0
UNCLASSIFIED

OAK RIDGE NATIONAL LABORATORY
Operated By
UNION CARBIDE NUCLEAR COMPANY

UIC

POST OFFICE BOX P
OAK RIDGE, TENNESSEE

EXTERNAL TRANSMITTAL
AUTHORIZED

ORNL
CENTRAL FILES NUMBER

CF- 56-11-130

DATE: November 28, 1956
SUBJECT: Procedures Developed At The Oak Ridge National Laboratory
For Fabricating Stainless Steel Clad B₄C-Cu Composite Plates
TO: Distribution
FROM: M. R. D'Amore

COPY NO. 42

DISTRIBUTION

- 1-40. M. R. D'Amore
41. LRD-RC
42-56. T.I.S.E.

NOTICE

This document contains information of a preliminary nature and was prepared primarily for internal use at the Oak Ridge National Laboratory. It is subject to revision or correction and therefore does not represent a final report.

UNCLASSIFIED

49-1

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.

1

PROCEDURES DEVELOPED AT THE OAK RIDGE NATIONAL LABORATORY FOR
FABRICATING STAINLESS STEEL CLAD B_4C -Cu COMPOSITE PLATES

The techniques developed at the Oak Ridge National Laboratory for fabricating panels of a B_4C -copper cermet clad with stainless steel are summarized in this report. The fabrication techniques were developed jointly by the Fabrication and the Process Metallurgy Groups of the Metallurgy Division.

B_4C -Cu Core Fabrication

The powder metallurgy procedures employed in the fabrication of B_4C -Cu cores are described below.

The copper powders are purchased from U. S. Metals Refining Company. Their designation is Electrolytic Copper Type C and the powders are 70-80% -325 mesh. The B_4C powders are purchased from The Norton Company and are designated High-Purity B_4C (76% Boron minimum). The B_4C particles are ground to -325 mesh prior to use.

Dispersions of B_4C particles in copper are obtained by blending the powders on an oblique blender rotating at 24 rpm. Uniform mixtures have been obtained in batch sizes up to 1 kg by blending for two hours. Batches larger than 1 kg are generally blended four hours.

The powders are compacted in hardened steel dies at pressures of 10-15 tsi, using stearic acid as a die lubricant. Exceeding these compacting pressures will result in expansion of the cores during sintering due to entrapped gases.

The compacted cores are sintered in a dry hydrogen atmosphere (-70 dew pt.) between 1550-1900°F. The lower temperatures are used for cores containing the highest proportion of copper (greater than 70 vol %) to control the shrinkage. Sintering times of one hour have been satisfactory. Longer sintering times result in no significant improvement of the bodies.

Coining is done in the same dies at pressures between 33 and 60 tsi. The higher coining pressures are favored since the density and strength of the cores are increased.

The density of 20 vol % B_4C -80 vol % Cu experimental compacts 1" x 3" x 0.4" thick after pressing at 10 tsi, sintering at 1550°F and coining at 35 tsi has been above 90% of theoretical.

Pack Assembly

The components of a pack and assembly sequence are illustrated in Fig. 1. The diffusion barriers are Oxygen Free High Conductivity copper. The B_4C -Cu core and copper foil barriers are inserted in the stainless steel frame. The cover plates and evacuation stem are welded to the frame to seal the assembly. The cover plates are

slightly wider and longer than the frame as shown in Fig. 2 in order that the weld may be heavy. This configuration also serves to reduce stress on the weld during hot rolling. The assembled pack is evacuated to about 10 microns and the evacuation stem sealed and cut-off by hot forging prior to rolling. Small packs are heated with a hand torch during evacuation to facilitate the release of gases absorbed in the cermet core. Larger packs are heated in a furnace at 1200-1300°F for the evacuation procedure.

Available press capacity at ORNL has limited the maximum core size to 2" wide x 2-1/4" long; however, packs may be assembled with multiple cores to produce larger panels. Bonding occurs between cores during the hot rolling operation and results in a continuous core in the finished plate. Packs containing up to ninety 1" wide x 3" long cores have been hot-rolled.

The cover plates and frames are plated with 0.001-0.003" nickel to facilitate bonding when cladding with a 300 series stainless steel.

Hot Rolling Procedures

The packs are hot rolled at 1800°F using intermediate reductions of 7% per pass. Total reductions of 10:1 are preferred; although adequate bonding of components occurs at reductions of 6:1. The rolling direction is reversed and the pack flipped over after each pass to obtain optimum thickness uniformity in components. Rupturing occurred at each end of the core during the initial roll-cladding experiments. A macrophotograph illustrating a typical clad rupture of a hot-rolled plate is shown in Fig. 3. Failures of this type have been observed at thickness reductions as low as 50%. The clad ruptures are attributed to the difference in plasticity between the B₄C-Cu core and the stainless steel clad at 1800°F. Packs have been fabricated successfully by rolling at 1500°F but poor bonding between the components results from the lower rolling temperature. Machining of V-notches into the frame ends or the use of a V-notch insert (Fig. 2) was required to fabricate packs at 1800°F without rupturing. The excess core extension is forced into the V-notch rather than through the clad during rolling as shown in Fig. 4.

UNCLASSIFIED

Fig. 1 Pack Components and Assembly

Fig. 2 - Sketch Showing End of Pack Assembly

- A. Copper Foil Barrier
- B. B_4C -Copper Core
- C. Void Space
- D. V-Notched Insert - Notch $1/8"$ to $1/4"$ depth
for frame thickness to $1"$
- E. Frame - $3/4$ to $1"$ Wide
- F. Clad

(Sketch not to scale)

Fig. 3

10X

Macrograph showing core end effect and clad rupture in a plate rolled from a pack with a square-edge frame.

Fig. 4

2.5X

Macrograph showing improved core end effect in a plate rolled from a pack with a V-notched insert.

0-5-