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Metallurgy

Development of Technology of Wear-Resistant Articles with Long-Term Operating Life

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ABSTRACT. The aim of the work was prolongation of exploitation term of wear-resistant articles. With this purpose industrial technology to produce wear-resistant manganese austenite steel of nano-oxide structure was developed. Durability, plastic and impact characteristics, Brinell hardness and wearability of nano-oxide structure steel produced by our technology were improved in comparison with an analogue Hadfield steel. *© 2011 Bull. Georg. Natl. Acad. Sci.*

Key words: *casting, wear-resistant steel, nano-oxide structure.*

Short-term operational life of wear-resistant steel casting articles is a global problem. Effective operating life of many products does not exceed 6-8 months, and under conditions of intensive wear it lasts for several tens of days (e.g. wheel tread, lining and balls of ball mill, crowns for dipper teeth of excavator, etc.). Inadequate friction-resistance and shock-dynamical impact cause occurrence of cracks and afterwards breaking of products. Therefore frequent change of products is needed. The aim of the present study was prolongation of the exploitation term of the mentioned products.

To solve the above-mentioned problem, industrial technology of production of nano-oxide structural wear-resistant manganese austenite steel was developed. Nano-Al_2O_3 obtained by a chemical method was used as nano-oxide material. Size of nanoparticles was 30-90 nm.

Research was carried out in the electric furnace of 2-tonne capacity. Wear-resistant austenitic manganese steel (the so-called Hadfield steel) was used as scrap-iron. Modification of steel by nano-oxide material was done in liquid metal by nano-oxide powder injection or by adding of nano-Al_2O_3-containing briquettes. Besides, steel was modified with vanadium and calcium.

Chemical composition of nano-oxide structure steel of industrial production in comparison with analogue (Hadfield steel) is given in Table 1 [1].

Table 1

Chemical composition of steels

Steel type	Elements, weight, %										
	C	Mn	Si	Cr	Ni	V	Al	nano-Al_2O_3	Ca	S	P
Nano-oxide	1.06	13.42	0.73	0.42	0.45	0.07	0.082	≈ 0.14*	0.0008	0.03	0.07
Analogue (Hadfield)	1.05	13.40	0.70	0.44	0.46	-	0.080	-	-	0.04	0.07

* X-ray test

Table 2

Mechanical properties of steel

Steel type	Tensile strength, σ_B, MPa	Yield strength, σ_{02}, MPa	Specific breaking elongation, δ, %	Impact strength, a_k, J/cm^2	Brinell hardness, HB
				V-notch-bar	
Nano-oxide	876	471	33	2.56	260
Analogue (Hadfield)	629	324	24	2.04	205

Table 3

Steel wear resistance

Steel type	Number of rotations									
	10000	20000	30000	40000	50000	60000	70000	80000	90000	100000
	Wear factor K_W*									
Nano-oxide	1.42	1.40	1.29	1.25	1.23	1.24	1.23	1.22	1.21	1.21
Analogue (Hadfield)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

* K_W is calculated as a ratio of loss in weight of specimen of the analogue and that of nano-oxide steel at wear-out.

Testing of mechanical properties, such as hardness and wearability of steel was conducted on specimens of traditional wear-resistant steel (Hadfield steel) and nano-oxide structure austenitic manganese steel melted in the laboratory induction furnace (Tables 2 and 3).

In Table 2 one can see the advantage of the nano-oxide steel in comparison with the analogue, in particular, hardness characteristics increased by 28% (σ_B) and 31% (σ_{02}), respectively; plastic and impact properties increased by 27 (δ) and 20 (a_k), respectively. Brinell hardness increased by 21%. Besides, it should be noted that as opposed to traditional steel increase of nano-oxide structure steel hardness does not cause decrease of plasticity.

Testing of wearability was carried out under dry friction conditions using special-purpose rotation machine at rotation rate 200 rpm, shaft load 70 kg, slippage - 20%. Testing specimens were rollers of 50 mm diameter and 12 mm thickness. This method is not approximated to the factual conditions because it does not consider shock-dynamical loading but it is quite satisfactory for comparative analysis. Testing results are given in Table 3.

Table 3 shows that in comparison with the analogue, wearability of nano-oxide steel decreases monotonously with the increase of the number of rotations. This can be explained by the well-known property of Hadfield steel - self-hardening within a certain exploitation period. Despite this, even the minimal advantage of nano-oxide steel (21% at 100 000 turns) is rather significant.

On the other hand, in the case of shock-dynamic load testing, considering the impact strength parameters of nano-oxide steel (see Table 2), higher wearability is predictable.

Using the technology worked out, crowns for dipper teeth of excavator as production prototype were produced

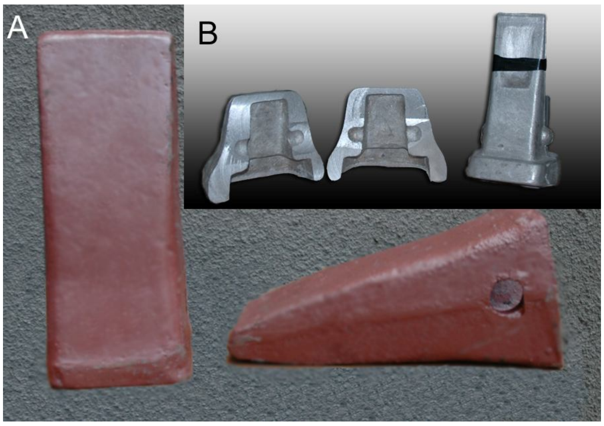

Fig. Crown for dipper teeth of excavator.
A) Finished product; B) Casting form.

of serial melting wear-resistant nano-oxide steel (see Fig.). The operation time of these crowns will presumably be 1.3-1.5 times longer than that of the analogue.

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მეტალურგია

ხანგრძლივი საექსპლუატაციო პერიოდის მქონე ცვეთამედეგი ნაკეთობების მიღების ტექნოლოგიის დამუშავება

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სხმული ცვეთამედეგი ნაკეთობების (როგორიცაა თვლების არტახები, ბურთულოვანი მსხვრევანას ბურთულები და ამონაგი და ა. შ.) საექსპლუატაციო პერიოდის გახანგრძლივებისათვის, დამუშავდა ნანოოქსიდური სტრუქტურის მქონე ცვეთამედეგი მანგანუმიანი აუსტენიტური ფოლადის წარმოების სამრეწველო ტექნოლოგია.

ანალოგთან — ჰადფილდის ფოლადთან შედარებით, დამუშავებული ტექნოლოგია უზრუნველყოფს სიმტკიცის მახასიათებლების გაზრდას ≈ 28 (σ_B) და 31 (σ_{02}) %-ით, პლასტიკური და დარტყმითი მახასიათებლები იზრდება შესაბამისად ≈ 27 (δ) და 20 (a_k) %-ით, ბრინელის სისალე ≈ 21 %-ით, ხოლო ცვეთამედეგობა ≈ 21 %-ით იზრდება.

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