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Chemical baling of oily cast iron turnings and use of bales to substitute expensive and scarce scrapes

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Abstract: The results of the research are presented as the technology of smelting cast iron using iron-containing substances with organic pollutants as a charge material. Iron- and carbon- containing substances are introduced into the melt as stable components of bales which are not damaged during transportation. Bales are formed under low pressure from iron- containing substances with organic pollutants which do not undergo the preliminary treatment. When bales are produced, cheap materials are used as binders. Binders are formed at the expense of chemical hardening and oxidation of organic pollutants to less environmentally harmful compounds, and refining the melt from contaminants. The composition of bales provides the reduction of iron from its oxide compounds.

Keywords: Industrial Wastes, Oily Cast Iron Turnings, Baling, Chemical Hardening, Oxidation Of Contaminants, Metallurgical Value of Bales, Structure Formation, Microcomposition and Morphology of non-Metallic Inclusions

1. Introduction

Processing and recycling of industrial wastes are not only important from the point of view of their use as an alternative source of raw materials, but also from the point of view of environmental protection [1].

Modern scientific and technological progress is connected with creation of energy-efficient technologies for the integrated use of raw materials and reduction of the harmful effects on the environment [1, 4].

To smelt cast iron it is reasonable to use turnings instead of iron scrapes and expensive pig foundry iron [2]. The use of turnings in the form of dumping leads to production reduction of melting units due to its low bulk density, metal loss during transportation, losses caused by corrosion, oxidation during remelting due to the large specific surface area, etc. When untreated turnings are used, non-collectable scrapes due to corrosion are 15%, remelting losses are from 20 to 30%, during transportation it is more than 5% [2].

Although advanced mechanical processing techniques, allowing increasing the efficiency of metal utilization are widely used in industry, the amount of turnings is expected to increase. Due to the application of oils and emulsions turnings surface is very dirty. The amount of these components in the turnings can reach 10%; the presence of oils inhibits its ball milling [2].

The development and application of the most effective methods and techniques for recycling and remelting turnings is of great economic importance. The problem of processing oily turnings of small size is practically unsolved [1, 3].

It is dangerous to dump oily turnings directly into the metallurgical units. Firstly, slopping of liquid metal is possible due to a high concentration of oils, and other contaminants, etc. Secondly, environmentally harmful emissions of toxic gases, soot and dust occur even if there are no disturbances in the melting methods. Currently, there are several ways to remove lubricant oils and emulsions from turnings [2]. Degreasing in a centrifuge does not provide residual oils below 1.5 - 2.0%. Wet cleaning of turnings by acids, alkalis, hot water, steaming, etc. provide a high degree of purification, but it is a costly and time-consuming operation [2, 3].

Removal of oils and emulsions from turnings by roasting in an oxidizing atmosphere leads to a loss of metal and air pollution by combustion products. Electrochemical method of degreasing turnings has low productivity and a low degree of de-oiling at high cost. Consequently, the existing methods do not degrease turnings effectively, their implementation is associated with high capital costs and certain technical difficulties.

The method which is presently used is briquetting untreated turnings contaminated by oils and emulsions by compression (under high pressure). It may not be effective because liquid (in this case oil) is incompressible and does not allow obtaining high-quality pellets with high mechanical strength and undamageability during transportation. The environment in the area of these enterprises is highly contaminated.

The technology for processing metal turnings, particularly oily cast iron turnings, to produce high-quality gray iron is designed to solve the problem of getting cheap products and facilitate the solution of the most important environmental problems. When the current processing techniques are implemented, the afterburning oils and emulsions emit into the atmosphere significant amounts of toxic gases, soot, and dust. In the proposed technology oils and emulsions are significantly oxidized during chemical hardening; being in durable bales isolated from the atmosphere, they undergo pyrolysis in the process of heating during melting thereby minimizing emissions.

In the Belarusian State University of Technology (BSTU) the method of smelting cast iron using iron as charge materials with organic pollutants is worked out [1, 3-4]. Iron- and carbon- containing substances are introduced into the melt as stable components of bales which are not destroyed during transportation. Bales are formed under low pressure from iron-containing substances with organic pollutants which do not undergo the preliminary treatment. When bales are produced, cheap materials are used as binders. Binders are formed at the expense of chemical hardening and oxidation of organic pollutants to less environmentally harmful compounds, and refining the melt from contaminants. The composition of bales provides the reduction of iron from its oxide compounds [1, 3].

2. Physicochemical Characteristics of the Starting Materials and Metal-Containing Bales

Loam and magnesite are used as binders in the manufacture of bales of oily iron turnings.

Investigations of the structure of the starting materials were conducted by scanning electron microscopy using the microscope JSM-5610LV (IEOL, Japan) with the electron-probe energy dispersive X-ray analysis. The structure of the material was recorded by the detector of secondary electrons. The composition and morphology of loam and magnesite inclusions were studied by electron - probe EDX analysis on the detector IED2201.

