Live Steel – Special Steels and Alloys Mini-Mill

INNOVATION PROJECT BUSINESS PLAN SUMMARY

The project aims at building a mini-mill for production of nanostructured multi-purpose alloys with special properties achieved by formation of a certain nano-atomic crystalline structure.

Implementation of low-tonnage production is becoming increasingly relevant for the following main reasons:

- need to obtain a high level of difficult-to-combine mechanical and physical-chemical properties in materials used for manufacture of new-generation high-tech products (accelerometers, hydroscopes, high-frequency lasers, deformation vacuum gauges, diesel fuel pumps, pump elements, etc.);
- considerably increased demand for alloys with special properties due to implementation of knowledge-intensive innovations in defense industry, navigation instrument engineering, surveying and calibration equipment, etc.;
- loss of earlier applied technologies for producing many high-tech alloys with special mechanical and physical-chemical properties;
- no integrated low-tonnage plants producing a wide range of special alloys in Russia.

The following products are planned to be commercialized:

1. Fundamentally new types of nanostructured multi-purpose alloys featuring difficult to combine high-level properties.

2. Nanostructured specialty alloys, i.e. tailored alloys with predetermined thermal and elastic properties, soft magnetic alloys, hard magnetic alloys, alloys with high electrical resistance, highly-sensitive and supersensitive thermo bimetals, shape memory alloys, damping alloys, corrosion-resistant alloys, heat-resistant alloys, hot-working steels, wear-resistant alloys, dental alloys, etc.

Assumed product range includes:

- ✓ rod ∅8 mm to 130 mm;
- ✓ skelp ∅85 mm to 160 mm;
- ✓ wire ∅0.1 mm to 6 mm;
- ✓ cold-rolled band 0.2-2.5 mm thick, up to 250.0 mm wide;
- ✓ cold-rolled sheet 0.2-2.0 mm thick, 100-300 mm wide;
- ✓ hot-rolled sheet 3.0 -12.0 mm thick, 100.0-250.0 mm wide.

Minimum lot weight starts from 30 kg.

The required application performance of final products is ensured by the use of science-based principles, established by the authors, which govern the nature of nano-atomic crystalline structure and its influence on phase transformations and properties of alloys.

Formation of a specified local atomic crystalline and magnetic structure is achieved by:

- ✓ Selection of alloy chemistry;
- ✓ Controlled phase transformations;
- ✓ Specific locations of interstitial atoms;
- ✓ Special processing of billets by means of thermal deformation;
- ✓ Exposure to high energy flows.

Depending on consumer's requirements, the mechanical, physical and chemical properties governed by specific features of nano-atomic crystalline structure may vary greatly (Table 1).

Table 1 – Products of special steels and alloys mini-mills – Competitive advantages based on customer's requirements

Parameter	Value
Low and controlled thermal expansion (TCLE)	from (-2.0 to +16) $x10^{-6}$, K^{-1}
Low and controlled temperature coefficient of Young's modulus (TKYM)	(-30 to +30)$x10^{-6}$, K^{-1}
High Q-factor with mechanical oscillation	up to 50 000
High damping	up to 10%
Strength	up to 2 000 MPa
High elasticity	30 %
High elastic strength	up to 1400 MPa
High resistance to corrosion and corrosion cracking	(1-2) units
High magnetic induction	up to 1.4 T
Good casting and processing properties	-

The key production performance indicators are listed in Table 2.

Table 2 – Manufacture of nanostructured multi-purpose alloys with special properties – Production performance indicators

Parameter	Value
Design capacity of mini-mill, tpy	45
Required amount of financing, RUB	875 000 000
Production cost, RUB/ton	1 853 345
Price (18% VAT included), RUB/ton	5 600 000
Annual net profit, RUB	134 879 598
Profitability, %	202.16
Payback period, years	5.3

The most important scientific and technological deliverables of the project are:

1. Implementation of innovative technology for production of multi-purpose alloys with difficult-to-combine high-level properties achieved by formation of a controlled nano-atomic crystalline structure.

2. Establishment of a unique integrated low-tonnage mini-mill to provide national high-tech industries with innovative special-purpose materials.

3. Possibility to carry out theoretical and experimental researches along with a pilot production of fundamentally new types of materials with advanced properties which make them different from contemporary equivalents.

