EFFECTS OF SVM-GENERATOR, DESIEGNED BY KURAPOV S.A., ON METAL MELTS

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SVM (structurally-wave magnetic resonance) generator

During the period from 1989 to 1991, the Institute of Problems of Materials Science of the Academy of Sciences of Ukraine carried out a series of works on changing the physical and chemical properties of metals under the influence of generator designed by A.E. Akimov on metal melts. Unambiguous results of the influence of this generator on metal melts in a state of overheating were obtained. We note that in the same period G.I. Shipov proposed the theory of physical vacuum [1].

During the period from 2002 to 2020 in conditions of existing industry we have conducted the researches on treatment of ferrous and non-ferrous metals and alloys melts, used in mechanical engineering and aviation engineering by electromagnetic-based generators (SVM generators). Results of changes in micro- and macro-structures were obtained, and they led to significant improvement of mechanical properties of metals and alloys [5]. Both new and old results achieved in this field are presented in this article.

Structural diagram of SVM generator.

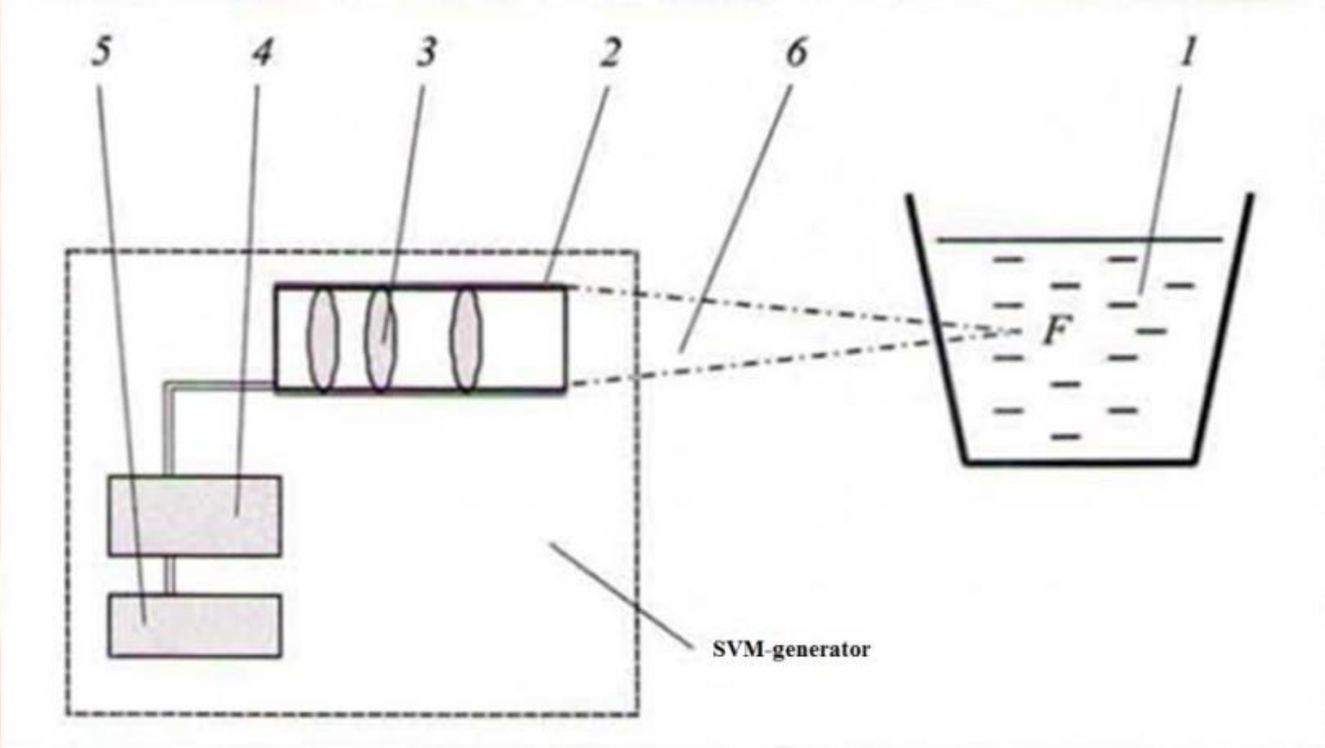

Diagram of wave treatment of the melt:
1 – melting furnace with metal (ladle); 2 – directed radiator (wave channel) of SVM generator; 3 – radiating element; 4 – forming modulator block with modifier;
5 – power supply; 6 – wave emission.