Magnesite consists of homogeneous crystals (Figure 1), which structure, except magnesium and oxygen, contains silicon, calcium and iron (see Table 1).

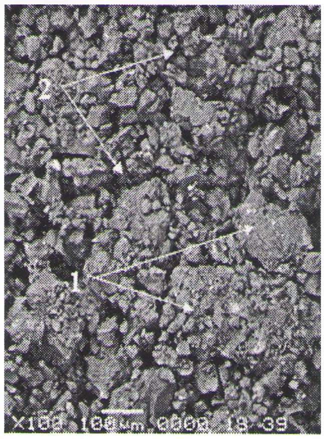


Fig 1. *Structure of magnesite (investigated by scanning electron microscopy).*

Table 1. *Average chemical composition and structure of some inclusions of magnesite.*

Position of inclusion	Contents of elements, % wt.				
	O	Mg	Si	Ca	Fe
Fig. 1(average composition)	46,31	46,38	2,50	2,24	2,58
1 (Fig. 1)	43,22	55,56	0,03	0,20	1,00
2 (Fig. 1)	47,16	47,02	1,96	0,95	2,91

Figure 2. *Structure of loam (investigated by scanning electron microscopy).*

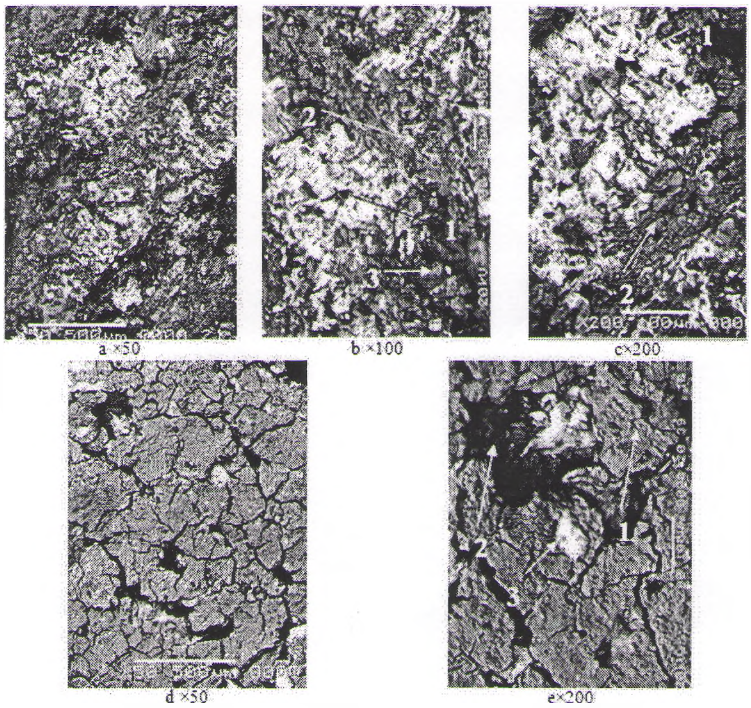
The structure of loam is characterized by the presence of heterogeneous inclusions (Figure 2) and the composition of such inclusions (Table 2).

The composition and structure (Figure 3) of oily cast iron turnings were investigated by scanning electron microscopy on the microscope JSM-5610LV.The study of the composition (Table 3) shows that the average contents of metallic iron is 23,38% in the wet bales, and it is 21,83% in the baked bales at 700 ° C (Figure 3). At the same time, the metal components of the bale contain 61, 63% and 66, 39% of iron respectively.

It is seen that as a result of baking there are microcracks in the bales which do not break down their continuity and durability.

Table 2. *Average chemical composition and structure of the some inclusions of loam.*

Position of inclusion	Contents of elements, % wt.								
	C	O	Mg	Al	Si	K	Ca	Ti	Fe
Fig. 2(average composition)	4,65	42,97	1,61	10,44	24,28	4,35	4,09	0,67	6,93
1 (Fig. 2)	8,58	40,90	2,96	8,77	22,64	2,81	7,47	0,31	5,56
2 (Fig. 2)		37,06	1,36	6,83	16,64	4,64	2,89	0,70	29,88



a, b, c – structure of wet bale; d, e – structure of the bale baked at 700°C.

Figure 3. *Microstructure of the bales with oily cast iron turnings (investigated by scanning electron microscopy).*

