Microscopic Evaluation of Cast Iron with Flake Shape of Graphite

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This paper deals with investigation of vibration damping properties of grey iron by means of modal analysis in SolidWorks software environment. Modal analysis is accompanied by material study of metal matrix and graphite particles evaluation. Grey iron is one of the most used cast materials, in relation to good damping properties and high pressure strength. To obtain the required mechanical properties it is necessary that the graphitic particles be evenly distributed in the metal matrix and had the optimum size and shape. Flake shape of graphite decrease tensile strength of grey iron, but a suitable method of inoculation, it can cause an increase of tensile strength up to 350 MPa. Flake shape of graphite particles increases the thermal conductivity. Grey iron is material with used in the manufacture of heavy machine stands, pump bodies and low-stressed sliding bearings in the context of with its characteristic material properties.

Keywords: Cast iron, Flake graphite, Microstructure, Finite element methods,

1 Introduction

Compared to the production of other graphite cast iron, the production of gray cast iron is not difficult in terms of technological processes and relatively low price. Flake graphite is a quasi-joint and branched structure that exhibits positively in foundry features [1]. Compressive strength and flexural strength are several times greater than tensile strength, but due to the graphite that is eliminated in the flakes, they are positively exhibited by the increased ability to attenuate and reduce the sensitivity on the effect of the notches. With regard to its strength, gray cast iron is mainly used for very loaded castings of machine components, heavy machine tool racks, fittings, gearboxes and others [2]. On the mechanical structures and equipment are emphasized more and more demands. Their performance and speed of operation is increased, resulting in undesirable oscillation. This undesirable feature and excess of critical machine oscillation limits negatively affects their lifespan, reliability, and may cause degradation of machines or their components. Absorbing oscillation by material can be considered to be its damping properties [3]. Factors that affect the size of material damping include, in particular, the amount of mechanical stress, load frequency or temperature [4]. Designing of 3D models accelerates the complete production process from design to the final product. In practice, this system is an integral part of many companies for their performance, reliability and continuous development. SolidWorks has technologies for work with extensive configurations, from the possibility to automatically generate drawing documentation to superstructures for simulation, animation, visualization.

2 Material characteristics

As the experimental material, gray cast iron was used. The standard STN 42 0461, which describes material characteristics of graphitic cast iron obtained from non-etched and etched cuts, is appropriate for the assessment of this material. The experimental material was analyzed using a Vega 3 Tescan thermo-emission scanning electron microscope. Samples for material assessment were obtained directly from the casting. The method of sampling ensured that there was no change in their structure. The flake-shaped graphite particles, the thickness of which decreases in the direction from the center to the edge of the flake [5] (Fig.1), are distributed over the entire analyzed sample area and are distributed in interdendriticand non-aligned way. Their size ranges from 30 μm to 60 μm, which corresponds to the grade 6 of the standard range according to the standard mentioned above (Fig. 2). This dimension does not correspond to the real length of graphitic flakes, but it is the distance drawn by the branchcut of graphite formations.

