NUCLEAR METALS, INC.

02 December 1994

Dr. Steven G. Fishman
Scientific Officer, Material Division
Department of the Navy
Office of Naval Research
800 N. Quincy Street
Arlington, Virginia 22217

Subject: Interim Report

Reference: ONR Contract No. N00014-94-C-0135
NMI No. 6441

Dear Steve:

Please find enclosed our third interim report, Item No. 0001AC for the above referenced contract. This report covers work through 1 December 1994.

Should you require any additional information or assistance, please do not hesitate to contact us. We would welcome the opportunity to be of service.

Sincerely,

Dennis J. Lehan
Manager, Specialty Products

DJL:swf

Enclosure

cc: Director, Naval Research Laboratory
Attn: Code 2627
Washington, DC 20375

Defense Technical Information Center
Bldg. 5, Cameron Station
Alexandria, Virginia 22304-6145

Ballistic Missile Defense Organization
Attn: T/IS
The Pentagon
Washington, DC 20301-7100

Paul Sullivan
DCMAO Boston
495 Summer Street
Boston, MA 02210-2138

94C0135-000I

Ductile - Ductile Beryllium Aluminum Metal Matrix Composite Manufactured by Extrusion[1]

Prepared by
Nancy F. Levoy

Nuclear Metals, Inc.
Concord, MA 01742

1994

Interim Report for the period November 1 through December 1, 1994

Contract N00014-94-C-0135

Prepared for
Program Officer
Office of Naval Research
Ballston Tower One
800 North Quincy Street
Arlington, VA 22217-5660

[1]Research is sponsored by BMDO/IST and managed by ONR

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1.0 Introduction

Beryllium-aluminum alloys are unique, in-situ ductile-ductile metal matrix composite alloys. Cast and extruded beryllium-aluminum composite alloys are expected to have a unique combination of properties that are attractive for applications such as ground and space based interceptor and tracking systems that require minimum weight, high stiffness, good damping capacity and thermal stability. Compared with other metal matrix composites, cast and extruded beryllium-aluminum composites are expected to have the advantages of: (1) lower cost; (2) significantly higher ductility; (3) higher temperature capability; (4) less directionality of properties; (5) applicability of all conventional metal processing techniques; and (6) joining by conventional welding and brazing technology.

The current program is designed to develop a method for extruding a cast beryllium-aluminum composite, establish a basis for estimating the properties that can ultimately be achieved with an optimized process, and produce an extruded structural shape of moderate complexity. Specific technical objectives are as follows:

1. Develop an extrusion process suitable for beryllium-aluminum composites that maximizes product yield, minimizes processing steps, gives good surface finish, and is suited for producing complex shapes.

2. Determine mechanical and physical properties to demonstrate potential.

3. Define potential for property enhancements and cost reductions that could be achieved through continued development of this technology.

2.0 Work Plan

The work covered by this program is divided into two main tasks and a number of subtasks. Task 1 involves the development of extrusion parameters. For this task, three ingots will be cast, each measuring approximately 47.5 mm diameter by approximately 200 mm length. The diameter of the ingots has been increased slightly from the original plan to ensure that a high quality surface finish can be achieved on the ingots prior to extrusion billet preparation. The ingots will be cast with a nominal composition of 65Be-33Al-2Ag (by weight percent). Each ingot will be cut in half to provide six cylindrical billets for extrusion.

Different pre-extrusion billet canning/coating techniques will be evaluated to determine the optimal conditions that produce extrusions having the best surface quality. The can or coating helps prevent surface cracking and aids lubrication.

Three billet preparation techniques will be evaluated. The first will be to enclose the billet in a metal sleeve or can. Sleeves of 6061 aluminum will be evaluated at thicknesses of 0.635 mm and 1.905 mm; a copper sleeve with a thickness of 1.905 mm will also be evaluated. The second billet preparation technique will be to plasma spray an aluminum alloy coating onto two billets, with coating thicknesses of 0.635 mm and 1.905 mm. The final billet surface will be plated with copper with a plated coating thickness of 0.635 mm.

