A NEW TYPE OF DUCTILE IRON FOR THE AUTOMOTIVE INDUSTRY

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Abstract

The paper deals with a new type ductile iron. Casting irons are most widely used construction materials all over the world. Our main aim was to look for a constructional material that would have the mechanical properties and homogenous structure homogenous in different wall castings. We believe that ferritic ductile iron grade 400-15 with a tensile Rm = 400 MPa meets the requirements. This material has a better machinability when compared to conventional grades. In spite of some disadvantages, e.g. lower strength yield good tensile, other characteristics as low costs of production or very good casting properties demand using of this sort of material. At our Department of Mechanical Engineering at the Technical University of Liberec, we deal with metallurgical preparation, structure and mechanical properties of a new type of ductile iron.

1. Introduction

Spheroidal graphite cast iron with a higher amount of silicon is a strong material with a high carbon 3,5 to 3,9 % and content of silicon max. 2,9 %, magnesium 0,03 to 0,06 % sulphur max. 0,015 %, phosphorus max. 0,04 %. It can be easily melted and cast into moulds. Production of ductile cast iron belongs to quite complex problems. The major factors effecting the properties are: melting metal processing, chemical composition, solidification and the cooling rate of the solid. The problem of globular graphite formation and controlling of casting structure, and thus their mechanical and physical properties require good management of basic knowledge. There are also special properties to be aware of to ensure crystallization of individual types of casting irons. The chemical composition is the primary factor affecting graphite shape control, and it has a major influence on the metallic matrix. Of course, for a successful production of ductile iron it is not enough to keep a chemical composition in the frame of prescriptions. The requisite graphite shape and the metallic matrix microstructure are very much influenced by inoculation and nodulization. A very important factor is the type of nodulizer and nodulizing processes. Nowadays, Compactmag or FeNiMg alloys are used. The processes of inoculation and the chosen type of inoculant result in the casting quality. In early times of the ductile iron production, inoculants taken from the grey iron production, especially FeSi 75 were used. Currently, inoculants FeSi 75 and Superseed have replaced them. As results were not satisfactory as excpected, small amouts of additions were necessary; they ensure more uniform and smaller size of metallic matrix grants and graphite globulars. They are generally based on ferrosilicium, whereas they contain one or more of the minor elements like magnesium, calcium, cerium, zirkonium or other rare earth elements, to stimulate their inoculating effects.

2. Practical experiments by production ductile iron with a higher amount of silicon

At our Department of Mechanical Engineering practical experiments were made. The castings were produced from ductile iron with a higher amount of silicon. As a melting unit a medium frequency induction coreless furnace Indukce IO 40 was used; its capacity I of 40 kg of melted metal. All the melting was carried out under the same conditions of melting, magnesium treatment (noduliziring) and inoculation. As the charge material, a pure raw iron (SORELMETAL) was used. The iron was melted with a first batch of FeSi 75 for increase of Si amount. A sandwich method was chosen for magnesium nodulization. The chemical composition of SORELMETAL is in Tab. 1; and nodulizer is in Tab. 2. During the application research, a question appeared about a correct and sufficient method of inoculation. The chemical composition of inoculant is in Tab. 3.

Tab. 1 Chemical composition of charge material SORELMETAL

Composition [%]						
Fe	**C**	**Si**	**Mn**	**P**	**S**	**Ni**
95,48	4,25	0,15	0,013	0,026	0,01	0,007

Tab. 2 Chemical composition of nodulizer (type MgFeSi)

Composition [%]					
Fe	**Si**	**Mg**	**Ca**	**Ce**	**Al**
Rest	43,6	5,6	<0,05	<0,01	<0,02

Tab. 3 Chemical composition of inoculants

Composition [%]					
Type of inoculant	**Si**	**Fe**	**Ca**	**Al**	**Sr**
FeSi 75	75	25			
Superseed	75	Rest	0,1	max. 0,5	0,8

For casting production we applied castings industry. These casings are the determination for the structure, mechanical properties (tensile and Brinell hardness) testing. The patterns of castings from the ductile iron are shown in Fig. 1. In this case we made melts of its composition of charge, as shown in Tab. 4. The quantity of inoculants and nodulizers can be seen in Tab. 5. We realized two steps of the inoculation method. The first step was inoculation with FeSi 75 as a cover of nodulizer, and the second step was the effected adding into a ladle before pouring. In Tab. 6 there is information on the chemical composition of test melts. A mould had been made from sand bentonite mixture. Microstructure of castings were looked at with the microscope Neophot 21 and microscope REM. These structures are illustrated in Fig. 2 to 4.

Fig. 1: Patterns of castings from ductile iron (lever and hub)

Tab. 4 The composition of charge

Melt number	Charge [kg]			
	Sorelmetal [kg]	Reversible material [kg]	FeSi 75 [kg]	FeMn 65 [kg]
1	3,6	12,70	0,01	0,01

Tab. 5 The quantity of inoculants and nodulizers

Melt Numer	Inoculants [kg]		Nodulizers [kg]	
	FeSi 75	Superseed	Rare earth metal	MgFeSi
1	0,098	0,065	0,0029	0,293

Tab. 6 Chemical composition of test melts

Melt number	Composition [%]								
	C	Mn	Si	P	S	Cr	Mg	CE	Sc
1	3,31	0,131	3,92	0,025	0,009	0,023	0,035	4,57	1,12

In the scope of research work, Brinell hardness of castings was tested. For a higher speed, we used a method (HBW 5/750 kp). The results of HB, Brinell hardness and microstructure of the ductile iron are in Tab. 7.