Focus F of the radiator is oriented into the volume of the melt. Wave treatment of the melt is made through the wall of melting furnace.

As it was ascertained, character of generator's influence on the melts significantly depends on the material of the substance placed into resonance chamber of modulator unit, i.e. of modulating substance which is virtual or passive metal modifier. Traditional for metallurgy doping and modifying materials were used as modulators: magnesium, manganese, rare earth metals and others. Modulator serves as a filter forming generator emission spectrum. Modifier may be used also for reducing necessary concentration of traditional doping and modifying materials (manganese, rare earth metals) without deterioration of end product physical properties. Examples of mode settings for ferrous metals treatment:

«Anti-ferrite» mode. Low-carbon and middle-carbon steels (carbon content < 0,8%), including alloyed steels – using of combination of austenite stabilizing elements: Mn – Ni – Cu – Nb. This mode reduces amount of ferrite in cast metal, tears continuous ferrite network, destroys granulation structure, decreases or fully destroys Widmanshtett pattern.

«Anti-carbide» mode. High-carbon steels and pig irons (carbon content ≥ 0,8%), including alloyed steels – using of elements increasing solubility of carbon in iron: Mg – Mn – (Y – La – Ne – Ce – Sm –Sc). This mode increases solubility of carbon in austenite, decreases amount of carbides in cast metals and tears continuous carbide network. It also gives rounded shape to residual carbides.

«Bainitic» mode. Heat resistant high alloy steels and alloys. This mode decreases critical speed of steel cooling, increases hardenability of low and middle carbon steels. Treatment of steel melt is performed by two modifiers groups. During the first half of melting period the melt is being treated in **«anti-ferrite» mode** for decreasing amount of ferrite in cast metal. During the second half of melting period modifiers consisting of following chemical elements: Cr – W – Mo – B – Co – (Ce – Y – Ne) are being used.

Results obtained with changing of micro and macro structure and improving of mechanical properties of metals and alloys:

- Reducing of steels thermo treatment time.
- Reducing of waste casting.
- Reducing of grain size from 1-2 units to 5-7 units.
- Controlling within certain limits of chemical activity of steel elements for obtaining prescribed properties of end product.
- Reducing of carbide heterogeneity of high carbon steels.
- Reducing of banding during rolling up to full disappearance.
- Increasing of plasticity of the steels with strength retention.
- Increasing of strength with plasticity retention.
- Increasing of impact viscosity for up to 100% at -70°C.
- Reducing of non-metal impurities for 2 to 5 times.
- Obtaining of low alloyed 40CrMo (42CrMo4) steel with the properties of high alloyed 34CrNi3Mo (34CrNiMo6) steel.
- Increasing of the strength of СЧ25 (EN-GJL-250) pig iron up to the level of СЧ40 (EN-GJL-400, such pig iron is not produced).
- Increasing of heat resistance of the steels.
- Increasing of resistance to thermal erosion of 25Cr2Mo1V (24CrMoV55) steel.
- Increasing of corrosion resistance of SAF2205 (X2CrNiMoN22-5-3) steel by 3 times.
- Increasing of long-term strength of turbine airfoil made of ЖС6У (20FeNi58Cr9Mo2W10Co10NbTi3Al5) alloy for 82%.
- Increasing of ultimate tensile strength of АК12 (AlSi12a) “Silumin” alloy by 2 times.
- Obtaining of technical (not alloyed) titanium at the level of alloyed one with thermal treatment.
- Increasing of the strength of 03Cr11Ni10Mo2Ti alloy for 28% with thermal treatment.
- Increasing of 09Mn2Si (9MnSi5) steel of 15 quality class rolling (at -70°C) from 0% to 87.5%.

Innovativeness of the technology.

- For the first time in metallurgy is being used generator on electromagnetic basis for radiation treatment of metal melt placed into industrial furnaces for electro slag remelting, arc steel melting and even into induction furnaces, wherein metal properties changing is obtained at whole depth of the melt, not only at its surface.
- For the first time in metallurgy are obtained the results when modifiers are not being put into the melt, but their properties are being transferred by resonance method with the help of NMR metal frequencies, and at that obtained properties of the metals are better than with traditional method.
- Absolutely identical results where obtained with thermo treatment of metals during hardening process, what significantly widens possibilities of using SVM generators.

The metal, processed by the SVM-generator,

retains its new properties after a new remelting.

Examples of influence of wave treatment on the structure and phase content of steels.

