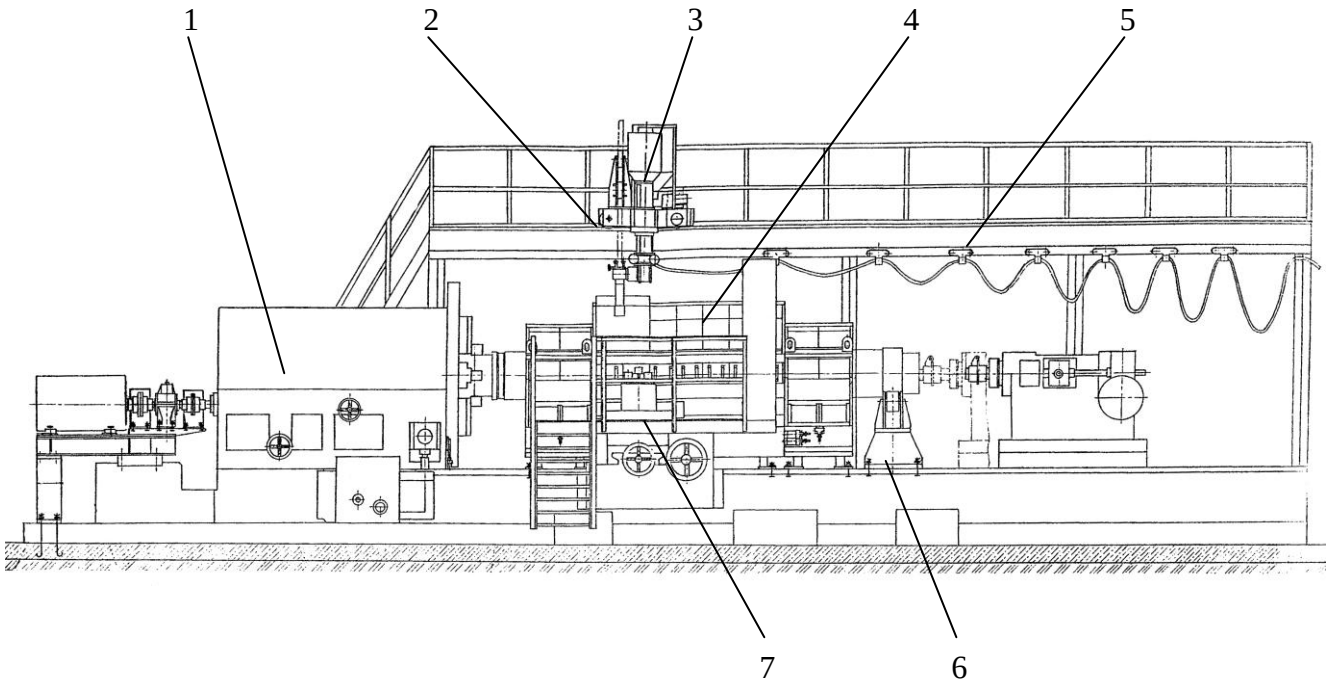
5. **Description and basic technical and economic characteristics.**

The installation is composed of the rotary mechanism *1* (Picture 2) of the surfaced item; the trestle *5*, along which the self-propelled transport *2* with the surfacing unit *3*, flux bunker and surfacing wire box travels parallel to the axis of the item; the thermostatic shell *4* and traveling operation platform *7* equipped with the instrument panel for the installation operator. The rotary mechanism is installed on the housing, along the guide rails of which the operation platform travels. Inside the thermostatic shell the surfaced part is held and the gas burner system and the dust and gas collector are assembled. The surfacing and flux apparatus, wire/film boxes are attached on the self-propelled transport that can travel along the supporting iron – trestle that is situated on the separate pillars along the rotation axis of the part. The construction of the installation presupposes the possibility of the pre- and post-surfacing mechanical treatment of the parts.

At OSC ILYICH Iron and Steel Works of Mariupol two installations for surfacing the steel rolls of rolling mills (Picture 1) have been designed and applied. The annual economic effect of the design made more than UAH 250,000. The costs for the reconditioning of the worn mill roll amount to approximately 15% of the price of the new one (Picture 3). The wear resistance of the surfaced rolls almost 2.5 times exceeds the parameters of the new rolls (Picture 4).

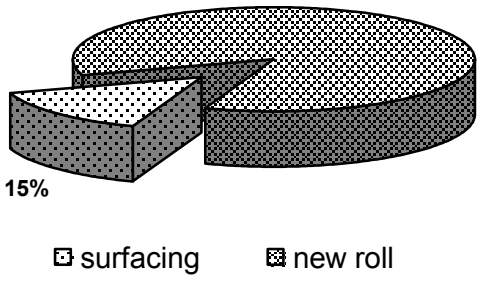
6. **Illustrations.**

Picture 1 – Installation for the surfacing of the rolls at the rolling mill ЛПШ-1700 of OSC ILYICH Iron and Steel Works of Mariupol

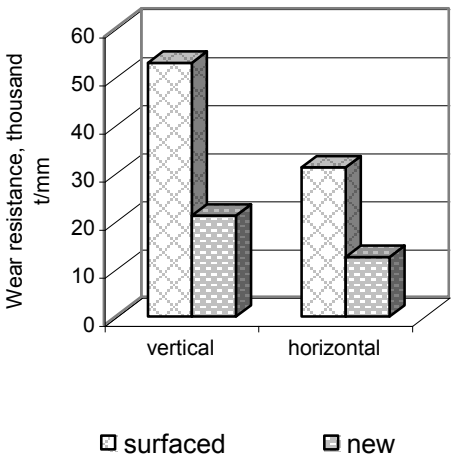


1. Rotary mechanism;
2. Self-propelled transport;
3. Surfacing unit;
4. Thermostatic shell with the installed dust and gas collector, gas burners, flux and slag crust collecting pan;
5. Supporting iron (trestle) with the guide rails for the travel of the self-propelled transport;
6. Rest device;
7. Enclosed operator's platform with the installed instrument panel and crust remover.

