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Y-1571
Metals, Ceramics
and Materials

GADOLINIUM OXIDE-30 WT % ALUMINUM OXIDE COMPACTS (U)

Paul E. Trent

UNION CARBIDE CORPORATION
NUCLEAR DIVISION
OAK RIDGE Y-12 PLANT

operated for the **ATOMIC ENERGY COMMISSION** *under* **U. S. GOVERNMENT Contract W-7405 eng 26**

UNION CARBIDE

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Oak Ridge, Tennessee

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ABSTRACT

Pellets made of 70 wt % gadolinium oxide-30 wt % aluminum oxide have been fabricated with densities > 99% of theoretical. Three of these compacts were ground to specific dimensions and, using interferometer techniques, the thermal expansion coefficient of this material was determined for the temperature range of 25 - 900° C.

CONTENTS

SUMMARY

Pellets made of 70 wt % gadolinium oxide-30 wt % aluminum oxide have been fabricated with densities > 99% of theoretical. Three of these compacts were ground to specific dimensions and, using interferometer techniques, the thermal expansion coefficient of this material was determined for the temperature range of 25 - 900° C.

INTRODUCTION

During a study of the ORNL specifications for fuel elements to be used in the Medium Power Reactor Experiment (MPRE) and Molten Salt Reactor Experiment (MSRE), it was noted that gadolinium oxide-aluminum oxide pellets were being used in place of boron.[1-2] Both materials have a high neutron cross section and are very effective at minimizing neutron leakage from the fuel elements. It was also found that little information was available on the fabrication of the desired gadolinium oxide-aluminum oxide (70 wt % Gd_2O_3-30 wt % Al_2O_3) compacts or the thermal expansion characteristics of this material.

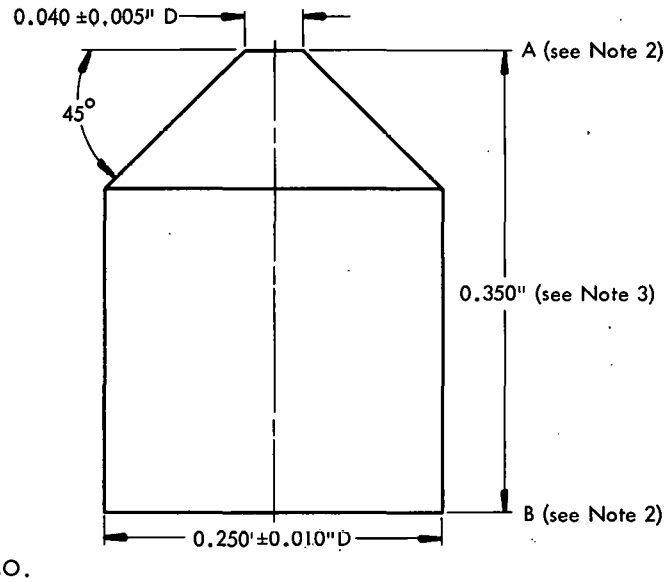
PELLET PREPARATION AND TESTING

PREPARATION

A gadolinia-alumina eutectic (70 wt % Gd_2O_3-30 wt % Al_2O_3) was prepared by blending the oxide powders and sintering the mixture at 1700° C for two hours in a hydrogen atmosphere.[1, 2] This fused mass was then ground to -325 mesh and several pellets were pressed from 20,000 to 50,000 psi at 5000-psi increments. These pellets were sintered at 1550° C in hydrogen for two hours. Their density consistently exceeded the theoretical density of 5.873 gms/cc set forth in the MPRE specifications.

TESTING

Three of the pellets were precision ground to conform with the dimensions given in Figure 1. These pellets were used to measure the thermal expansion of the oxide mixture using an interferometric technique. The resulting data are presented in Table 1 and Figure 2.



NOTES

1. 32√FAO.
2. Surfaces A and B to be parallel within 0.002 TIR; small diameter to be concentric with large diameter within 0.002 TIR.
3. Three required as a set. Each set must have lengths within ± 0.0002 inch. The 0.350 inch length is optional as long as all pellets are the same length within ±0.0002 inch.

Figure 1. THERMAL EXPANSION SPECIMEN.

