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Use of Lightweight Composites for GAS Payload Structures

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Abstract

A key element in the design of a small self-contained payload is the supporting structure. This structure must support the experiments and other components while using as little space and weight as possible. Hence, the structure material must have characteristics of being both strong and light. Aluminum was used for the structure on the first Purdue University payload, but consumed a relatively large percentage of the total payload weight. The current payload has a larger power supply requirement than did the previous payload. To allow additional weight for the batteries, a composite material has been chosen for the structure which has the required strength while being considerably lighter than aluminum.

A radial fin design has been chosen for ease of composite material lay-up and its overall strength of design. A composite plate will connect the free ends of the fins to add strength and reduce vibration.

In this presentation I will describe the physical characteristics of the composite material and the method of open lay-up construction. I will also discuss the testing, modifications, and problems encountered during assembly of the experiments to the structure.

INTRODUCTION

The use of composite materials in the aerospace industry is rapidly becoming a standard practice. For some time, control surfaces, access panels, engine nacelles and radomes of most modern commerical aircraft have been made of such materials. The vertical take offs and landings of the Harrier fighter plane are made possible through the use of lightweight composites. In the business aircraft world, the new, soon-to-be certified turbo-prop Starship is built mostly of composite materials. There are already many private aircraft in the air today which are made exclusively from composites. The Space Shuttle is no exception, with its huge cargo bay doors and many other components being made with these strong lightweight materials.

A key element in a Small Self-Contained Payload (SSCP) is the supporting structure. This structure must support the experiments and other components while using as little space and weight as possible. The design constraints imposed by the SSCP canister require that the structure be rigidly affixed only to the NASA-furnished experiment mounting plate; only stabilizing rubber "snubbers" or lateral mounts can be used to brace against lateral motions.

COMPOSITES VS. ALUMINUM

The aluminum structure used on the first Purdue University Small Self-Contained Payload proved to be more than adequately strong to support the experiments and control units (see Snow et al., 1985 for a description of this structure). However, there is planned for the second Purdue SSCP an experiment which will use a large amount of electrical current, and thus requires an extensive (and heavy) set of batteries. Another set of heavy items scheduled to be flown are the cans of thermal salt which will be used to control the temperature in the canister throughout the flight (Stark, 1985).

The last heavy item in the original design for this second payload was the structure itself. Originally projected to be made from aluminum, it was found to consume an unacceptably large percentage of total allowable payload weight. A material that was strong, easily manufactured, relatively inexpensive and most importantly light weight was needed for a replacement. Composite materials met all of these requirements.

It was decided to use a "sandwich" type construction wherein a foam core is covered (laminated) with several layers of glass cloth and resin. In our case, "DERAKANE" vinyl ester resin laminated with C-glass forms the outer portion of the sandwich. As different parts of the structure had different strength requirements, 4.5 and 20 lbs/cu. ft. polycrethane foam was used to form the core. The material chosen was readily available from an aircraft company which produces all-composite aircraft kits, one of which is being constructed at Purdue.

FABRICATION

The techniques used to fabricate structures from composite materials range from direct forming in large (and expensive) autoclaves to a simple open lay-up. The open lay-up procedure was chosen for present purposes because its low cost and practicality. It requires only easily found hand tools and common shop machinery. It is particularly attractive for an educational SSCP as the student-workers can quickly learn the techniques of making and combining simple shapes.

THE STRUCTURE

The three radial fin design shown in Fig. 1 has been chosen for ease of composite material lay-up and its overall strength. This structure is made up of 3 basic parts: a circular base (which is to be bolted to the NASA-furnished experiment mounting plate), 3 rectangular fins on which the experimental hardware is mounted, and a top plate.

The base and fins are made of a 1/2", thick 20 lb/cu. ft. foam core laminated with 4 layers of glass cloth on each side. These four pieces were layed-up oversized then cut to the indicated dimensions with a band saw. The fins were then attached to the base using resin and a thixotropic agent. This held the fins in place while glass cloth reinforcing strips were laminated along the edges in the shape of L-brackets. Holes were then drilled in the base to accommodate the mounting bolts.