Picture 2 – Design of the installation for the submerged mechanized arc surfacing



Picture 4 – Costs for the purchase of the new roll and the recondition of the worn one



Picture 4 – Wear resistance of the surfaced and new rolls at the rolling mill Slabbing-1150 of OSC ILYICH Iron and Steel Works of Mariupol

7. **Comparison with analogues, advantages.**

The installation meets the high requirements of reliability. The construction of the installation presupposes the thermostatic shell with the aim of securing the most efficient conditions for surfacing the metal layer of advanced quality and characteristics. The gas burner system and the dust and gas collector for the welding aerosol and products of gas combustion by the additional heating of the surfaced unit are assembled inside the thermostatic shell.

The thermostatic shell ensures the stabilization of the temperature mode of the overall heating of the part with gas burners, protection against cooling with cold air streams, and the isolation of the combustion products and pulverized-coal and gas evolutions during surfacing and slag crust collection. The thermostatic shell equipped with the gas burner system gives the feasibility to quickly preheat the part to the desired temperature directly at the installation. Hence, the part is installed in cold condition that substantially facilitates the installation service. The thermostatic shell is also suitable for heat treatment of the surfaced part.

The deployment of the electrode material (wire, film) boxes and flux bunker of increased capacity on the self-propelled transport ensures the continuity of the process of multilayer, multipass surfacing without almost any brakes for box recharges and flux bunker refilling.

The design of the self-propelled transport ensure the stable and plain shockless travel of the apparatus without any oscillations along the surfacing zone when carrying out the complex surfacing procedure through the alteration of the spout motion trajectory along the roll surface with the aim of obtaining the metal layer of specific properties (different hardness, wear resistance, crack resistance etc.). This greatly influences the final result – the quality of the formation of the surfaced metal layer.

8. **Consumers.**

Metallurgical and mechanical engineering enterprises. Industrial enterprises that have the equipment with fast wearing change parts, which undergo wearing processes, under high temperature in particular.

9. **Expectant market geography.**

The suggested development can be introduced in Ukraine, and in near and far abroad countries.

10. **Legal Protection.**

The development is protected by the certificate of authorship and patents of Ukraine.

11. **Suggested conditions of the implementation of the technical proposal.**

Contract. License agreement.

12. **Proposal validity period.**

Unlimited.

13. **Contact information:** tel.: +38 0 629 44 64 98; fax: +38 0 629 34 52 94;
e-mail: omid@pstu.edu

Appendix (publications):

1. Повышение долговечности стальных валков прокатных станов ОАО «ММК им. Ильича» / Матвиенко В.Н., Степнов К.К., Гулаков С.В., Климанчук В.В., Зеленский В.Е., Шебаниц Э.Н. // Металлургические процессы и оборудование. – № 2. - 2005. - С.39-42.
2. Восстановление наплавкой деталей металлургического оборудования в условиях ОАО «ММК им. Ильича». / Матвиенко В.Н., Гулаков С.В., Роянов В.А., Степнов К.К., Климанчук В.В., Зеленский В.Е., Шебаниц Э.Н. // Металл и литье Украины. - №7-8. – 2005. – С.66-69.
3. Опыт промышленного использования технологии дуговой наплавки ленточным электродом для восстановления стальных прокатных валков. / Матвиенко В.Н., Степнов К.К.,

Климанчук В.В., Шебаниц Э.Н. // Бизнес-мост. Промышленность и технологии. – 2007. – № 5. – С.26 –27.
4. Новые наплавочные участки для восстановления крупных и уникальных прокатных валков. / Лещинский Л.К., Матвиенко В.Н., Щетинина В.И., Степнов К.К. и др. // Автоматическая сварка. - № 8. - 1996. - С. 58 – 59.
5. Матвиенко В.Н. Наплавка ленточным электродом валков прокатных станов. // Вестник Приазовского государственного технического университета: Сб. научн. тр. Вып. 16: Мариуполь, 2006.- С.162-166.
6. Матвиенко В.Н., Степнов К.К. Промышленная установка, новые материалы и технология наплавки прокатных валков. // «Модернизация и переоснащение предприятий. Эффективные технологии ремонта и восстановления деталей» - Сб. научн. тр. 3-ой научно-практической конференции, 10 октября 2007 г.: Днепропетровск, ООО «Экспо-центр «Метеор», 2007. - С. 35 – 40.

TECHNICAL PROPOSAL 26

1. **Name.**
   "Technology for obtaining lime from briquetted chalk grit".

2. **Key words.**
   CHALK GRIT, LIQUID GLASS, BREAKAGE, MIXING, BRIQUETTING, DRYING, ROASTING, LIME.

3. **Purpose.**
   Obtaining high-quality lime from chalk grit that forms during lump chalk production. Utilization of mining industry waste products. Fresh raw material saving.

4. **Application field.**
   Ferrous metallurgy, chemical industry, calcareous material production.

5. **Description and basic technical and economic characteristics.**

The most efficient way of the application of chalk grit that is formed during chalk production and afterwards goes to waste, is the lime production. The production can be set on the ground of almost the same equipment used in the production of common lime. The basic method for palletizing the chalk grit before roasting is briquetting.

The best adhesive is presented by liquid glass. The use of certain salts is also possible. Organic adhesives are less preferable, as they contain sulfur and undergo pyrolization during roasting that causes preliminary destruction of the briquettes.

Lime and lime dust screenings produced during chalk briquette roasting can also be used as the adhesive. This fact is determined by the necessity of utilization of these materials in their own production; moreover, their price is lower than that of the liquid glass.

