UDC 669.112.22

Yu. Zhiguts, V. Shurokov

THE FEATURES OF PROPERTIES AND STRUCTURE OF THERMITE HIGHSTRONG CAST-IRON

Nowadays the improvement of properties of materials is arrived mainly by the development of traditional technologies of production. Their high power-intensive, the necessity of combination of several technical stages lead to search other ways of giving new properties of materials. One of such perspective ways is the usage, offered in this papers, of the method which is theoretically developed and experimentally well-grounded, the method of production of steels with the usage of high-exothermic reactions. The method of conducting of thermite synthesis consists in the following. From the initial of powder like materials – ingredients of chemical reaction arrange a metallothermic mixture. The components of mixtures after interfusion and weighing take a place in metallothermic reactor and anneal, that results in the synthesis of necessary alloy.

As a result of leadthrough of the experimental thermite melting with mass of mixture 150-600 g were got the shaped founding's. For them seated chemical composition, mechanical and technological properties. A size of free shrinkage volumetrically for highstrong thermit cast-iron was within the limits of 1,8-2,3%. Separate research found out the change of mechanical properties of highstrong thermite cast-iron at a temperature.

The conducted work allowed determining the composition of mixture for the synthesis of highstrong thermite cast-iron, to develop the method of preparation of metallothermic mixture and synthesis of alloy.

Keywords: *thermit, metallotermic, highstrong thermit cast-iron, reaction, mechanical, technological and special properties, structure.*

Fig. 5. Tab. 10. Ref. 14.

Ю. Жигуц, В. Широков

ОСОБЛИВОСТІ ВЛАСТИВОСТЕЙ І СТРУКТУРИ ТЕРМІТНОГО ВИСОКОМІЦНОГО ЧАВУНУ

На сьогодні покращення властивостей матеріалів досягають переважно розвитком традиційних технологій їх отримання. Але висока енергоємність, потреба у використанні декількох технологічних етапів обробки привели до необхідності застосування інших шляхів, що надають нових властивостей матеріалам. Один з таких перспективних шляхів є використання, запропоноване в цій роботі методу, який теоретично розроблено і експериментально обґрунтованого, а саме виробництво високоміцних чавунів за допомогою високоекзотермічних реакцій. Метод проведення термітного синтезу полягає у наступному. Вихідні порошкові матеріали – інгредієнти хімічної реакції вступають у металотермічну взаємодію. Компоненти шихти після перемішування і ущільнення розміщують у металотермічному реакторі і відпалюють, що призводить до синтезу необхідного сплаву.

В результаті експериментальних термітних плавлень масою шихти 150-600 г було отримано фасонні виливки. Для них встановлювали хімічний склад, механічні і технологічні властивості. Величина вільної лінійної усадки термітного високоміцного чавуна знаходилася у межах 0,7-1,2%. Окреме дослідження з'ясувало зміну механічних властивостей термітного високоміцного чавуна від температури. Проведене дослідження дозволило визначити склад шихти для синтезу термітного чавуну, розвинуло технологію отримання металотермічної шихти і синтезу сплаву.

Ключові слова: *терміт, металотермія, високоміцний термітний чавун, реакція, механічні, технологічні і спеціальні властивості, структура.*

Ю. Жигуц, В. Широков

ОСОБЕННОСТИ СВОЙСТВ И СТРУКТУРЫ ТЕРМИТНОГО ВЫСОКОПРОЧНОГО ЧУГУНА

В наше время улучшение свойств материалов достигают преимущественно развитием традиционных технологий их производства. Но высокая энергоемкость, потребность в использовании нескольких технологических этапов обработки привели к необходимости применение других путей, которые придают новые свойства материалам. Один из таких перспективных путей является использование, предложенного в данной работе, теоретически разработанного и экспериментально обоснованного метода, а именно производства высокопрочных чугунов с помощью высокоэкзотермических реакций. Метод проведения термитного синтеза заключается в следующем. Исходные порошковые материалы – ингредиенты химической реакции вступают в металлотермическое взаимодействие. Компоненты шихты после перемешивания и уплотнения размещают в металлотермический реактор и поджигают, что приводит к синтезу необходимого сплава.

В результате экспериментальных термитных плавок массой шихты 150-600 граммов было получено фасонные отливки. Для них устанавливали химический состав, механические и технологические свойства. Величина свободной линейной усадки термитного высокопрочного чугуна находилась в пределах 0,7-1,2%. Отдельное исследование выяснило изменение механических свойств термитного высокопрочного чугуна от температуры. Проведенное исследование позволило определить состав шихты для синтеза термитного чугуна, усовершенствовало технологию получения металлотермической шихты и синтеза сплава.

Ключевые слова: *термит, металлотермия, высокопрочный термитный чугун, реакция, механические, технологические и специальные свойства, структура.*

Introduction. Thermite reactions are known already more than age and they are utilized for making of ferrous-alloys and warming-up of exothermic castings incomes in a casting production [1-5].