The top plate serves to reduce the amplitude of vibrations of the free ends of the fins and provides a strong supporting surface for the required lateral mounts or "snubbers". This plate was constructed from 1/3", 4.5 lb/cu. ft. foam with 3 layers of glass laminated on each side. To reduce weight and allow for easier accessi-

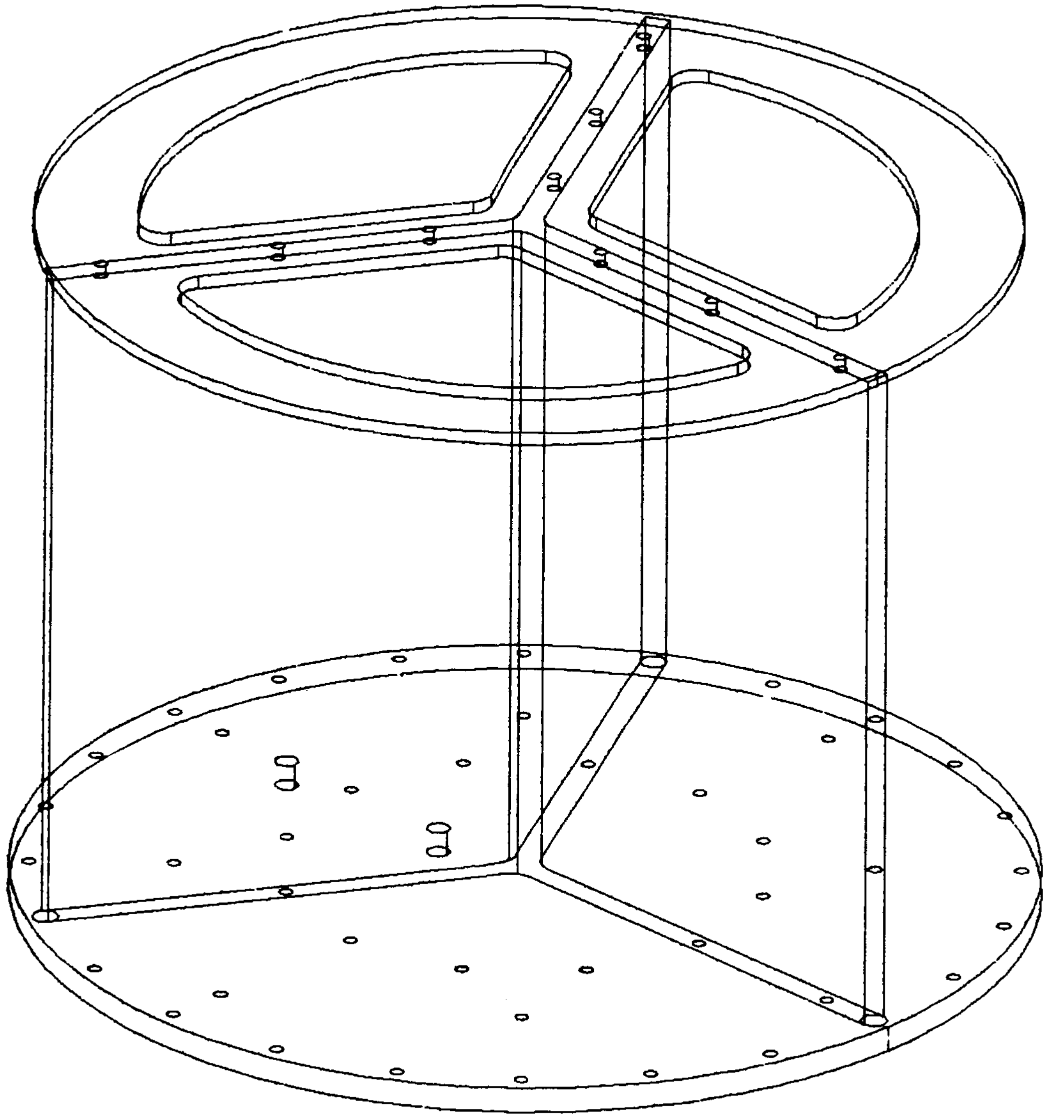

Fig. 1. Schematic showing the major components of the prototype supporting structure for PUGAS II.

bility, the top plate was trimmed down with 3 lightning holes. Holes were then drilled to allow for the Sur-Lock fasteners to pass through and attach to the ends of the fins. This top plate will be held in place with standard aircraft hardware; it can be quickly removed and set aside for improved accessibility. The lateral mounts will be attached to the top plate spaced equi-distantly around the outer circumference.

THE ENVIRONMENT

The vibration the payload will encounter during launch will be simulated on the structure both prior to and after the attachment of the components. Adjustments to the structure (i.e., reinforcements) will be added as needed.

Using thermal salt as a passive control system, the temperature within the canister should remain near room temperature. However, the structure material would retain its strength through a temperature range of -200°F to 300°F. Thermal expansion of the material is negligible through a 300° temperature change. The aluminum mounting plate will expand and contract more than the composite structure and this will be taken into consideration.

Another environmental concern is the waste heat the materials processing experiment will give off. Upon testing, insulation and closeness of this experiment to the thermal salts will be adjusted.

SUMMARY

The role of composites in the aerospace industry will continue to grow because of its proven performance and desired characteristics. The information we receive from this payload will help us and others in determining the best designs and materials to use on future payloads. Perhaps in a few years, the use of composite structures in GAS payloads will be the rule instead of the exception.

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