The industrial process of obtaining the lump lime that resembles the given one can be implemented the following way (see Picture).

The chalk grit is extracted from the dump, then it is dried on site to the 6% humidity content in order to prevent clogging of the dispersing and size reduction equipment, and if appropriate the grit is ground to the 10 mm fraction. This determines the normal capacity of the pressing tools and prevents the cells from breakdown through accidental penetration of hard particles.

Afterwards the chalk grit is mixed with the slaked lime dust and fines, as well as with other waste products of lime production (10-20 % of the overall output) that are used as the adhesive. The moisture content of the grit is lowered to 10-14%; the girt is then pressed under the pressure of 50 MPa.

In case of shortage of the lime adhesive the solution of liquid glass (in the quality of 1-2% on dry basis) is used. The obtained briquettes are than dried in the stove for 30 minutes at the temperature of 300-350 ^{0}C. In order to increase the drying efficiency the heat of the gases emerging during briquette roasting is used. After drying, the briquettes are taken to the rotary, shaft or circular kiln and roasted at 1050 - 1150 ^{0}C until the lime is produced.

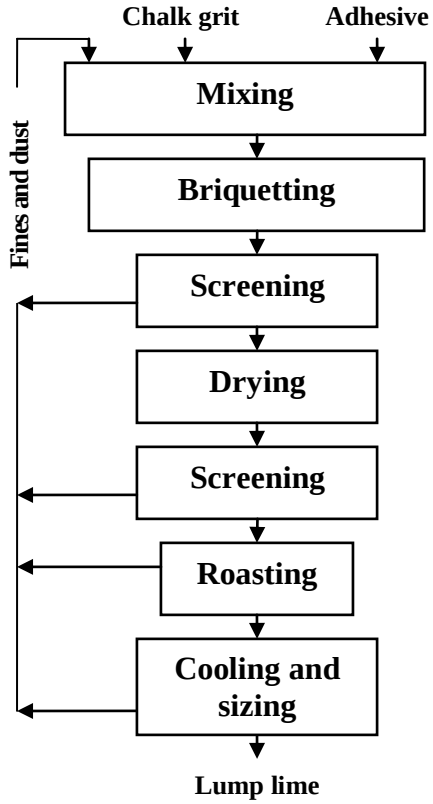
The suggested technology ensures:

- involving into the circle large quality of the chalk production wastes;
- clearing vast space occupied by waste storage;
- improving the ecological condition of nearby territories;
- organizing more profitable staflux production on the cleared ground;
- increasing the efficiency of metallurgical production;
- acquire a considerable economic effect.

The estimated specific saving form the use of 1 ton of chalk grit for the production of lump lime makes approximately UAH 100. Moreover, a positive ecological effect is reached through the reduction of the influence of chalk dumps on the environment.

The payback period of capital investments is 3 years.

6. Illustrations.



Picture. Process design of obtaining lime form chalk grit

7. Comparison with analogues, advantages.

The proposal ensures the maximum level of utilization of secondary recourses in flux production in comparison with the known analogues. The higher quality and the lower price of the product are guaranteed.

8. Consumers.

Ironworks with steelmaking production; chemical industry enterprises with high lime consumption.

9. Expectant market geography.

Donetsk-Prydniprovskyi economic region, Ukraine, GUAM countries.

10. Legal Protection.

The method for obtaining lime is now at the stage of patent protection in Ukraine. For the interested party a new patent can be acquired, taking into account the operation specifics and "know-how's".

11. Proposal validity period.

Unlimited.

12. Suggested conditions of the implementation of the technical proposal.

The license agreement, technological task development, technical and economic assessment, scientific monitoring of the project and construction, technology elaboration. Contractors: Pryazovskyi State Technical University, "Azovengineering" Ltd (Mariupol). Research and development costs are

UAH 100-200 thousand, the estimated project and construction works costs depending on the installation productivity are UAH 5-10-20 mln.

The complement and delivery of the equipment, including foreign equipment, supplier and contractor search can be carried out by Azovengineering" Ltd.

The lime production can be introduced on the ground of "Soda" Slovyansk Industrial Union that meets all the necessary requirements: production facilities, skilled labour, commercial reserves of chalk grit, connecting tracks etc.

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TECHNICAL PROPOSAL 27

1. **Name.**
   "Technology for the production of staflux on the basis of chalk grit".

2. **Key words.**
   CHALK GRIT, CHIP, SCALE, LIQUID GLASS, GRINDING, MIXING, BRIQUETTING, DRYING, ROASTING, STAFLUX.

3. **Purpose.**
   Obtaining the high-quality staflux on the basis of chalk grit that is formed during lump chalk production. Utilization of mining industry waste products. Fresh raw material saving.

4. **Application field.**
   Ferrous metallurgy, fluxing material production, utilization of metallurgical production wastes.

5. **Description and basic technical and economic characteristics.**

Staflux is a material that has a low melting temperature; it quickly builds up slag and improves the flow of steelmaking processes. However, the mass staflux production is hindered due to the difficulties connected with the production of stafluxes of necessary quality.

The chalk grit that is obtained during chalk production can be used as the fluxing component. The grit is a cheap material requiring utilization, possessing the skeletal structure of high porosity of 45-50% that ensures active absorption of ferrous components. The chalk grit is also easily and quickly roasted.

The palletizing of the named components should be realized through briquetting that provides an environmentally safe method for palletizing and the desired degree of the metal homogeneity. The effective adhesive is liquid glass that provides not only the desired hardness of the briquettes, but the contained SiO_2 facilitates the formation of the compounds of low fusion temperature. Lime production wastes can also be used as the adhesive.

The industrial process of staflux production can be implemented the following way (see Picture). The chalk grit is extracted from the dump; if necessary it is dried in the open air to the 6% moisture content in order to prevent the clogging of the dispersing and size reduction equipment. The grit is afterwards ground to the 5 mm fraction.