© Yu. Zhiguts, V. Shurokov

Use of thermite reactions for the synthesis of materials, opens wide possibilities of receipt of the cast alloys practically of any chemical composition and structure.

Purpose and raising of research task. Improvement of properties of materials is arrived mainly by the use of traditional technologies of receipt of alloys and subsequent thermal, chemical-thermal and by another ways of treatment. But their high power-hungryness, necessity of combination of a few technological stages of treatment, the observances of ecological requirements result in the necessity of search of other ways of receipt of necessary properties of materials, enabling to avoid the adopted failings. One of such perspective ways may be the use of the method of receipt of thermite highstrong cast-irons developed and experimentally grounded in theory as a result of high exothermic reactions.

Taking into account the advantages and specific areas of the use of thermite methods of receipt of high-carbon alloys there is a problem of complex research of thermite cast-irons, determinations of their physical and mechanical, technological and official properties, and on the basis of findings establishment of the most optimum areas of the use of these alloys.

Analysis of research method. Advantages of thermite processes talk in behalf on thermite alloys, namely, their noninteraction, absence of requirement in the sources of electric power, simplicity and cheapness of technological equipment, high performance of process (time of leadthrough of synthesis lasts depending on mass and volume of metallothermic mixture from a few ten of seconds to a few minutes) [3,6-10]. Except for transferred, pays attention on itself the possibility of the use for arrangement of mixture of offcuts of metal-working and thermal productions (ferrous dross, grade of the aluminium shaving and candle-ends of graphite electrodes, sifting out of dust of alloy steel from filters in castings workshops and other). The wideuse of highstrong cast-irons is conditioned except for their high mechanical and technological properties with quite good welding.

Thus, for making and shaped component overhaul possibility to utillize thermite methods which find all of greater distribution lately appears from highstrong cast-irons.

Materials and method of preparation of exothermic mixture. For arrangement of metallothermic mixture such materials were used: chrome metallic; ferrokhrome; silicocalcium; aluminium for aluminotermic; silicomanganese; ferrosilicon; powder of aluminium; ferromanganese; soot is acetylene (technical carbon); powder of titanic chemical; powder of chrome; ferrous dross (blacksmith's and rental productions) of middle chemical composition (in % on mass): 0,05 C; 0,10...0,35 Si; 0,10...0,35 Mn; 0,01...0,03 S; 0,01...0,03 P; 40...50 Fe_2O_3; 50...60 FeO.

For determination of mass of metallic bar and output of metal from a mixture, micromelting were conducted in a metallothermic reactor [3] with different percent correlation of components in mixture. Initiation of process of burning was conducted by the special primer, made from titanic powder. In subsequent the construction of metallothermic two-cameral reactor was improved and utilized both for the receipt of thermite highstrong cast-iron as foundings and for welding of cast-iron purveyances [3,6].

Thermite synthesis and welding of cast-irons in a two-cameral reactor carried out as follows: in the chamber of reactor, where burning of thermite mixture and small burned down components passed, and also dissociating due to the difference of specific mass of liquid-metal phase from a slag, synthesized the overheated liquid cast-iron. In the chamber of alloying and retrofitting there was co-operating of well-educated fusion of cast-iron with ligature iron-silicon-rare-earth metals during flowing of it in the cavity of the thermite welding. At such co-operation liquid cast-iron was satiated silicon and elements-modifiers, necessary for a globular graphite. Thermite highstrong cast-iron, entering cavity of the thermite welding, firmly welded cast-iron details, preliminary warmed-up gas flame or electric contacts method to 300...350 °C.

It should be noted that powder-like mixture preliminary dried out at the temperature of 150...180^{0}C mixed up and made more compact, and after it placed in the overhead chamber of metallothermic reactor. For the improvement of separate slag in a mixture added feldspar (CaF_2).

A mixture was counted on stoichiometrical correlations of components of reaction [3,8], and in subsequent mastering of separate components of reaction was taken into account by the proper coefficients. At the same time was conducted a thermodynamics calculation, which allowed to set the adiabatic temperature of reaction which must be higher than temperature of melting of an aluminum containing slag's (approximately 2400^{0}C).

For adjusting of temperature of burning in the complement of mixture were entered inert additions. At maintenance in mixture less calculation amount of inert additions the adiabatic temperature of burning rose higher necessary, that gave burning down of alloying elements and, accordingly, to the decline of their maintenance in an alloy less low bound regulated by a standard. At maintenance in mixture of inert

© Yu. Zhiguts, V. Shurokov

additions over the rationed amount the adiabatic temperature of burning went down below possible, that gave away by the synthesized alloy unstable burnt and impossibility of separation of slag.

Theoretical researches. After establishment of stoichiometrical composition of mixture and correction of it by the coefficients of mastering of separate components the calculation of adiabatic temperature of burning of metallothermic reaction (T_a) and thermal effect of reaction (Q_r) [3,11,12] was conducted.