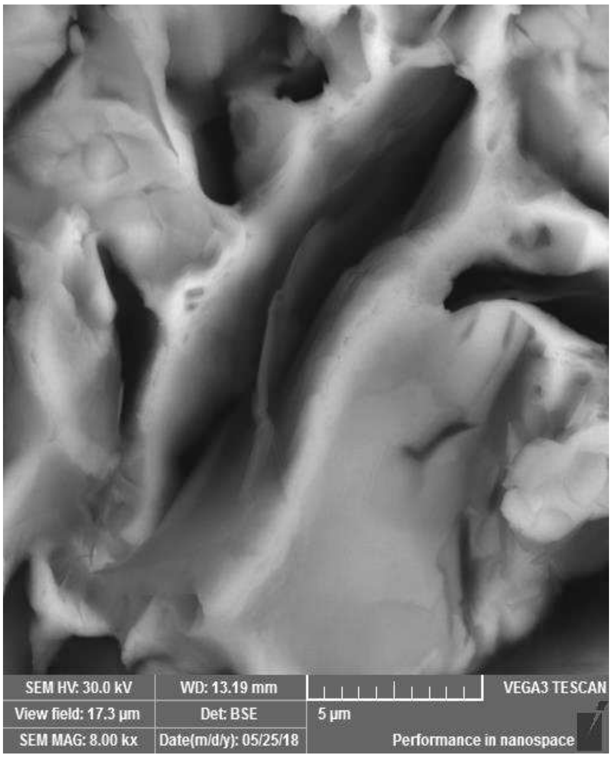

Fig. 1 *Graphite flake on fracture surface*

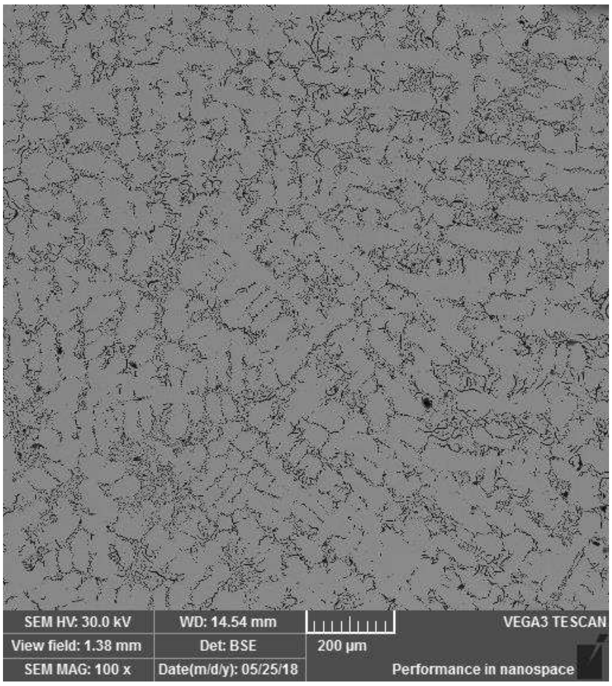

Fig. 2 *Interdendritic non-directional distribution graphitic particles*

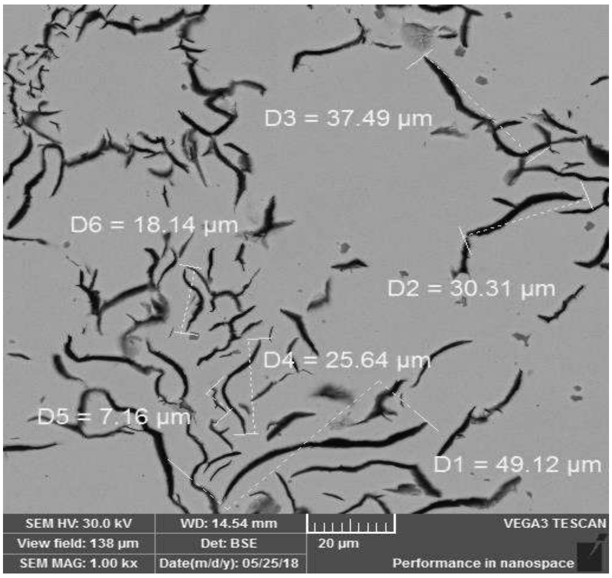

Fig. 3 *Size of graphite flakes*

At 1000-fold magnification, very fine flake graphite was observed (Fig. 3). The cast iron matrix consists of a lamellar perlite structure with no visible presence of ferrite grains, which corresponds to a 98% perlite kontent (Fig. 4). The high content of the perlite structure is likely to be associated with a higher rate of cooling, which was also shown in the fine grain structure [6]. The average distance between cementite lamellas in perlite grains is 131.63 nm (Fig. 5). Small distance of cementite lamellas is associated with increasing values of strength and hardness of cast iron at the expense of decreasing ductile properties, such as ductility and contraction [7]. This structure occurring over the whole casting volume, provides increasing of abrasion resistance and mechanical properties (Rm, HB), and also improves corrosion resistence [2].

