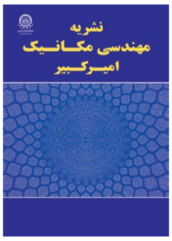

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Corrosion and Vibration: Effective Factors on Orientation Changes of Porous Phase in Grey Cast Iron

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ABSTRACT: Two specific characteristics of grey cast iron, i.e. good machinability, as well as, high vibration damping, results in widespread applications in industry. In this research the grey cast iron powder which was fabricated via machining was utilized as raw material for producing foams. The porous structures were manufactured by powder metallurgy method were subjected under two major industrial destructive processes, i.e., corrosion and vibration, in a continuous and parallel manner. To demonstrate the degradation potency and comparison of these two destructive factors, changes of porous phase orientation as a result of energy absorption was measured. It was found that the amount of energy absorption, which was associated with the most changes in the porous phase orientation, is depend on porosity volume, the type of destructive processes and the priority of corrosion and vibration. In the case of applying two destructive media successively, the corrosive atmosphere which induced less microstructural changes is the dominant mechanism. If destructive processes were applied in parallel, a sample with a mean value of 42% porosity can absorb the maximum energy, in which vibration is the dominant mechanism for this case.

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1. Introduction

Among different types of porous materials, i.e.; metal, ceramic and polymer, structures based on metal are numerous applications for noise controlling system in various industries [1]. High capability of sound and noise absorption, as well as, the potential of mechanical and electrochemical energy absorption, are consequence of porous media [2]. The amount of vibration damping and corrosion resistance in porous structures depend on type of materials, chemical composition and the microstructure of the raw material [3]. Vibration is a kind of wave, which alter the microstructure due to its energy. In the case of corrosive media, the effect of destructive condition is different compared to vibration. Definitely, the microstructure of foam materials under corrosive atmosphere is being affected via the stress induced by corrosion products [4]. The microstructure alteration due to destructive media depends on the operation condition, and the type of material. For instance, grey cast iron is a good candidate for vibration damping due to the presence of graphite flakes, which scattered the waves [5]. In the case of fabricating grey cast iron in the form of porous structure, it is possible to obtained both high vibration damping and specific strength, simultaneously. Casting [6] and Powder Metallurgy (PM) are two routine methods for producing porous grey cast iron. Although fabricating foam based on liquid state results in structures with proper controlling on gas phase geometry, the final product of porous materials may be reduced using PM method compared to liquid one. Indeed in solid state it is possible to utilized swarf of machining process as raw material, which reduce fabrication costs [7].

In this research, grey cast iron swarf, without any post processing, was utilized as raw material for fabricating metal foam based on PM method. Considering corrosion and vibration are two main destructive condition in industrial applications, these two situations were considered as catastrophic factors which might changes microstructure. Meantime, to obtain the magnitude and the importance of the subversion mechanism, the effect of the sequence and coincidence of two destructive processes of corrosion and vibration on microstructure changes was investigated.

2. Methodology

In this research, the annealed grey cast iron was used for machining at 250 rpm. As was reported in Table 1, the chemical composition of this material was the same as GG25

It is notable that, contrary to previous studies [7, 8], in this research, the GG25 swarf without any post processing method, was utilized as raw material. The size distribution of GG25 chips, as well as, the apparent density of these flakes were studied using sieving method and Hall funnel, respectively. Porous samples fabricated by uniaxial cold

Table 1. Chemical composition of grey cast iron used in this study

Element	C	Si	Mn	P	S	Fe
wt.%	2.9	1.8	0.5	0.2	0.07	Base

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Table 2. Symbols used in this study