On condition that all of heat is outlaid to heating of mixture, that is enthalpy of initial and eventual products is identical, we find:

$$\sum_{i=1}^{m}\left(H\left(T_a\right)-H\left(T_o\right)\right)_i = Q, \tag{1}$$

where T_0 – is a set temperature of mixture; Q – is a thermal effect of reaction; H – are enthalpy of ingredients of reaction; m is an amount of products of reaction.

For more complicated variants of design at education of more than three products of reaction T_a a formula was used:

$$T_a = \frac{Q-\sum H_i\left(T_{melti}\right)-\sum L_i+\sum C_{ip}\cdot T_{melti}}{\sum C_{iliq}}, \tag{2}$$

where C_i and L_i – heat capacity and warmth of melting of products of reaction accordingly; γ – it is part of liquid phase in the product of burning.

It is clear that, in connection with null data about dependences C from T at high temperatures [3,8], extrapolation of values was conducted by a formula:

$$C_{sol(Tmelt)}=7n\cdot k \text{ (J / mole·degree)}, \tag{3}$$

where k – is a transitional coefficient from calorie to Joule; $C_{sol(Tmelt)}$ – is a heat capacity of product at the temperature of melting; n is a number of atoms in the molecule of well-educated product.

At the simplified chart of calculation that determined without the account of the exact meanings of thermal capacity, and a thermal effect was set at a middle temperature (for example, 2500 ^{0}C). By the change of thermal effect, when products of reaction are in the liquid state, it is possible to scorn.

This method was fixed in basis of the programs for a calculation T_a and Q_r for the special highstrong cast-irons and other alloys [8,12-14].

In the examined thermodynamics model of defervescence the macrokinetic theory of burning was used, at which

$$T_a = T_{melt} + \frac{Q-L-\Delta H\left(T_{melt}\right)}{C_{liq}}, \tag{4}$$

where Q and L are accordingly warmth of education and warmth of product; $\Delta H(T_{melt})$ – is a difference of enthalpy of initial and eventual products; C_{liq} – is a heat capacity of liquid product regardless of temperature.

An error, related to the offered extrapolation, is estimated as 100…150 ^{o}C.

Experimental researches. As a result of leadthrough of the experimental thermite melting the shaped founding's which probed complex were got. Chemical composition, mechanical, technological and some official properties of the synthesized alloy where set.

The distinctive feature of thermite highstrong cast-iron was not only it method of receipt but also very compact, near to spherical form of including of graphite. As well as in industrial cast-iron, regulating properties of thermite highstrong cast-iron is possible by changing the structure of metallic basis.

Varying chemical composition of mixture at the metallothermic method of synthesis, the terms of cooling of founding was formed thermite cast-iron with a ferritic, pearlitic, sorbitum, martensitic, austenitic structure and accordingly with the set durability and operating properties.

It is set that thermite highstrong cast-iron possessed high durability on tension, compression and bend, by high enough plasticity and shock viscidity, by satisfactory castings properties (namely good fluidity of fusion, small linear and by volume shrinkage, small propensity to the firecracking). It was well processed mechanically except for welded, added the autogenous cutting, possessed high wearproofness, heat-tolerance and anti-friction properties.

Research of physical properties of thermite highstrong cast-iron rotined that it differed from properties of industrial. So, a closeness of it at a room temperature was 7000...7600 kg/m^3. The results of comparison of coefficients of thermal expansion of thermite cast-irons are rotined in table 1.

Table 1 **Coefficient of thermal expansion of thermite highstrong cast-iron**

Thermite cast-iron	Contents of elements, %						$\alpha \cdot 10^{-6}$ at the temperature of 0...200°C
	C	Si	Mn	P	S	Mg	
With a plate graphite	3,6	3,02	0,8	0,05	0,06	-	10,4
With a globular graphite	3,2	3,10	0,57	0,04	0,02	0,05	11,7

Heat conductivity of highstrong thermite cast-iron is less heat then conductivity of grey thermite cast-iron and changed depending on the structure of metallic basis. With the increase of amount of ferrite heat conductivity was increased, being within the limits of 8,7...9,0 kal/m·s·grad. The set dependence of influence of chemical composition and temperature of thermite cast-iron on heat conductivity is rotined in table 2.

Table 2 **Influence of chemical composition and temperature of thermite highstrong cast-iron on heat conductivity**

Contents of elements, %							λ, kal/m·s·°C, at a temperature °C				Type of matrix
C	Si	Mn	S	P	Ni	Mg	100	200	300	400	
3,51	2,5	0,43	0,006	0,056	1,4	0,09	91,0	90,5	90,2	69,5	Ferrite
3,75	2,7	0,51	0,012	0,047	2,1	0,07	81,0	80,5	80,1	79,5	
3,10	3,5	0,34	0,013	0,061	1,3	0,08	93,0	92,1	91,6	91,1	
3,20	2,4	0,38	0,011	0,060	1,3	0,05	84,0	78,2	78,2	73,1	Ferrite

Electrical resistivity of thermite highstrong cast-iron depended on chemical composition of cast-iron, form of the graphite including, their distributing and structure of matrix (table 3).