Distinctive features of SVM treatment of the steel is structure refinement (reducing of austenite grain size in average for 3-4 units) and increasing of its homogeneity, including equal distribution of carbides, what as a rule leads to improvement of mechanical properties for 1,5 times at minimum and also to decreasing of properties anisotropy. Research results allow assert about increasing of plastic properties of the steel with retaining its strength properties. Ferrite-pearlite steels demonstrate changes in phase content towards increasing of pearlite amount. Phase gradient is being decreased, phases' borders are becoming more blurred. Dependence between fining of microstructure and improvement of mechanical properties (exception was 110Mn13 (X120MN12) steel), though the cases of increasing of mechanical properties after SVM treatment without visible changes in metal's structures were observed.

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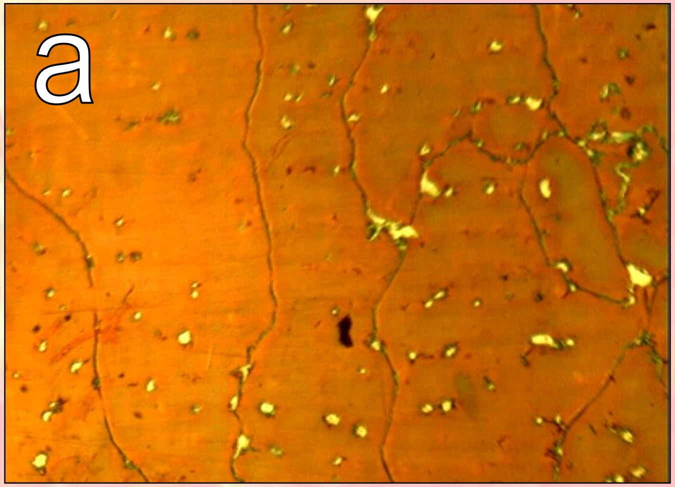
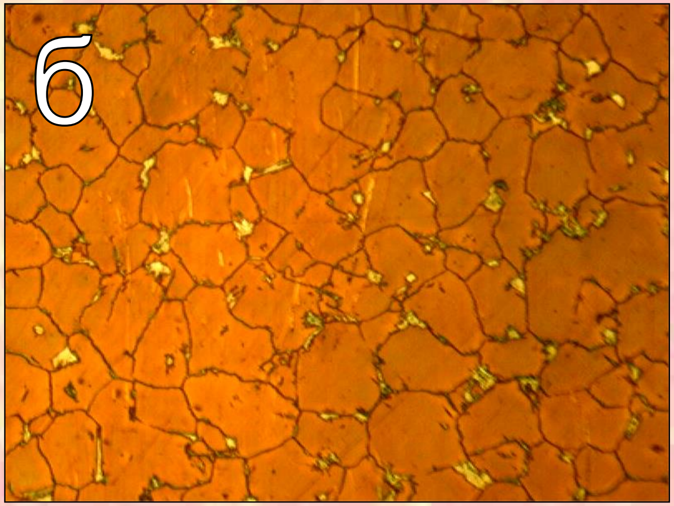
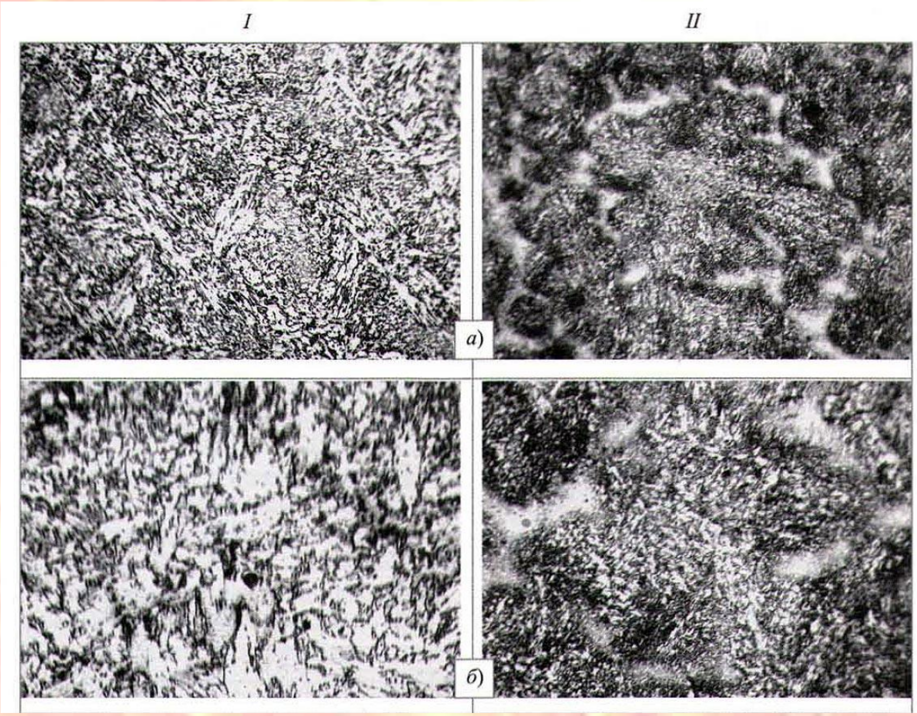




