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IMPROVED GAS DISTRIBUTOR FOR COATING HTGR FUEL PARTICLES*

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SUMMARY

Coatings for thorium- and uranium-bearing fuel particles for High-Temperature Gas-Cooled Reactors are deposited in a fluidized bed coating furnace.¹ The most important component of the coating furnace is the gas distributor, which brings the coating gases into contact with the fuel particles. The important criteria to be considered in design of the gas distributor are:

1. The distributor should ideally spread or disperse the gas over the full area of the coating chamber to maximize the particle gas contact area and thereby increase both particle circulation and the percentage of the input gas that ends up as coating.

2. The gas should not heat up during its passage through the distributor. Otherwise the gas would partially decompose prematurely, causing excessive coating deposition within or on the distributor.

3. The distributor should be designed to minimize accidental drainage of particles from the furnace and blowover of particles into the effluent system.

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4. The distributor should be capable of depositing both carbon and SiC coatings of high quality as regards to density, preferred orientation, permeability, defective fraction, and other product attributes.

5. The distributor should be amenable to use with large particle charges and short turnaround times and be simple, inexpensive, and reliable.

Most commonly some form of an inverted hollow cone is used as the gas distributor for coating fuel particles. This class of distributors suffers from limited particle-to-gas contact and slow circulation of particles through the coating zone. Other gas distributors made of a uniform thickness or porous carbon work well during the very initial portion of a coating run but soon plug from coating deposition within the pores. Still other designs have used multiple gas inlets protruding through either a porous carbon base or an array of dense carbon cones. However, both these approaches suffer from being too complex and therefore costly and unreliable. Also, particles are lost down through the multiple inlets, or gas flow varies from inlet to inlet. The implementation of uniform gas dispersion up to this point has not been successful. We have devised a simple distributor that incorporates the five criteria listed above.

The new design, which is termed a blind-hole frit, is shown in Fig. 1. All the gas passes through the thinned or blind-hole regions, and thus the gas velocity is considerably higher than for a flat frit of uniform thickness. Because of its high velocity, the gas does not have time to reach a high enough temperature to cause deposition within the frit. Also most of the resistance to gas flow is provided by the porous distributor and not by the particle bed; therefore, localized variations

of the quantity of particles above any particular gas inlet do not significantly alter the flow rate through that inlet. Further discussion of the advantages of the new distributor in terms of the above criteria is available.²

The coating efficiency (i.e., the percentage of input carbon that ends up as coating) is higher when the frit is used rather than a single-inlet cone. Pyrocarbon coatings are most readily deposited near the apex of the single-inlet cone. Since so few particles are in this region at one time, the efficiency is quite low. When the blind-hole frit is used, pyrocarbon can be deposited near each hole simultaneously, so more particles are exposed to the decomposing gas, increasing the efficiency. Typically, the efficiency with which the carbon is utilized during buffer and LTI coating with a frit is about 60 and 55%; corresponding values for the cone are 50 and 30%.

A statistically designed experiment using a 13-cm-diam coating furnace was performed to compare the frit and the cone. Numerous coatings made with frits having several different hole patterns were compared with similar coatings made with a cone. Particles coating with the frit were more spherical³ and LTI coatings were more isotropic than ones produced with a cone. Typically the Bacon Anisotropy Factor⁴ for LTI coatings is about 0.02 unit lower for coatings deposited with the frit, and the within-batch particle-to-particle variation of anisotropy is less.

The frit has been successfully used in our 13-cm-diam coater for four years to deposit good quality coatings, including silicon carbide having high densities and low defective fractions. Recently, the blind-hole frit was used at General Atomic Company to successfully deposit carbon and silicon carbide coatings in a 24-cm-diam coater, which is

the size currently considered for commercial fabrication plants. The silicon carbide had a density of 3.206 g/cm^3 and the defective fraction was 3×10^{-5} . These values are comparable to the best obtainable with smaller coatiers.

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FIGURE CAPTION

Fig. 1. Frit or Blind-Hole Porous Plate Gas Distributor.