Table 3 **Dependence of electrical resistivity from chemical composition of thermite highstrong cast-iron**

№	Chemical composition, %									ρ, mkOhm/m
	C	Si	Mn	S	P	Ni	Cu	Mg	Ce	
1	3,6	2,3	0,81	0,010	0,04	-	2,1	-	0,047	5800
2	3,7	2,9	0,63	0,012	0,02	0,61	1,6	0,041	-	6400
3	3,1	2,4	0,27	0,014	0,03	0,67	-	0,061	-	5100

There was conformity that the resistance of thermit highstrong cast-iron is higher, than in grey and malleable thermite cast-irons. It was succeeded to set, that the pearlitic structure of thermite cast-iron had

© *Yu. Zhiguts, V. Shurokov*

more high resistance, than ferritic, and with the increase of temperature specific resistance of thermite cast-iron increased.

As well as industrial cast-iron, thermite is possible to classify on classes: ferritic, pearlitic and austenitic. Accordingly to magnetic properties thermite cast-iron is subdivided into magnetic and paramagnetic.

Magnetic properties were mainly influenced by structure of basis, there was a carbon and temperature of thermite cast-iron in the free state, nevertheless, it is exposed, that the globular form of graphite promoted it magnetic properties. It is evidently demonstrated by comparative information of table 4. In highstrong cast-iron with a pearlitic structure was looked an increase to 8...9% of magnetic induction compared with thermite highstrong cast-iron with a plate graphite.

Table 4 **Magnetic properties of thermite highstrong cast-iron**[1]

Thermite highstrong cast-iron	σ_b, MPa	Field strength at M_{max}, T	Remaining magnetic induction of Br, T	Coercive force, H_c, T
With a pearlitic matrix	$\frac{785}{734}$	$\frac{0,10178}{0,09424}$	$\frac{0,6210}{0,6075}$	$\frac{0,10053}{0,09425}$
With a ferritic matrix	$\frac{510}{485}$	$\frac{0,03779}{0,03393}$	$\frac{0,5670}{0,5400}$	$\frac{0,03142}{0,01885}$

[1]In the numerator of property of thermite cast-iron, in a denominator - industrial

The increase of amount of graphite making structure lowered magnetic induction, which is caused by diminishing of volume of ferromagnetic basis and division of basis by unmagnetic including of graphite.

With the increase of maintenance of graphite remaining and maximal permeance diminished. Some increase of maintenance of phosphorus (to 0,6%) diminished permeance and simultaneously increased coercitivity (table 4).

Mechanical properties of cast-iron determined on standards Ø10 mm and long 50 mm, intagliated from special tests, and are rotined in table 5. An analysis and comparison of findings testified that basic mechanical properties of thermite brands of highstrong cast-irons is not worse than industrial.

Table 5 **Mechanical properties of thermite highstrong cast-irons**

№	Thermite cast-iron, analogue of industrial	Σ_b	$\sigma_{0,2}$	δ, %	$a_н$, MPa	HB
		MPa				
1	"ВЧ 45-0"	470	380	-	-	210...250
2	"ВЧ 45-5"	460	360	5	20	190...210
3	"ВЧ 50-1,5"	510	370	1,5	15	220...240
4	"ВЧ 60-2"	600	430	2	15	210...240

At the spherical form of graphite and pearlitic structure of basis thermite cast-irons were rotined by the most high values of tensile strength, and maximal plasticity is got – at a ferritic structure.

As-cast tensile of thermite cast-iron strength with a pearlitic structure was arrived at 600...700 MPa. Tensile strength made at the compression of thermite highstrong cast-iron ~2000 MPa, on a bend – 700...1200 MPa, and a sagitta changed within the limits of 4...30 mm. Tensile strength at twisting was 440 MPa at a ferritic structure and 700...800 MPa at a pearlitic structure. The limit of fluidity of thermite cast-iron is higher, than at carbon steel and 320...430 made MPa, and for some standards 800 was arrived at MPa. The attitude of limit of fluidity toward tensile strength at tension at thermite cast-iron was 0,75...0,8 (for comparison at industrial steel 0,55...0,61). The relative lengthening of thermite highstrong cast-iron was 1,5...3,0%.

At maintenance of phosphorus more than 0,15% a fragile phosphorus eutecticum which diminished the relative lengthening appeared in thermite cast-iron.

The module of resiliency substantially depended on the structure of metallic basis of thermite cast-iron, that is rotined in table 6. It is the considerably anymore module of resiliency of thermite cast-iron with a plate graphite and less module of resiliency of carbon steel of У8. At the increase of temperature the module of resiliency diminished (fig. 1).