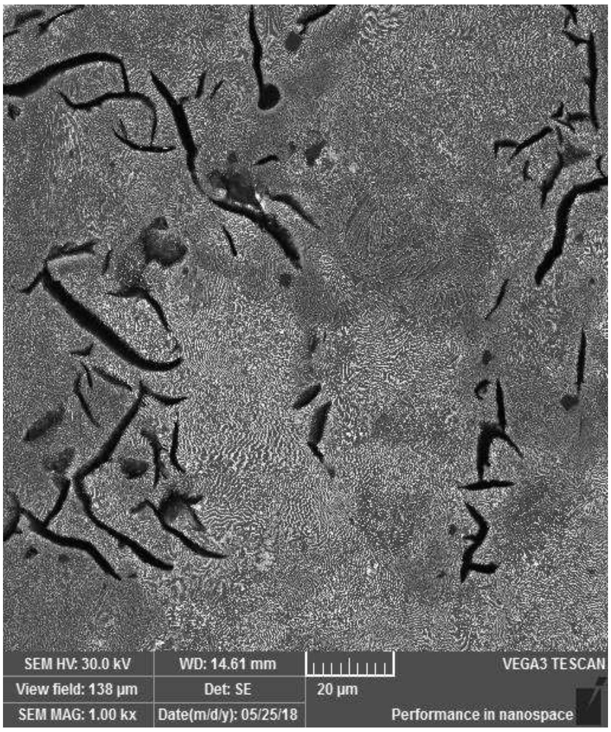

Fig. 4 *Lamellar perlite, Nital*

The occurrence of other structural phases and components was not observed. In terms of the presence of non-metallic inclusions in the material structure, mainly titanium carbonitrides were observed, the occurrence of which was rare. The size of these inclusions was 5 μm or less (Fig. 6). The mechanical properties of the cast iron structure can be increased by alloying [8]. Main alloying elements are, in particular, chromium, vanadium, molybdenum, copper, nickel or tin. Less frequently used are aluminum, titanium or other elements.