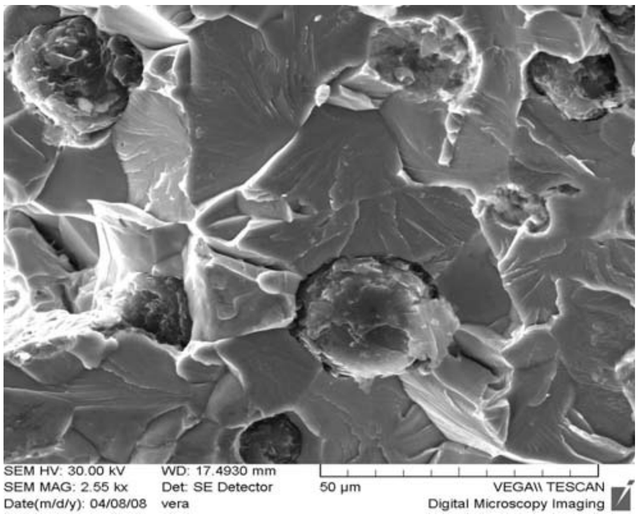
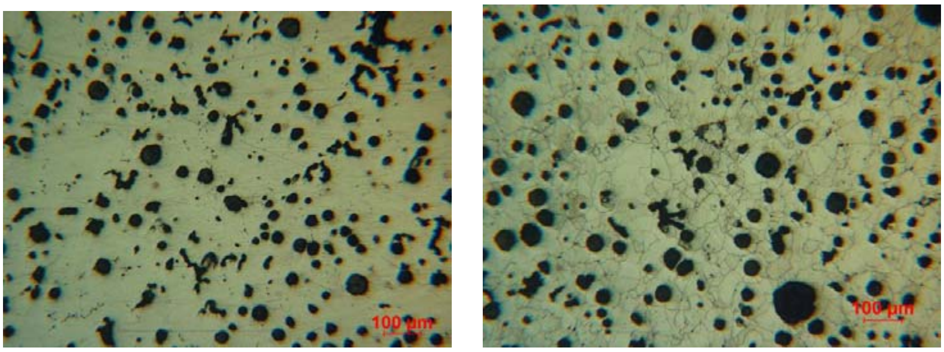


Fig. 2: Microstructure of ductile iron with a higher amount of silicon



Non-etched 100x Nital 100x

Fig. 3: Structure of ductile iron with a higher amount of silicon (lever - of thickness wall casting 18 [mm])

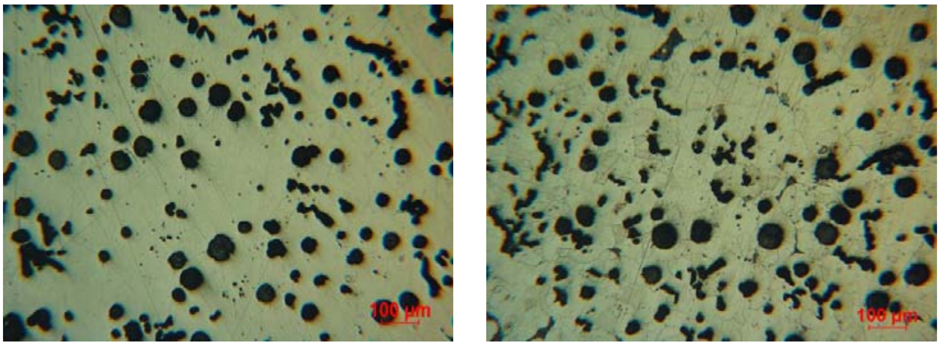


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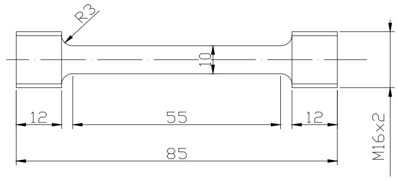
Fig. 4: Structure of ductile iron with a higher amount of silicon (hub of thickness wall casting 20 [mm])

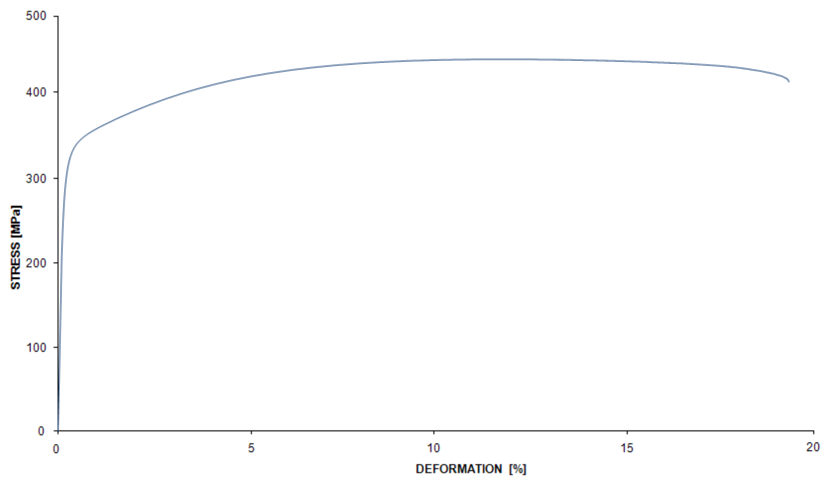
Tab. 7 Results of casting from ductile iron