a) – control sample, austenite, 0 – 1 unit
b) – after SVM treatment: distinctve fining of grain size (4 – 5 units), fining and more even distribution of carbiden is observed

Microstructure of 10CrNi3MoCu steel



Without SVM treatment. Apparent borders between ferrite and pearlite

After SVM treatment. Phases borders are blurred, pearlite amount is increased

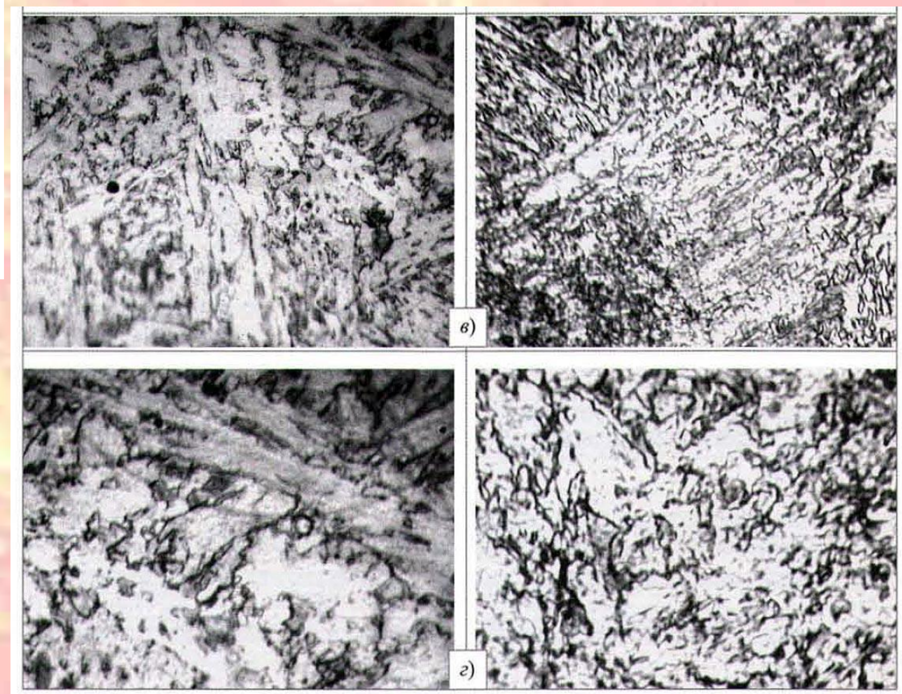


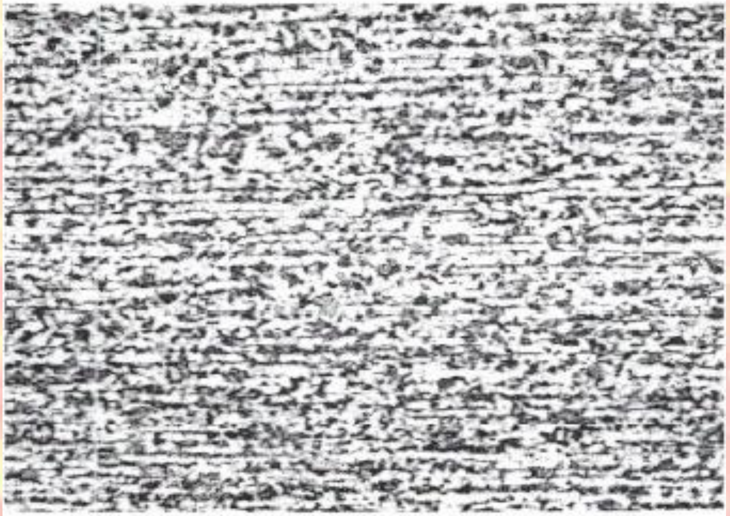
Рис. 5. Микроструктура образцов необработанной (*I*) и обработанной (*II*) стали 10ХН3МДЛ при различном увеличении:
а — × 517; *б* — × 1300; *в* — × 2200; *г* — × 4200