Table 3. *Chemical composition of bales.*

Bales with oily cast iron turnings	Position of inclusion	Contents of Elements, % wt.											
		C	O	Mg	Al	Si	P	K	Ca	Ti	V	Fe	Zr
Wet bales	Fig. 3*a*	41,10	23,09	2,02	2,03	4,93	1,86	0,73	0,86			23,38	
	1 (fig. 3*b*) 3 (fig. 3*c*)	28,23	6,14	0,81	0,21	1,62	1,12	0,12	0,12			61,63	
	2 (fig. 3b) 2 (fig. 3c)	49,40	28,58	1,12	2,27	4,75	1,97	1,20	0,86	0,23		9,61	
	3 (fig. 3*b*)	31,90	17,75	1,84	1,91	4,26	3,94	1,09	2,46			34,84	
	1 (fig. 3*c*)	49,77	20,45	1,48	1,76	4,23	2,13	1,54	2,55	1,81	2,83	11,45	
Baked bales at 700°C	Fig. 3*d*	13,70	33,77	2,75	2,88	7,11	9,32	1,14	2,97	-	-	21,83	4,53
	1 (fig. 3*e*)	11.07	46,94	2,33	3,34	5,10	12,78	1,05	9,01			8,39	
	2 (fig. 3*e*)	16,31	33,84	3,04	2,24	4,55	10,32	1,16	2,11			19,42	7,03
	3 (fig. 3*e*)	9,41	21,88	0,14	0,06	0,45	0,28	0,11	0,33			66,39	1,15

3. The Analysis of Physical and Chemical Processes in the Implementation of the Technology of Chemical hardening of Bales of Iron-Containing Materials with Organic Pollutants

In accordance with the developed technology [3] during the chemical hardening the following components are involved: cast iron turnings with an organic pollutants, loam, magnesite, and phosphoric acid solution.

The nature of the physical and chemical interaction between components of the bale in the process of chemical hardening was investigated.

The action of H_3PO_4 on magnesite (it typically contains typically ~ 90% of MgO and ~ 10% of $(MgOH)_2CO_3$):

$$3(MgOH)_2CO_3 + 4\ H_3PO_4\,(excess) \rightarrow 2Mg_3(PO_4)_2 + 9H_2O + 3CO_2;$$

$$3(MgOH)_2CO_3 + 4\ H_3PO_4\,(lack) \rightarrow 2(MgOH)_3PO_4 + 3CO_2 + 3H_2O$$

Interaction of H_3PO_4 with loam:

$$(Na,K)AlO_2 + H_3PO_4 \rightarrow (Na,K)_3\ PO_4 + AlPO_4 + H_2O;$$

$$(Na,K)_2SiO_3 + H_3PO_4 \rightarrow (Na,K)_3\ PO_4 + H_2\ SiO_3$$

Magnesite performs the main function in the process of hardening. Basic salts like $(MgOH)_3PO_4$ or ($MgOHAlO_2$ + $(MgOH)_2SiO_3$) are formed under the following conditions: excess of loam (alkaline medium), lack of magnesite, and the action of H_3PO_4 (acidic medium).

The presence of H_3PO_4 promotes the formation of basic salts of Mg, interaction of additives of industrial oils containing amines when reacting with phosphoric acid:

$$8R\text{-}NH_2 + H_3PO_4 \rightarrow PH_3 + 8R\text{-}H + N_2 + 4H_2O,$$

where R – hydrocarbon residue (benzyl – unsaturated; alkyl – saturated).

An excess of O_2 may cause a reverse oxidation of phosphorus by reaction:

$$PH_3 + O_2 + H_2O \rightarrow H_3PO_4$$

This in turn promotes better oxidation of oils, metal surface (turnings) becomes less hydrophobic, and the process of adhesion of the structural components of magnesite and loam to the surface of the turnings accelerates. When iron contacts acid there maybe not only the destruction of the loose oxide film reacting:

$$3FeO + 2H_3PO_4 \rightarrow Fe_3(PO_4)_2 + 6H_2O;$$

$$Fe_2O_3 + 2H_3PO_4 \rightarrow 2FePO_4 + 6H_2O;$$

$$3Fe_3O_4 + 8H_3PO_4 \rightarrow Fe_3(PO_4)_2 + 6FePO_4 + 12H_2O,$$

but also the formation of denser phosphate film (phosphatization) than the starting oxides had. This contributes to the adhesion and strength of the formed structure.

4. The Study of Metallurgical Utility of Bales of Oily Cast Iron Turnings

The melting of iron with the introduction of blocks of oily cast iron turnings was conducted in the induction furnace of 400 kg capacity.

At the stage of final melting according to the technology [3], developed by the author the alloying modifying additives were introduced in to the metal cast iron in the form of briquettes (Table 4).

The morphology of graphite inclusions was studied on non-etched polished section, and the metal base was studied in the sections after etching. To etch the surface of the section the following reagents were used: 4 ml of HNO_3 (density is 1.4 g/cm^3), and 96 ml of ethyl alcohol.

To determine the structure of cast iron the sections were viewed under the microscope with the following power:

(a) an overview of the structure – at 10 to 200 times power;
(b) to define the form, the principle of distribution , size and number of graphite inclusions – at 100 times power;
(c) the type of metallic base – at 500 times power;
(d) the amount of pearlite and ferrite – at 100 times power;
(e) the dispersion of lamellar pearlite – at 500 times power.

The structure of cast iron was analyzed in accordance with the state standard 3443-87 comparing visually the structure that is visible in the microscope and the structure of an appropriate scale.