The six billets will be extruded through a round die as a group using similar extrusion parameters. Extrusion parameters will be selected based on results from previous NMI IRAD work. The extruded rods will be evaluated primarily for the effects of billet preparation on surface finish. Overall product integrity will also be evaluated.

Task 2 will lead to development of the capability to extrude a structural shape of moderate complexity of beryllium-aluminum composite. Three beryllium-aluminum ingots will be cast in molds measuring 63.5 mm diameter by approximately 200 mm length. The method of extrusion billet preparation will be selected based on the results of Task 1. The extrusion shape selected for this program is a modified I beam, and is representative of types of shapes previously used with other metal matrix composite materials. Extrusion conditions will be optimized based on results of the first two extrusions in Task 2 and the optimized conditions will be applied to the third extrusion. Extruded product will be evaluated for surface quality, mechanical properties and microstructure.

3.0 Work Accomplished

Casting of the three ingots for Task 1 has been completed. The cast ingots were surface machined and sectioned to produce 6 billets for extrusion. Two billets have been shipped to the plasma spray vendor for coating. Application of plasma sprayed 6061 aluminum coating measuring 0.635mm thickness on one billet and 1.905mm thickness on the other billet should be complete by 12/9/94.

Difficulties encountered while developing a process for plating copper onto beryllium-aluminum by the original plating vendor has required a change to a new plating vendor. Preparation of the beryllium-aluminum billet with 0.635mm plated copper is expected to be complete by 12/9/94.

Casting molds have been prepared for task 2 castings. A die for the shaped extrusions to be produced under Task 2 has been ordered. Figure 1 shows the modified I beam shape of the die.

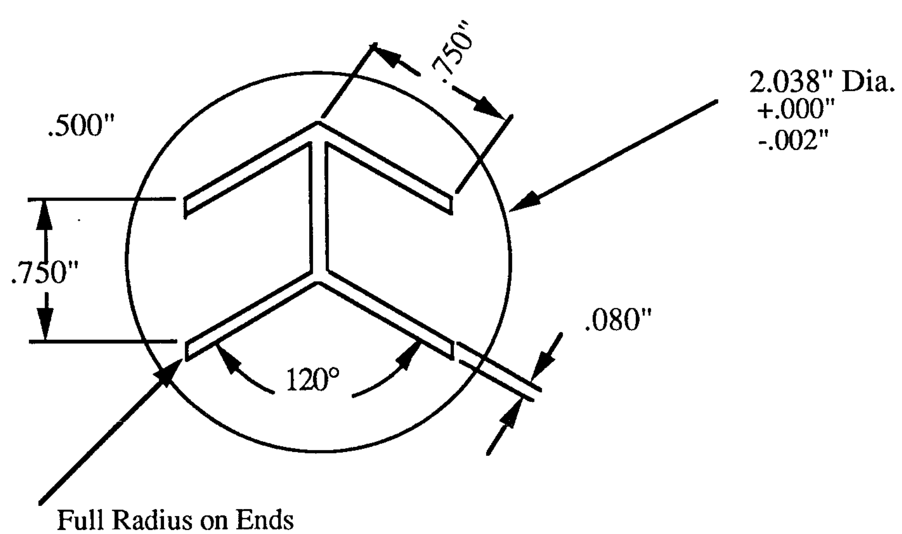

Figure 1. Task 2 shaped extrusion die design

4.0 Work Planned Through Next Reporting Period

Task 1 billet preparation, extrusion, and evaluation will be completed during the next reporting period. Casting of the three Task 2 ingots will be done concurrently. Based on the results of the task 1 evaluation, billet preparation of Task 2 billets should begin during the next reporting period. Production of the die needed for Task 2 extrusions should be completed during the next reporting period.

5.0 Conclusions

Work is continuing for the preparation of billets for Task 1 extrusions, which are designed to assist in the development of extrusion parameters for beryllium-aluminum alloys. Task 1 should be completed by mid-December. Preparation for Task 2 extrusions, which will lead to the development of extrusion technology for extrusion of beryllium-aluminum through a die of complex shape, is also in progress.