PAPER REF: 4034

A NEW MATERIALS DESIGN CONCEPT AND PROCESS PRINCIPLES FOR LOW WEIGTH STRUCTURAL COMPONENTS

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ABSTRACT

This work is concerned with both the concept and the processing of a new class of materials. The new class of materials consists on cellular materials with a stress dependent controlled cellular structure involved by a skin that gives the final shape of the component. The cellular structure is designed in accordance with the local stresses in the whole volume of the component. Further, the skin that involves the cellular structure and that gives the shape of the component, is also designed along with the internal cellular structure, for mechanical resistance purposes. Along with the design this work will also address the basic principles for the processing of these new materials/components concept.

Keywords: low weight, high strength, cellular materials, casting.

INTRODUCTION

The rise of the price of raw materials as well as the high price of fuel is originating a demand of low weight products with high resistance. When modern man builds large load-bearing structures, he uses dense solids: steel, concrete, glass. When Nature does the same, she generally uses cellular materials: wood, bone, coral." [Ashby, M. F] as represented, in an example in Fig. 1. Really, natural materials are strong enough to withstand loads in bones of running elephant or to carry the weight of 100 m high redwood tree. Cellular structure in these cases provides the tool for the realization of optimal combination of properties, e.g. highest stiffness at minimum weight.

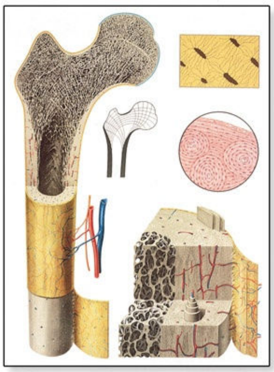


Fig. 1 - Illustration of natural made structural components.

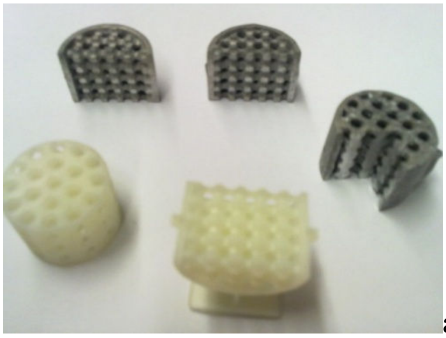
Cellular Metallic Materials (CMM) are a relatively new class of materials which have been the focus of numerous scientific studies over the past few years and in the past various technologies of manufacturing and applications of cellular metals have been explored [John Banhart; V. C. Srivastava]

Commonly, manufacturing technologies involve either the use of liquid metals in combination with blowing agents or bubbles, or the use of solid state methods [Ashby, M.F.; Andersen, O.] Regarding structural components the most promising technique for the manufacturing of net shape foamed parts is based on PM-process [Allen, B.C.]. There are almost no constraints considering complexity of the outer shape and geometry. Complex 3D-shaped foams can be produced in this way with a wall thickness from 3 mm. However the main drawbacks are the skin that has non controllable variable thickness and sometimes contains small holes or even cracks, the low reproducibility of the cellular structure, and the complicated and relatively expensive preparation technology [Ashby, M.F.; Andersen, O.]. As a result, in spite of being one of the most promising materials concept and a long time since the first patents concerning manufacturing of metallic foams appeared, this material has not been put into the large commercial production yet.

The present work proposes a technological process that is able to overcome the drawbacks of the existing foam production technologies. The external wall/skin thickness is designed according to local requirements and the internal cellular structure is also defined according to the local solicitations and its geometry is controllable in any desired geometry. This represents a substantial step forward in cellular materials concept. It also proposes a technology that allows for fast and competitive production costs for certain structural components. A pending patent has been submitted and is waiting for revision [Silva, F.S.].

RESULTS AND CONCLUSIONS

The results obtained, as illustrated with an example in Fig. 2 show that it is possible to design structural components with substantial savings in weight. Further, it will be shown that previous structural components may be obtained with a cost competitive process.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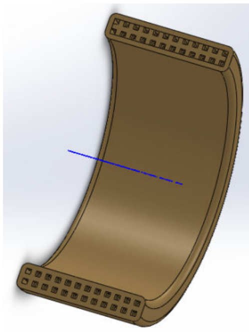
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Fig. 2 - (a) samples of components during process stages; (b) Component example with 55% savings in weight

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