2003 ME Graduate Student Conference
May 3, 2003

High Strain Rate Compressive Properties of Syntactic Foams

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ABSTRACT

Syntactic foams are fabricated by dispersing hollow spherical particles, called cenospheres, in a matrix material. The foams are used as core in sandwich composites. Syntactic foams demonstrate superior compressive properties, low density, low radar detectability, low moisture absorption and adaptability to a wide range of environment and service conditions compared to most other materials used as cores. These properties make syntactic foams suitable for aeronautical and marine applications. Cenospheres made of polymers, metals or ceramics can be selected depending on the mechanical property requirements for a particular application. Additional reinforcement in the form of continuous or discontinuous fibers or other types of particles can also be incorporated in syntactic foams.

Quasi-static mechanical behavior of syntactic foams has been studied extensively. However, studies on high strain rate response and properties of these materials are sparse. High strain rate characterization of syntactic foams is highly desirable for aerospace applications. The present study is aimed at characterizing the dynamic compressive mechanical properties of syntactic foams. The high strain rate compressive response of syntactic foams is compared to their quasi-static compression test results to understand the strain rate dependence. Four types of syntactic foams are fabricated and tested in this study. The same epoxy resin system is used as matrix material in both types of foam. Four different types of cenospheres (S22, S32, S38 and K46) with the same outer radius but different inner radius are used to fabricate these foams to achieve the same cenosphere volume fraction and particle-matrix interfacial area. Hence, any difference in high strain rate properties of these materials can be attributed directly to the inner radius of cenospheres.

Split Hopkinson pressure bar technique is used to carry out the high strain rate compression tests of the materials. Tests have been carried out at six or more different strain rates within the range of 600 s^{-1} to 1800 s^{-1}. High strain rate compressive strength values are presented in Figure 1 for all types of syntactic foams. Quasi-static compressive strength values are also shown in Figure 1 for comparison. Optical and scanning

electron microscopy of failed specimens is carried out to understand the failure mechanisms. A scanning electron micrograph is shown in Figure 2. Results demonstrate considerable increase in peak strength of syntactic foams compared to the quasi-static values. It is observed that the elastic modulus increases with increasing strain rate. Effect of cenospheres inner radius variation on the dynamic mechanical properties of syntactic foams is also analyzed and discussed.

FIGURES

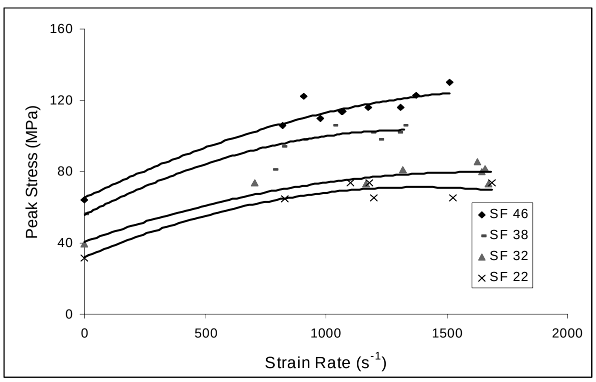

Figure 1 Peak Stress values for various syntactic foam densities at different strain rates.

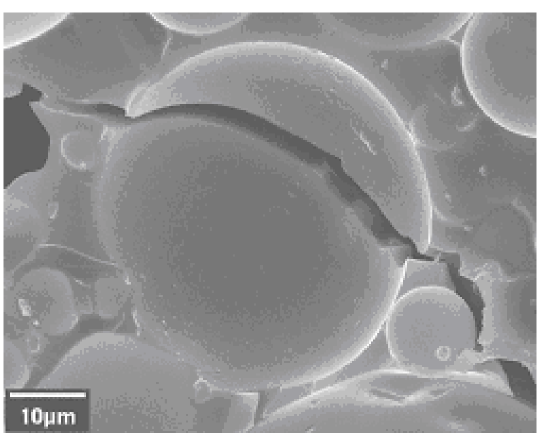

Figure 2 SEM Image showing the crack propagating through a cenosphere causing its hemispherical fracture.

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