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The Optimization of Costs and the Carbon Content in Cast Iron

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Abstract

In the article was introduced the conceptions of the optimization of the cast-iron batch near the use the mathematical programmer MATLAB. The results of industrial tests were showed with the use of the batch from sheet metals. It was showed on the possibility of formulating the tasks of optimizing with the use of the programming linear. It was showed on more effective utilization the power of productive foundries and minimalizing losses coming into being in the result of the inappropriate selection of the raw material composition. The conduct of optimizing the intervention of the fusion of cast iron was talked over.

Keywords: Cast-iron, Optimum chemical composition, Zinc influence on iron

1. Introduction

Pig iron is the significant component of costs while the fusion. The price of pig iron still grows and the enlargement her part in charges for obtainment of the suitable content of the carbon raises the costs of the cast [1-3]. One gives to notice the made difficult access to materials fulfilling definite requirements on the raw material market. Applying among others optimum methods enabling the quick correction of the carbon lets on reduces the costs of the production bearing this alone the quality of cast iron. Situation such forces the casting industry to the search of the new solutions of receiving cast iron. The analysis of costs shows on the possibility of getting profitable economic effects using to the charge of sheet metals dragged zinc.

From the attention on the fact, that the obtainment of the suitable structure is problem in the production of cast iron, related with the content of the carbon in the liquid state closely, one can distinguish among others two the main areas which they should be subject to the optimisation:

- the technology
- costs.

In the area of the preparation of the preliminary batch cast iron, particularly near establishing the component proportions of the furnaceman bearings, there are no checked and good, mathematical optimum solutions [4-6]. Special difficulties step out near the questions of batches with recognized elements for pollution, how zinc [6].

The problem of the suitable selection of added materials as the of the programming rope task will allow to use the power of productive foundries minimalizing losses coming into being in the result of the proper selection of the raw the material composition [5]. The majority of the foundry possesses extends chemical laboratories allowing to the qualification of the chemical composition of individual articles. The test of the optimisation of the process of fusion with regard of the presence in the charge of zinc possible is so, near the help of maximization and the minimization of the linear function and near the limitations of equality or unevenness.

The study is the aim of the work and verifying in the industrial conditions of optimisation programme enabling adapting the entrance composition to the waited proprieties of cast iron. The use in the production will be introduced on the examples of charges dirtied zinc.

2. The analysis of the question

2.1. The optimization of batch through the minimization of costs

Thanks to utilization of the packet mathematical possible MATLAB is comparison of costs of producing cast iron near utilization of accessible materials and near regard of only their parts to this alone quantity. The problem of optimizing the cast-iron batch was defined in the following way:

near limitations $c^{\mathrm{T}} x$,

with $A_X \geq b$, $x \geq 0$, (6.3.1.1.1.)

where , $x = (x_1 ... x_n)$ - x_i is the quantity of and-this material used to the production of the definite species of cast iron

where, $c = (c_1 ... c_n)$ – c_j is the price of the purchase of the individual of j-this material

where $A_{[a_{ij}]}$ is the matrix of the type m x n defining the contents settled chemical elements in materials used to the production - a_{ij} (he is the quantity of and-this element in the individual of j-this material)

$b = (b_1 ... b_m)^T$ -where. b_i is the admissible content of and-this element in melting

Formulating the objective question raw materials losses coming into being in the process of melting were considered. Taking into account zinc additionally the minimum and maximum contents of the main components and pollutions in cast iron were established, - maximally 0,002 % masses. and the chemical composition of added materials (pig iron, cast-iron scrap-iron, sheet metals with zinc and steel scrap-iron black).

So the written programme lets observe as the composition will change the chemical and total cost of the mixture, when we alter one parameter. We can change raw the materials parts, the prices of the purchase, raw the materials parts or the content of elements.