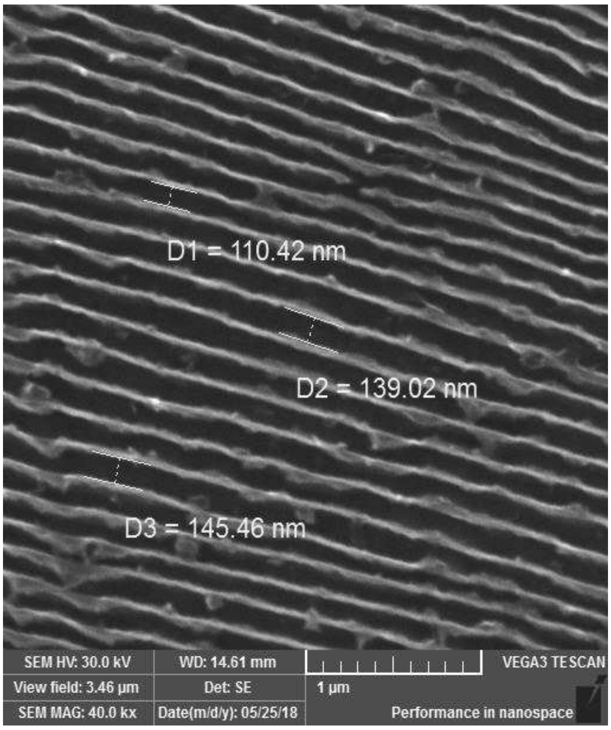

Fig. 5 *Detail of globular graphite in the fracture area.*

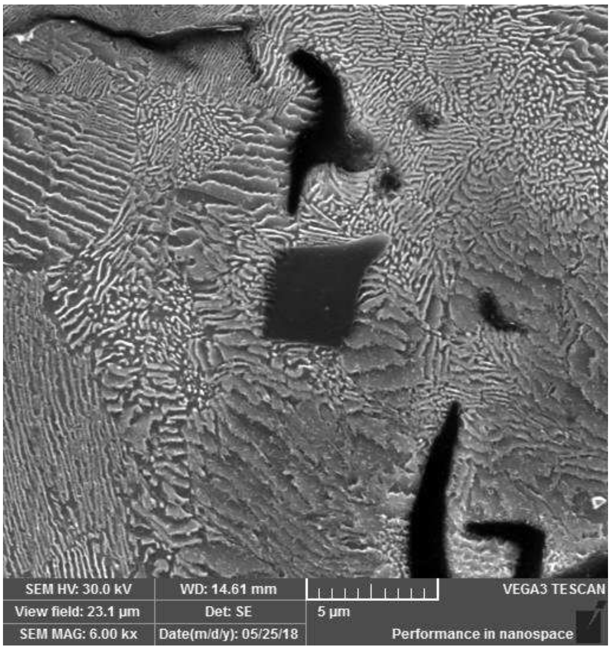

Fig. 6 Titanium carbonitride, Nital

3 Experimental modal analysis

An important factor in the oscillation of construction materials is their own shapes and frequencies [9]. Modal analysis and the associated determination of basic dynamic characteristics is a fundamental step in dynamic calculations [10]. In the use of FEM (Finite Element Method), a discrete system is used, which is characterized by discrete mass points and their corresponding rigidity. The sample calculation model was created under the standard [11]. The analysis of the homogeneous strength and damping beam (Tab.1) sample was carried out using the finite element method in the SolidWorks software environment (Fig. 7). The input material parameters of gray graphite cast iron were defined with respect to the fact that the elastic modulus E is closely related to the structure (strength, hardness). The higher the strength and hardness, the greater the elastic modulus [12].

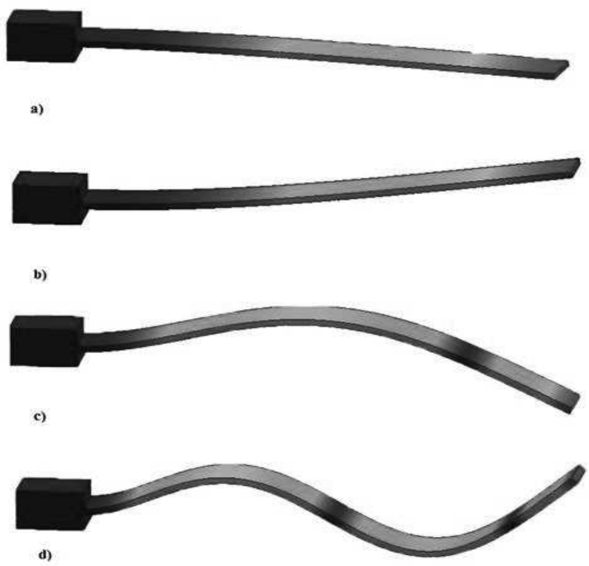

***Fig. 7** The first four eigenshapess and the inherent frequencies of the homogeneous beam*

***Tab. 1**Eigenshapes and eigenfrequencies*

Eigenshapes	Frequency
a	51.31 H
b	321.24 Hz
c	336.69 Hz
d	898.66 Hz

4 Conclusions

Nowadays, graphitic cast iron, especially gray cast iron and spheroidal graphite cast iron, predominate on the market, which is also proven by their production volume. Modal analysis is an area of research that combines signal processing and computing interaction, theory of mechanics, oscillation, acoustics, applied mathematics and engineering prediction. Internal damping occurs in the material structure and may be due to its imperfection. Therefore, in this view it is also essential to know the particular material before introducing it into service.

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