The simulation method of chemical composition of vermicular graphite iron on the basis of genetic algorithm

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Abstract. The paper presents a methodology of modeling the chemical composition of the composite material via genetic algorithm for optimization of the manufacturing process of products. The paper presents algorithms of methods based on intelligent system of vermicular graphite iron design.

Progress in industry is inextricably linked with the development and wide deployment of advanced materials: volumetric nanomodified materials, composite materials, steel and cast iron for special purposes. Cast iron with vermicular graphite (CGI) has a number of specific properties that place it at the number of new promising structural materials for various purposes castings [1, p. 170].

Currently there is no complete theoretical description of the chemical mechanism of the process of graphite forms formation, as there is no satisfactory explanation of the influence of various spheroidizing and graphitizer modifiers on the final performance properties.

In this regard, modeling of optimal chemical composition on the basis of input information about the required physical and mechanical properties will reduce the number of experimental studies and will allow producing castings of the required quality CGI, without a large number of production operations, which will ultimately have a positive impact on the cost of manufactured parts.

Modeling of technological process based on the determination of optimal chemical composition in the final stage of detail processing and find the optimal process parameters to obtain a given chemical composition. Criteria of optimality in solving this problem are quality indicator (at the stage of finishing) and cost parameters (at all other stages).

The structural model of formation of technological process on the basis of the inverse problem [2, p. 72-78] (finding the optimal composition on physical and mechanical specified value) is presented in figure 1.

When modeling the following tools of knowledge-base intelligent system of CGI design are used [3, p. 2] (figure 2):

- rule base;
- precedents database;
- cascade neural network.
Technological process modeling (on the basis of the inverse problem)

The rule base serves as a tool to determine various parameters of chemical composition and provides control of the restrictions and requirements imposed on the CGI design process.

Using precedents database the response of the system (without model) on the output parameters of technological process is checked. On the basis of the obtained parameters the precedent is composed and the availability of similar precedents in the precedent database is being searched.

Cascade neural network is the main tool for predicting the physical-mechanical properties according to the parameters determined by the parameter of chemical composition, which are determined by the rule base.

Figure 1 – Structural model of technological process formation on the basis of the inverse problem

As mentioned above, when modeling chemical composition using genetic algorithm, all elements of the intelligence system are addressed: rule base, database, precedents database, cascade neural network (figure 3).
In the first stage of generating initial population, the system runs a search of precedents depending on the casting type for which you want to predict chemical composition. The found results are presented in the form of a set of chromosomes. In the case when the results of the experiments are not found, the generation of new chromosomes is implemented. Next, the function of chromosomes suitability is evaluated, and the elite selection is made. For initial population 4 chromosomes must be generated.

The chromosomes for the parent pairs are selected from a set of initial population by random selection.

With the selected pair of parents the operation of mutation is made. Mutation can occur both randomly and directionally. When directed mutations, the direction of mutation (change of process parameters) is derived using the rule base and cascading neural networks.

![Simulation Algorithm using genetic algorithm based on GA](image)

Figure 3 – simulation Algorithm using genetic algorithm based on GA

After mutation mechanism the population is being renewed. New population will contain 2 chromosomes of parents and 2 randomly selected chromosomes from the previous generation (the duplicate chromosomes are excluded). Increasing the number of iterations the chance of elite selection during the update of the population increases. The algorithm of the mutation mechanism is presented in figure 4.
The proposed method can be used to solve optimization problems, problems of choosing the rational parameters of technological processes at different stages of processing, choosing the optimal solution in the precedents database and for finding the optimal chemical composition on the required physical and mechanical properties.

References

[1] Girshovich N G 1978 *Handbook of cast iron casting* (L. mechanical engineering) 758p.
[2] Klochkova K V, Petrovich S V, Simonova L A and Yusupov L R 2015 Stages of vermicular cast iron properties modeling in the intelligent design system *IOP Conf. Series: Materials Science and Engineering* Vol 86 Issue 1 012015
[3] Klochkova K V, Petrovich S V, Simonova L A and Yusupov L R 2015 Stages of vermicular cast iron properties modeling in the intelligent design system *IOP Conf. Series: Materials Science and Engineering* Vol 86 Issue 1 012015
[4] Klochkova K V, Petrovich S V and Yusupov L R 2014 Model formation of knowledge base of intelligent system design of cast iron with vermicular graphite Student scientific magazine "Faces of science" Volume 2 No 2 pp 73-8

[5] Panov A G, Kornienko A E, Degtyareva N G and Zinoviev Yu A 2013 Homogenizing modification of foundry melts of graphitizer cast iron: a monograph Nizhny Novgorod: Nizhegorodskiy state technical university named after Alekseeva R E 191 p

[6] Bolshakov V I, Dubrov Yu I, Tkachenko A N 2010 The Problem of identifying the quality characteristics of materials based on expert systems D.: PDABA No 1 pp 46-9