Microstructure of 20CrMnNiMo (20NiCrMo2) steel

After SVM treatment (bainite, absence of banding)

Without SVM treatment (apparent ferrite-pearlite banding)

Образец с ОРП (бейнит) x125



Образец без ОРП (феррито-перлит) x125

Material	Parameter	Without SVM	After SVM
Non-alloyed steel	Points AC1, AC3 on Fe-C diagram		Reduced for 20-30°C
Alloyed steel	Points AC1, AC3 on Fe-C diagram		Reduced for 30-50°C
40CrMo steel (42CrMo4)	Average diameter of coherent scattering block, Å	998±96	580±18
SAF2205 steel (X2CrNiMoN22-5-3)	Corrosion strength, mm/yr	10,69	3,95
AlMg6 alloy	Electrical conductivity, γ MSm/m	10,72	13,05
Polypropylene	Melting temperature	156 **°C**	146 **°C**
	Melt flow index	0,97 g/10 min	>10 g/1 sec
Waste oil	Acid index, mgKOH/g	1,88	0,77

Material	Parameter	Without SVM	After SVM
110Mn13 steel (X120MN12)	Grain size, units	0-3	3 - 4
	Impact viscosity, Kcu, kJ/m²	122	180
10CrNi3MoCu steel	Strength limit, σ_t, MPa	940	1040
	Relative elongation, δ, %	10	14
	Impact viscosity, Kcu, kJ/m²	383	686
35 steel (S355JRC)	Strength limit, σвр, MPa	560	1010
	Relative elongation, δ, %	21	13
	Impact viscosity, Kcu, kJ/m²	590	384
	Grain size, units	3-7	7-9
СЧ25 pig iron (EN-GJL-250)	Strength limit, σвр, MPa	250	390
	Non-metal impurities content, %	0,0558	0,012
20 steel (C22)	Non-metal impurities, units	3,5	1,5
20CrMnNiMo steel (21NiCrMo2)	Non-metal impurities, units	4,5	1,5
SAF2205 steel (X2CrNiMoN22-5-3)	Non-metal impurities, units	4,5	0,5

Material	Parameter	Without SVM	After SVM
АК12 "Silumin" (AlSi12a)	Strength limit, σвр, MPa	122	288
	Relative elongation, δ, %	3	3
	Hardness, HV	71.5	78
AlMgCu5 alloy	Strength limit, σ_t, kg/mm²	8,1	12,9
40Cr steel (41Cr4)	Strength limit, σ_t, MPa	500	900
	Relative elongation, δ, %	12	18
	Impact viscosity, Kcu, at +20°C, J/sm²	40	105
09Mn2Si steel (9MnSi5)	Strength limit, σ_t, MPa	470	560
	Relative elongation, δ, %	21	32
	Impact viscosity, Kcu, at +20°C, J/sm²	29	130
	Impact viscosity, Kcu, at -70°C , J/sm²	29	120
40CrMo steel (42CrMo4)	Strength limit, σ_t, MPa	740	880
	Relative elongation, δ, %	16	12
	Impact work, A at -20°C, J	39	70
17Mn1Si steel	Strength limit, σ_t, MPa	450	550
	Relative elongation, δ, %	17	29
	Impact viscosity, Kcu, at +20°C, J/sm²	140	189
	Impact work, A at -20°C , J	23	130
9Cr2MoV steel	Strength limit, σ_t, MPa	620	1033
	Relative elongation, δ, %	12	12
	Impact viscosity, Kcu, at +20°C, J/sm²	8	36
	HB	200	300

We offer several

main directions

of the development

of SVM technology

in metallurgy

1. Savings on rare-earth metals

Shafts of steel 45 with a diameter of up to 750 mm with the use of SVM technology and the exception of rare earth metals:

1. Fully meet the requirements of SEW-550
2. Plastic characteristics are higher than the average values by 6-12%
3. All shafts meet the customer's SEP 1921 requirements for ultrasonic testing
4. Reduced holding time during recrystallization by 30%
5. Savings on rare-earth metals