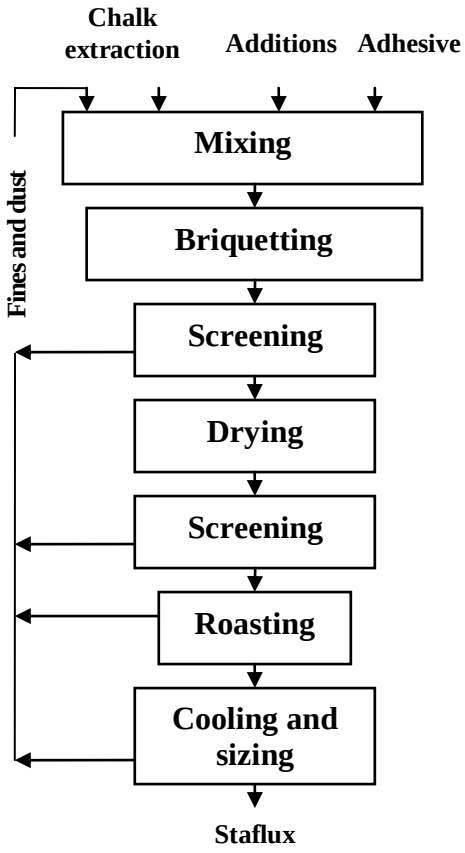
Hereafter, the chalk grit is wetted with the solution of liquid glass providing the 10-14% moisture content of the briquetted charge, ferritizer is added, and the mix is pressed under the pressure of 50 MPa. The ready briquettes are dried in the stove for 30 minutes at the temperature of 350 ^{0}C. With the view of increasing the drying efficiency it is recommended to use the heat of gases emerging during staflux roasting.

The dried briquettes are taken to the rotary, shaft or circular kiln and roasted at the temperature of 1250 ^{0}C until lime is obtained and staflux is produced.

The high quality staflux is obtained under the following conditions: 70-90% content of the chalk grit, 10-30% of ferritizer, liquid glass consumption of 3-7% (over 100%). The mixture with the 10-14% moisture content is briquetted under the pressure of 50-90 MPa; briquettes are dried for 30 minutes at 250-350 ^{0}C, roasting and sintering – at 1150-1200 ^{0}C. The fractional composition of the chalk grit is determined at the level of 0-5 mm that excludes the occurrence of "whites", ensures the homogeneous composition of the charge and decreases the treatment period. Staflux does not decompose during 7-30 day and longer, which is enough for creating the reserves needed for continuous operation.

The estimated specific saving of the consumer after using 1 t of staflux produced according to the suggested method amount to more than UAH 100. With the consideration of the clearing the space occupied with wastes and the reduction of their influence on the environment, the effect is to be of more importance. The capital investment payback period is 2.5 years.

6. Illustrations.



Picture. Staflux production design.

7. Comparison with analogues, advantages.

The proposal ensures the maximum level of utilization of secondary recourses in staflux production in comparison with the known analogues. It provides high quality of the product.

8. Consumers.

Ironworks with steelmaking production.

9. Expectant market geography.

Donetsk-Prydniprovskyi economic region, Ukraine, GUAM countries.

10. Legal Protection.

The method for obtaining staflux is now at the stage of patent protection in Ukraine. For the interested party a new patent can be acquired, taking into account the operation specifics and "know-how's".

11. Proposal validity period.

Unlimited.

12. Suggested conditions of the implementation of the technical proposal.

The license agreement, technological task development, technical and economic assessment, scientific monitoring of the project and construction, technology elaboration. Contractors: Pryazovskyi State Technical University, "Azovengineering" Ltd (Mariupol). Research and development costs are UAH 100-200 thousand, the estimated project and construction works costs depending on the installation productivity are UAH 5-10-20 mln.

The complement and delivery of the equipment, including foreign equipment, supplier and contractor search can be carried out by Azovengineering" Ltd.

The lime production can be introduced on the ground of "Soda" Slovyansk Industrial Union that meets all the necessary requirements: production facilities, skilled labour, commercial reserves of chalk grit, connecting tracks etc.

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TECHNICAL PROPOSAL 28

1. **Name.**
   "Technology for the production of complex staflux of the metallurgical production wastes".

2. **Key words.**
   LIME DUST, FERRIFEROUS WASTES, FACRINT, MIXING, BRIQUETTING, DRYING.

3. **Purpose.**
   Obtaining complex staflux of the metallurgical waste products. Utilization of metallurgical waste products. Fresh raw material saving.

4. **Application field.**
   Ferrous metallurgy, fluxing material production, utilization of metallurgical production wastes.

5. **Description and basic technical and economic characteristics.**

The basic method for the utilization of the fine metallurgical production waster products, dusts and slimes, is the injection of these materials into the sintering mix. Therewith, the consumption of dusts and slimes is limited with 140-160kg/t of agglomerate. Further increase of the waste product concentration in the charge results in the reduction in the sintering machine productivity and agglomerate quality. This hinders the utilization of the metallurgical production waster product, especially at the enterprises with the insufficient or lacking agglomeration plant capacity.

The basic components requiring utilization are: lime kiln gas-cleaner dust and other lime waste products; ferriferous metallurgical waste products including dust and slimes from the sludge reservoir; aluminum production wastes including aluminous slime (facrint), ground slags of the aluminum production.

It is suggested to briquette the fine waste products and their subsequent application in metallurgical production.

The industrial implementation of the method requires a briquetting plant that includes storage bins equipped with measuring hoppers, mixer, roller briquette press and belt drying stove. The adhesive is not required as the active components are presented by calciferous and aluminous constituents forming solid alumocalcareous compounds. The industrial method for the complex staflux production of the metallurgical waste products can be realized the following way (see Picture).

