27
11-24-80
94C
240 NT/5

#1

BDX-613-2358

Syntactic Foam Composites and Bonding

By R. J. McWhirter

Published September 1980

Final Report

MASTER

Prepared for the United States Department of Energy
Under Contract Number DE-AC04-76-DP00613.

**Kansas City
Division**

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

Printed in the United States of America

Available From the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, Virginia 22161.

Price: Microfiche \$3.00
 Paper Copy \$4.50

SYNTACTIC FOAM COMPOSITES
AND BONDING

By R. J. McWhirter

Published September 1980

Final Report
R. J. McWhirter, Project Leader

Project Team:

G. T. Crow
R. A. Daniel
L. R. Deford
S. L. DeGisi
H. M. McIlroy
D. E. Rex
A. H. Schloman

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Technical Communications

Kansas City
Division

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

See

SYNTACTIC FOAM COMPOSITES AND BONDING

BDX-613-2358, Final Report, Published September 1980

Prepared by R. J. McWhirter

A manufacturing process has been developed to produce billets molded from a composite of carbon microspheres, a polyimide resin, and carbon fibers. The billets then are machined to configuration which results in extremely sharp and fragile edges on one part. To strengthen these parts, a parylene coating is applied, after which the parts are assembled with other parts by bonding. Bonding and assembly problems are discussed in detail; other problems encountered are summarized, and several are referenced to previous reports.

FOA:djb

This report was prepared as an account of work sponsored by the United States Government. Neither the United States, nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, expressed or implied or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.

The Bendix Corporation
Kansas City Division
P. O. Box 1159
Kansas City, Missouri 64141

A prime contractor with the United States
Department of Energy under Contract Number
DE-AC04-76-DP00613

CONTENTS

Section	Page
SUMMARY.	5
DISCUSSION	6
SCOPE AND PURPOSE.	6
PRIOR WORK	6
ACTIVITY	6
<u>Molding, Mixing, and Blending.</u>	7
<u>Clip Bonding</u>	10
<u>Groove Strengthening</u>	23
<u>Bonding Miscellaneous Parts.</u>	25
ACCOMPLISHMENTS.	25
REFERENCES	31

ILLUSTRATIONS

Figure		Page
1	Outer Support Assembly (P97616)	7
2	Plate for Clip Holder (P105349)	11
3	Support Clip Bonding Operation (P105350) . . .	12
4	Applying Adhesive to Support Clip (P105625) . .	13
5	Adding Shims to Clip Holder Stop (P105352) . .	14
6	Typical Monthly Charts of Part Acceptance and Parts Defective by Characteristic.	15
7	Typical Histograms for Determining Trends and Variances.	16
8	Percentage of Defective Parts in January 1979	17
9	Depth Fixture and Depth Micrometer (P105627)	19
10	Measuring Clip Depth (P105628)	20
11	Diagonal and Full-Face Clip Holders (P105354)	21
12	Comparison of Part Acceptance Using Old and New Specifications	22
13	Part Acceptance and Parts Defective by Characteristic for the Period of June 1978 Through February 1979.	23
14	Sketch of Slit Teflon Tape Used for Strength- ening Groove	25
15	Shoehorn Bonding Fixture (P105355)	26
16	Shoehorn Trim Fixture (P105357)	27
17	Shoehorn Dimpling (P105353)	28
18	Compression Pad Location Fixture (P105356) . .	29
19	Installation of Edge Pad on Outer Support (P105626)	30

SUMMARY

A process has been developed to blend, mix, and mold a syntactic foam composite which can be machined to part requirements for a light weight, thermally conductive, high strength foam. Shortly after the initial material selection was made, a new design criteria was received which required a higher thermal conductivity. Several composites were considered; a composite of carbon microspheres, a polyimide resin, and graphite fibers was selected. Later, alternate materials also were qualified (silver-coated microbubbles and a phenolic resin). Several improvements were made in mixing, blending, and molding. Molding to size was unsuccessful. The visual appearance of the machined surface improved significantly when the chopped fibers were replaced with Thornel mat.