2.2. Analysis from the maximization of the content of the carbon

Problem was transformed from the task of the minimization of costs on the function of aim as the task of maximization from attention on the essential part of the content of carbon in the production of sferiond cast iron. Our task looks as follows then:

to maximalize $c^{\mathrm{T}} x$

near limitations $Ax \leq b \qquad x \geq 0$ (6.3.2.1)

Remaining foundations similarly as in the previous case with except:

$b = (b_1 ... b_m)^T$ -where. b_i is the admissible content of carbon in melting

3. The test industrial

3.1. Technological tests for the minimization of costs

Process with the utilization worked out programme founded technological tests for the minimization of costs receipt of the exit cast iron of qual . EN-GJS-500-7 in the quantity 4000 kg. The use of the method of programming linear near solving the problem of the optimization of the melting of cast iron allowed to comparison and the opinion of the large number of the variants of the compositions of the batch what - was introduced in the appendix. Only several chosen examples were put in the work. The obtainment of cast iron about the composition was put for first cycle(%): C - 3.9, Si - 1.2, Mn - 0.2, P - 0.02, S - 0.01, Zn 0.002. The outcome window was already introduced on fig . 1. the whole the calculation, for the received foundation. The patern of the received conduct is introduced below.

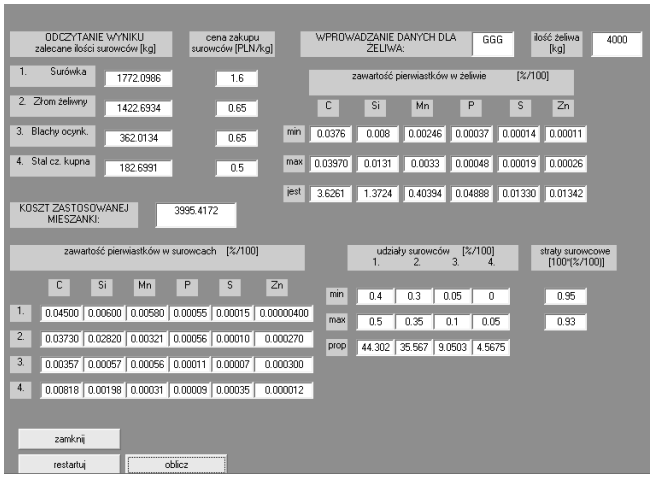

Fig.1. The window of the optimizing programme - the minimization of costs

Taking into account the losses the raw the materials quantities of individual added materials were established, without the coal factor, the added bearings of the stove *(*fig.1) was holding.. Loading of the stove in the following order:

1) the salad + sheet metal zinc-plated,
2) the steel scrap-iron black + salad,
3) the current scrap-iron + salad

After finishing the process of the fusion take the tests from the crucible in the aim the settlement the chemical composition

before and after the modification the seasoning Si75 % required cast iron was received.

Being based on the preliminary data decide to mark the quantities of materials skipping (fig.3) entirely or partly (fig. 2) raw materials parts.

As the proposal introduced on fig.2 shows the programme he can not be received for planned melting with the part of sheet metals zinc-plated from the attention on the proposed part of sheet metals zinc-plated (despite the minimum content of zinc). Because the study of the technology of melting is the main aim with their part in the quantity from. 5% to even 30% the conduct he is not recommended. The content of the carbon should us however convince that he is profitable for the party of zinc as exclusively dirts.

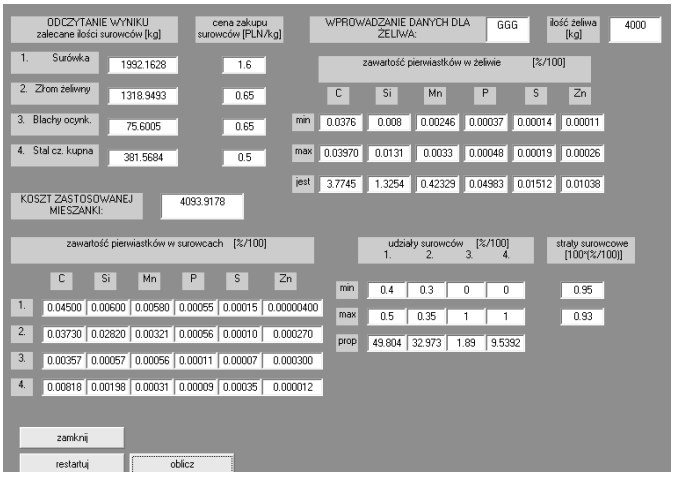

Fig.2. The optimization of melting without defining the parts of sheet metals zinc-plated and steel scrap-iron - the minimization of costs

For second course of the conduct, renouncement from the qualification from the mountain of the parts of materials, it was introduced on drawing 3.