The components are extracted form the dump; if necessary they are dried in the open air to the 6% moisture content in order to prevent the clogging of the mixing equipment. Slaked lime components are used immediately; unslaked lime components are mixed with the moistened slime or are slaked with the use of common methods.

The prepared components are thereafter mixed, moistened to 10-14% and pressed under the 50-90 MPa pressure. The ready briquettes are dried in the stove during 30 minutes at the 350 ^{0}C. With the view of increasing the drying efficiency it is recommended to use the heat of gases emerging during primary production.

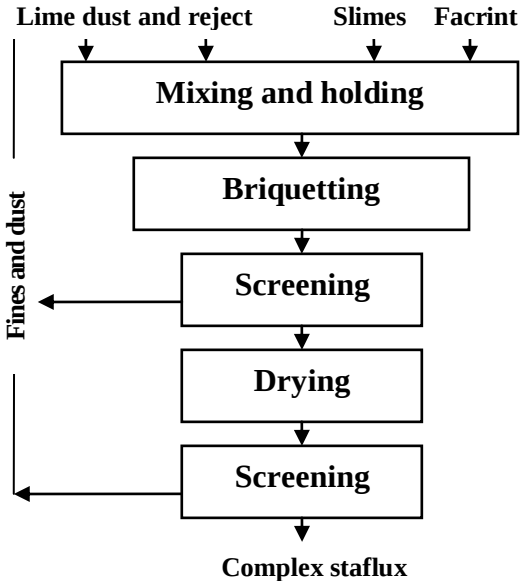
The suggested technology ensures:

- increasing the consumption waste product not used before due to their pulverized state;
- clearing vast space occupied by waste storage;
- improving the ecological condition of nearby territories;
- increasing the efficiency of metallurgical production;
- acquire a considerable economic effect.

The expected annual economic effect of employing the suggested technology for the production of complex staflux due to the involvement of cheap secondary materials for an average metallurgival enterprise makes UAH 5-10 mln. With the consideration of the clearing the space occupied with wastes and the reduction of their influence on the environment, the effect is to be of more importance.

The capital investment payback period is 3 years.

6. Illustrations.



Picture. Design for the production of the complex briquetted staflux

7. Comparison with analogues, advantages.

The proposal ensures the maximum level of utilization of secondary recourses in staflux production in comparison with the known analogues. It provides high quality of the product.

8. Consumers.

Ironworks with steelmaking and blast-furnace production.

9. Expectant market geography.

Donetsk-Prydniprovskyi economic region, Ukraine, CIS countries.

10. Legal Protection.

The technology for the staflux production is patented in Ukraine. Patent № 75154 Ukraine IPC C21C 7/04: Complex flux for metallurgical production / V.V.Ozhogin, V.A.Noskov, A.A.Tomash and others. - Промислова власність (Industrial Property), 2006. - № 3, book 1. With the participation of the interested party a new patent can be acquired, taking into account the operation specifics and "know-how's".

11. Proposal validity period.

Unlimited.

12. Suggested conditions of the implementation of the technical proposal.

The license agreement, technological task development, technical and economic assessment, scientific monitoring of the project and construction, technology elaboration. Contractors: Pryazovskyi State Technical University, "Azovengineering" Ltd (Mariupol). Research and development costs are UAH 200 thousand, the estimated project and construction works costs depending on the installation productivity are UAH 10-20-40 mln. The complement and delivery of the equipment, including foreign equipment, supplier and contractor search can be carried out by Azovengineering" Ltd.

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TECHNICAL PROPOSAL 29

1. **Name.**
   "Domestic combined pneumo-track-mounted switcher based on the wheeled tractor used for the realization of the energy saving technology".

2. **Key words.**
   SWITCHER, COMBINED TRAVEL, WHEEL-TIRE TRACTOR, LIMITED CAR TRAFFIC, TRANSPORT TECHNOLOGY, ENERGY SAVING, SMALL AND MEDIUM ENTERPRISES.

3. **Purpose.**
   The switcher is for track-mounted transportation services at manufacturing entities with limited cargo traffic. The switcher shall still be used as a road-transport tractor. The switcher can be instead of high-powered diesel locomotives allowing the enterprises to reduce their transportation costs.

4. **Application field.**
   Industrial transport (transport systems and technologies in metallurgy, mechanical engineering, coal and chemical industries, power engineering, construction industry, agroindustrial complex, sea and river ports etc.).

5. **Description and basic technical and economic characteristics.**

The real sector of economy of Ukraine is by 75% represented with the enterprises of low productivity; the transportation service of these enterprises involves only outer car fleet supply and picking executed buy the railroad transport. The enterprises have limited freight traffic (up to 0.25 mln t per year) and car traffic volume (up to 30 cars per day).

Moreover, large enterprises have at their disposal separate industrial and storage facilities of the similar hauling operations volume.

However, under considered conditions conventional transportation technologies of large enterprises are employed. These technologies presuppose the use of expensive energy-intensive hauling equipment (locomotives) with the capacity up to 1200 hp and the trailing weight up to 100 t.

The carried research show that the enterprises with limited transportation volumes are characterized with extremely low values of the heavy duty locomotive use: in the trailing weight – by 12-15%, in the capacity – by 12-16%, in the daily time – by 23-28%. Under these circumstances the annual amount of work for a locomotive ranges within 16-47 thousand t, while at large enterprises it reaches 300,000 t.

The use of locomotive with the capacity of 800-1200 hp (this kind of locomotives dominates the locomotive fleet of the Ukrainian enterprises) on the districts with limited traffic volume results in quite heavy transportation costs, up to 70% of which are connected with energy supply.

One of the methods of reducing transportation costs is replacing the high-powered diesel locomotives with more cost-efficient hauling equipment. The substantial reduction of the transport service costs is connected to the employment of combined-travel hauling equipment. The transformation of the driving machine ensures time transgressive use of the hauling equipment in railway and road transport, thus greatly increasing its usage time.