2. Increasing of metals' corrosion resistance

Material	Without SVM	After SVM
12Cr18Ni10Ti steel (X12CrNiTi18-9)	Presence of inter-crystal corrosion	Inter-crystal corrosion is absent
SAF2205 steel (X2CrNiMoN22-5-3)	Speed of pitting corrosion 10,69 mm/year	Speed of pitting corrosion 3,95 mm/year
40CrMo steel (42CrMo4)	Average diameter of coherent scattering block, 998+-96 Å	Average diameter of coherent scattering block, 580+-18 Å

3. Improving of heat resisting alloys' quality

Results of testing of aviation engines blades made of alloy ЖС6У
for long-term strength

(20FeNi58Cr9Mo2W10Co10NbTi3Al5)

Reference number of melt	Number of the sample in the melt	Technical conditions of the testing	Time of exposure to the strain	Remarks	Reference number of melt
		Strain kgf/mm2	Test T, °C		
1	1 2 3	25 25 25	975 975 975	42 52 55 Average 49,6	Without influence
2	1 2 3	25 25 25	975 975 975	69 47 86 Average 67,3	Influence at Mode №1
3	1 2 3	25 25 25	975 975 975	66 51 131 Average 82,6	Influence at Mode №2
4	1 2 3	25 25 25	975 975 975	48 56 126 Average 76,6	Influence at Mode №3

03Cr11Ni10Mo2Ti alloy.

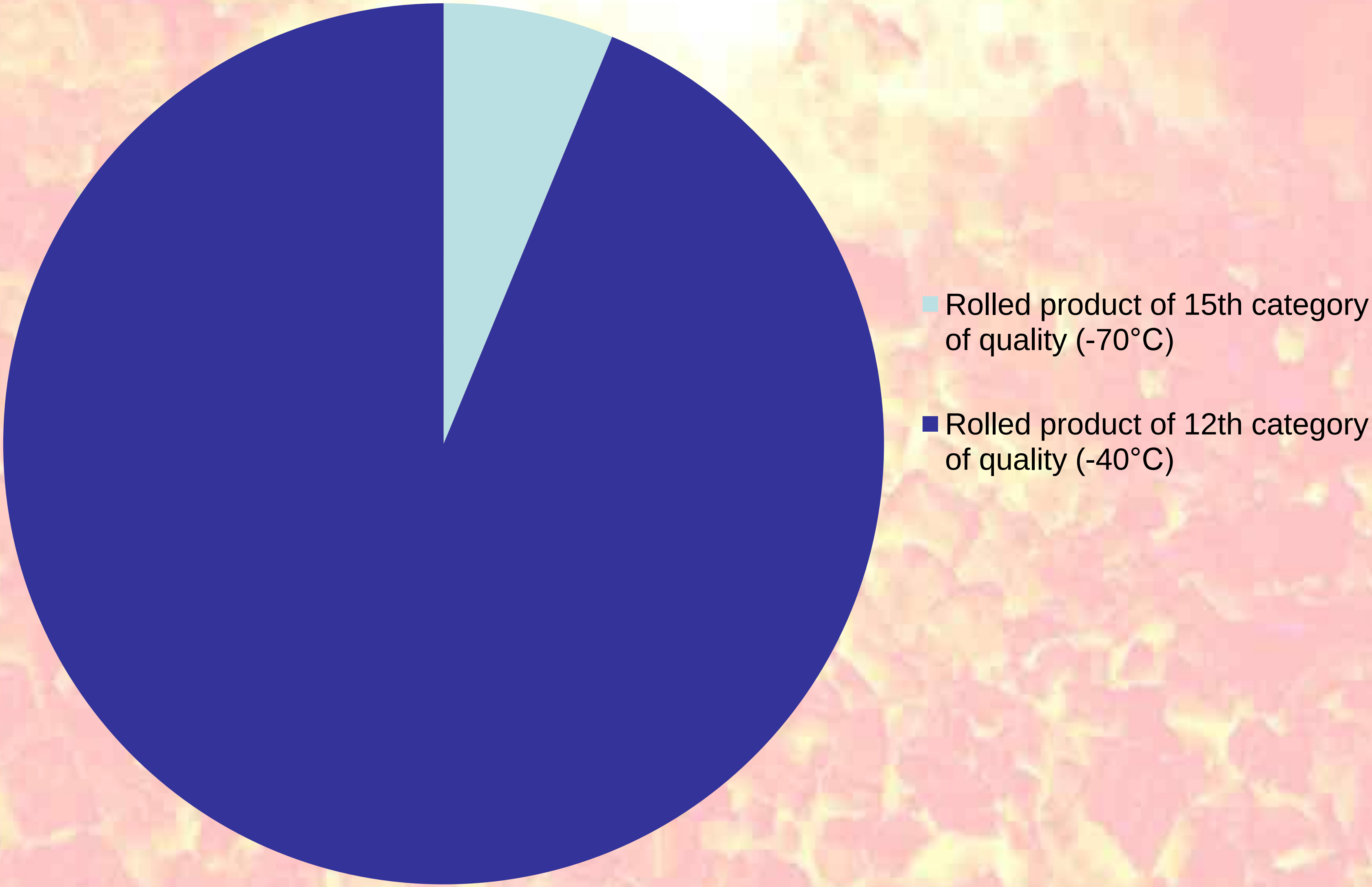
Sample number	Strength limit бв, kgf/mm²	Flow limit бт, kgf/mm²	Relative elongation δ, %	Relative narrowing, Ψ, %	
Control_1	126	121	14	65	without SVM treatment
Control_2	122	118	14,5	67	without SVM treatment
3	162	158	12	59	28,60%
4	161	158	12,5	58	27,80%
5	161	158	11,5	59	27,80%
6	162	158	12	58	28,60%

