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**WEAR RESISTANT COMPOSITE STRUCTURE OF VITREOUS CARBON
CONTAINING CONVOLUTED FIBERS**

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BACKGROUND: The current business climate is one in which manufacturing firms are not seeking new solutions to their problems, but seeking instead to lower costs. Because MRCC is both a low cost material and a cost saving material we can still attract interest from several major firms. We continue to be in contact with about 20 companies all of whom have perceived needs for a material improvement such as MRCC can provide.

PROGRESS: This quarter has seen several major project milestones.

PolyCorr have requested a license to manufacture MRCC. We are planning a face to face meeting in May 1995 to discuss the details. PolyCorr manufacture a wide range of polymer products including wear components. We do not yet know what applications or volume PolyCorr have in mind.

Many of the firms that we are dealing with are short of funds for evaluating new materials and must request those funds. In order to keep their interest up and to keep other interested parties informed of the state of MRCC we have inaugurated the MRCC Newsletter. This is an almost monthly publication. Each issue will carry news and highlight one property or attribute of MRCC in detail. By singling out properties in this way we feel that they will have more impact than when buried in with other material.

The North Carolina College of Veterinary Medicine has put together a large and well thought out program for evaluating new materials for joint prostheses. The materials involved are MRCC, Diamond Like Carbon Coated Polyethylene, and Amorphous Diamond coated polyethylene. This is the first head on test of these materials. The program will evaluate wear and wear product production. MRCC is scheduled for a future wear study at Sandia National Laboratory but funding has not been forthcoming.

MRCC was presented at the Innovative Concepts Technology Fair in Denver in April. There was dissappointing attendance at the fair but we managed to get two good things out of it. First we were provided with a new brochure from Batelle Pacific Northwest Laboratory. This is useful and timely as it provides another way of contacting and informing potential licensees for MRCC. In the preparation of the brochure we learned a lesson in communication. The preparers were nontechnical people as are many business executives. We had some miscommunications where we thought we had clearly stated something and it was clearly not understood at the other end. This has resulted in a simpler and clearer brochure and a

lesson to us to be sure that our message is being received in the way in which we intend.

I did not attend the second day of sessions for the Inovative Concepts Fair because of the low turnout. Instead I spent some time in consultation with Mr. Ken Hunter. Mr Hunter is the CEO of two firms which were spun off from John Manville by a management buyout. These firms make refractory materials under their own name and OEM for other companies. One of the road blocks we were facing was the next step beyond prototype evaluation. Few of the companies which we are talking want to make MRCC themselves, they want to buy MRCC products made elsewhere. Mr. Hunter explained both private label and toll manufacturing. Toll manufacturing seems to be the answer to our problem. In toll manufacture one rents for a toll the manufacturing facility of another company. The period of rental runs from parts of a day to full time. This is a way of obtaining access to manufacturing capacity without the capital investment. Because of the excess capacity of many factories at the present time, this is attractive to both parties. Because MRCC has three separate stages where there is no commonality of technology, we can split the manufacture among three specialized companies in a toll manufacturing arrangement and maintain confidentiality as there is no reason for these companies to even be aware of the others. We have already lined up one company for one stage of this process and are close to the others.

A further advantage of the toll manufacturing arrangement is that it allows to pool our customers together in order to get up to a sufficient volume to justify a manufacturing run.

FUTURE: We are scheduled to present our paper at the STLE annual convention in May 1995. We are scheduling several face to face meetings around the meeting. We have also scheduled a new face to face meeting with Rotary Power Inc. There is renewed interest from RPI and the Institute for Gas Technology. Toll manufacturing is beyond the scope of the present program and represents the first step in what happens after ERIP. This new manufacturing capacity will also be of assistance with other firms who are looking at the availability of larger volumes of specimens than we can provide. ThermoKing is one such firm.

1995 has been a year so far of increased activity and interest in our program. The pace seems to be increasing and we expect a new round of interest to be generated by our new flyer from the Innovative Concepts Technology fair. A copy of this brochure is attached. We expect to sign our first licensing agreement soon.