Machining the part to final configuration required care in handling because the surface was soft and the inner support edge was very thin and sharp. Numerous attempts were made to strengthen the edges with filament winding, plasma spray, fiberglass mat layup, vacuum forming, and parylene coating. The parylene coating method selected to strengthen the edge also eliminated the dusty surface of the part.

Strengthening the groove on the inner support also was required so that the parts would not separate if they cracked. Again, numerous materials were tested, and, in this case, Teflon tape became the prime candidate. The major problem was removal of the protective paper from the tape after cutting the tape to shape. A modified dinking operation was used successfully to solve the problem.

Considerable effort was devoted to bonding of the support clip because of the extremely tight depth tolerance when applied to the outer support. Redesigning the face of the clip holder greatly improved part acceptance; other modifications to the bonding equipment and process also improved acceptance levels.

DISCUSSION

SCOPE AND PURPOSE

This project was initiated to develop a production capability to process syntactic composites used as structural parts for mechanical support and thermal protection. The syntactic material was selected for compressive strength, thermal conductivity, density, and ability to withstand a relatively high thermal environment. The syntactic material selected is composed of carbon microspheres, graphite fibers, and Kerimid 601 resin (a polyimide resin by Rhodia Inc. of France).¹

Originally initiated to develop a billet molding process, this endeavor was expanded to include developing alternate materials for the resin and carbon microspheres, strengthening at the groove and at the thin edges of the inner support, and bonding the support clips to the outer support.

PRIOR WORK

Syntactic materials have been used on other programs. Most of those parts were sufficiently strong to be handled easily; however, one part required considerable development effort to strengthen the part when the wall thickness was reduced from 6.0 to 2.25 mm. Processes were developed for vacuum forming a thin film and for spraying on a liquid resin coat. The spray coat method was used for initial production lots but was not sufficiently repeatable to avoid low yields. Therefore, that method was discarded in favor of vacuum forming. Some experience was obtained in the parylene coating operation by use of a laboratory model; full production experience was initiated with this program.

ACTIVITY

The inner and outer supports are machined into a ring configuration after the syntactic material is mixed and molded into a billet form. Because of the thin edges on the inner support, the parts are parylene coated for strength. Final machining is a slitting operation; the inner support is cut in half, and the outer support is cut into four segments. Each outer support is made into an outer support assembly by adding a compression pad, a shoehorn, two support clips, and an edge pad (Figure 1). The inner support is made into an inner support assembly by adding an edge pad and placing a reinforcing tape over the groove.

Figure 1. Outer Support Assembly

Molding, Mixing, and Blending

Much of the development work on molding, mixing, and blending the syntactic billets has been reported previously.² Several items, however, required additional work, and this section contains a summary of that work or additional information developed since that report was issued.

Vibratory Table

Several methods were tried to improve the tamping operation required when loading the mix into the mold; however, none were successful. The table-mounted vibrator did not settle the material sufficiently to delete the tamping with the mold cap either on or off the mold. With the cap off, vibration greatly increased the dust condition. In addition, the carbon microspheres and resin tended to separate from the fibers on the top surface.

Optimizing Mold Size

The molds were altered to allow a taper, which decreased the volume of material by approximately 20 percent. This change was implemented into the manufacturing process.

Reducing Postcure Time

The original cure time and temperature were reevaluated. Static load testing and chemical degree of cure tests indicated a shorter cure time was sufficient. However, because dynamic tests and effect tests at the design agency had been conducted using parts with the longer cure, the shorter cure cycle was not implemented.

Molding to Size

The economic advantages of molding to size are obvious, because all machining operations would be eliminated. Molding to size was attempted using the inner and outer support ring molds and an outer support segment mold. However, with the fibers in the mix the thin edges resulted in a void. The process was altered to allow material to push into the thin area (permitting air to escape from the mold), but the resin and carbon microsphere mix sifted out of the vicinity. The fibers left in the thin edge area again resulted in a void condition. The outer support ring mold also produced an unsatisfactory part when voids developed near sharp edges or thin sections.

The segment mold was fabricated so that the material could be loaded from the end or the flat. Although both loading methods were used, the resulting parts continued to have void areas. A part made without fibers in the blend revealed a minimal void condition. The part appeared good; however, work on molding to size was stopped because the fibers were required in the blend and because voids could not be tolerated or eliminated.

