Impact assessment on aerospace structures

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Project Overview :

Our project focuses on the goal of coming up with a shock absorbing material

to be used for industry purposes through the study and research of lightweight

energy absorbing materials as we conduct tests and studies upon varieties of

aluminum alloys as metallic foam.

Introduction

The development of materials in any industry plays an important role in order to retain the performance ,safety and cost of the product. Metal foams have evolved as an idea for new material in the industries since it can absorb energy when deformed and is good for impact and energy absorption.

Over the years, researchers have shown peculiar interest in metallic foams and Aluminium foam sandwiches to further maximize the energy outburst during a shock impact.Metal foams are one of the ideas to evolve new material in industries since it can absorb energy when it deformed and is good for crash management.

As we start to get into the topic, it leads us to dwell deep into the understanding of Lightweight energy absorbing materials as material selection plays a vital role in order to meet the functional requirements of components. Aluminum alloy foams, which are good energy absorbers and lightweight, provide a wide range of potential applications.

Metallic Foam

Upon consideration of all the evident usefulness of metal foams, we started to study more about them and their making as well as properties. Metal foams are a new class of materials with low densities and novel physical, mechanical, thermal, electrical and acoustic properties. Which offer potential for lightweight structures, for energy absorption, and for thermal management; and some of them, at least, are cheap.

Metallic foams also offer significant performance gains in light, stiff structures, for the efficient absorption of energy, for thermal management.

How are metallic foams beneficial for the project?

During an impact , metallic foams deform in such a way that they increase the total time of energy dispersion and thus reduce the resulting forces on the body.

They are very light (low density) in comparison to their respective metals.

The cost of production of metallic foam is relatively low.

Making of metallic foams

The properties of metal foam and other cellular metal structures depend upon the properties of the metal, the relative density and cell topology (e.g. open or closed cell, cell size, etc.).

There are few distinct process-routes that have been developed to make metal foams in the industry of which we will be taking a look into the process that we have chosen to adapt.

Gas-releasing particle decomposition in the melt

Metal alloys are foamed by mixing the metal into a foaming agent that releases gas when heated.

The process begins by melting aluminum and stabilizing the melt temperature between 670°C and 690°C. Its viscosity is then raised by adding 1–2% of calcium which rapidly oxidizes and forms finely dispersed CaO and CaAl2O4 particles.

As soon as these are dispersed in the melt, the stirring system is withdrawn, and a foam is allowed to form above the melt under controlled environment by adjusting the pressure, temperature and time of foaming.

Properties of metal foams

The characteristics of a foam are best summarized by describing the material from which it is made, its relative density, and stating whether it has open or closed cells. Beyond this, foam properties are influenced by structure, particularly by anisotropy and by defects – by which we mean wiggly, buckled or broken cell walls, and cells of exceptional size or shape.

Foam structure

the structure of metal foams from three different suppliers: Cymat, Mepura (Alulight) and Shinko (Alporas). The structures are very like those of soap films: polyhedral cells with thin cell faces bordered by thicker cell edges (‘Plateau borders’). Some of the features appear to be governed by surface energy, as they are in soap films: the Plateau borders are an example. But others are not: many faces have non-uniform curvature or are corrugated, and have occasional broken walls that still hang in place.

The three figures are ordered such that the relative density increases from the top to the bottom.

Open cell metallic foam structure

Open cell foams are permeable materials with metallic properties. They feature a very homogeneous structure which guarantees constant characteristics over a wide range.

Open-cell metal foams can be produced in a large spectrum of pore sizes and densities. The adjustable pore sizes range from 0.3 to 5 mm, the relative density can vary between 5 and 30 %. Because of the structure‘s high variability, the functional properties like mechanical strength, sound absorption, fluid and heat transfer can be precisely adjusted. With this, functional materials with an enormous application range arise.

Closed cell metallic foam structure

Closed-cell metal foams are primarily used as an impact-absorbing material, similarly to the polymer foams in a bicycle helmet but for higher impact loads. Unlike many polymer foams, metal foams remain deformed after impact and can therefore only be deformed once. They are light (typically 10–25% of the density of an identical non-porous alloy; commonly those of aluminium) and stiff and are frequently proposed as a lightweight structural material. However, they have not been widely used for this purpose.

Closed-cell foams retain the fire resistance and recycling potential of other metal foams, but add the property of flotation in water

Aluminium Foam Sandwich

In the past few years, metallic foams has been attracting considerable attention. One of the excellent metal foam that are used by previous researchers in automotive application is aluminium foam sandwich due to their unique properties such as low density, good energy absorption characteristics. Aluminium foam sandwich panels are good energy absorbers and light weight which provide wide range of potential applications in automotive industries.

The sandwich panel structures with aluminum foam core and metal surfaces have light weight with high performance in dispersing energy. This has led to their widespread use in the absorption of energy. The cell structure of foam core is subjected to plastic deformation in the constant tension level that absorbs a lot of kinetic energy before destruction of the structure.

Compressive stress - strain curve for an ideal foam

For the first region, it refers to collapse stress, whereas for the plateau region, total deformation energy is absorbed at constant stress value. The final region which is densification region related to increasing of stress at constant strain value. At this region, the cell walls are in close contact each other.

Uniaxial compression test

A typical uniaxial compression stress–strain curve for an aluminum foam is shown. The slope of the initial loading portion of the curve is lower than that of the unloading curve. Surface strain measurements indicate that there is localized plasticity in the specimen at stresses well below the compressive strength of the foam, reducing the slope of the loading curve. As a result, measurements of Young’s modulus should be