Adaptable, Metal-Reinforced Carbon Composites

**Ralph A. Burton and
Gaines Burton**
Burton Technologies

An innovative process produces a tailored, composite carbon material that can be used to manufacture wear and structural components that do not require any lubricants. The process is compatible with high temperatures up to 400°C and with hostile environments.

Cross Section of MRCC Grade 300 (~300X)

Introduction

Moving parts fabricated from commercially available material generally require a lubricant. The use of lubricants can create several problems: explosions in the compressed gas industry; contamination of the fluids being pumped in the refrigeration, food processing, and chemical

industries; and a tendency to boil off in aerospace applications. Using lubricants adds energy, maintenance, and supply costs, and creates environmental concerns.

Concept Description

Metal-reinforced carbon composites (MRCC) that require no lubricant are a new class of material made up of nongraphitic, continuous-phase, unstructured carbon binder and continuous metal fibers. A noteworthy advantage of the MRCC process is that it can be applied not only to small parts, such as bearings and seals, but also to large castings, such as pump bodies and compressor cylinders.

The process for manufacturing the MRCC is a simple, single-stage pyrolysis of a resin-formed greenbody, i.e., metal and carbon composite particles held together by binder or resin. Machining can be performed on the greenbody or on the final fired component, depending on required tolerances.

The MRCC material offers several desirable features:

- Self-lubricating - When run in a dry condition, the material has lower friction and wear than conventional materials that are run lubricated. The chances of contamination of lubricant streams and the potential for catastrophic failure in high-speed rotary components, such as jet engines and large computer coolant systems, are almost eliminated.

- **Impermeable** - The material is impervious to diffusion when used in seal systems, which makes it exceptionally useful in air-conditioning and other high-pressure, chemical-containment-system components.
- **Chemically resistant** - The binding matrix of MRCC is a continuous glassy phase of unstructured carbon, which is completely invulnerable to chemical attack from most acids, bases, and other corrosives.
- **Lightweight** - MRCC can be made in grades that have 50% of the specific gravity of conventional, graphite/copper materials. These lightweight composites are especially efficient in dynamic components, such as pistons and other moving parts.
- **Controlled strength and conductivity** - The continuous metal fibers allow for control of the properties of the thermal and electrical conductivity material. Selective cooling of high-temperature components opens up many possible applications of the process.
- **High-temperature tolerance** - The integrity of MRCC materials has been verified for wear up to 218°C. No loss of integrity occurred when specimens were subjected to temperatures of 1,650°C in static tests.
- **Vacuum and dry atmosphere** - MRCC components do not require special atmospheres for high performance; the components' wear performance in a vacuum atmosphere is actually superior to that in air.

Economics and Market Potential

MRCC costs can be well under \$1.75/lb, depending on the metal content. Its cheapest competitor, electrode carbon, which is essentially a pencil lead material, costs over \$2/lb. The nearest performance competitor, chemical vapor deposition (a coating process for conventional materials), is very expensive. It costs about \$1,000 to have a component coated with a thickness of a few thousandths of an inch--of almost an intangible weight. Another competitor, low-temperature diamond material, is too new to evaluate economically, but it is expected to cost many thousands of dollars per pound--if it is even feasible and/or practical to produce in large quantities.

Any of the material characteristics of MRCC can be optimized for specific applications by choosing the appropriate fiber in the matrix and by adjusting the process parameters. A detailed market analysis of applications is available for review by potential investors. These applications include

- current collectors (motor brushes, slip rings, railroad pantographs, and other high-temperature and electromagnetic applications)
- mechanical components (tip seals for rotary engines compressors, seals, vanes, bushings, bearings, gears, and piston rings for engines)
- biomedical needs (prosthetics and valves).

Key Experimental Results

Material samples have been tested by four independent laboratories: NASA and three U.S. Department of Energy laboratories. Information on these tests is available upon request.

A family of MRCC materials has been developed by Burton Technologies. Specimens of up to 2-in. diameter and 8-in. long can be produced now, and larger components will be possible when the equipment is scaled up. Formula selection for custom applications is under development.

Future Development Needs

Burton Technologies can provide drop-in prototype specimens for evaluation by equipment manufacturers who may directly license the process and material. Burton Technologies does not plan to manufacture specific materials or components, but can make arrangements with other manufacturers.

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