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INVESTIGATION OF THE POSSIBILITY OF DUCTILE IRON PLASTICITY INCREASING

ДОСЛІДЖЕННЯ МОЖЛИВОСТІ ПІДВИЩЕННЯ ПЛАСТИЧНИХ ВЛАСТИВОСТЕЙ ВИСОКОМІЦНОГО ЧАВУНУ

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Cast iron with spheroidized graphite (ductile iron) finds lot of application as material for details, which must combine the high strength, plasticity with good cast properties, in order to be produced by casting. Main peculiarity of ductile iron as material is dependence of its mechanical properties mostly on microstructure (ferrite/pearlite ratio, degree of nodularization, size and distribution of graphite particles). But formation of these parameters depends not only on chemical composition, but on time-temperature parameters of cast mould pouring and following crystallization of metal. That's why choosing of optimal ductile iron composition needs experimental determination of chemical composition for certain detail. It is time and cost consuming process.

The determination of material composition and manufacturing technologies, which permit to obtain high level of mechanical properties in details with different wall thickness is actual task. In this case there will be no necessity to experimentally adjust the composition of material for details with different geometrical parameters. For example, authors of article [1] proposed variants of technological process of ductile iron production with extremely high complex of mechanical properties, relative elongation A_5, in particular, for wide range of geometrical parameters of details. Process includes high quality raw material selection, using of multicomponent nodularizators and heat treatment of cast part. This technology permits to obtain combination of strength and plasticity, that exceed the requirements of standard [2].

But this technology has high productive cost. The main aim of current investigation was to develop less expensive technology for cases, when main requirements was high plasticity – relative elongation A_5 more than 15% in combination with R_m in the range 400 – 500 MPa. Main approach was to obtain fully ferritic matrix of the ductile iron in details with wall thickness in the range 10 – 40 mm without heat treatment. This result may be obtained with using of iron compositions with increased content of Si. Materials of this type are included in standard [2] under the name of spheroidal graphite cast iron with a matrix mainly consisting of ferrite, solution strengthened mainly by silicon. But standard does not determine the chemical composition of such iron, it determines only grades, in particular EN-GJS-450-18 ($A_5 \geq 18\%$, $R_m \geq$ 450 MPa) and EN-GJS-500-14 ($A_5 \geq 14\%$, $R_m \geq 500$ MPa).

Ductile iron was produced from pure raw materials – scrap of low-carbon steel and ductile iron return scrap by melting in electric induction furnace and treatment of molten iron in the ladle by Fe-Si-Mg nodularizator (1,5 kg/t). Following composition, proposed in [3] was used as basis for experimental determination of new composition (Table 1, Test 1)

Table 1

Chemical composition of metal in the ladle after pouring, % wt.

Technology	C	Si	Mn	Mg	P	S	R_m, MPa	A_5, %
Test 1	3,63	2,48	0,3	0,0418	0,04	0,011	585	10,6
Test 2	3,21	3.21	0,19	0,036	0,021	0,009	506	16
Test 3	3,49	3,43	0,37	0,037	0,02	0,006	566	14
Test 4	3,51	3,53	0,44	0,033	0,018	0,006	610	18

To obtain the fully ferritic matrix, it is necessary to increase the content od Si, but as it was shown in [3], it may lead to decreasing of tensile strength and plasticity due to increasing of ferrite pearlite ratio in combination with solid solution strengthening of ferrite and its embrittlement. To compensate this effect, the content of sulfur and phosphorus must be decreased simultaneously. Carbon content was decreased too. Examples of experimental compositions and their mechanical properties are shown in Table 1.

General view of microstructures for analysis of graphite particles parameters and ferrite pearlite ratio are shown at Fig. 1. Microstructure is formed by fully ferritic matrix with dispersed, well spheriodized graphite particles. Quantitative parameters of microstructure are shown on Fig. 1.

From analysis of mechanical testing results depending on chemical composition it is possible to make an assumption that increasing of silicon content up to 3,53% and carbon content up to 3.5% leads to increasing of strength properties. Tensile strength, comparable with the properties of GJS-500-7 ДСТУ EN 1563:2015 ductile iron with ferritic/pearlitic matrix may be obtained with increasing of plasticity to the level of 14-18%. But simultaneous decreasing of sulfur and phosphorus is necessary.

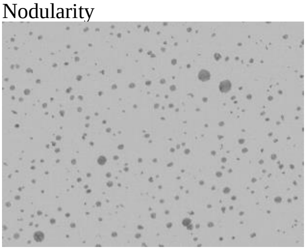
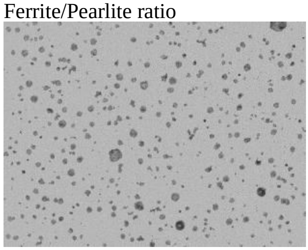
Technology Test 4	Nodularity 	Ferrite/Pearlite ratio 
Parameters according to ISO 945	Graphite form – VI Nodularity – 90% Nodular density -250 n/mm^2 Graphite size – 6	Ferrite/pearlite ratio 100%/0%

Fig. 1. Microstructure of ductile iron with highest mechanical properties (Test 4)

Conclusions. Obtained results shows that the ductile iron for cast details with wall thickness up to 40 mm with mechanical properties that corresponds to grade EN-GJS-500-14 ДСТУ EN 1563:2015 may be obtained without heat treatment due to reglamentation of C, Si, Mn content and decreasing of S and P content.

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RESOURCE-SAVING TECHNOLOGY FOR STRENGTHENING PRESS EQUIPMENT IN CONDITIONS OF SELF-PROPAGATING HIGH-TEMPERATURE SYNTHESIS WHEN OBTAINING SPECIAL-PURPOSE PARTS

РЕСУРСОЗБЕРІГАЮЧА ТЕХНОЛОГІЯ ЗМІЦНЕННЯ ПРЕСОВОГО ОСНАЩЕННЯ В УМОВАХ САМОРОЗПОВСЮДЖУВАЛЬНОГО ВИСОКОТЕМПЕРАТУРНОГО СИНТЕЗУ ПРИ ОТРИМАННІ ДЕТАЛЕЙ СПЕЦІАЛЬНОГО ПРИЗНАЧЕННЯ

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Strengthening of structural materials with multicomponent chromium coatings obtained under non-stationary temperature conditions of self-propagating high-temperature synthesis (SHS) is a promising way to obtain