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 35-50 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 other way of effective use of the switcher is the employment of it together with the crane facilities for loading and unloading works, car drawing, rearrangement, classifying and other yard operations (ports, warehouses, grain elevators).

Combined pneumo-track-mounted switchers are widely used abroad. The largest automobile company "Mercedes-Benz" (Germany) has a subsidiary "Unimog" specializing in the production of switchers. The firm manufactures switchers of two types – "Loctrac" 82 S and "Loctrac" 100 S, the firm markets its production on more than 50 countries (Picture 1, 2).

The main advantage of the switchers is that, whilst their mass is only 10-12 t and the power amounts to 200-300 hp, they are capable to make the tractive effort enough to move 6-8 railcars on 8% slopes, and it still can be used for road transportation.

For the enterprises with limited freight traffic we have developed a promising domestic combined pneumo-track-mounted switcher on the basis of the wheeled tractor ХТЗ-150К-09 in order to implement the energy-saving transportation technology (Picture 3).

The estimated annual economic effect of the use of the switcher makes UAH 200-250 thousand. The major share of the economic effect is reached through energy saving (fuel saving per unit is 20-35 t per year).

The use of the switcher makes it feasible for the enterprise to find an essentially new solution of the transport service issues, to greatly improve the maneuvering operations performance, to deliver in proper time the multinomenclature freights, to substantially decrease the energy resources consumption.

Technical characteristics of the switcher

Table 1

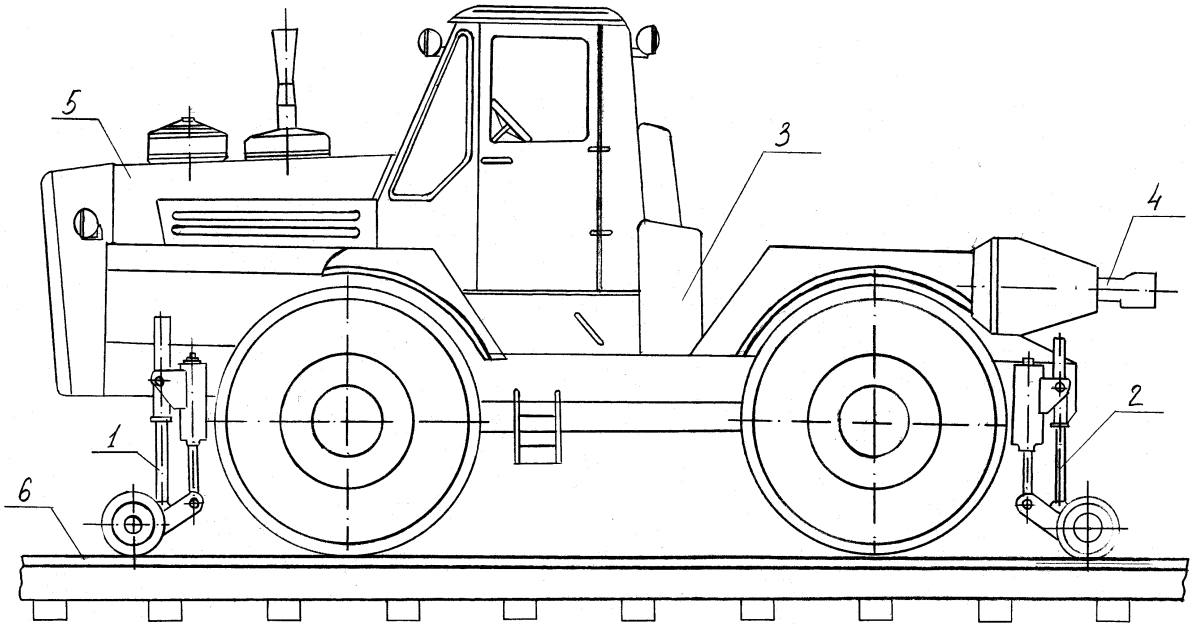
1. Purpose	Performance of the maneuvering operations with the railroad equipment and auto train operations.
2. Travel type	Combined: - rail, with the use of с применением guide roller carriers; - pneumo-tire, typical.
3. Tractor carrier make and type	ХТЗ-150 К-09 wheeled, industrial (the engine rating is 175 hp)
4. Speed - running forward - running backward	 5-13.9 kmh 5.82 kmh
5. Base - main wheels - carrying rollers	 2860 mm 2900 mm
6. Wheel gauge of carrying rollers	1524 mm
7. Carrying roller tread diameter	350 мм
8. Carrying rollers lift and down drive	Hydraulic
9. Minimal curve radius run on the carrying rollers	50 m
10. Automatic coupling device - type - coupler height from the rail head	 СА - 3 980-1080 mm
11. Compressor - type - compressor drive	 РС-1.75 Mechanical from the engine shaft through the reduction unit or directly from the diesel engine.
12. Main reservoir capacity	250-300 l
13. Pneumatic brake system	Typical ХТЗ with additional crane operator equipment (№ 394).

14. Switcher railway mounting time	5~10 min
15. service weight	13.2 t
16. Boundary dimensions length width height	 6500 mm 2400 mm 2970 mm

6. Illustrations.

Picture 1 – “Loctrac” 82 S switcher

Picture 2 – “Loctrac” 100 S switcher



Picture 3 – General view of the switcher on the basis of the wheeled tractor XT3-150K-09:

1. front guide rollers;
2. back guide rollers;
3. fuel tank;
4. separable coupling device;
5. tractor carrier;
6. guide rail.

7. Comparison with analogues, advantages.

In comparison with the existent analogues the price of the domestic switcher on the basis of the wheeled tractor is lower, and the technical characteristics of the switcher equal those of the foreign units.

