

# APM, aluminium-polymer foams and derived materials: A survey on properties, applications and development trends

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**Abstract – Aluminum foam granules have been derived from the Foaminal aluminum foam technology and can be combined with polymers and polymeric foams using various processes. The resulting light-weight materials are specially adapted for the production of sandwiches and the flexible filling of hollow structures.**

**Key Words – metal foam, granules, hybrid foam.**

## I. INTRODUCTION

Polymer foams are widely used in manifold fields of applications, e.g. in combination with compact materials as sandwiches with foam core, foam filled profiles or crash absorbing elements. Because of their limited strength the foams are used in zones of the components with low mechanical requirements, contributing mainly with their low density, their high mass specific stiffness and crash/vibration absorption capability to the overall component performance. In contrast, metal foams – especially aluminum foams - have found only limited market access, despite their generally higher strength and stiffness. This is mainly due to the high process temperatures (Al: >650°C) leading to complicated manufacturing processes and low productivity. In comparison to 3D aluminum foam components aluminum foam granules [1] can be produced in a productive and flexible way; their further processing requires significantly lower temperatures. They are especially suited for the filling of hollow components and the production of sandwich structures.

## II. PRODUCTION METHOD

The production of aluminum foam granules is based on the Foaminal technology [1] with the difference that small segments of precursor wire are expanded in continuous belt furnaces to almost spherical granules, whose sizes (typically between 1 and 12mm; Figure 1) and densities

(0.55 und 0.7 g/cm<sup>3</sup>) can be adapted via the wire segment sizes and the furnace parameters. Due to the expansion and the high process temperatures the granules' surfaces are clean so subsequent coating measures can easily be done.



Figure 1 Small aluminum foam granules

## III. SUBSEQUENT PROCESSING

The first method to produce hybrid materials from aluminum foam granules was the “APM process” [2] consisting of coating the granules with thermally activated adhesive powder (e.g. polyamide PA12), filling the pourable granules into molds for 3D components or into hollow components for in-situ reinforcement and bonding them by heating to moderate temperatures of 120-190°C. A further development was the production of hybrid aluminum polymer foams by simply adding foaming agent to the hot-curing polymer (Fig. 2). Advantage of latter approach is an improved transfer of forces in the structure.

For structures which do not allow even moderate heat treatments (e.g. thermo-sensitive materials like polymers or heat-treated aluminum, or very large structures) APM-structures and hybrid foams can also be produced using cold-curing polymers. Aluminum foam granules are mixed with the polymer on-site and the slurry is filled

into the mold resp. hollow component. This technology is in some aspects similar to the production of polymer concrete [3]. In comparison to polymer mono foams, cold-curing hybrid foams show reduced fire load density, well-defined filling of large volumes, reduced release of curing heat and reduction of shrinkage effects. If high thermal stability is needed heat resistant polymers (e.g. silicones) can be used instead of organic polymers.

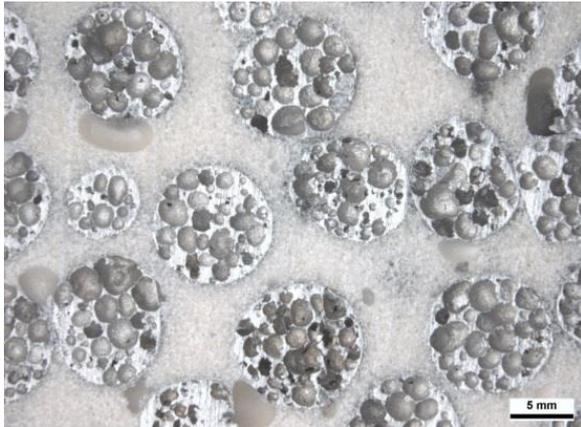


Figure 2 Cross-section of cold-cured hybrid foam

For very small aluminum foam granules an alternative process is available. Granules can be added during injection molding into polymers and injected into molds.

#### IV. PROPERTIES AND APPLICATION STUDIES

The such-produced materials show a foam-type character with low density, high specific stiffness, reduced strength (in comparison to massive materials) and good absorption capability for both deformation energy and vibration. They allow a targeted adjustment of the mechanical properties in a wide range; see Fig. 3 for the example of cold-curing epoxy aluminum hybrid foams. Compressive and tensile strength can be varied by a factor of 5 resp. 2 for materials with the same basic components by adjusting the density level. Furthermore, rather unusual material combinations can be produced, e.g. the stiff aluminum foam granules can be integrated into flexible elastomer foam

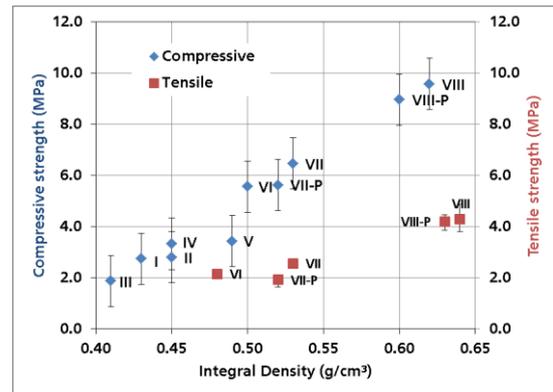


Figure 3 Compressive and tensile strength of cold-cured epoxy aluminum hybrid foams with different compositions in dependency on the integral density



Figure 4 Battery module with hybrid foam sandwiches

#### V. CONCLUSION

Aluminum foam granules can be combined with organic polymers and polymeric foams, but also heat-resistant inorganic binders to large foam structures whose behavior can easily be tailored in accordance with the requirements of a specific application. First examples of practical usage as well as several prototype studies demonstrate the potential of this new material.

#### REFERENCES

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