© Yu. Zhiguts, V. Shurokov

Table 6 **Module of resiliency for the different structures of basis of thermite highstrong cast-iron**

№	Type of thermite cast-iron	$E \cdot 10^6$, MPa
1	Cast-iron with a pearlitic structure	176,00...184,00
2	Cast-iron with a ferritic structure	161,00...178,00

Hardness of thermite cast-irons changed depending on the structure of matrix (for ferritic – 160…210 HB, for pearlitic – 190…260 HB, for the bleached thermite cast-iron – 280…340 HB), temperature and maintenance of carbon. Dependence of relative plasticity, tensile and limit of fluidity strength from hardness at tension are rotined on a fig. 2 and 3.

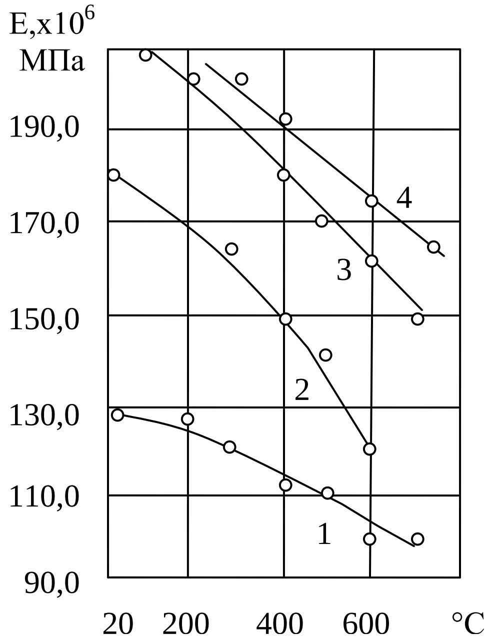

Fig. 1. **The influence of temperature on the module of resiliency:**
1 – is an analogue "ВЧ 50-1,5"; 2 – "ВЧ 60-2"; 3 – is steel 45; 4 – "СЧ 21"

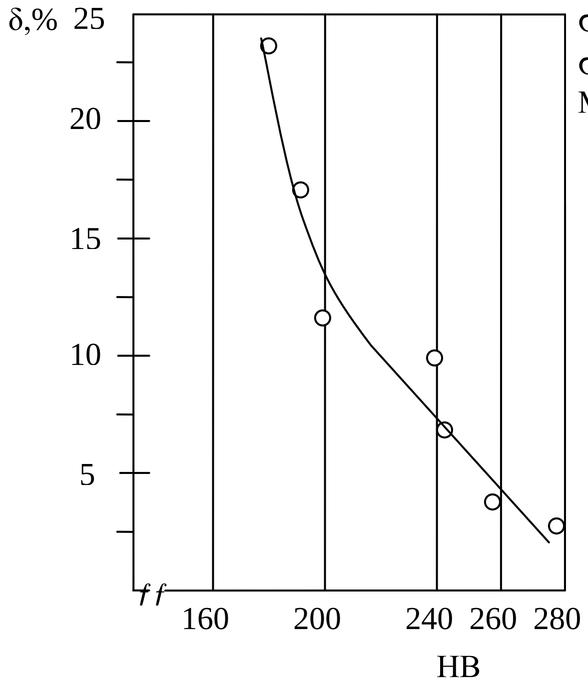

Fig. 2. **Dependence of relative plasticity at tension from hardness**

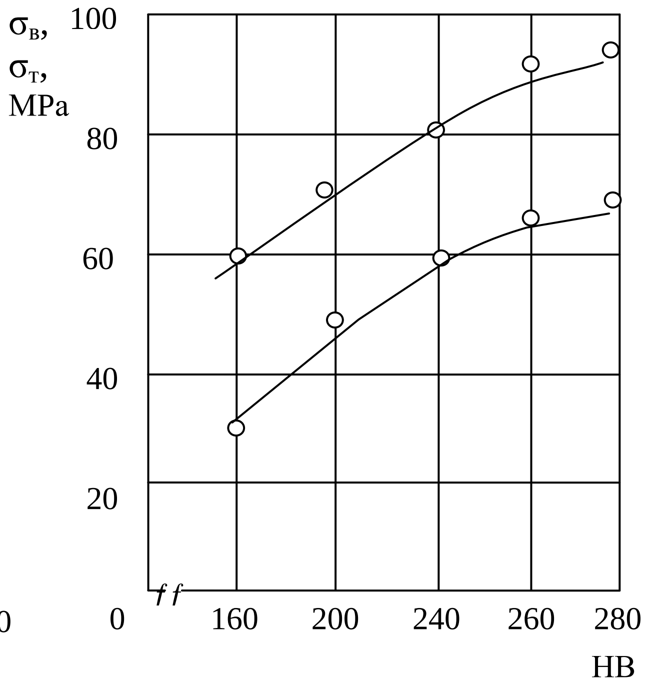

Fig. 3. **Dependence of tensile and limit of fluidity strength on hardness at tension**

© *Yu. Zhiguts, V. Shurokov*

Subsequent research rotined that thermite cast-iron had most shock viscidity with a ferritic structure (fig. 4), here enhanceable maintenance of silicon, manganese, phosphorus and sulphur lowered shock viscidity.