Back-Up Materials

Silver-coated glass microbubbles have been shown to be an acceptable alternate for carbon microspheres in the preparation of thermally-conductive syntactic foams.³ The density, thermal conductivity, and compressive properties are similar for the two foam systems. Also, the blending, molding, and curing of foams made from the two types of fillers are equivalent; therefore, the existing processing equipment can be used if the silver-coated micro-bubbles are required as a second source.

Phenolic resins also have been shown to be suitable as alternate resin binders for syntactic foam made with carbon microspheres as filler. Foams made with phenolic resin and carbon microspheres have compressive properties and thermal conductivities equivalent to foams made with Kerimid 601 (polyimide) and carbon microspheres.⁴

Handling Fragile Parts

Early developmental work revealed a problem in handling the parts after machining. The initial attempt to strengthen the thin edge was to formulate a two-density material billet, with the higher density in the thin edge portion. The resulting billets, however, proved to be inadequate.

Several additional methods were attempted, including vacuum forming, plasma spray, filament winding, wet layups, and parylene coating. Parylene coating was chosen because that method did not increase the foam density significantly and because the flexural strength was increased to allow manufacturing and assembling the parts with minimal breakage. An additional advantage of the parylene coating is process uniformity. The required product contour band of 0.13 mm was met successfully without any subsequent machining operations.

Improving the Screening Process

The screening operation requires that the resin powder be inserted into the top opening of a Sweco Separator using a 0.9-L scoop. The production operator removes the powder from a 453-kg barrel, climbs a ladder, and drops the material into the 235-mm-diameter opening. The top screen inside the separator must be watched to ensure that the material passes through. If more material is added before the previous material processes through the screen, the unit will jam, and the unit must be disassembled to clean the screens. Using this method, approximately 8 labor-hours are required to process one barrel of resin powder. In addition, the operator must wear protective clothing and a respirator because of the large amounts of dust generated during the operation. Even with great care to prevent jamming, a resin build-up on the screens causes jamming after processing 900 to 1350 kg of material.

The time required to process a barrel of resin now has been reduced to less than 1 hour by adjusting the top and bottom weights and placing metal discs on the screens. In addition, the amount of dust generated during processing has been decreased

greatly. Disassembly of the separator has been reduced by a 6:1 ratio. Previously, disassembly was required after processing a maximum of three barrels of powder; with the modifications, disassembly is not required until a minimum of 18 barrels of powder have been processed. Disassembly takes approximately 5 to 7 labor-hours.

Clip Bonding

Early development efforts revealed that bonding the support clip to the outer support within the specified tolerance (0.88 ± 0.05 mm) would require an extensive tooling effort. A design was initiated for development tooling to hold the outer support so that two clips could be bonded at the same time (Figure 2). The clip holders were removable from the bonding fixture guides and could be lifted out to install the clip on the holder (Figure 3). Vacuum was used to hold the clip on the clip holder, which then could be turned upside down and placed in the guide for alignment and clip installation without the clip dropping off the holder. This method is necessary because the clip must be located with such precision that both the clip cavity on the outer support and the clip itself must be resin coated before installation (Figure 4). The vacuum also holds the clip in position until the resin is cured. Stops provided in front and back of each clip holder contact the upper surface of the outer support to set the clip depth and to locate the clip vertically. The vacuum keeps the clip from bottoming on the clip cavity; therefore, the clip is placed at exactly the same depth on each installation. Originally, the stops had no adjustment; tape was placed on the bottom of the stop if depth adjustment was necessary (Figure 5).

Only a few parts were made during development because of problems in machining and inspection, and those parts were used for analysis. Adjustment of the stops proved to be very difficult. When a clip was found to be too deep and the stops adjusted, the next part might be too shallow or still too deep. The amount of vacuum, the operation hand pressure, the stop adjustment, and the support clip all had some causal effect on the high rejection rate.