Condition	Symbol
GG	Grey cast iron (GG25)
GG185	GG25 pressed under 185 MPa
GG250	GG25 pressed under 250 MPa
GG350	GG25 pressed under 350MPa
(*S*)(*V*)	Exert vibration after applying salty corrosive media
(*V*)(*S*)	Exert salty corrosive media after applying vibration
(*VS*)	Simultaneously applying vibration and salty corrosive media

press under different pressure; i.e. 185, 250 and 350 MPa, to produce green samples having discrepancy in porosity. It is noteworthy that, there was any cracks on the surface of green discs having the dimension of 2.5 mm height and 17 mm diameter. To prevent oxidation on the surface of samples sintering stage was not performed [9]. In order to applying vibration condition, the frequency of 50 Hz, which is the half of wave amplitude in the most destructive industrial application [10] was selected. The wave was applied in one direction for 15 minutes. To simulate other catastrophic state, the green samples were exposed for 15 minutes under seawater atmosphere, which is the most prevalent corrosion media [11]. To examine the effect of subversion processes on microstructural changes, the design of the experiment has been done based on the sequence of two destructive processes, as well as, the concurrency of them. The symbols used in this study were presented in Table 2.

3. Results and Discussion

The angular and elongated shapes of GG25 swarf were shown Fig. 1. Considering this micrograph, the size distribution of chips was widespread.

Apparent and green density of swarf and green compact were examined using hall funnel and Archimedes method, respectively. While the density of powder was 2.11 g/cm^3, the density of compact specimens increased via rising load of

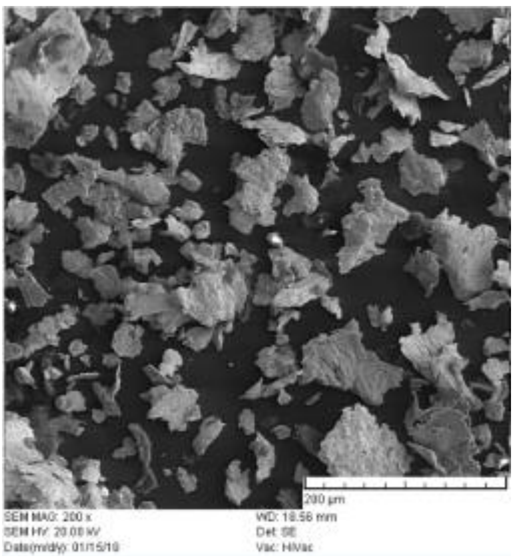


Fig. 1. Scanning electron microscope image of produced grey cast iron powder

cold pressing. Green density for GG185, GG250 and GG350 were 3.55, 3.83 and 5.88 g/cm^3, respectively. It is notable that, considering the low height of samples (less than 6 mm), no gradient of density inspected in green compacts [12].

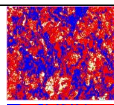
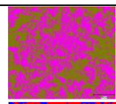
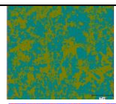
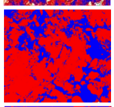
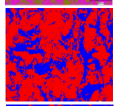
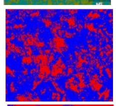
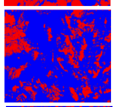
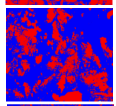
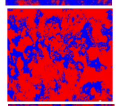
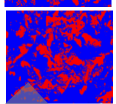
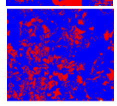
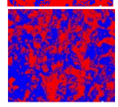
Considering destructive condition alter the microstructure owing to induced stresses, the microstructure of all samples, including green specimens, as well as, discs exposed to vibration and salty atmosphere were investigated using Clemex software. The results of this image analyzing process were illustrated in Table 3. According to this Fig., the orientation of porous phase changed due to applying vibration and corrosive media compare to primary states.

Considering Table 3, the relative orientation changes of porous phase compared to primary stages can be found. Fig. 2. Demonstrated this variation for (*V*)(*S*) condition.

According to this Fig., the cold pressure enhancement led to further variation of orientation changes in (*V*)(*S*) condition compared to green discs. It is noteworthy that, in sample with more porosity, the amount of corrosion product, which prevent the microstructural alteration, increases. Therefore the relative disparity of (*V*)(*S*) samples compared to green disc lessened.

