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PROGRESS on THE OHIO STATE UNIVERSITY GET AWAY SPECIAL G-0318: DEAP

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ABSTRACT

The Get Away Special program became a major presence at The Ohio State University with the award of GAS-0318 by the American Institute of Aeronautics and Astronautics. There are about twenty engineering researchers and students currently working on the project. GAS-0318 payload is an experimental manufacturing process known as Directional Electrostatic Accretion Process (DEAP). This high precision portable microgravity manufacturing method will revolutionize the manufacture and repair of spacecraft and space structures. The cost effectiveness of this process will be invaluable to future space development and exploration.

INTRODUCTION

Currently, NASA is planning a permanent presence in space through the development of the space station. In order to be cost effective on the economic returns from such a development, scientists and engineers must develop resourceful techniques of space utilization. One way to achieve this is to maximize productivity in space. This can be accomplished by performing production and repair in space instead of on earth. The DEAP process is one such manufacturing and repair technique which will help achieve this end.

This paper presents a summary of the preliminary design of the experiment and its major subsystems combined with a discussion of the process performed by each subsystem. Some of the major subsystems discussed include the furnace, containment structure, small orifice device, directional controller, target and accreation process. In the design of this payload, a general purpose graphics oriented interactive finite element system is utilized. Final drawings of the subsystems are obtained from a computer aided design system. Each subsystem will be separately bench tested to verify compliance with the design requirements.

THE DEAP METHOD

Researchers have been investigating possible space manufacturing techniques for the past two decades. Most manufacturing and construction techniques studied to date are directed at large space structures. The DEAP unit concentrates on small scale manufacturing and repair capabilities.

DEAP requires five material processing steps. Each step has associated with it one or more experimental subsystems that perform each processing step. The five processing steps are;

- Bulk material liquefaction,
- Droplet formation and charging,
- Droplet directional guidence,
- Target surface accreation,
- Three dimensional build-up.

Bulk material liquefaction:

Producing or repairing parts and structures through the DEAP method requires that a reasonably pure material be utilized. That is, microstructural inclusions which degrade material purity be minimized to preclude clogging of the DEAP unit and failure to guide and accrete the material. Liquefaction is accomplished by the subsystem known as the furnace.

The current furnace design consists of an electrical resistance heater wrapped around a cylinder which houses the bulk material. Since the furnace consumes most of the power required to operate the experiment, battery requirements are substantially impacted by the amount of energy required to liquify the material. Thus, material selection will be limited by this power requirement. An electronically controlled displacement pump will produce the molten flow delivered to the small orifice device.

Droplet formation and charging:

The small orifice device collects the supply of molten flow in a chamber which supplies a convergent channel. This channel, or nozzle, is responsible for producing the droplets which will be accreted to the target surface. In this unit, two separate nozzles will be utilized and each will have a separate droplet directional controller.

Droplet directional guidence:

Since each droplet carries a small charge, electrostatic fields are used to impart accelerations to each droplet, thereby permitting directional control. Because it is exteremely important to accurately guide each droplet, separate deflection systems will be applied at each nozzle. Accurate directional control permits the production of a variety of geometric shapes with considerable dimensional precision in the unfinished condition. Thus, finishing work is largely unnecessary and can be avoided.

Target surface accretion:

Droplets are deposited on the target surface in a precise manner. As the droplets are deposited, two important phenomena must occur; surface wetting and solidification. Surface wetting must occur or the material droplets will simply rebound or be displaced by newly arriving droplets. Solidification of the wetted droplets must be rapid upon contact with the target or splattering and loss of dimensional tolerance is likely to result.

The target consists of a muliposition disc plate with individual target plates attached. Separate targets of different selected materials will be tested for accretion properties. One aspect of this experiment is to determine which materials yield desireable accretion properties such as surface wetting and rapid solidification.

Three dimensional build-up:

To date, the accretion process is largely untried. Accretion layering is an even greater unknown process. Layering, or three dimensional build-up, must be achieved to produce a complete part or to repair a damaged structure.

Additional Subsystems:

There are two additional subsystems which are important to the success of the experiment. They are the containment structure and the microprocessor.

The containment structure houses the small orifice device, the directional controller and the target. This structure consists of a cylindrical pressure vessel which is evacuated to the space environment such that the vacumn of space will be simulated within the containment vessel. The accretion process will be contained within the containment vessel.

The microprocessor is responsible for operating the experiment from the system level. Once the "on" signal is received from the mission specialist, the microprocessor will run the experiment and then shut down.

COST EFFECTIVENESS

The cost effectiveness of the DEAP method is without doubt an important aspect. There are three attributes to this method which account for this important criteria:

- Bulk material packaging,
- High precision tolerance finish,
- Transportability.

Bulk material packaging:

Payload bay packaging has limited most space launches in their ability to boost material into space. However, if parts and structures were manufactured and assembled in orbit, then only bulk material need be delivered to orbit. This ability would ease packaging constraints and improve the efficiency of delivering material to orbit for constructive use. The DEAP method utilizes bulk material as the process working material.

High precision tolerance finish:

Due to the accurately controlled placement of material droplets, the DEAP method inherently produces a high precision finish. There is little or no need for finishing work which results in potentially huge cost savings. Also, material properties will retain high quality and reproducibility as well.

Transportability:

Since the DEAP unit is a relatively simple machine, it can vary in size and complexity depending on the intended product or use. Large units could be placed in stationary orbits for space structure production while small units could be transported about for special assignments. In fact, hand-held DEAP units could be designed for mobile repair of craft and structures.

DEVELOPMENT and VERIFICATION

The design development and layout of this experiment are being performed on an IBM/370 and a VAX/11-780 with CADAM and GIFTS systems. The CADAM models are utilized to perform part of the finite element analysis to verify compliance with design requirements. Eventually, each subsystem will be build and bench tested to verify the performance.