One of major properties of thermite cast-iron is its ability to extinguish vibrations. This property straight depends on the size of cyclic viscidity which in the same queue depends on the form of the graphite including. In thermite highstrong cast-iron cyclic viscidity less, than at thermite cast-iron with plate graphite on 4...8%, and more than at industrial steel almost in two times. Thus cyclic viscidity fluently increased with the increase of tensions in cast-iron.

The limit of endurance of thermite cast-iron with the increase of static durability gradually rose to the values of 1,5...2 time more than the limit of endurance of grey thermite cast-iron.

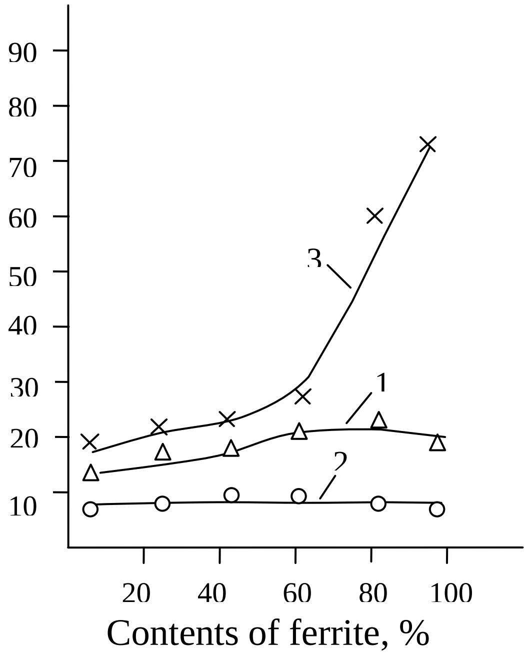

Fig. 4. **Dependence of shock viscidity on the amount of ferrite in thermite cast-iron:** *1* **– are standards without an incision;** *2* **– are standards notched;** *3* **– are standards without an incision after heat treatment**

It was marked as a result of researches, that a ferrous dross, in-use in a metallothermic synthesis, can worsen castings properties of cast-iron. The increase of maintenance of carbon in highstrong cast-iron resulted even in some increase of mechanical properties, unlike influence of carbon on basic of mechanical properties of grey thermite cast-iron. Taking into account the optimization of properties of cast-iron, maintenance of carbon must be within the limits of 3,1...3,6%. Diminishing maintenance of carbon from 3,9% to 2,8% led to the increase $\sigma_в$ and $\sigma_т$ – on 30 MPa, and to hardness on ~10 HB.

Table 7 **Tireless durability ferritic and pearlitic thermite highstrong cast-irons**

Limit of endurance	Tireless durability of thermite cast-iron, MPa	
	With a ferritic structure	With a pearlitic structure
$\sigma_в$	410...470	580...660
σ_{-1}	145...180	190...320
τ_{-1}	-	19...220
$\frac{\sigma_{-1}}{\sigma_{â}}$	-	0,4...0,42
$\frac{\tau_{-1}}{\sigma_{-1}}$	-	0,71...0,83

Silicon, being strong graphitizer, resulted in diminishing of amount of pearlite in the structure of thermite cast-iron and, partly dissolving in a ferrit, promoted his durability. The increase of maintenance of silicon in thermite cast-iron from 2,1 to 3,9% resulted in growth of tensile strength at tension, and maximal shock viscidity was set to 2,1...3,6%. Diminishing of maintenance of silicon less than 2,1% resulted in appearance of whiten and increase of hardness due to formation of far of cementite.

The microhardness of ferrit rose with the increase of concentration of silicon in an interval 3,9...5,5%, and the microhardness of pearlite went down from 5100...5400 MPa at 2,0...2,7% with to 3400...3700 MPa. Microhardness of eutecticum phosphorus's, exposed in the structure of thermite cast-iron, 11000 made...14100 MPa.

With diminishing of maintenance of silicon the amount of pearlite was increased in the structure of thermite cast-iron, and the increase of Si results in appearance of far of ferrite and diminishing of durability. Regulating the amount of ferrite in the structure of cast-iron is possible changing maintenance of ferrosilicon in a metallothermic mixture.

The increase of maintenance of manganese was diminished by maintenance of ferrit in a matrix and increased the pearlitic constituent of structure, that resulted in growth of durability. Therefore maintenance of manganese in thermite cast-iron must be within the limits of 0,4...1,3%. Thus maintenance of phosphorus must not exceed 0,12...0,15%, and grey – 0,03%.

Combining of aluminotermic and magneziumtermic allowed to increase maintenance of magnesium in highstrong cast-iron to 0,03...0,08%, that stabilized a globular graphite. Exceeding of the indicated maintenance of remaining magnesium was instrumental in appearance in the structure of cementite and as a result of substantial worsened mechanical properties.

An aluminium presented in composition of the alloys synthesized aluminiumtermic type of tracks (to 0,003%), as a result of aluminiumtermic method of their receipt. It is known that the increase of maintenance of Al more than to 0,4% hinders formation of spherical graphite and diminishes mechanical properties of highstrong cast-iron, therefore maintenance of Al in an alloy was limited by 0,2...0,3%.