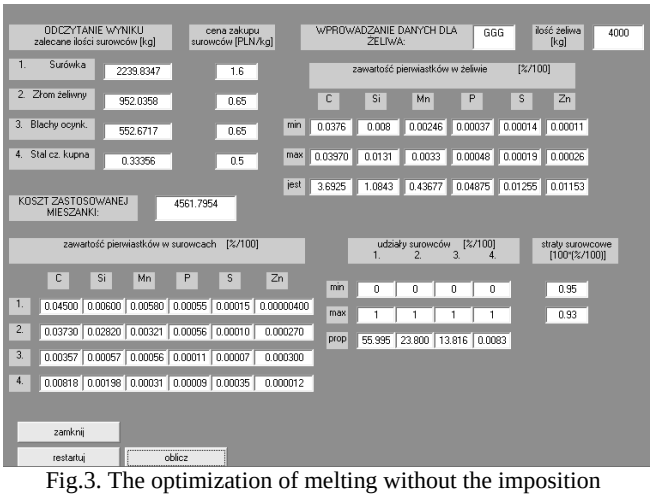

Fig.3. The optimization of melting without the imposition of the parts - the minimization of costs

In this case, what the truth fulfils the part of sheet metals zinc-plated our expectation, but the suggested content of the carbon is already lower and what the most important is the total cost of the mixture higher.

Table1.
The chemical Composition of cast iron according to proposals introduced on drawings 1-3

No.	Cost	Chemical composition %					
		C	Si	Mn	P	S	Zn
1	3995	3,6	1,3	0,4	0,048	0,013	0,01
2	4093	3,7	1,3	0,4	0,049	0,015	0,01
3	4562	3,6	1,0	0,4	0,048	0,0125	0,01

3.2. Industrial tests near endeavour optimization through the maximization of the carbon content

The maximization of the content of the carbon was accepted this time for the criterion. The parts of all materials were qualified in first case from the mountain. What came true then it will happen when the part of the salad be enlarged. And would let by the programme itself on the end he proposed proportions for cast-iron scrap-iron and salad. Results were taken down in the table 2 .

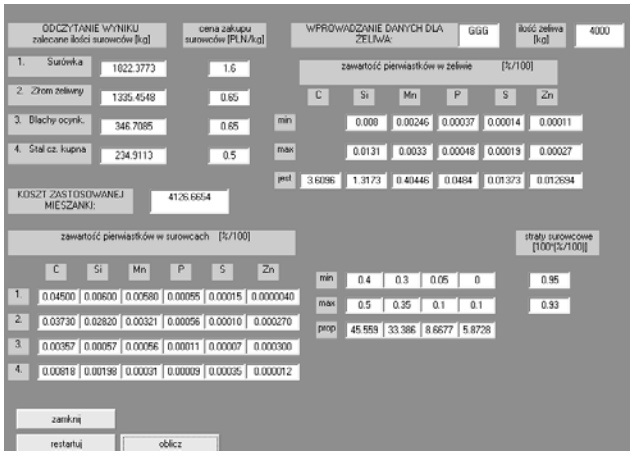

Fig. 4. The optimization of batch near the qualification of raw the materials parts - the maximization of the content of the carbon

The analysed example shows that raw materials parts play the not only essential part in the obtainment of cast iron about the demanded chemical composition but also in costs. Enlargement of the part of the salad about 10 % did for what gave the larger content of the carbon, and every he goes the decrease for this the cost of used coal factors (fig.5) underwent.