Maintaining the proper clip depth during bonding requires close control of many items. Two measurements are taken on each clip, and each part has two clips. The maximum production of 20 parts a day required considerable analysis. Trend lines were determined on a support clip basis and on a part basis. A data card, indicating bonding date, part serial number, and actual clip depth measurements, was secured to each bonding fixture. The operator measured the clip depth after removing the part from the

Figure 2. Plate for Clip Holder

Figure 3. Support Clip Bonding Operation

Figure 4. Applying Adhesive to Support Clip

fixture and recorded the information on the card. The daily results were reviewed for production trends. Also, each card was reviewed to determine trends by bonding fixture. The bonding fixture was inspected when parts showed shallow depth readings to determine if the fixture might be the cause. Vacuum, fixture adjustments, or unusual observations also were recorded by the operator.

Using the daily measurements, charts were plotted monthly for percentage of defective parts by characteristic and for percentage of part acceptance. Examples of these charts are given in Figure 6. Histograms, based on daily and cumulative data, were used to determine longer trends and variance when fixture modifications were implemented. Three plots, for June 1978, September 1978, and February 1979, are given in Figure 7. These data also indicated the magnitude of change.

Figure 5. Adding Shims to Clip Holder Stop

An added benefit from the charts was highlighting occasional problems, which show up on the charts as spikes. Figure 8, showing percentage of defective parts in January 1979, contains an example of these spikes.

Sensitivity of the process to operator technique is displayed graphically in Figure 6. Most alterations to the fixture were made to eliminate that sensitivity and the effect of changing operators. In early production, the defective rate was approximately 30 percent; later, that rate decreased to less than 8 percent. During the same period, part acceptance increased from 45 to 85 percent. These figures are based on measurements of 0.88 (+0.10, -0.05) mm.

Actual part acceptance is far better. The drawing specifies that the dimension applies along the center line of the support clip. If the part was not within the limits given, it could be

Figure 6. Typical Monthly Charts of Part Acceptance and Parts Defective by Characteristic

Figure 7. Typical Histograms for Determining Trends and Variances

Figure 8. Percentage of Defective Parts in January 1979

accepted if all tabs on the support clips were within 0.13 mm below and 0.42 mm above flush. However, rework of the tabs to meet the requirement was strictly forbidden. Thus, if the clip depth was within the +0.10 mm to -0.05 mm tolerance, no further measurements were made. However, if this requirement was not met, each individual tab was measured to ensure that none exceeded the tab height requirement. Some otherwise discrepant parts were accepted after tab inspection, thereby increasing the part acceptance percentage.

Production operators originally measured depths using a depth micrometer modified to clear the tabs. This device was milled 1.5 mm on a width of 51 mm. Later, a clip depth design fixture was procured as a direct copy of the design gage. The special micrometer now is used as a backup to the design fixture and to measure tab height. Both these measuring tools are shown in Figure 9, and the depth fixture is shown installed on a part in Figure 10. Use of these measurement devices by production operators offers timely information, confidence in the process, and early discovery of any out-of-control conditions.

More vacuum pumps were added and care was taken not to permit an interruption in the vacuum while the clips were in the initial position of the cure. Seven alterations were made to the bonding fixtures during this period; all the changes were made on the clip holders. While the alterations were in design and fabrication operator training continued, and adjustments were made on the bonding fixture clip holders by analyzing results of the previous bonding. This technique continued into the WR units using 0.1-mm-thick tape on the bottom of the stops. This attempt to decrease the range of readings required analysis of data on both the forward and aft clip measurements.

Operator skills continued to improve at installing clips on the clip holder. Operator pressure and vacuum were critical, and a change of operators required several days to return to the original quality level.

A feature was added to the stops so that brass shims (25.4 μ m) could be added to adjust the stop height rather than placing tape on the bottom of the stop. This change provided a more sensitive adjustment and removed the possibility of process variations which occurred when tape was removed inadvertently during cleaning. Forty clip holders had to be cleaned each day, and clip depth on one or two units often was too deep because the tape was missing from the stop.

Another alteration was made to preclude the operator from installing a clip upside down (the tangs pointing in the opposite direction). Two plugs were installed on the face of the clip

Figure 9. Depth Fixture and Depth Micrometer

holder so that the support clip would not rest against the face. Prior to this change, the support clip would rest very well in both positions.