8. Consumers.

Metallurgical, mechanical engineering, building, power engineering enterprises, agroindustrial complex enterprises, iron and chemical industry, sea and river ports, warehouses, grain elevators, small and medium enterprisers of various specializations.

9. Expectant market geography.

Ukraine, CIS, far abroad countries.

10. Legal Protection.

The proposal is patentable. Separate elements are protected in the “know-how” mode.

11. Suggested conditions of the implementation of the technical proposal.

The conclusion of the contract can be preceded, upon consultation between the parties, by the free development of the technical and economic assessment of the employment of the switcher under the specific condition of the consumer.

12. Proposal validity period.

Unlimited.

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TECHNICAL PROPOSAL 30

1. **Name.**
   "Method for the sintering of agglomeration mixture".

2. **Key words.**
   AGGLOMERATION, OXYGEN, PRELIMINARY HEATING, RECOVERY, DRUM SAMPLE.

3. **Purpose.**
   The suggested method for the sintering of agglomeration mixture is designed for introduction on the currently used sinter machines.

4. **Application field.**
   Ferrous metallurgy, agglomerate production.

5. **Description and basic technical and economic characteristics.**

Before firing the agglomeration mixture is heated with the hot return heat that is supplied directly into the rotary drum mixer. The temperature of the return is 250-400 C that ensures increasing the temperature of the pelletized charge to 60-80 C.

After firing of the agglomeration mixture layer oxygen-rich air is drawn in. For this purpose oxygen spraying jets are installed behind the ignition furnace immediately over the layer of the sintered charge.

The interaction of the used intensifying factors makes it feasible to remove the defects occurring during sintering with the separate use of each of them, and the agglomeration process productivity exceeds the amount of effects for each factor in particular.

The designed method for the sintering of the heated agglomeration mixture with the use oxygen-rich air for the acceleration of the fuel ignition process under the combustion zone presupposes adding to the raw charge the fuel the ignition temperature of that is lower than that of the basic fuel used in sintering, with its partial replace. An example of the fuel with low inflammation temperature $t_i \approx 250$-300 C is activated peat. The new fuel content in the agglomeration mixture determines the calculation of the sintering process heat balance. The used activated peat is added into the mixture in the dispatching or the ore-blending plant.

The most efficient method is preliminary heating of the mixture to the temperature over 100 C ensuring that the moisture is moved away from it. When the pelletized mixture is heated over 100 C an adhesive should y added to the raw charge. The adhesive prevents the destruction of granules during drying and gas permeability deterioration; among the proper adhesives are: bentonite, water solution of polyacrilamide, sodium humate etc.

The technical and economic assessment provides the comparison of characteristics of the standard sintering of the agglomerate without intensifying factors with the characteristics of the sintering with simultaneous use of oxygen for air enrichment to 25%, preliminary heating of the charge to 120 C, adding bentonite and peat to the mixture (1 and 3% of the mixture weight respectively). The calculations are made for the sinter machine of the K3-50 type and are presented in the Table 1. If the layer height is 400 mm and the depression is 9500 Pa, the air consumption through the layer is 0.25 ÷ 0.43 $m^3/(m^2 \cdot s)$. If the oxygen content in the air is increased to 25% the oxygen consumption is –

$$(0.25 \div 0.43) \cdot 0.04 = 0.010 \div 0.017 \ m^3/(m^2 \cdot s).$$

For the sinter machine with the area $S_a = 50\ m^2$ the consumption of oxygen through the spraying jets makes $Q_{O_2} = 50 \cdot (0.010 \div 0.017) = 0.5 \div 0.85\ m^3/s$. For the calculations we shall accept $Q_{O_2} = 3000\ m^3$/hour with the price P_{O_2} = UAH 356.03 per 1000 m^3. The price of coke fine is P_t = UAH 350 per ton; of bentonite P_b = UAH 1250 per ton; of peat P_p = UAH 170 per ton.

Table 1 – Comparison of technical and economic characteristics of the operation of

the K3-50 type sinter machine with the employment of intensifying factors

Temperature of pelletized charge t_c C	Air oxygen enrichment degree	Fuel consumption. %	additive		Sintering index				Production volume Pr_2, thousand t	Increase of the agglomerate cost price ΔCP, UAH/t	Economic effect E_{year}, UAH thousand
			Bento-nite, %	Peat, %	τ^{sint}, min	Reco-very, %	Drum sample, %	ΔPr, %			
20	-	5.02	0	0	11.0	80.1	69.6	0,0	1000	-	-
20	-	5.02	0	3	7.5	82.7	73.9	421	1421	5.72	28544.10
80	-	5.02	0	0	5.5	59.1	71.0	47.5	1475	0	40952.66
80	-	5.02	0	3	5.5	72.3	74.2	121.6	2216	5.72	93237.64
120	-	5.02	1	0	2.6	51.7	53.5	173.2	2732	15.88	110162.65
120	-	5.02	1	3	4.5	67.0	76.3	192.2	2922	21.59	108970.31
20	+	5.02	0	0	9.0	85.2	81.9	29.9	1299	8.42	17864.58
80	+	5.02	0	0	4.3	77.2	70.2	149.5	2495	4.38	121442.21
120	+	5.02	1	0	3.0	65.1	72.8	198.2	2982	19.54	120986.39
120	+	4.02	1	0	3.5	70.1	68.8	174.9	2749	15.41	115025.15
120	+	4.02	1	3	4.0	66.8	75.2	129.4	2294	21.91	68132.46
120	+	3.02	1	3	3.5	77.8	77.3	205.3	3053	16.28	134858.83