Casting	Thickness of wall casting [mm]	Brinell hardness [HB]	Graphite shape	Matrix
Lever	8	202	50 % VIA 6 + 50 % VIA 7	Fe
	11	200	80 % VIA 5/6 + 20 % IIIA 5	Fe
	18	198	90 % VIA 6 + 10% IIIA 5	Fe
	55	193	80 % VIA 6 + 20 % VIA 5	Fe
Hub	12	201	80 % VIA 6 + 20 % IIIA 5	Fe
	20	200	80 % VIA 5/6 + 20 % IIIA 5	Fe
	34	200	90 % VIA 6/7 + 10 % IIIA 5/6	Fe
	55	197	80 % VIA 6/7 + 30 % IIIA 5/6	Fe

Simultaneously we cast Y-blocks. From these blocks we made samples for monitoring of the tensile strength and elongation.



a)



b)

Fig. 5: Tensile test: a) test bar for tensile test
b) stress - stain diagram

Conclusion

The paper describes the production of the new type of ductile iron, i.e. ductile iron with a higher amount of silicon. The hardness variation is an important parameter as it has a direct effect on machinability. The material with about 3,92 % silicon is the ductile iron 440-20 i.e. Rm = 440 MPa. The results of Brinell hardness test (5mm/750 kp) are 193 to 201 [HB] for 18 to 20 [mm] thickness wall of casting. There are structures in castings 80 to 90 % globular graphite and ferrite matrix 100 %. This material has better machinability compared to conventional grades and is widely used in the vehicle industry.

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DER NEUE TYP DES MODIFIZIERTEN GUSSEISENS FÜR DIE AUTOINDUSTRIE

Dieser Beitrag beschäftigt sich mit der Herstellung von Gusseisen mit Kugelgraphit und höherem Siliziumgehalt. Es wurde ein Konstruktionsmaterial (Baustoff) gesucht, das eine Homogenität von mechanischen Eigenschaften in verschiedenen Wänden des Gussstückes ausweisen würde. Diese Bedingungen erfüllt das Ferritgusseisen mit dem Kugelgraphit des Typs 400 – 15, mit der Festigkeit Rm = 400 MPa. Dieses Material weist eine bessere Bearbeitbarkeit auf als der traditionelle Gusseisentyp mit Kugelgraphit. In dieser Zeit beschäftigen wir uns an der Technischen Universität in Liberec mit der metallurgischen Gusseisenherstellung mit Kugelgraphit mit höherem Siliziumgehalt und in diesem Beitrag präsentieren wir unsere Ergebnisse.

NOWY GATUNEK ŻELIWA MODYFIKOWANEGO DLA PRZEMYSŁU SAMOCHODOWEGO

Artykuł poświęcony jest zagadnieniom związanym z produkcją żeliwa z grafitem kulkowym o większej zawartości krzemu. Poszukiwano materiału konstrukcyjnego, który charakteryzowałby się homogenicznością właściwości mechanicznych w różnych ściankach odlewu. Takie właściwości posiada żeliwo ferrytyczne z grafitem kulkowym typu 400-15 o wytrzymałości Rm = 400 MPa. Materiał ten posiada lepsze właściwości mechaniczne niż tradycyjne rodzaje żeliwa z grafitem kulkowym. W Katedrze Technologii Budowy Maszyn, na Wydziale Budowy Maszyn Uniwersytetu Technicznego w Libercu prowadzimy obecnie prace dotyczące metalurgicznego przygotowania żeliwa z grafitem kulkowym o większej zawartości krzemu. W niniejszym artykule zaprezentowano wyniki prowadzonych przez nas badań.

NOVÝ TYP MODIFIKOVANÉ LITINY PRO AUTOMOBILOVÝ PRŮMYSL

Příspěvek se zabývá výrobou litiny s kuličkovým grafitem s vyšším obsahem křemíku. Byl hledán konstrukční material, který by vykazoval homogenitu mechanických vlastností v různých stěnách odlitku. To splňuje feritická litina s kuličkovým grafitem typu 400 – 15, pevností Rm = 400 MPa. Tento materiál má lepší obrobitelnost než tradiční typy litiny s kuličkovým grafitem. V současné době se zabýváme na Katedře strojírenské technologie Fakulty strojníTechnické univerzity v Liberci metalurgickou výrobou litiny s kuličkovým grafitem s vyšším obsahem křemíku a v tomto příspěvku prezentujeme naše výsledky.