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PROCESSING POLYMERIC POWDERS

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ABSTRACT

Background

The concept of uniformly and continuously depositing and sinter-fusing nominal 0.1 to 40 micron dimensioned electrostatically charged polymer powder particles onto essentially uniformly spread 5 to 20 micron grounded continuous fiber tow to produce a respoolable thermoplastic composite tow-preg was formulated at NASA Langley last summer [1]. The process was reduced to practice under a NASA grant at the University of Akron this spring. The production of tow-preg is called Phase 1. This work continues in Akron.

This summer, the production of ultrafine polymer powders from 5% to 10% (wt) polymer solids in solvent has been considered. This is Phase 0 and is discussed below. The production of unitape from multiple tow-pregs has also been considered. This is Phase 2 and is also discussed below. And another approach to Phase 1, also proposed last summer, has been scoped. This is Phase 1A and is also discussed below.

Phase 0 - Spray Drying

Most high-performance thermoplastic polymers are produced in solvent. LaRC TPI is available in an amic acid state in either diglyme, DMAC or n-MP. At solids contents of 5-10% (wt), the solution has syrup-like consistancy. Spray drying is one way of producing very fine powder from the first two solvents. Spherical particles of <1 to 20 microns were produced by air atomizing a solution through a conventional paint gun into a 5-liter heated reaction vessel [2], Figure 1. Powders of this particle size range are ideal for the Phase 1 powder coating facility. In the current scoping process, the powders appear to have some residual solvent. They fuse and change shape when washed with water, a standard solvent extraction fluid. A larger spray dryer with proper spray heads, tangential air flow and proper particle collection equipment is now being designed [3]. The development of this prototype facility will allow in-house production of small quantities of powder from experimental resins. These powders can be used with the current in-house fluid bed tow-pregging system or with the Akron electrostatic system.

Direct spraying of 5% solution of LaRC TPI in diglyme and DMAC onto spread tow, then oven-drying the tow, yielded very uniform coating with surprisingly good fiber bundle penetration. The amount of solids that can be applied in a single pass is small. As a result, multiple stages are required. This technique remains unscoped.

Phase 1A - Wet Sand Tow-Pregging

Coating of water-wet fibers with dry powder was probed briefly last summer, in what was called the "wet sand" approach [4]. This year, spread tow was first exposed to moisture from a home humidifier. Then dry LaRC TPI powder was aspirated with nitrogen and blown directly against the damp tow surface. Multiple applications yielded up to 40% (wt) resin on the spread tow. The final dampened tow-preg was then sinter-fused in a tube furnace. Although some powder was shaken off in handling, the final tow-preg contained 31.6% (wt) resin. The penetration was quite good despite the crude manual process and the coarseness of the powder used for the experiments.

The aspiration system used here was the same one proposed for the electrostatic coater last year [4]. This system was recommended as a possible replacement for the NASA fluidized bed.

Phase 2 - Consolidation to Unitape

The original intent of this summer's work was to determine the contact time, temperature and pressure needed to produce a prepreg from multiple tow-pregs. Some simple contact heating experiments using a soldering iron and a hot plate yielded interply temperature profiles. A finite difference computer program was developed for the two-dimensional moving heat source heat conduction problem with direction-dependent thermal conductivities. The model agrees reasonably well with the data, Figure 2. From this model, the interply temperature can be determined as a function of the velocity of the unitape under the contact heater. The dimensions of the contact heater can be then ascertained, knowing the time for autohesion [5].

A Minnesota company [6] has loaned us a prototype incandescant heater. It has been used to heat multiple tow-pregs to produce a prepreg and to heat individual tow-pregs to reduce boardiness. This company also fabricates electrostatic coating lines and is interested in working with us on Phase 1.

1. This 1988 work was done with A.L. Ogden, now at VPI&SU.

2. This work was done with Dennis Working, PMB/MD, NASA.

3. This work was done with Jim Nelson and Ricky Smith, PMB/MD, NASA, and John Marcello, ODU.

4. J.L. Throne, and A.L. Ogden, "Dry Powder Prepregging: A Status Report", 10 August 1989.

5. P.H. Dara and A.C. Loos, "Thermoplastic Matrix Composite Processing Model", Interim Report No. 57, NASA-Virginia Tech Composites Program, NAG-1-343, 1985.

6. BGK Finishing Systems, Inc., 4131 Pheasant Ridge Rd. N, Minneapolis MN 55434. Personal communication with Rick Ganyo, President, 20 June 1989.

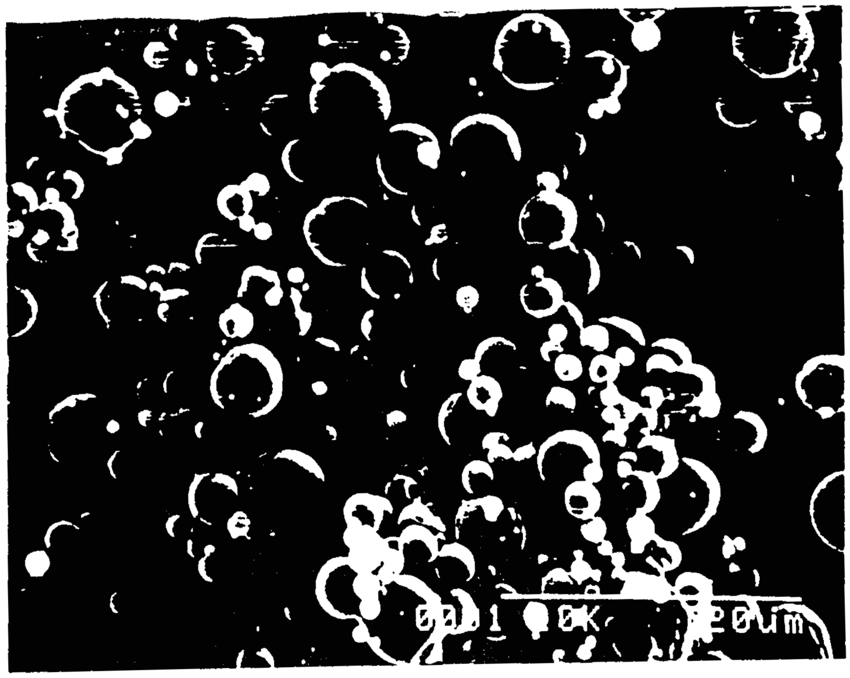

Figure 1. Scanning Electron Micrograph of Particles Recovered from Spraying 5% LaRC TPI in Diglyme and DMAC Through a Commercial Paint Spray Gun into Heated Reaction Vessel. [12 July 1989, with Dennis Working at NASA Langley].

Figure 2. Experimental and Theoretical Dimensionless Temperature Profile Through and Along LaRC TPI-Impregnated Carbon Fiber Tows (Two Plies). Steady State Stationary Heat Source with Thermal Conductivity Ratio, Along Fiber to Cross-Fiber, at 2500. 0.010 Inch Thick Tow-Pregs Produced at University of Akron. Solid Circles: Experimental Data Obtained With Soldering Gun at 720F and Hot Plate at 290F.