4. Increasing of steels' cold resistance.

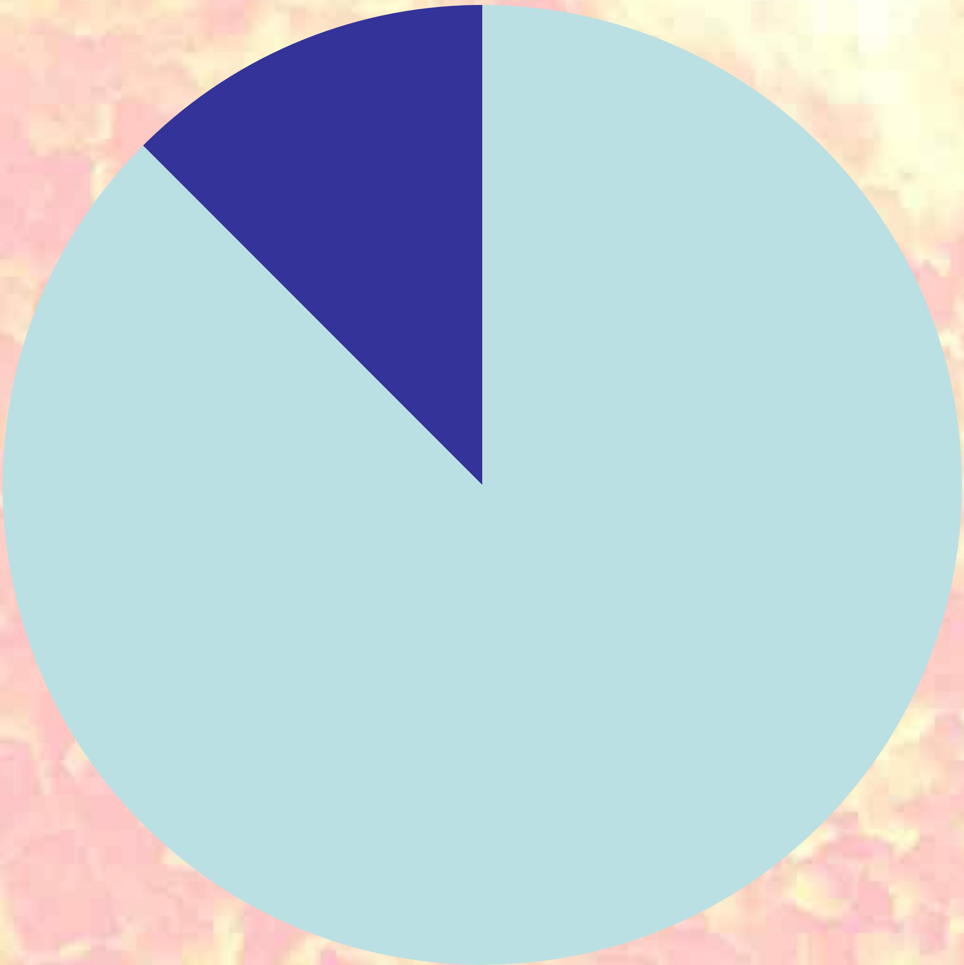
Increasing of impact viscosity of construction steels for 100% at -70°C at example 09Mn2Si steels

Output of quality metal of 15^{th} category is represented at the next diagrams in Gray.