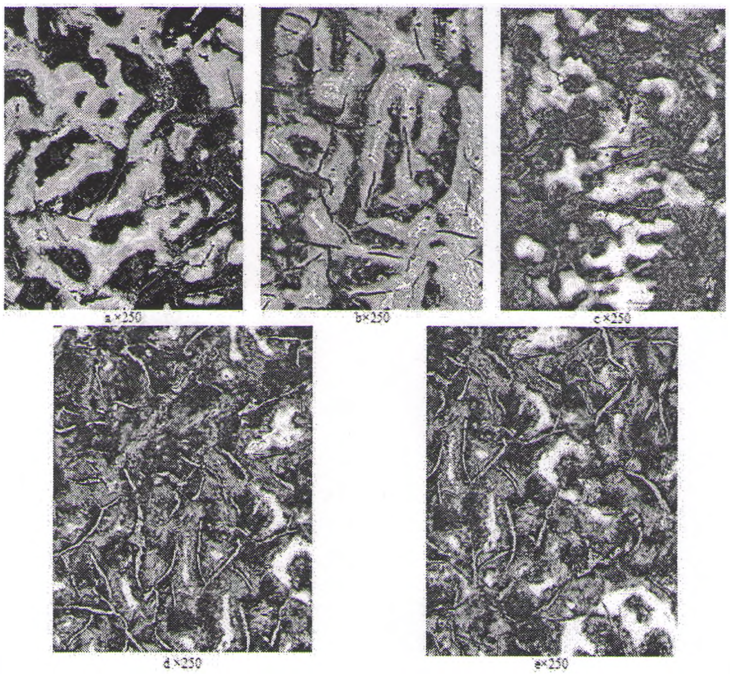
To determine graphite it is necessary to evaluate: form, distribution, size, and number of inclusions of graphite. To determine the metal base it is necessary to evaluate: type of structure, form of pearlite, the amount of pearlite and ferrite, pearlite dispersion.

The structure of the original cast and after introducing the block of oily cast iron turnings (Figure 4) has been investigated according to the state standard 3443-87 (Table 5).

The structure of the original cast (Figure 4a and 5) is gray cast iron with laminar graphite, which forms pearlite around its laminas. The rest is inhomogeneous ferrite. It is formed of cement.

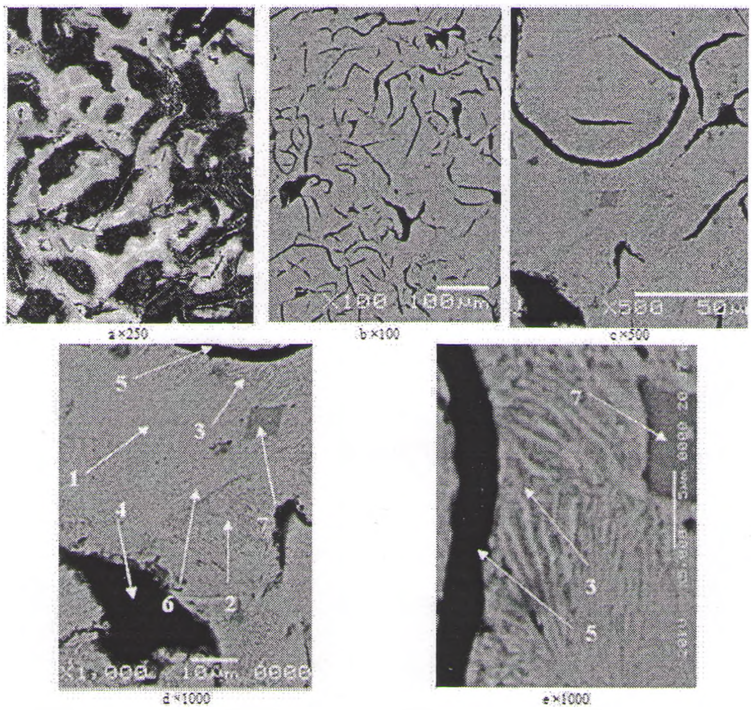
In some types of cast iron with the addition of oily turnings (Figure 4 (b, c, d), 6, 7, 8), the structure is similar. It differs only by the ratio of ferrite and pearlite.

The results of the investigations of the cast iron structure by scanning electron microscopy on the microscope JSM-5610LV using the electron - probe EDX analysis on the IED detector 2201 allowed to determine possible effects of the charge materials to form the macro-and micro-composition, nature of nonmetallic inclusions, specify the composition and morphology of the obtained chemical associations (non-metallic inclusions and other "secondary" phases), and their role in the formation of the elements of the structure (Table 6).



a- original cast iron; b – introduced: oily (8% of oil) cast iron turnings- 7,14%, loam – 0,92 %, magnesite – 0,22 %; c- introduced: oily (8% of oil) cast iron turnings - 14,86%, loam – 1,84 %, magnesite – 0,44 %; high molecular compound -0,23 %; e – introduced: oily (8% of oil) cast iron turnings - 29,18%; loam – 3,70 %; magnesite – 0,87 %; high molecular compound -0,68 %.

