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MATERIALS FOR METAL BOMB LINERS

SYMBOL: EPD:ABB:pt

I. Introduction

On March 14, 1951, I discussed with Dr. Wayne Keller of MCW the general history and technology of metal bomb liner materials. This discussion was desirable in view of the fact that we are planning certain tests and research on the reuse of liner materials in the new Feed Materials Production Center.

II. History

Dr. Keller outlined the work that had been done at Ames and Los Alamos on bomb liner materials for the manufacture of various project metals. When this work was done (believed to be about 1942-3), many possible liner materials were tested. These tests showed that, chemically, the oxides of the alkali earth metals, MgO, CaO, BeO, were satisfactory, as well as the compounds of uranium which were insoluble in uranium metal, such as UO_2, and UN. The more obvious materials, such as alumina (Al_2O_3), Zirconia (ZrO_2), and Zircon ($Zn(SiO_3)_2$) reacted with uranium to form the metal and uranium oxide.

Of the suitable liner materials, BeO was discarded as a practical liner because of its high cost and its unavailability. UO_2 was discarded because it was believed that undesirably large quantities would be required. MgO and CaO, and calcined dolomite, a mixture of the two, were all satisfactory providing the moisture content was low.

From the standpoint of fabrication of liners, both sintered and jolted liners were tried. The sintered liner, however, was dropped in favor of the jolted liner because of the high costs of the sintering process (approximately $200 to $300 per liner crucible.)

In the MCW research of jolted liners, MgO was found to have poor packing properties as well as having, in general, high boron content.

Therefore, the main emphasis of this research was on dolomitic lime and high calcium lime (CaO). Both of these latter materials were sufficiently free of impurities and both possessed equally good packing properties.

III. Reasons for Selection of EFD

In order to get the CaO sufficiently free of water, it was necessary to go beyond the temperature of ordinary commercially calcined or dead-burned lime. Unless the CaO was heated to these high temperatures, it would remain somewhat hygroscopic and would be difficult to use as a liner material.

Dolomite of high purity could be fused at a lower temperature than either CaO or MgO so that it would not be hygroscopic under ordinary storage conditions. Electromet fused some dolomitic lime, CaO and MgO in their calcium carbide arc furnaces for the work at Ames. In the tests which followed, the fused dolomitic lime (EFD) was considered best because it was low in moisture, was of satisfactory purity, and had satisfactory packing properties. CaO was equally good in every respect to EFD except that higher temperatures were required for fusion.

IV. Tests with Calcined Materials

At one time, Mallinckrodt believed that it would be adequate to "top" a charged metal bomb with calcined CaO or dolomite in the interests of economy. For this purpose, they used "Kelly Island" unfused CaO which had been calcined commercially. However, it was found that the metal yields decreased when the calcined CaO was made during the summer months since the CaO had absorbed sufficient water from the time it was calcined until it was used. After this trouble, the calcined CaO was repaced with EFD and no further difficulties were found.

One interesting point is that EFD after being fired in the metal bomb changes its physical characteristics and becomes hygroscopic. Therefore, for the purpose of recycling used EFD, it would be necessary to either calcine or fuse the once used material. Dr. Keller stated that the thermal energies required to fuse or to calcine dolomitic lime are approximately the same so a production unit to fuse once used EFD would cost approximately the same in both capital and operating costs as one for calcining.

Dr. Keller also said that at one point in the liner program he had proposed that calcined CaO or dolomitic lime be used for liner material. This proposal was based on the relative costs of EFD and ordinary CaO or dolomitic lime. CaO is approximately one-fourth to one-fifth the price of EFD. (Present EFD price is about 13½¢ per pound.) The Manhattan District, according to Dr. Keller, requested that the EFD be used in spite of its higher cost presumably because of its non-hygroscopicity.

V. Effect of Moisture in Liner Material

Dr. Keller explained the part played by moisture during a bomb run. MCW prefers that all their EFD contain 0.3% or less water, although up to 0.7% is usable but will cause correspondingly lower metal yields. Water in the bomb run will react with the UF_4 to form UO_2 and HF. The HF, in turn, will react with the CaO and MgO (both in EFD) to form the fluoride and water. This water will then react with more UF_4 to repeat the cycle. In this manner, a very small quantity of water can reduce the metal yields by a large factor. Tests performed at Mallinckrodt with a charged bomb without magnesium metal present showed that UO_2 was formed in increasing quantities with increased time of heating even though very little water (less than 1%) was present. To prevent this in the regular production runs, powdered magnesium metal is added to the UF_4 charged to react with this excess water and and prevent the formation of UO_2.

VI. MCW Plans for Testing Air Tabled Liner Material

I told Dr. Keller of the plans to air classify C-Liner and C-Special materials at Sutton, Steele & Steele, Inc., Dallas, Texas. Dr. Keller was very interested in this work and was willing to perform the following tests on the table concentrates (recycled material):

A. Determine the moisture content.

B. Calcine the table concentrates (about 100 pounds) in a vacuum furnace.

C. Test the packing and hygroscopic properties of the calcined material.

D. If the above tests are satisfactory, run the calcined concentrate in a metal bomb.

Dr. Keller did not think that the uranium content of the recycled liner would have any effect whatsoever on liner properties. He was worried, however, of the effects of any residual fluorides or magnesium metal. The concentrate from the air tables should be tested for these materials before test "D".

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VII. Conclusions:

I believe that this whole program will develop principally into one of economics. There are three alternatives for liner materials at the new site: (1) use EFD as in the present process, (2) use high calcium lime which is calcined or fused at the site, or (3) air classify used liner and calcine or fuse the concentrate for reuse. (Starting material in the latter case could be either EFD or CaO.)

The following costs must, therefore, be evaluated in order to reach a decision (providing, of course, that recycle material is suitable physically and chemically):

A. Cost of starting material.

B. Cost of table plant and operating costs.

C. Cost of calcining (or fusing) equipment and operating costs.

D. Cost of uranium recovery from tabled and suitable liners in scrap plant.

E. Reduction in uranium sent to tailings pile (recycle vs. no recycle).

F. Cost of research and development of new processes.

VIII. Recommendations:

It is recommended that, after the basic research program by Sutton, Steele & Steele, Inc. and MCW, the economics of the program be evaluated by the Catalytic Construction Company for final recommendations of plant design.

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