During analysis of fixture adjustment and of operator training, redesign of the clip holder proceeded with two separate concepts in mind. First, the face of the clip holder was redesigned into a three section-three hole, full vacuum across the entire face of the clip holder (Figure 11) rather than the two triangular sections on the original design. This modification was designed to obtain vacuum over the entire surface; thus, the outer sections would be pulled down tight until the center section of the clip holder pulled the center section of the clip to a uniform contour for the resin cure.

Figure 10. Measuring Clip Depth

The second concept was a design change to eliminate the flat metal stop contacting the conical syntactic surface in a line contact. By placing a plate between the aluminum stops and the relatively soft syntactic surface, the compressive force of the clip holder is distributed over a surface of 60 by 100 mm, rather than a line contact of approximately 10 mm on each stop. The plate is designed so that the clip holder aligns the plate to the outer support and picks up the larger contour area between the metal plate and the syntactic surface. Depth is then determined by a metal-to-metal contact between the stops and the plate. Figure 2 shows this process improvement as a comparison to the old process. When the first bonding fixtures with the three section-three hole vacuum on the clip holders were placed in operation, the percent defective and range of readings decreased significantly (Figure 12). With the first set of full-face bonding fixtures, 34 parts were bonded, and

Figure 11. Diagonal and Full-Face Clip Holders

31 (91.1 percent) were accepted. With the old fixtures, 63 parts were bonded, and only 36 (57.1 percent) were acceptable. The percentage defective by characteristic dropped from 13 to 3.7 percent.

With only a few readings over high limits and under low limits to the revised specification, consideration was given to placing a stop order on the next modification; however, the revised specification (0.88, +0.10, -0.05 mm) was approved only with the intent that Bendix would try to process to the old specification. After reviewing results for November 1978, spanning the increased tolerance allowed by the new specification, a decision was made to continue with the plate modification.

Figure 12. Comparison of Part Acceptance Using Old and New Specifications

As shown in Figure 13, considerable improvement has been made, and process improvements are expected to continue. The addition and deletion of shims to adjust the clip holders has decreased, with adjustments required primarily when an altered fixture comes back on line. A number of operators now have considerable experience, and the variation between operators is almost non-existent. The use of brass shims in lieu of plastic tape to adjust the stops and the plate addition undoubtedly helped decrease operator variations. An additional vacuum pump and modification of all the bonding fixtures with the plate is in work.

Figure 13.. Part Acceptance and Parts Defective by Characteristic for the Period of June 1978 Through February 1979

Groove Strengthening

Both the inner and outer supports were strengthened using a parylene coating process. Additional strengthening, however,

was required in the groove section of the inner support. This area has the thinnest cross section, and a cracked unit was found at the next assembly site. Cracking, in itself, is not too detrimental if the two halves do not separate longitudinally. To strengthen the groove, several methods were attempted: plasma spray (aluminum), filament winding, fiberglass tape, mats, and numerous tapes and films.

Many of the methods were studied previously for thin edge strengthening. A Teflon tape was selected as the prime candidate because it could be obtained in the thickness desired in relation to the strength required. Other materials that were thin enough, such as filament winding, had the radial strength but not the longitudinal strength. Initial attempts to apply the tape to the groove cross section produced a stretch in the tape, where the center section tended to lift off the bottom of the groove. To alleviate the stress, the edges of the tape were slit (Figure 14). During the initial development period, this method was used by cutting the parts by hand after the tape was applied to the inner support. An automatic slitting device was designed and fabricated which incorporated an internal slit feature. The end of the slit had a tendency to tear when the tape was pulled in tension from the roll to apply the tape to the groove. Throughout this period, the tape was applied on the inner support as a machined syntactic ring and before it was sawed into halves. When the unit was cut in half, the ends of the tape tended to lift up and off the groove. The automated slitting device, which required a considerable amount of tension, was redesigned to apply the tape to an inner support (one-half of the ring) using the hand-cut tape in which the slits had been replaced with scallops. Attempts were made to scallop the edge by machining the scallop on the roll of tape. However, removal of the tape was difficult because the tabs tended to tear off. Use of the laser resulted in the same problem. Use of the hand method with a female die continued, but this method was frustrating to the operator in that any slip of the knife ruined the part. The female die was used because a male die necessitated keeping the protective paper on the tape which in turn resulted in the old problem of not being able to separate the paper from the tape without tearing off the tabs. Use of the female die permitted removing the paper from the tape without damage to the tape and then cutting the tape without it sticking to the die.

