satellites

Redefining the CubeSat, a structure for mass production

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The growing popularity of CubeSats has increased the demand for a low-cost CubeSat structure. GTM Advanced Structures and Promolding have joined forces to develop a carbon fibre-reinforced plastic structure that is suitable for mass production.

CubeSats are versatile small satellites that provide affordable access into space for varied applications. Their popularity is growing rapidly; thousands of CubeSats are expected to be carried into orbit over the next ten years by companies and space agencies as well as institutes, universities and governments. This development has led to a growing demand for low-cost structures. A carbon fibre-reinforced thermoplastic structure is developed that meets this demand. It is the first CubeSat structure ever that is suitable for mass production by injection moulding.

This project is a unique collaboration between a company that develops and manufactures high-performance polymer products (Promolding) and a product development company that is active in the aerospace and space industry (GTM Advanced Structures) – a collaboration that has its origin in the recently established TPY programme (see box).

From machining to injection moulding

Today, most CubeSat structures are manufactured from aluminium. Machining these aluminium parts is very costly and entails a considerable amount of material waste. By developing an injection-moulded structure, manufacturing costs will be substantially lower. The injection moulding process is significantly more efficient in terms of material use, and it takes much shorter time to produce parts. Furthermore, a composite structure does not require any special surface treatment for corrosion protection. This will considerably lower the structure's environmental impact.

There are stringent requirements for materials used in space applications. One of the key requirements is the level of outgassing. Gas released from the material can condense on electronic components and equipment, this can degrade their performance or even make them inoperative. For this reason, the allowed amount of outgassing is extremely limited. In addition, requirements were set for electrical conductivity, strength, stiffness and thermal expansion. A carbon fibre-reinforced polymer, suitable for the injection moulding process, was selected that met all these requirements.

Complete redesign

The newly designed structure is a 1U CubeSat measuring 10x10x10cm. Like its predecessor, this new CubeSat has to be suitable for the use of COTS components (commercial off-the-shelf components) and meet all the requirements that are set for dimensions, stiffness, weight, etc. Since the design specifications for plastic are very different from aluminium, a complete redesign was required.

During the design process the ease of

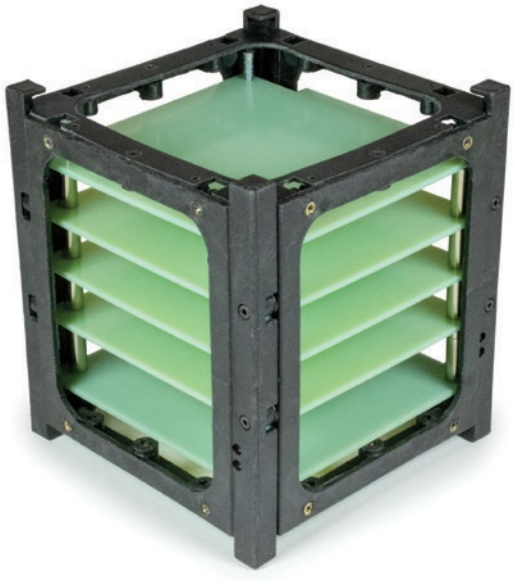

Fig. 1: Prototype of the 1U CubeSat structure (Courtesy of GMT Advanced Structures and Promolding)

assembly of the structure received special attention. CubeSats are frequently assembled and disassembled to position and reposition components and for testing purposes. Therefore, a structure that is easy to assemble would be extremely beneficial.

The new CubeSat structure (Figure 1) surpasses the rigidity of the aluminium structure without exceeding the maximum weight requirements. It comprises four identical side frames and a top and bottom part. All these parts are easy to handle, and the integrated ridges and gaps facilitate positioning during assembly. Metal inserts are applied to allow for frequent fastening of bolts. The limited number of different parts benefits the mass production process greatly. It only requires three moulds to manufacture a complete CubeSat structure.

3D printing

Different 3D printing techniques were used during the individual steps of development. Using 3D printing, quick iterations such as new geometries and function integrations were made that sped up the design process. 3D-printed functional prototypes provided important insights on ease of assembly, handling and rigidity. With this valuable information, adaptations were made that enhanced the quality of the product.

A special 3D printing technique used was PRIM® (PRinted Injection Mould), which employs 3D-printed polymer moulds to produce small series of injection-moulded products (Figure 2). This unique technology is developed by P3D, a subsidiary of Promolding. Using this technique, an actual injection-moulded fibre-reinforced plastic structure was realized, making it possible to test essential elements like fitting, shrinkage and draft during the development process.

Next steps

The final injection-moulded CubeSat structure was ready in March 2019. Vibration tests and thermal vacuum tests will be performed to thoroughly test and validate the structure. After successful completion of this project, other injection-moulded CubeSats structures (from 2U up to 12U) will be developed. The CubeSat structure was on display at the JEC World 2019 trade show. □

More information:
www.gtm-as.com
www.promolding.nl/en/
www.p3d-prim.com/en/

Focus

The Ypenburg business park in The Hague houses several high-tech companies (Airborne, KVE, Promolding and GTM) that focus on the development and production of composite and hybrid components. In April 2018, these companies joined forces to make The Hague an international hot spot for the manufacturing industry of products based on high-tech materials by establishing the Technology Park Ypenburg (TPY). The TPY programme aims to become the foundation for strengthening the regional innovation power and the growth of business, jobs, knowledge institutes and investments aimed at innovative manufacturing industries specialized in high-tech and advanced materials.
www.technologyparkypenburg.nl

Fig. 2: PRIM® mould with injection-moulded 1U CubeSat side frame (Courtesy of GMT Advanced Structures and Promolding)