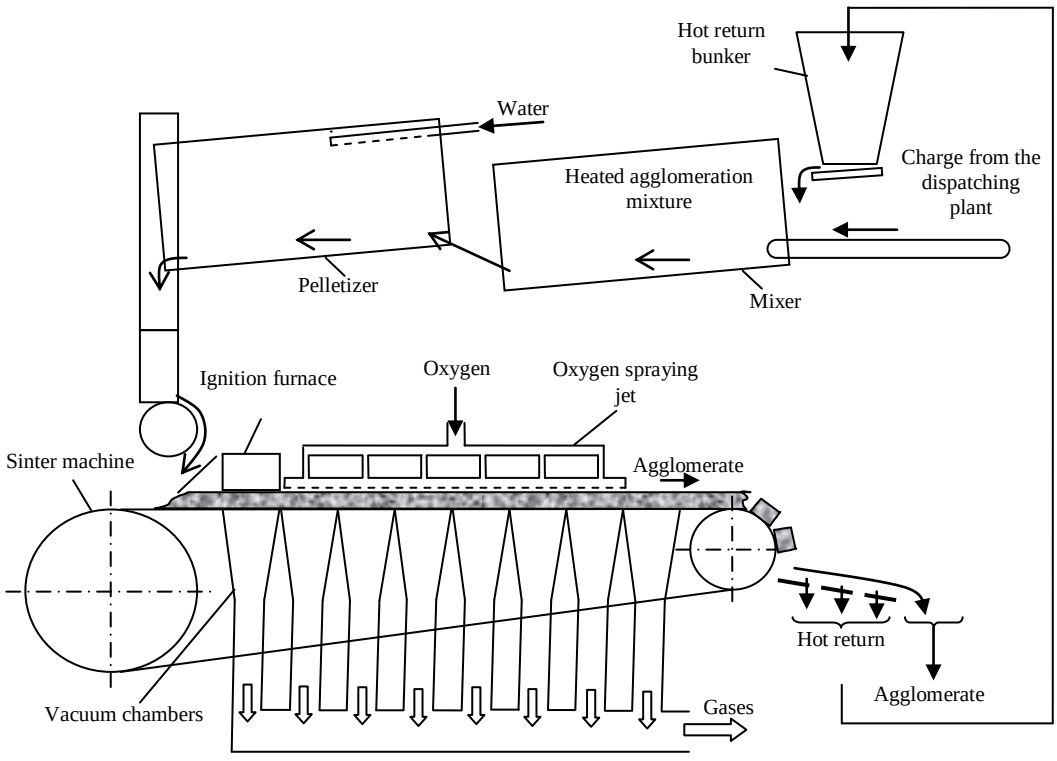
The table 1 shows that the cost price of agglomerate increases by all sintering methods. The economic effect is reached through replacing the imported raw materials (pellets) with the own-produced agglomerate. Thus, the coefficient of the replacement of the pellets with agglomerate depends on the iron content in the pellets Fe_{pell} and in the agglomerate Fe_{aggl} and equals the basicity of the agglomerate and pellets

$$k = Fe_{aggl} / Fe_{pell} = 52.5\% / 62.0\ \% = 0.847.$$

The price of the pellets produced by the Central mining-and-processing integrated works is

$$P_{pell} = \text{UAH } 581.9 \text{ per ton.}$$

6. Illustrations.



Picture 1 – Method for the sintering of the heated agglomeration mixture with the use oxygen-rich air.

7. Comparison with analogues, advantages.

According to the table 1, the lowest productivity of the sintering process corresponds to sintering carried out without using any factor for intensifying the fuel combustion in the layer. This sintering method is common for the agglomeration technology introduced at most of the sinter plants in CIS countries.

The preliminary heating of the agglomeration mixture to the temperature of 80 C ensures increasing the productivity of the sintering process by 47.5 %, however the produced agglomerate is of unsatisfying quality. Thus, the recovery has reduced by 80.1% / 59.1% = 1.36 times. This substantially degrades the blast furnace operation mode, and the overall economic effect of the agglomerate and blast-furnace production can be negative. Hence, the increase of the agglomeration process productivity is limited for the production of agglomerate of satisfying quality in size.

Adding 3% of activated peat into the raw charge ensures considerable improvement of the agglomerate quality and increase of the sinter machine productivity. On the ground of the result given in the Table 1, the sintering of the unheated charge with added peat corresponds to the minimum productivity increase and economic effect. However, the use of peat makes it feasible to significantly increase the agglomerate quality during sintering of the charge heated to the temperature of 80 C. Therewith, the time of sintering of the heated charge does not change τ_{sint} = 5.5 min, and the productivity increase by 121.6 – 47.5 = 74.1 % and the economic effect are reached thorough the agglomerate quality improvement only.

The efficiency of oxygen in the intensification of the sintering process depends on the temperature of the sintered charge. Thus, during the sintering of the unheated charge the lowest productivity increase of 29% and economic effect occurred. The use of oxygen for the sintering of the 80 C charge provides one of the prominent economic effects notwithstanding that the productivity increase is relatively low ΔPr = 149.5 %. This fact results from the saving of bentonite and peat and the high agglomerate quality. The use of oxygen during heating the charge to the temperatures over 100 C with the addition of bentonite and peat greatly facilitates the coke fines saving. Therewith, the maximum productivity growth ΔPr = 205.3% and economic effect were obtained. Although the consumption of the basic fuel has decreased by 39.8 $\%_{relat}$, the drum sample of the agglomerate surpasses that of the basic agglomerate. Hence, the use of the agglomerate of this kind in blast-furnace production ensures the improvement of technical and economic characteristic of the blast-furnace plant.

8. Consumers.

Ironworks.

9. Expectant market geography.

Ukraine, far abroad countries.

10. Legal Protection.

The application for the proposed invention is proceeded with. The technology for agglomeration mixture sintering is protected in the “know-how” mode.

11. Suggested conditions of the implementation of the technical proposal.

On the terms of the agreement.

12. Proposal validity period.

Unlimited.

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