SPACE MANUFACTURING UTILIZING THE DIRECTIONAL ELECTROSTATIC ACCRETION PROCESS

Presented by

Mr. Alan Mortensen

The Ohio State University
Department of Aeronautical and Astronautical Engineering

ELECTROSTATICS
DEPOSITION
SPACE MANUFACTURING
SPACECRAFT MAINTENANCE
COST EFFECTIVENESS

PORTABLE EQUIPMENT
SPACE STATIONS
LIQUEFACTION
DROPS (LIQUIDS)
SURFACE FINISHING

ABSTRACT

The Directional Electrostatic Accretion Process (DEAP) is described with respect to both the physical process and its application to manufacturing in space. This high precision portable manufacturing method will revoluntionize current practices in manufacturing and repair of spacecraft and space structures. The cost effectiveness of this process will be invaluable to future space manufacturing projects.

1.0 Introduction

Through scientific space exploration and development, newly developed technologies have generated considerable assets which are currently benefiting mankind in many ways. For example, minicomputer and composite material technologies have spun-off of earlier space missions into multi-billion dollar industries benefiting the entire humankind. Furthermore, these same technologies continue to permit further maturation of the space environment for human use.

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 development, scientists and engineers must develop resourceful techniques of space utilization. One way to achieve this end is to maximize productivity per each trip into space. This can be achieved by performing production and repair in space instead of on the earth. Thus, new manufacturing and repair techniques are being developed to achieve this end. The DEAP method is one such manufacturing and repair technique (ref. Fig. 1).

2.0 The DEAP Method

Scientists and engineers have been investigating possible space manufacturing techniques for the past two decades. Most construction techniques investigated to date are for large scale (from feet to miles in length) space structures with only minor attention given to smaller scale capabilities. The DEAP unit will greatly facilitate filling needs of small scale manufacturing and repair capabilities.

DEAP requires five major material processing steps:

a. bulk material liquefaction
b. droplet formation and charging
c. droplet directional guidance

d. target surface accretion
e. three-dimensional build-up

Each of these steps will be described in the following text.

2.1 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 the purity of the material must be minimized to preclude clogging of the DEAP unit. Liquefaction of bulk material by heating is performed to produce a molten flow of material which is then developed to the small orifice device via a mechanical displacement pump.

2.2 Droplet Formation and Charging

The small orifice device collects the initial supply of molten liquid in a chamber which supplies a convergent channel. Through control of this small orifice channel molten material droplets are formed. Utilizing a charging technique, a small surface charge is imparted to each droplet.

2.3 Droplet Directional Guidance

Since each droplet carries a small charge, electrostatic fields are utilized to impart accelerations to each droplet, thereby permitting directional control of the molten droplets. Through directional control, a variety of geometric shapes may be produced with considerable dimensional precision in the unfinished condition. Thus, finishing work is largely unnecessary and can be avoided.

2.4 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 from the target 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.

2.5 Three-Dimensional Build-Up

To date, the accretion layering process is largely untried and will be an important factor in the success of this manufacturing technique. Through layering of desired two-dimensional geometries, three-dimensional build-up can be achieved to produce a completed part or to repair a damaged structure.

3.0 Cost Effectiveness

Although there are many ways to produce high precision parts in space, cost effective methods must be developed to preclude excessive expenses which diminish returns from investments in space development. The DEAP method is one such potential cost effective method due to the following cost effective criteria:

a. material bulk packaging
b. high precision finish tolerance
c. facility mobility

3.1 Material Bulk Packaging

Due to packaging constraints, boosting cumbersome payloads into orbit is inefficient with respect to spatial arrangements in payload bays. However, if structures were manufactured and assembled in orbit, then bulk material need only be supplied to low earth orbit for use in processing. This approach would greatly ease packaging requirements and increase the efficiency of delivering needed materials to orbit. The DEAP method utilizes bulk material for manufacturing and repair.

3.2 High Precision Finish Tolerance

The DEAP method inherently produces a high quality finish, thereby minimizing, if not completely precluding, the need for finishing work. Thus, additional man-hours, machine-hours and materials will largely be deleted from the required production schedule. Also, repairs on present structures and spacecraft could be achieved without having large stores of spare parts on hand. Parts and repairs could be made on location in orbit resulting in largely improved efficiency of mobility and utilization of available resources and time. As a general result, further increases in cost effectiveness yield improved returns from investment in space.

3.3 Facility Mobility

Since the DEAP method can vary in size from small to large units, manufacturing facilities could be placed in stationary orbits or transported about to fulfill manufacturing and repair needs as they become determined. In fact, DEAP units as small as current NASA manned-manuevering units could be designed for mobile repair services on spacecraft and space structures.

4.0 Experimentation

The DEAP unit is currently being developed by engineering researchers and students at The Ohio State University (OSU) under research funds supported by AIAA, OSU and donations from the commercial sector. This experiment will be flown as a NASA Get Away Special payload on board a future shuttle mission.

5.0 Results

Experimental findings will be published after completion of the experiment.

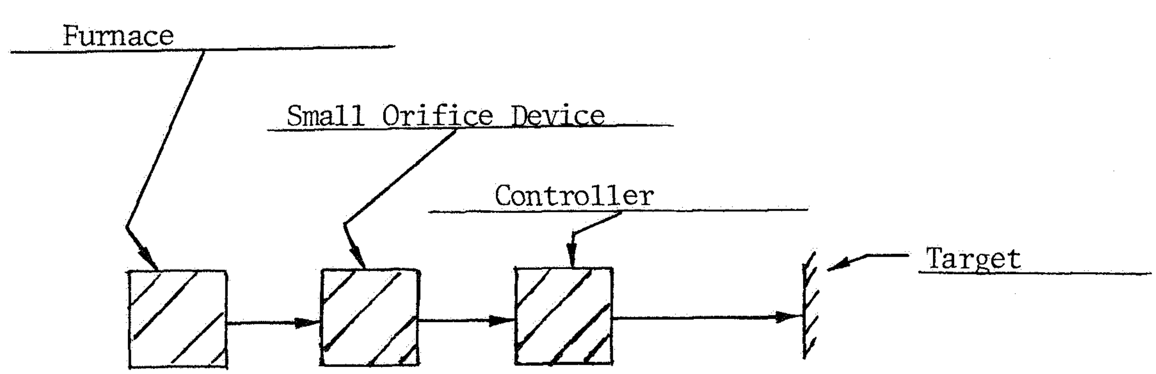

Figure 1. The Directional Electrostatic Accretion Process Unit