Table 1

THERMAL EXPANSION OF GADOLINIUM OXIDE-ALUMINUM OXIDE PELLET

Temperature (° C)	Observed $\Delta l/l_o$	Calculated $\Delta l/l_o$	α/° C
35	0.615E-04	0.578E-04	0.601E-05
42	0.922E-04	0.101E-03	0.621E-05
52	0.154E-03	0.164E-03	0.643E-05
75	0.307E-03	0.316E-03	0.681E-05
97	0.461E-03	0.469E-03	0.709E-05
141	0.768E-03	0.792E-03	0.754E-05
179	0.108E-02	0.108E-02	0.786E-05
217	0.138E-02	0.139E-02	0.814E-05
236	0.154E-02	0.154E-02	0.826E-05
271	0.184E-02	0.184E-02	0.849E-05
308	0.215E-02	0.216E-02	0.870E-05
339	0.246E-02	0.243E-02	0.887E-05
374	0.277E-02	0.274E-02	0.905E-05
409	0.307E-02	0.306E-02	0.923E-05
443	0.338E-02	0.338E-02	0.939E-05
476	0.369E-02	0.369E-02	0.954E-05
507	0.400E-02	0.399E-02	0.967E-05
538	0.430E-02	0.429E-02	0.980E-05
571	0.461E-02	0.462E-02	0.993E-05
601	0.492E-02	0.492E-02	0.101E-04
632	0.523E-02	0.523E-02	0.102E-04
662	0.553E-02	0.554E-02	0.103E-04
694	0.584E-02	0.587E-02	0.104E-04
724	0.615E-02	0.618E-02	0.105E-04
751	0.645E-02	0.646E-02	0.106E-04
780	0.676E-02	0.677E-02	0.107E-04
809	0.707E-02	0.708E-02	0.108E-04
836	0.738E-02	0.738E-02	0.109E-04
862	0.768E-02	0.766E-02	0.110E-04
890	0.799E-02	0.797E-02	0.111E-04
905	0.815E-02	0.814E-02	0.112E-04

The data were fitted to an equation of the form:

$$\frac{\Delta l}{l_o} = A\,(t-25) + B\,(t-25)^c,$$

where:

A has a value of 0.530×10^{-5},
B a value of 0.163×10^{-6}, and
c a value of 1.47.

The average coefficient of expansion was determined to be:

$$\bar{\alpha}\ (25 - 905^\circ\ C) = 0.924 \times 10^{-5}/^\circ\ C.$$

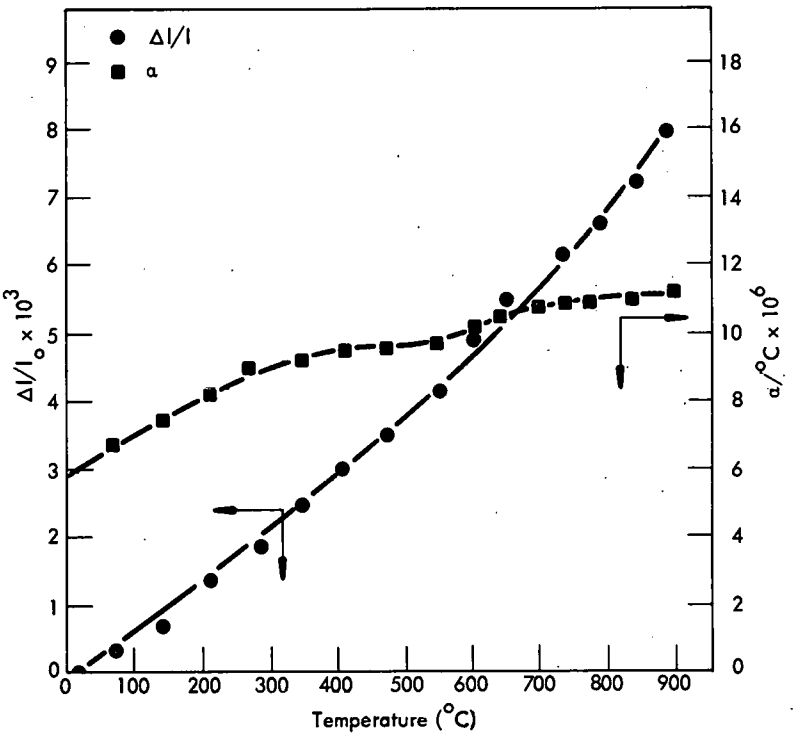


Figure 2. THERMAL EXPANSION OF GADOLINIA-ALUMINA PELLET.

DISCUSSION

Cold pressing and sintering mechanical mixtures of gadolinia and alumina at 1500 - 1650° C resulted in severely distorted pellets. This condition resulted from the formation of a low-melting-temperature compound, identified by X-ray diffraction analysis as the primary perovskite-type phase Gd-AlO_3.(2) This distortion, however, was minimized by using a blend of the powders that had been prereacted at 1700° C. Some flaring of the bottom ends of the compacts still occurred due to frictional restraint during sintering.

In order to eliminate this pellet flaring during sintering, half of the pellets were used to support the other half in the furnace. In this way the top pellets shrank with the top of the bottom pellets at the same rate, and to the same size, eliminating frictional restraint. The bottom pellets flared, but they were reground and the powder reused.

REFERENCES

(1) Taylor, A. J.; Personal Communication; September 9, 1964.

(2) Molten-Salt Reactor Program Semiannual Progress Report For Period Ending August 31, 1962, ORNL-3369, p 98; Union Carbide Corporation, Oak Ridge National Laboratory, Oak Ridge, Tennessee; December 4, 1962.