Use of a mechanical dinking die was attempted, but the tab tear-off problem reappeared. When the rubber release pad and the protective paper were removed prior to dinking, success was apparent with the first parts made. This process was adopted immediately, and the hand operation was discontinued.

Figure 14. Sketch of Slit Teflon Tape Used for Strengthening Groove

Bonding Miscellaneous Parts

The shoehorn is bonded to the outer support (Figure 15) using the same liquid resin system as the support clip. The shoehorn is punch pressed to a blank and trimmed to size for each outer support (Figure 16). Then the shoehorn is dimpled for the cable groove cutout (Figure 17).

The compression pad is bonded using a location fixture as shown in Figure 18. The dry film adhesive used has a protective paper backing until ready for bonding. The pad is trimmed to size. Edge pads on both the inner and outer supports are applied by hand with the same dry film adhesive (Figure 19). On thin edges, the dry film adhesive tends to lift up with very little force. Permission to bond the very end portions with the same liquid resin system used in bonding the support clip and shoehorn was requested.

ACCOMPLISHMENTS

A capability has been achieved to mold billets to a uniform density, to strengthen the machined part using a parylene coating process, and to bond the support clip within a very close tolerance. A technique that maintains the integrity of the inner support in the final assembly has been developed and incorporated into production. In addition, alternate processes and materials have been developed for the critical items in the manufacture of these supports.

Figure 15. Shoehorn Bonding Fixture

Figure 16. Shoehorn Trim Fixture

Figure 17. Shoehorn Dimpling

Figure 18. Compression Pad Location Fixture

Figure 19. Installation of Edge Pad on Outer Support

REFERENCES

¹H. M. McIlroy, High Temperature Syntactic Foam (Final Report). Bendix Kansas City: BDX-613-1534 (Rev.), July 1977 (Available from NTIS).

²R. J. McWhirter, Carbon Microsphere/Fiber/Polyimide Binder Syntactic Composite (Topical Report). Bendix Kansas City: BDX-613-1636 (Rev.), September 1976 (Available from NTIS).

³H. M. McIlroy, Syntactic Foam From Silver Coated Microbubbles (Topical Report). Bendix Kansas City: BDX-613-1790 (Rev.), February 1978 (Available from NTIS).

⁴H. M. McIlroy, Phenolic Resin Syntactic Foams (Topical Report). Bendix Kansas City: BDX-613-2408, June 1980 (Available from NTIS).

BDX-613-2358

SYNTACTIC FOAM COMPOSITES AND BONDING, R. J. McWhirter, Final, September 1980.

A manufacturing process has been developed to produce billets molded from a composite of carbon microspheres, a polyimide resin, and carbon fibers. The billets then are machined to configuration which results in extremely sharp and fragile edges on one part. To strengthen these parts, a parylene coating is applied, after which the parts are assembled with other parts by bonding. Bonding and assembly problems are discussed in detail; other problems encountered are summarized, and several are referenced to previous reports.

PLASTICS: Foams

SYNTACTIC FOAM COMPOSITES AND BONDING, R. J. McWhirter, Final, BDX-613-2358, September 1980.

A manufacturing process has been developed to produce billets molded from a composite of carbon microspheres, a polyimide resin, and carbon fibers. The billets then are machined to configuration which results in extremely sharp and fragile edges on one part. To strengthen these parts, a parylene coating is applied, after which the parts are assembled with other parts by bonding. Bonding and assembly problems are discussed in detail; other problems encountered are summarized, and several are referenced to previous reports.

SYNTACTIC FOAM COMPOSITES AND BONDING, R. J. McWhirter, Final, BDX-613-2358, September 1980.

A manufacturing process has been developed to produce billets molded from a composite of carbon microspheres, a polyimide resin, and carbon fibers. The billets then are machined to configuration which results in extremely sharp and fragile edges on one part. To strengthen these parts, a parylene coating is applied, after which the parts are assembled with other parts by bonding. Bonding and assembly problems are discussed in detail; other problems encountered are summarized, and several are referenced to previous reports.