Figure 4. *Microstructure of cast iron melted with addition of bales with oily cast iron turnings:*



a – metallographic observations; b, c, d, e – investigations by scanning electron microscopy

Figure 5. *Microstructure of original cast iron (etched samples)*

Table 4. Chemical Composition and mechanical properties of cast iron smelting with oily turnings

Composition of the block	Component composition, % wt.													
	C	Si	Mn	P	S	Mg	Cr	Ni	Mo	Cu	Al	Ti	V	Nb
Original cast iron	2,87	2,39	0,484	0,284	0,079	<0,001	0,082	0,045	<0,001	0,062	<0,001	0,032	0,016	<0,001
oily (8% of oil) cast iron turnings - 7,14%, loam – 0,92 %, magnesite – 0,22 %	3,12	2,26	0,472	0,304	0,089	<0,001	0,089	0,046	0,001	0,058	<0,001	0,030	0,014	<0,001
oily (8% of oil) cast iron turnings- 14,86%, loam – 1,84 %, magnesite – 0,44 %; high molecular compound -0,23 %	3,00	2,27	0,465	0,325	0,084	<0,001	0,099	0,051	<0,001	0,059	<0,001	0,029	0,015	<0,001
oily (8% of oil) cast iron turnings - 29,18%; loam – 3,70 %; magnesite – 0,87 %; high molecular compound -0,68 %	2,98	2,25	0,472	0,316	0,090	<0,001	0,090	0,048	<0,001	0,058	<0,001	0,028	0,013	<0,001

Table 4. (continue)

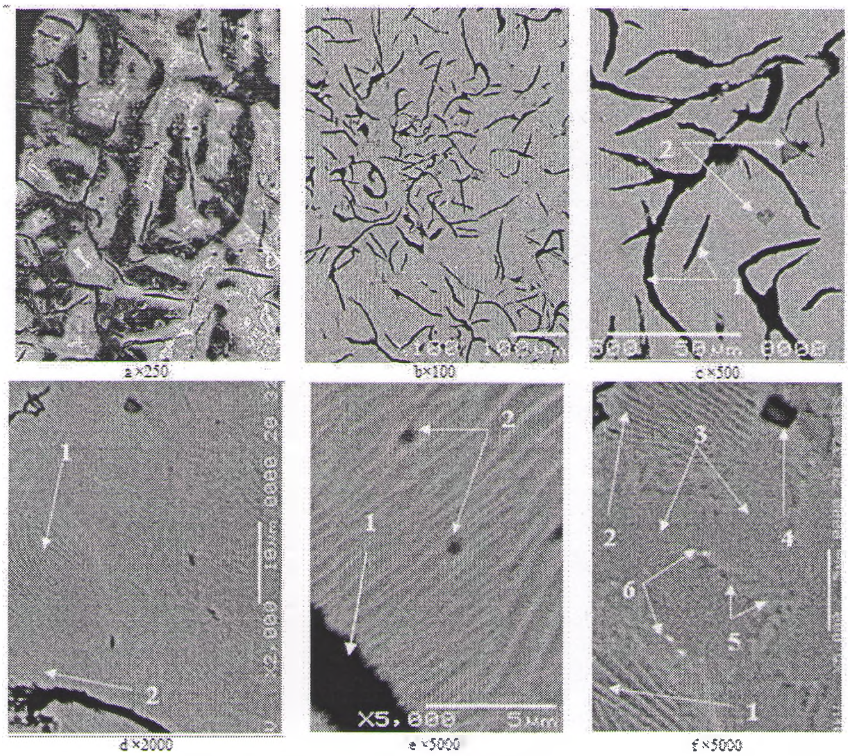
Composition of the block	Component composition, % wt.									Mechanical properties	
	W	Co	Zr	B	Ca	Sb	As	Sn	Pb	Zn	HB, MPa	σ_t, MPa
Original cast iron	0,059	0,003	<0,001	0,0083	<0,0001	0,187	0,007	0,001	<0,001	≈0,050	2070	118,0
oily (8% of oil) cast iron turnings - 7,14%, loam – 0,92 %, magnesite – 0,22 %	0,048	0,002	<0,001	0,0119	<0,0001	0,173	0,006	<0,001	<0,001	0,015	2290	124,0
oily (8% of oil) cast iron turnings- 14,86%, loam – 1,84 %, magnesite – 0,44 %; high molecular compound - 0,23 %	0,052	0,002	<0,001	0,0118	<0,0001	0,164	0,006	0,001	<0,001	0,009	2410	128,0
oily (8% of oil) cast iron turnings - 29,18%; loam – 3,70 %; magnesite – 0,87 %; high molecular compound - 0,68 %	0,041	0,002	<0,001		<0,0001	0,148	0,004	<0,001	<0,001	0,006	2410	133,0

Table 5. Results of the Investigation of the Cast Iron Structure with the Bales of Oily Cast Iron Turnings