Continuation of researches was directed on establishment of technological properties of thermite highstrong cast-iron. Above all was exposed his castings properties. Thermite highstrong cast-iron possessed high fluidity, that allowed, not looking on the high temperatures of synthesis, get founding's without shrink shells, to shrink porosity and without gas shells. Dependence of fluidity of highstrong thermite cast-iron on a temperature is rotined on a fig. 5.

It is set, that the more maintenance of carbon is the higher fluidity of cast-iron. It arrived the maximum for thermite cast-iron of hypereutectic composition. Thermite cast-iron of eutecticum composition has more volume of shrink shells, and there was shrink porosity in cast-iron of hypoeutectic composition.

The characteristic feature of thermite highstrong cast-iron was a large shrink expansion, that considerably diminished its propensity to the firecracking. On the average linear shrink of highstrong cast-iron was 0,7...1,2%.

At the receipt of founding's of difficult form from thermite cast-iron it is necessary to take into account remaining tensions which arise up due to flowages after passing of cast-iron to the area of resilient deformations. Removing them is possible either by simplification of casting form or subsequent heat treatment of founding.

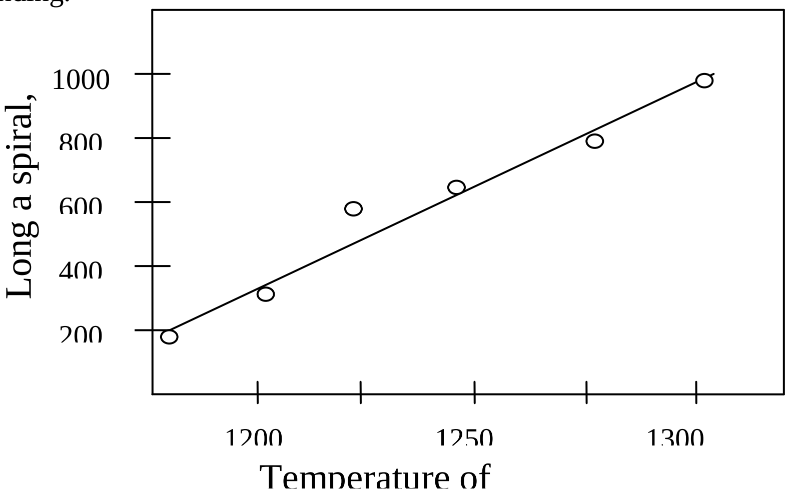

Fig. 5. **Dependence of fluidity of thermite highstrong cast-iron on a temperature**

© Yu. Zhiguts, V. Shurokov

Simultaneously with research of technological properties possibility of organization of the thermite welding of highstrong cast-iron was examined. It is set that weldability of highstrong thermite cast-iron was at the level of weldability of carbon steel. It positive property was utilized for welding of not only purveyances a thermite method from highstrong but also grey cast-iron. Thus, it succeeded to get the welded guy-sutures with the properties best, than at the weldable material.

In the conducted experimental melting utilized thermite cast-iron with a spherical graphite, got in a two-cameral reactor as a result of burning of thermite mixture of the following composition (% on mass): powder of graphite is 3,5...6,3; ligature iron-silicon-rare-earth metals (for example, cerium) – 3,0...6,0; a fluor-spar is a 2,0...3,0; iron-aluminium thermite – the other. The results of these tests are rotined in table 8.

Table 8 **Properties of the thermite welded guy-sutures**

№	Alloy	Properties of welding area			
		An amount of spherical graphite is in a structure	Hardness, *HB*	$\sigma_в$, MPa	σ_{10}^{1}, %
1	Grey cast-iron	0	170	210	0
2	Transitional zone[2]	30–70	–	–	–
3	Highstrong thermite cast-iron	85–95	190	550	4,5

[1]Mechanical properties are certain on standard standards diameter of 10 mm
[2]White zone is not

The synthesized highstrong cast-iron allowed to weld cast-iron purveyances with the receipt of the welded guy-sutures durability on tension ~550 MPa.

Thermite welding of cast-iron in this way is at 2,5...4 time dearer than traditional technology of welding of cast-iron details [3,5]. An economic effect is arrived only in that case, when cast-iron details must be welded in the conditions of absence of standard welding equipment, outsourcings of electric power and in the compressed terms.

In the process of welding high quality of guy-sutures turned out due to absence in him of area of white zone of acquisition of structure and properties of highstrong cast-iron guy-sutures.

Workability of cast-iron depended on its durability and hardness. Thermite cast-iron with a ferritic structure had low durability, hardness and the best workability. Firmness of chisels from high-speed steels at sharpening of ferritic thermite highstrong cast-iron is almost in 2 times higher, than at sharpening pearlitic, and cutting effort can be increased to 50...60%. For ferritic cast-iron optimum speed of cutting arrived at 200...350 m/mines, that is to 20...25% more than pearlitic.

