Aluminum Nitride Refractories for Handling High-Nickel Alloys

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The properties of many of the new high-nickel alloys are excellent. In the molten state, however, they are extremely aggressive toward most refractories. Their attack of refractories increases the cost of their fabrication, but even more importantly, this reaction with refractories often changes the alloy composition or leads to the formation of crystalline inclusions within the resulting parts. The result is a material that is more difficult to

Figure 1. The reaction interface between alloy IN-100 and aluminum nitride after exposure for one hour at 1,700°C in argon.

machine, and one in which inclusions can give rise to premature failure.

Aluminum nitride has recently become one of the most actively investigated refractory materials.^{1,2} It has unique combinations of properties which set it apart from the classical refractory materials. Its high thermal conductivity [180–200 W/(m · K)] is comparable with that of the more conductive metals such as aluminum [236 W/(m · K)]. It also has high electrical resistivity, a dielectric constant comparable to the best ceramic insulators, and a low thermal expansion coefficient.

Also unique is the fact that AlN is readily wetted by molten aluminum, yet it is completely stable with little or no solubility in the metal.³ Table I presents some of the properties of AlN in comparison with several currently available engineering materials.

Advanced Refractory Technologies has been investigating the possible use of AlN as a refractory to handle high-nickel alloys. Two alloys selected were Merl 76 and In 100, the compositions of which are given in Table II.^{4,5} To be

Table II. Nominal Composition of Alloys (wt.%)

Element	MERL 76*	IN 100†
Ni	54.76	60.5
Co	18.5	15
Cr	12.4	10
Al	5.0	5.5
Ti	4.3	5
Mo	3.2	3
Nb	1.4	
V		1
Hf	0.4	
C	0.025	0.18
Zr		0.06
B	0.02	0.01

* From Reference 4.

† From Reference 5.

acceptable, the alloys were to exhibit minimum attack after 15 minutes at 1,600°C. It was decided to increase the severity of the test and expose the alloys at 1,700°C for an hour in argon.

A quantity of each alloy powder, obtained from Homogeneous Metals, Inc.,⁴ was placed in fully dense AlN crucibles. These crucibles were sintered with either calcia (CaO) or yttria (Y₂O₃) sintering aids. No difference could be found between crucibles prepared with either of the two methods.

After the alloys were exposed to the high temperatures, only limited evidence of attack was seen. On cooling, the Merl 76 pellet fell out of the crucible. Both crucibles and pellets were sectioned and polished (Figure 1). Microscopic examination of the metal-ceramic interfaces showed slight evidence of reaction. The depth of this reaction zone was less than 150 μm at the worst area of attack, by the IN-100 alloy, and was typically of the order of 20 μm or less for both alloys.

Based on these limited tests, AlN would seem to be a candidate material for use in handling high nickel-cobalt alloys.

References

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2. P.T.B. Shaffer, J.R. Schorr and R.L. Hexemer, Jr., "Aluminum Nitride, An Emerging Advanced Ceramic Material," *Ceramic Age*, to be published.
3. T.B. Massalski, *Binary Alloy Phase Diagrams* (Metals Park, OH: ASM, 1986).
4. Homogeneous Metals Inc., P.O. Box 294, Clayville, NY 13322; personal communication, 1988.
5. *ASM Metals Reference Book* (Metals Park, OH: ASM, 1981).

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Table I. Properties of Aluminum Nitride in Comparison with Other Materials					
Property	AlN	SiC	Al ₂ O ₃	304 S.S.	Al
Density (g/cm ³)	3.26	3.21	3.97	8.02	2.70
Thermal Expansion (10 ⁻⁶ /°C)	4.6	4.6	7.0	17.3	25
Thermal Conductivity [W/(m · K)]	185	100	29	17	237
Young's Modulus (GPa)	343	460	378	192	69
Electrical Resistivity (ohm-cm)	>10 ¹⁴	variable	10 ¹⁴	72 × 10 ⁻⁶	4 × 10 ⁻⁶

process available today that can provide a certificate of destruction for every ton of EAF dust processed. Because all material is recycled, the process should comply with future EPA regulations or changes to regulations.

Inclined rotary reduction system facilities can be built on-site or as regional processing centers, and will be operated by Zia Technology. A regional IRRS facility is currently under construction in Caldwell, Texas, in EPA Region 6. Scheduled for startup in May 1990, the plant will be capable of processing 54,000 tonnes per year of EAF dust. Currently, about 63,500 tonnes of dust is produced annually by the steel plants in that region.

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Correction to the December Issue

During the editing and production process, several errors were inadvertently included in the December 1989 article "Refractory Concentrate Gold Leaching: Cyanide vs. Bromide," by A. Dadgar. The following corrections were sent to us by the author:

On page 38, in the fifth line of the second paragraph after Reaction 5, [Br₄⁻] should actually be [Br⁻], and AuBr₄ should be AuBr₄⁻. In Reaction 6 on the same page, the product should be 2AuBr₄⁻ plus three molecules of water. Two lines below Reaction 6, AuBr₄ should read AuBr₄⁻. On page 39, the caption for Figure 5 should include the line [Br⁻] = 10⁻⁵ M in the description of Figure 5a.

The editors regret any confusion these errors may have caused.

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