Composition of the block	Forms of graphite inclusions	Length of graphite inclusions	Distribution of graphite inclusions	The number of graphite inclusions	Structure type of metal base	Pearlite dispersio n	The amount of pearlite and ferrite	The amount of cement
Original cast iron	Plastic linear PGph1	PGd180	PGph1	PG10	PT1 F	Pd1.4	P45 (Fe55)	C10
oily (8% of oil) cast iron turnings - 7,14%, loam – 0,92 %, magnesite – 0,22 %	Plastic linear PGph1	PGd 350	PGph 1	PG10	PT1 F	Pd1.4	P 45 (Fe55)	C 10
oily (8% of oil) cast iron turnings- 14,86%, loam – 1,84 %, magnesite – 0,44 %; high molecular compound -0,23 %	Plastic linear PGph1	PGd180	PGph 1	PG10	PT1 F	Pd 1.4	P 45 (Fe55)	C 10
oily (8% of oil) cast iron turnings - 29,18%; loam – 3,70 %; magnesite – 0,87 %, high molecular compound -0,68 %	Plastic linear PGph1	PGd 180	PGph 1	PG10	PT1 F	Pd1.4 Pd0,3	P70 (Fe30)	C25

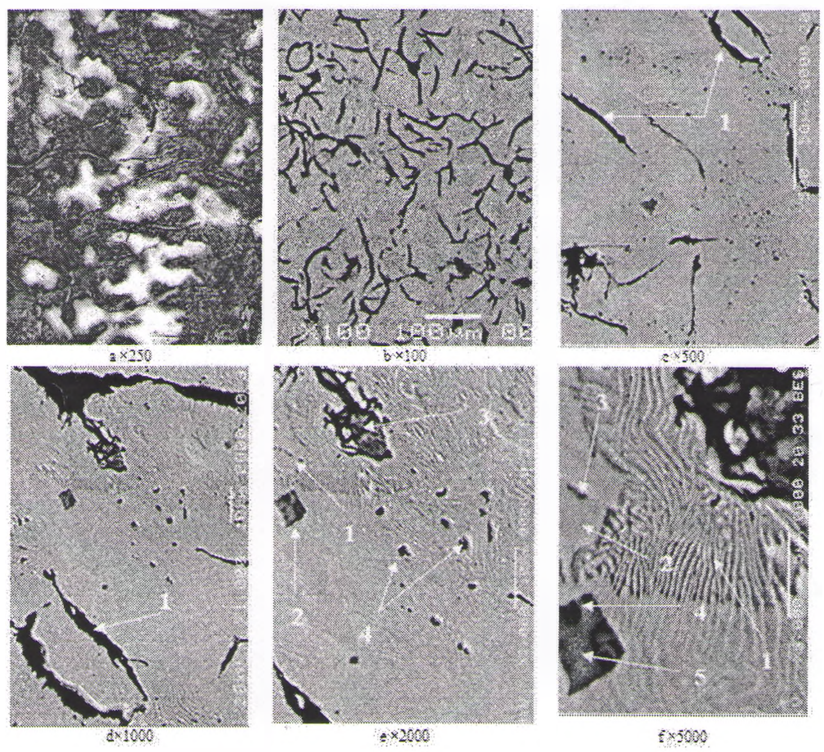
Table 6. Chemical Composition of Cast Iron with Non-metallic Inclusions, smelted with Bales with Oily Turnings in Charge