Not only the number of destructive steps influenced on orientation of gas part, but also the sequence of theses

Table 3. Analyzed images of optical microscope by Celmex software

Condition	185 MPa	250 MPa	350 MPa
Green Compact			
(*V*)(*S*)			
(*S*)(*V*)			
(*VS*)			

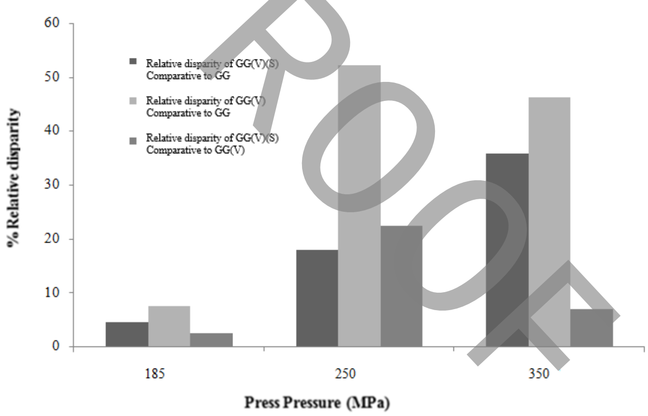


Fig. 2. %Relative changes of porous phase orientation compared to green material and (*V*)(*S*)

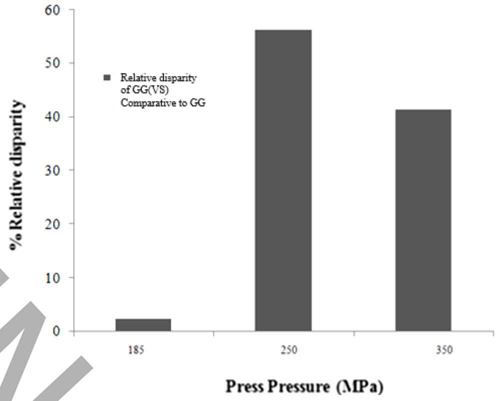


Fig. 3. %Relative changes of porous phase orientation compared to green material and (*S*)(*V*)

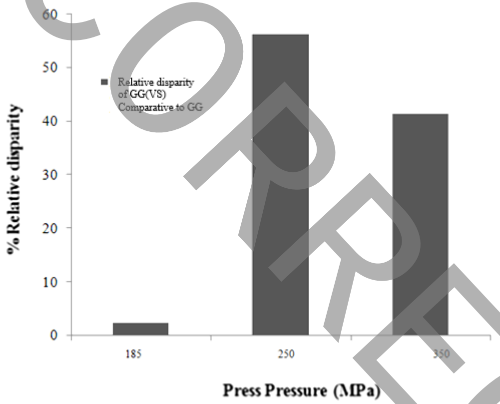


Fig. 4. %Relative changes of porous phase orientation compared to green material and (*VS*)

subversion conditions dominated the energy absorbed by solid phase. This matter was displayed in Fig. 3.

Three effective mechanisms, such as: the content of mother/solid phase, the corrosion product, and the un-locked/un-filed porosity, which can damping the vibration wave, determined the variation represented in Fig. 3.

In other cases, the role of applying vibrated/salty atmosphere on the alteration of porosity orientation was investigated in parallel manner (Fig. 4).

Comparing the results of Fig. 4 with Figs. 2 and 3, it was found that**,** the microstructural modification was highlighted in the former case, due to the overlapping effect of two destructive media at the same time.

4. Conclusion

1- The green compact discs fabricated based on GG25 swarf.
2- The density of green discs enhanced by increasing the pressure applied during cold pressing.
3- The microstructure of porous samples changed due to the presence of vibration and corrosion, which alter the orientation of gassy phase.
4- Exposing green discs to destructive media can be performed in parallel or serial states, which influenced on microstructural alteration differently.

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