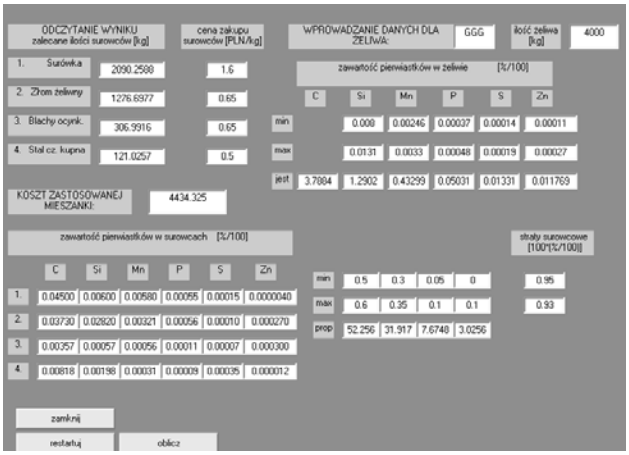

Fig. 5. the Optimization of the batch- enlargement of the part of the salad - the maximization of the content of the carbon

As previously it was described from the attention on the main aim of the work what there is the optimization of the melting of cast iron with the part of sheet metals zinc-plated, bottom and upper limitations were accepted for them. Waiting the proposal of the programme (fig.6) the prompt was not passed for remaining.

Table 2.
The composition results the chemical composition melting for tests according to fig.4-6

No.	Cost	Chemical composition %					
		C	Si	Mn	P	S	Zn
7.1.2.1	4126	3,60	1,31	0,40	0,05	0,01	0,01
7.1.2.2	4434	3,78	1,29	0,43	0,05	0,01	0,01
7.1.2.3	4405	3,59	1,11	0,42	0,05	0,01	0,01

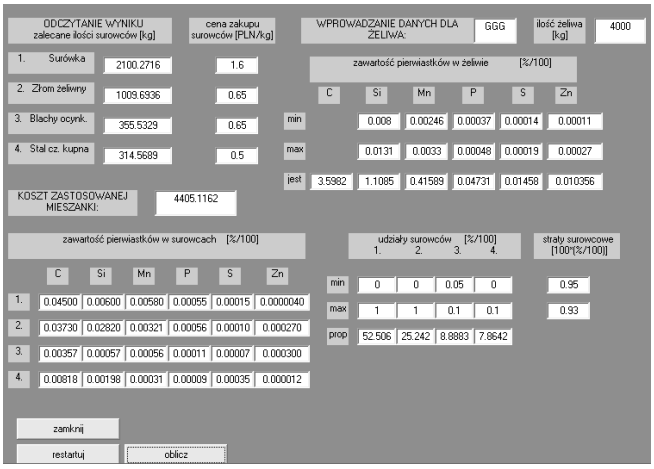

Fig.6. The optimization of the batch with qualification of the parts of sheet metals, zinc-plated and steel scrap-iron (with omission of imposition from the mountain of the parts of salad and current scrap-iron) - the maximization of the content of the carbon

3. Summary and conclusions

Underlining once again the meaning of the precision in the planning of melting turn the special attention on the fact, that we could not let on comparison of such number of variants without the help of the packet computational MATLAB.

The comparison of the of chemical analyse all of conducted tests with the proposals of the programme shows, that though melting is already the folded physics-chemical process this on the preliminary stage of establishing the batch we can partly foresee the chemical composition of exit cast iron. The results of investigations will let lower on the introduction of next computational variants letting both the costs of exploitation how and the influence on the environment

Above mentioned examples show that manipulating only raw materials parts we can get various results near the same criterion near utilization of these alone materials.

References

[1] W. Kurz, D. J. Fisher, Fundamentals solidification, Trans. Tech. Publ. Second Edition, London–Paris, 1984.

[2] J. Gawroński, J. Szajnar, The conditions of close-grained structure formation in castings of solidification with magnetic field, Acta Metallurgica Slovaca, vol. 4, No. 2 (1998) 224-230.

[3] E. Fraś, Crystallization of metals, WNT, Warsaw, 2003 (in Polish).

[4] S. Pietrowski, g. Gumienny, B. Pisarek: Arch. Odlewnictwa, nr 17, R. 5, 2005, 417.

[5] A. Zalewski, R. Cegieła: *MATLAB – obliczenia numeryczne i ich zastosowanie*, Wydawn. NAKOM, Poznań, 2001.

[6] M. Grzybowska, A.W. Bydałek, A. Cegielski: Arch. Odlewnictwa, nr 18, R.6, 2006, 523.