Composition of Introduced Blocks	Position of Inclusion	Component composition, % wt.											
		C	O	Si	Mn	S	Cr	W	Cu	Ti	Sb	N	Fe
Original cast	1 (fig. 5*d*)	9,81	3,85	1,56	5,27			1,90		0,01			77,61
	2 (fig. 5*d*)	3,14	2,01	2,53	4,85				4,29	0,24			82,93
	3 (fig. 5*d*) 3 (fig. 5*e*)	6,23	6,03	1,96	4,59			1,90	0,15	0,23			78,90
	4 (fig. 5*d*)	71,89	26,34		0,19			0,40	0,02	0,05			1,10
	5 (fig. 5*d*) 5 (fig. 5*e*)	66,71	23,13	0,32	0,86			0,24	0,05				8,68
	6 (fig. 5*d*)	4,93	2,92	2,02	4,97			1,00		0,03		1,30	82,83
	7 (fig. 5*d*) 7 (fig. 5*e*)		42.66		35,81	21,53							
Oily cast iron turnings-7,14%; loam – 0,92 %; magnesite – 0,22 %	1 (fig. 6*c*) 1 (fig. 6*e*)	60,40	16,58	0,54	1,56				0,37	0,17			20,38
	2 (fig. 6*c*)	20,27	9,00	0,46	42,79	21,82		1,02	1,74				2,41
	1 (fig. 6*d*) 1 (fig. 6*f*)		4,61	1,52	4,85	0,26		1,27	0,86	0,14			86,49
	2 (fig. 6*d*) 2 (fig. 6*f*)	4,44	1,18	2,12	5,53			1,66	0,12	0,13			84,82
	2 (fig. 6*e*)	12,64	3,51	1,77	4,31			0,49	1,16	0,02			76,09
	3 (fig. 6*f*)	3,10	3,96	0,20	5,14	0,29	0,58	0,33			0,12		86,28
	4 (fig. 6*f*)	20,23	10,73		0,19	1,28	3,72	8,09	0,10	48,80			6,86
	5 (fig. 6*f*)	8,00	2,72	1,00	4,35			2,96	1,40	0,17			79,40
	6 (fig. 6*f*)	7,60	0,73	0,31	5,55	0,02	0,30	0,53	0.08	0,05	7,76		77,07
Oily cast iron turnings-14,86%; loam – 1,84 %; magnesite – 0,44 %; high molecular compound– 0,23 %	1 (fig. 7*c*) 1 (fig. 7*d*)	75,75	18,71	0,05	0,40	0,02	0,12		0,07				4,88
	1 (fig. 7*e*) 3 (fig. 7*f*	19,78	0,64	1,02	4,44		0,12	0,69			0,65		72,67
	2 (fig. 7*e*)	20.67	2,49		0,15	0,22	2,77	8,41	0,61	56,78	1,45		6,45
	3 (fig. 7*e*)	20,23	1,21	0,17	45,01	25,98	2,04	1,48	0,34				3,54
	4 (fig. 7*e*)	8,82	6,86	1,50	4,69	0,28	0,20	0,24	4,16		0,51		72,75
	1 (fig. 7*f*)	5,70	1,90	1.47	4,97	0,04	0,32	2,06		0,09			83,46
	2 (fig. 7*f*)	10,69	1,10	1,58	4,56	0,17	0,18	1,49	0,47		0,74		79,02
	4 (fig. 7*f*)	17,87	2,41		1,22	0,60	4,84	6,63		53,41	2,03		11,00
	5 (fig. 7*f*)	7,44		0,06		0,89	4,15	9,18		72,34	1,33		4,60
Oily cast iron turnings - 29,18%; loam – 3,70 %; magnesite – 0,87 %; high molecular compound– 0,68 %	1 (fig. 8*d*)	76,37	20,61	0,09		0,01			0,21		0,55		2,17
	1 (fig. 8*e*)	10,08	5,10	1,50	4,87	0,27		0,55	2.54		0,32		74,78
	2 (fig. 8*e*)	3,05		2,54	5,11	0,07		0,38			0,94		97,90
	3 (fig. 8*e*)	9,15	13,35	1,08	3,45		5,07	0.20	1,85	0,02	0,57		65,27
	4 (fig. 8*e*)	16.85		0,29	0,44	0,29	1,56	8,96		66,49	1,19		3,93
	5 (fig. 8*e*)	11,70	0,32	0,46	35,18	19,97	1,20		0,23		0,18		30,75
	6 (fig. 8*e*)	11,12	0,43	0,30	2,39	0,13	0,22	0,83	0,52	43,46	1,66	3,64	35,30
	7 (fig. 8*e*)	2,96	4,87	1,07	4,57	0,13	0,29	1,72	2.95				81,45
	1 (fig. 8*f*)	2,00	1,77	1,73	4,14	0,16		0,11	1,42				88,68



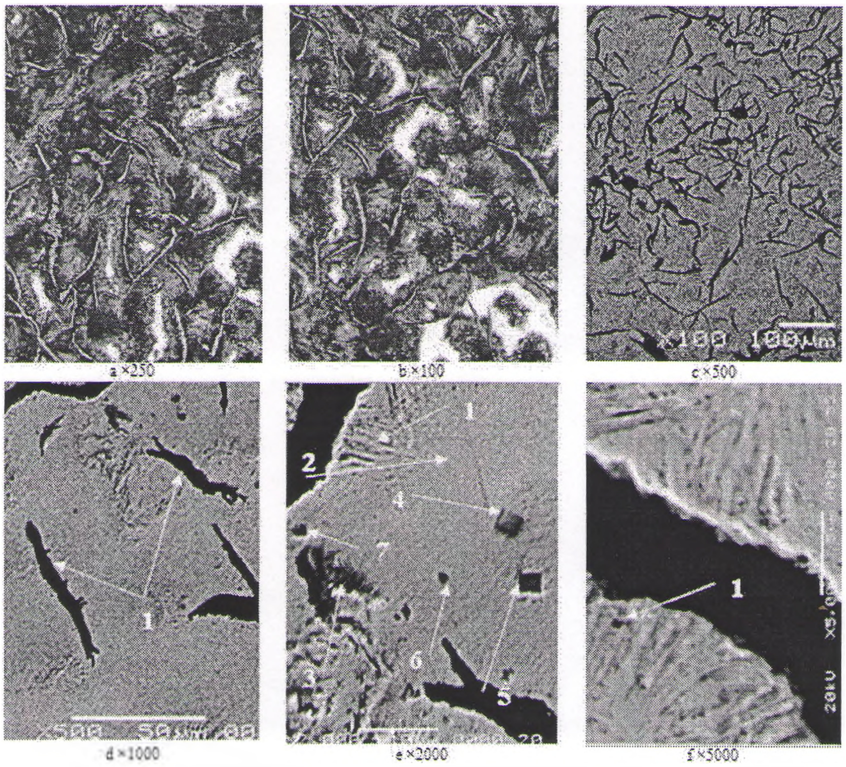
a – metallographic observations; b, c, d, e, f– investigations by scanning electron microscopy