Cutting speed for thermite highstrong cast-iron is rotined in table 9.

The feature of thermite highstrong cast-iron was that it can be applied for making of both shallow and large details. The use of metallothermic mixture for the synthesis of thermite highstrong cast-iron in technology of making of founding's with the thermite incomes of high temperature gradient allowed to save a to 70% alloy arrived. Feed arrived by the overheated highstrong cast-iron of that chemical composition, what inundated in a form, resulted in the removal of liquation of subprofitable area. In addition, by comparison to steel this material

Table 9 **Speed of cutting at treatment of thermite highstrong cast-iron**

Structure of cast-iron	Cutting speed, m/mines	
	Instrument from high-speed steel of P6M5	Instrument from the hard alloy of ВК8
Ferritic	45...70	90...180
Ferritic-pearlitic	35...45	60...100
Pearlitic	35...45	60...90

is more high operating characteristics – wearproofness, heat-tolerance, enhanceable anticorrosive and anti-friction properties.

© *Yu. Zhiguts, V. Shurokov*

Information about firmness and expense of industrial rental highstrong rollers of the thermite incomes made with the use of technology is indicated in table 10.

Table 10 **Firmness and expense of rental billows, made on experimental technology**

Type of rental	Uptime rollers from thermite cast-iron	Expense of rollers on 1 t of rental, kg
Dynamo steel	410	23,5
Transformer steel	560	12,7
Tin	320	33,2
Roofing steel	1490	6,7

Hardness of worker of layer of rollers from the bleached highstrong cast-iron was 380...410 HV.

Conclusions: 1. In theory and possibility of the use of thermite highstrong cast-iron is experimentally well-proven not only for the receipt of foundings, welding but also for the use of the overheated fusion in technology of thermite incomes of high temperature gradient. 2. Physical and mechanical properties of thermite highstrong cast-iron are set is a closeness, coefficient of thermal expansion, heat conductivity, dependence of heat conductivity and electrical resistivity from a temperature and chemical composition, magnetic properties; mechanical properties are durability, hardness, relative lengthening, shock viscidity, limit of fluidity depending on the structure of cast-iron and temperature of its use. 3. Technological properties of thermite cast-iron are set, namely fluidity and influence on it of temperature, linear expansion and linear shrinkage, workability of cast-iron and other 4. The change of some official properties of thermite cast-iron is set depending on a structure and chemical composition (tireless durability and other). 5. Application of highstrong thermite cast-iron in technology of making of rental rollers allowed to save material, which was expended on an income, removed the liquation of subprofitable area, replenish the supply and heated a roller and positively influenced on an uptime rollers at diminishing of their expense.

1. *M.Z.Zolkover, A.S.Gridunov, S.O. Byl'nickiy-Birulya*, The Shaped Casting from Thermite Steels, Dorizdat, Moscow (1950) [in Russian].
2. *A.S.Dubrovin*, Metallotermija spetsialjnyh splavov. Theljabinsk, YuRGU (2002) [in Russian].
3. *Yu.Yu.Zhiguc*, Alloys synthesized metalotermieyu and by SHS-processes. Grazhda, Uzhgorod (2008).
4. *A.G.Merzhanov*, Tverdoplamenoe gorenie. ISMAN, Thernogolovka (2000) [in Russian].
5. *Yu.Yu. Zhiguts*, Lit. Proizvodstvo, 5, (2007) [in Russian].
6. *Yu.Yu.Zhiguts*, Visti Akad. Inzh. Nauk Ukrajiny, 32 (2007) [in Ukraine].
7. *Yu.Zhiguts, I.Kurytnik*, Arch. Found. Engin. Polish Acad. Sciences, 2, 8 (2008).
8. *Yu.Zhiguts, V.Shirokov*, Machinoznavstvo, 4 (2005).
9. *I. Amato, D. Martorana, M. Rossi*, Powder metallurgy, 18, 3. (1975) 339 p.
10. *Y.Miyamoto, S.Kanehira, O.Yamaguchi*. Development of Recycling Process for Industrial Wastes by SHS. Journal SHS (2000).
11. *V.I.Itin, Yu.S.Najborodenko, A.D.Brathikov*, Issledovanie gorenija kompozitsionnyh system. Fiz. Gorenijs i Vzryva 8. 37, 4 (2001) [in Russian].
12. *V.A.Pogergin*, Metallotermitheskie sistemy. Moscow (19592) [in Russian].
13. *P.L.Longland, A.I. Moulson* , J. Mater. Science, 13, 10. (1978). p. 2279-2284.
14. *L.J.Kashporov, Yu.E.Sheludjsk, V.V.Uhov*, Osobennosti gorenija smesej na osnove aljuminija. Fiz. Gorenija i Vzryva, 30, 6 (1994) [in Russian].

Стаття надійшла до редакції 28.04.2013.

© *Yu. Zhiguts, V. Shurokov*