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Research Article

Vibration Behavior of Composite Materials Produced by Waste Metal Recycling

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Abstract:

In this study, waste metal chips were transformed into metal matrix composites by isostatic hot pressing and the vibrational behavior of these composite materials was investigated. Bronze chips (CuSn10) was used as a matrix component and spheroidal cast iron (GGG40) chips were used as reinforcement component. The metal matrix composites are produced with different GGG40 contents as 40%-30%-20% and 10%. Metal chips were pressed at pressure of 170 MPa and a temperature of 450 °C during production. The results of natural frequency and modal stiffness were evaluated on the basis of mixture ratios by applying the impact hammer test to the metal matrix composite materials produced.

1. Introduction

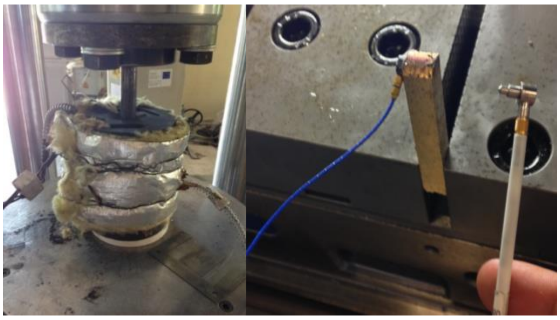
Metallic chips are created during machining of metals. These chips are considered as waste materials in these days [1-2]. However, some recycling methods are presented. The most common recycling method is melting and casting process whereas, this process requires very high energy due to oxidized surfaces of chips and very low heat and electrical conduction. Conversely, very harmful gasses released during melting process of chips and results in environmental pollution. As a result of above mentioned situation, the melted chips converted to 10% of slag, 8% of casting scrap, 10% of melting losses and 18% of other losses and the overall process efficiency can be as low as 54% [2-5]. Copper has easy deformability, low modules and low strength. However, alloys such as bronze and brass are widely used in the sliding parts of machines. Recycling of metallic chips were investigated by some researchers. The melting/casting method is the most common recycling technique which can be applied to almost any metallic chips. The waste metallic chips generally covered with oxide layer formed during machining. Literature review revealed that the most of the works were concentrated melting and sintering processes. But cast iron and bronze chips can be successfully converted into metal matrix composites by isostatic hot pressing. The representative of the pores is reported to be critical for mechanical properties. It is clear that, strong bonding between particles creates a higher resistance against to static or dynamic loads [5-6].
Traditionally the mechanical properties of materials are directly related to vibration behaviors, deformation, stress, and strain [9]. Vibration analyses such as modal analysis are used to obtain information of vibration characteristics such as natural frequencies, damping ratios, mode shapes, modal stiffness, etc. [10-11]. In this study, the vibration behaviors of porous metal matrix

composites have been investigated. The metal matrix composites were produced by hot isostatic pressing with different bronze (CuSn10) contents as %60-70-80 and 90. The hot isostatic pressing was performed under 170 MPa pressure and 450 °C temperature. In order to obtain vibration characteristics of the proposed structures modal analysis was implemented and modal stiffness, natural frequencies and mode shapes are investigated. Four specimens of porous metal matrix composites are presented and compared with the help of Table.1 and Figure.2

2. Experimental Details

2.1.Material and Methods

In this study, bronze and cast iron chips were used. The used materials were prepared by casting for compatible of chemical composition and the materials were machined and changed into metallic chips. The cast bronze was machined by lathe and changed into metallic chips, the metallic chips eliminated by using sieves of 1 mm and 2 mm severally. The hot pressing a die made of hot work tool steel has been produced optimal material properties. The heaters enables us to reach up to 650℃ in short time. Figure 1a shows the production equipments and resistance heaters holes and thermocouple hole. The whole system was covered by isolation material in order to avoid heat loses and get homogeneous temperature distribution over die. The production system is then ready for placing the metallic chips into die opening and pressing under hydraulic press. Figure 1b shows the application of impact hammer tests. After production, prismatic composite materials brought to appropriate geometries were connected vertically and tests were carried out. Modal analysis was carried out by modal hammer.



a) **b)**

Figure.1 a) Production equipments b) Application of Impact hammer test

The specimens were fixed on one end. An accelerometer was placed on the other end. In order to obtain required vibration characteristics such as modal stiffness, natural frequency and damping ratio of the specimens, the hammer based vibration analysis was performed according to the linear modal analysis rules. Moreover, to obtain mode shapes, method of roving hammer analysis is implemented. In the roving hammer method, six points were identified, one of which is a fixed end. These points except for the fixed end were excited sequentially by the hammer. The FRFs (Frequency Response Function) for each excitation were obtained to show mode shapes of first natural frequency.

3. Results and Discussions

Impact hammer tests have been carried out to determine the vibration behavior of metal matrix composite materials produced at different mixing ratios. Table 1 shows the impact hammer test results of composite materials produced at constant pressure and temperature. The data obtained vary depending on the amount of cast iron in the mix ratio of the composite materials. Thus, as the amount of reinforcing material increases, the damping rate increases while the natural frequency decreases.

Table.1 *Results of hammer impact test*

Mixing Rate (%)	Temp. (°C)	Pressure (MPa)	Modal Stiffness (N/m)	Natural Frequency (Hz)	Damping Ratio
90B10C	450	170	2,12E+06	1970,22	0,634
80B20C			2,38E+06	1975,25	0,509
70B30C			1,87E+06	1968,18	0,757
60B40C			1,36E+06	1563,26	0,805

The most flexible vibration mode represents the first natural frequency of the material. Further measurements were made to investigate the behavior of the most flexible mode. The results can be seen in Fig.2. Also in Fig. 2, the modes shown by the materials during the impact hammer test are visible. The resulting mode shapes are a result of elastic behavior. It is also important to show homogeneity of material behavior [11]. As can be seen in the figure, the elastic properties of the composite materials change from point to point with small amount of behavior homogeneity.

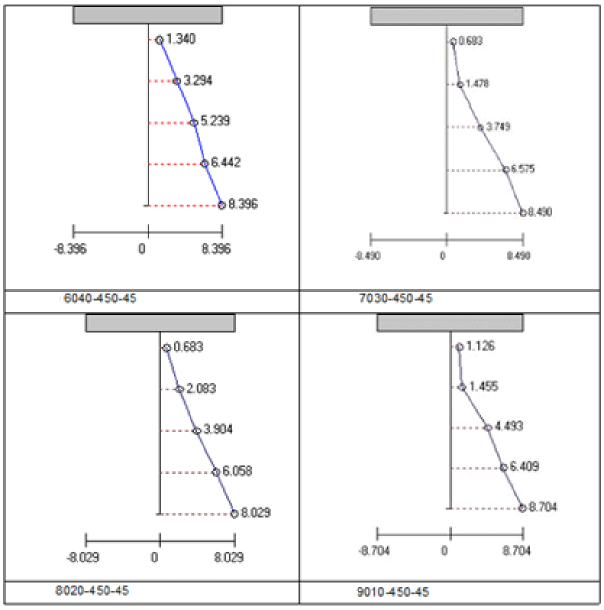


Figure.2 *Mode shapes of materials at different mixing ratios*

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