Figure 6. *Microstructure of original cas tiron (etched samples) smelted with bales with oily cast turnings in chargeintroduced: oily (8% of oil) cast iron turnings- 7,14%, loam – 0,92 %, magnesite – 0,22 %*



a – metallographic observations; b, c, d, e, f– investigations byscanning electron microscopy

Figure 7. *Microstructure of original cast iron (etched samples) smelted with bales with oily cast turnings in chargeintroduced: oily (8% of oil) cast iron turnings- 14,86%, loam – 1,84 %, magnesite – 0,44 %, high molecular compounds -0,23 %*



a – metallographic observations; b, c, d, e, f– investigations byscanning electron microscopy

Figure 8. *Microstructure of original cast iron (etched samples) smelted with bales with oily cast turnings in chargeintroduced: oily (8% of oil) cast iron turnings- 29,18%, loam – 3,70 %, magnesite – 0,87 %, high molecular compounds -0+,68 %*

In the cast irons (Figure 4 (b, c, d), 6, 7, 8), melted in the charge of oily cast iron turnings, the increase of the pearlite amount in the metal base, and its dispersion (Table 5), as well as the presence of the significant amount of the finely divided strengthening phases (Table 6), provides the growth of the strength characteristics sσ_t 118.0 MPa to 133.0 MPa σ_t (Table 4).

5. Conclusion

The method of baling iron-containing substances (oily cast iron turnings) containing 0 - 8.0 % organic pollutant is worked out. Loam, magnesite, and acid-containing reagent are used as binders when a bale is made.

According to the developed technology of baling by pegging rammer, oily cast iron turnings with the limit of 8 % weight mass of hydrocarbon oils are placed into chill mold. Visual examination indicates sufficient density and strength of the received bales. In accordance with the manufacturer's specifications the bales were tested for strength by hitting them on a metal plate from a height of 1.5 m. The bales bore 2-3 hittings without breaking. The tests show that the proposed method provides high-quality bales with sufficient mechanical strength.

The developed technology of smelting cast iron allows using iron-containing substances as charge materials, which form a mixture of iron oxides of natural origin or industrial production and metal industrial wastes: iron ore, iron ore concentrate, oxide scale, oily cast iron or steel turnings. Baling materials with organic pollutant is carried out by chemical hardening; no energy-intensive or expensive baling equipment is used. During the process oils are partially oxidized, simultaneously environmental danger decreases, providing thereby high mechanical strength and undamageability of bales at transportation, which provides a high degree of reduction of iron at melting and high quality castings.

The technology for processing metal turnings, particularly oily cast iron turnings, to produce high-quality gray iron is designed to solve the problem of getting cheap products and facilitate the solution of the most important environmental problems. When the current processing techniques are implemented, the afterburning oils and emulsions emit into the atmosphere significant amounts of toxic gases, soot, and dust. In the proposed technology oils and emulsions are significantly oxidized during chemical hardening; being in durable bale volume isolated from the atmosphere, they undergo pyrolysis in the process of heating during melting thereby minimizing emissions.

The composition formula of binding materials for baling (briquetting) cast iron turnings with different degrees of contamination by oils and emulsions comprising loam (alkaline condition), magnesite and oxidizer are worked out. The method of baling oily iron turnings provides high mechanical strength and undamageability of the bales during transportation. Smelting of cast iron was made to determine the metallurgy value packs of the bales (briquettes).

The result of hardening is the formation of the basic salts such as $(MgOH)_3PO_4$ or $(MgOHAlO_2 + (MgOH)_2SiO_3)$ when the excess of loam (alkaline medium), lack of magnesite and H_3PO_4 (acidic medium) are mixed. H_3PO_4 facilitates the formation of basic salts of magnesium, it also promotes the interaction of industrial oil additives containing amines, and it contributes to better oil oxidation. In this case, the surface of cast iron turnings becomes less hydrophobic; it provides a more efficient adhesion of structural components of magnesite and loam to the metal surface. When iron reacts with phosphoric acid film, the decomposition of loose oxide film can be observed.

The process of formation of non-metallic inclusions is scientifically proved. The microcomposition and morphology of the obtained chemical associations are investigated, the mechanisms of interaction of the chemical components of charge, containing industrial wastes and by-products of the related industries is clarified, when the resource-saving technology is implemented.

Thus, oily cast iron turnings can be efficiently recycled with the proposed technology.

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