09Mn2Si 6,25% Without SVM treatment



09Mn2Si steel 87.5% USING of SVM technology



Rolled product of 15th category of quality (-70°C)

Rolled product of 12th category of quality (-40°C)

Mechanical properties ("cold impact") of sheet roll of 09Mn2Si steel with the thickness of over 10 mm, obtained

WITH THE USING of SVM technology

Melt number	Sheet thickness, mm	KCU-70, J/cm²	KCU-70, J/cm² (repeat)
		29	
2073	16	177	
		173	
		207	
		189	
2132	15	99	105
		59	84
		51	**19,4**
		20	58
2415	10	95	
		36	
		103	
		97	
2522	18	121	
		122	
		140	
		104	
2739	14	68	
		78	
		55	
		89	
2952	20	75	
		33	
With red color values, not conforming to .		35	
GOST are highlighted		**20**	

Mechanical properties ("cold impact") of sheet roll of 09Mn2Si steel with the thickness of over 10 mm, obtained WITHOUT USING of SVM technology

Melt number	Sheet thickness, mm	**KCU**-70, J/cm²	**KCU**-70, J/cm² (repeat)
		29	
790	16	29	**27**
		130	29
		22	45
		28	**20**
			49
			32
797	16	**26**	**19**
		20	49
		10	29
		26	**31**
			68
			29
			13
			17
797	20	**29**	**5**
		20	**11**
		52	**8**
		22	**16**
			12
			20
			20
			5
797	20	**20**	103
		11	**29**
		23	105
With red color values, not conforming to		**14**	**11**
GOST are highlighted.			180
			29

We offer some hypothesis explaining influence of our generator on metals melts.

In the works of G.I.Shipov [1,2] the theory of physical vacuum integrating Einstein's general theory of relativity with Dirac-Feynman's quantum field theory is proposed. In this theory internal frame of reference is absent in principle, and all accelerated movements are being described as rotation in 10-dimantional fibered curved and twisted space of absolute parallelism. In this theory all known interactions (strong, weak, electromagnetic and gravitational) are described with three fundamental physical fields given to us in senses of everyday life: gravitational, electromagnetic and field of inertia. These fields satisfy to generalized system of non-linear spinoral equations of Heisenberg-Einstein-Young-Mills [1,2]. Solutions of these equations describe excited states of physical vacuum – elementary particles and anti particles having positive and negative energies and able to move with superluminal speeds and even backward in time. In [1,2] experimental consequences of the theory of physical vacuum in mechanics and gravidynamics of gyroscopic systems, electrodynamics of spinning particles and theory of strong and weak interactions were studied. In new quantum theory [1,2] connection of de Broglie's wave function with the field of inertia was revealed.

Influence of electromagnetic potential of the generator may lead in quantum manner to polarization of melt’s atoms spins, which changes the character of crystal lattice of solid metal. Changes in crystal lattice may be connected with scattering of spin-polarized electrons in the metal due to Aharonov-Bohm effect [4], which is determined by the potential of electromagnetic field of our generator. Herewith density of electrons distribution probability in the metal changes and the character of exchange forces changes in quantum manner what finally leads to the changes in formation of long range order structures formation – crystal nucleus. At this one can say that Aharonov-Bohm effect is too small, but from the other side we do not know any works for computing this effect in metals and also probably we have a deal with some modification of this effect.

Explanation of remote influence in metallurgy demands special argumentation. Virtual transfer of “informational properties of modifier metal” onto the melt needs special consideration. In simple quantum systems quantum non-locality and quantum entanglement come out. Probably in the experiments on metals’ melts (complicated systems) multi-particle quantum entanglement come out. Herewith the action of SVM generator must be described in the scope of quantum mechanics with respect to non-locality and multi-particle quantum entanglement. Informational transmission of modifier metal properties in quantum manner is transferred onto metal’s melt with respect to quantum non-locality. This question demands more deep consideration.

Further let’s note that E.A. Gubarev in his work [3] has formulated equations of the point being oriented electrodynamics based on the principle of real relativity. In the frames of proposed in [3] theory were predicted quasi static free electromagnetic fields of non-sinusoidal character and exciting no electromotive force in the plane perpendicular to the direction of propagation. Such quasi static fields must have high penetration ability on the conductors, as by their structure they produce no work at free charges and thus do not dissipate in the conductors. Quasi static fields in quantum manner may have influence on metal’s melt crystallization effect. From this side it would be interesting to investigate SVM generators in respect to exercitation of such fields.

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