The socio-economic impact of these deliverables includes:

1. Job creation;
2. Considerably improved quality, serviceability and competitiveness of domestic high-tech products;
3. Lower consumption of power and materials;
4. More complete and multiple use of raw and recycled materials;
5. Higher production flexibility;
6. Development of regional infrastructure;
7. Contribution to competitiveness of national science and business.

Once achieved, these deliverables would drive the innovative development of domestic high-tech products to be applied in aviation, rocket and space industry, instrumentation, medicine, nuclear-power engineering, geodesy, shipbuilding, defense industry, oil and gas industry, metallurgy, etc.

Successful implementation of the project is ensured by involvement of all-round professionals, the use of high-performance production and research equipment along with advanced research techniques.

The project team includes:

✓ **A.V. Gorbunov –** Director of OOO Synthes, PhD in Engineering Science, a knowledgeable expert in development of advanced metal forming techniques, experience in administrative and scientific management. The labour experience covers 15 years in metallurgy, 7 years in executive positions at a leading steelmaking company in Russia (Magnitogorsk Iron & Steel Works): development and implementation of innovative production technologies, advanced products, new process equipment, as well as approval of innovative products with Russian and foreign car makers, original equipment manufacturers and white goods manufacturers. Over 80 scientific papers and 50 patents.

✓ **Yu.L. Rodionov** – Dr. Sci. in Physics and Mathematics, Professor. Academic advisor of the project, one of the leading experts in physical metallurgy. He supervised fundamental works on studying the effect of radiation, deformation and heat on atomic re-arrangement in sub-microdomains (areas of one or several coordination spheres) and further transformation behavior. A new research area was defined and developed: “Establishing the principles of interaction between atomic re-arrangement in sub-microdomains, martensitic transformations and properties of alloys”. Several of developed alloys with special physical and mechanical properties as well as processing methods thereof were introduced in manufacturing industry with scientific, tech-

nical and economic benefits achieved. He is the author of over 120 articles, 17 inventor's certificates and patents, advisor of 8 master's theses; a senior research scientist in the Center of Physical Chemistry, Materials Science, Bimetals and Special Corrosion at I.P. Bardin Central Research Institute of Ferrous Metallurgy.

✓ **I.A. Korms** – a leading research scientist in charge of Metal Physical Test Department in the Center of Physical Chemistry, Materials Science, Bimetals and Special Corrosion at I.P. Bardin Central Research Institute of Ferrous Metallurgy. She has a wide range of experience in production and assessment of alloys with special physical and mechanical properties; involved in development and implementation of new methods for determining thermal, physical and mechanical characteristics.

✓ **S.V. Yaschuk** – PhD in Engineering Science, Project Manager, Deputy Head of Laboratory of General-Purpose High-Quality Steels in the Center of Physical Chemistry, Materials Science, Bimetals and Special Corrosion at I.P. Bardin Central Research Institute of Ferrous Metallurgy. Over 12 published papers and one RF patent.

The project has a high degree of readiness. By now, a feasibility study has been prepared. Process flows and equipment for production of special alloys have been defined. Prospective equipment manufacturers and suppliers have been identified. Furthermore, a possible low-tonnage production program has been shaped.

The project roadmap is shown in Annex I.

СИНТЕЗ
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Annex I

Live Steel – Special Steels and Alloys Mini-Mill

PROJECT ROADMAP

Phase	Brief description	Month																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	Organizational arrangements and design works in connection with establishment of a mini-mill and legal coverage of its activities. Rent or Purchase of land with adjoining facilities to be used for construction of a mini-mill producing nanostructured multi-purpose alloys with special properties.	■	■	■																					
2	Conversion of buildings. Repair works.				■	■	■	■	■	■	■	■	■												
3	Development of operating practices and process conditions to produce alloys with special properties on the basis of scientifically proven principles which govern the nature of nano-atomic crystalline structure and its influence on phase transformations and properties of obtained materials. Provision for legal protection of intellectual properties received under the project.				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
4	Piping and wiring for utilities. Purchase of process equipment. Installation of process equipment.							■	■	■	■	■	■	■	■	■	■	■	■						
5	Preparation of technical documents (design, process, operation and/or maintenance). Development of preliminary test and acceptance test procedures and programs.													■	■	■									
6	Commissioning. Production of a trial lot of alloys with special properties. Preliminary tests.																■	■	■						
7	Low-tonnage production learning curve for special-property alloys. Correction of process conditions with regard to pre-test results. Equipment checkout/adjustment.																			■	■	■			
8	Pilot production. Assessment of material structure and properties on obtained samples.																						■	■	■