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MICROWAVE ENERGY FOR POST-CALCINATION [illegible] HIGH-LEVEL NUCLEAR WASTES

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ABSTRACT

High-level radioactive wastes generated from nuclear fuel reprocessing require treatment for effective long-term storage. Heating by microwave energy is explored in processing of two possible waste forms: (1) drying of a pelleted form of calcined waste and (2) vitrification of calcined waste. It is shown that residence times for these processes can be greatly reduced when using microwave energy rather than conventional heating sources, without affecting product properties. Compounds in the waste and in the glass frit additives couple very well with the 2.45 GHz microwave field so that no special microwave absorbers are necessary.

I. INTRODUCTION

In many of the current and prospective phases of radioactive waste treatment at the Idaho Chemical Processing Plant (ICPP) such as calcining, concentration by evaporating, drying of pelleted waste, or waste vitrification, heat is required. Microwave energy is considered in this paper as a source of the process heat in the latter two cases because of its potential for remote application for a radioactive process and its inherent quality of "volume" instead of "surface" heating.

II. MICROWAVE ENERGY

Microwave power consists of electromagnetic (E-M) radiation of relatively short wavelength. The frequency used for the studies reported here is 2450 MHz, which has a 12-cm free-space wavelength. A microwave heating system consists of three main parts: the microwave generator, the applicator and the connecting waveguide. The 6 kW variable generator used here included a 60 Hz to dc power source, a magnetron with isolator to generate the microwaves, reflected power dummy load, and a [illegible] impedance matching tuner. The applicator is simply a vessel to contain the microwaves and the material to which they are to be applied. The microwaves are routed from the generator to the applicator through a hollow rectangular waveguide

III. PREVIOUS STUDIES

A. Microwave Process Application

In a previous study, microwave energy was found to be potentially advantageous for either drying pellets or melting glass to produce a final radioactive waste form by remote processes.[1] Microwave heating has several potential advantages. The intrinsic properties of microwaves allow them to be channeled from a non-radioactive area to a radioactive processing cell with only minimal (about 0.2 dB/meter) power loss. Virtually all of the microwave equipment can be kept outside of the radioactive contamination zone, leaving only the hollow waveguide and the containment vessel (applicator) in the radioactive environment.

The greatest advantage of microwave heating comes in that the process material is heated and not the process. Product temperatures are not limited by the temperature of the heat source as they are by conduction, convection, or radiation. The absorbent temperature is limited only when its rate of heat loss is equal to its rate of absorbtion. For an absorbent material, adequately insulated, temperature has no upper limit using even the least powerful generator. Practical limitations are mostly due to the materials' ability to couple with and absorb the microwaves, the maximum temperature allowable in the applicator, power available and the generator efficiency (about 75% for most magnetrons).

B. Microwave Breakdown

As in large dc electric field strengths, but by a slightly different mechanism, gases can undergo electron avalanche breakdown when operating at microwave frequencies with high-intensity electric fields.[2] Calculations were done to determine the effects of ionizing radiation and off-gases on the level at which microwave breakdown occurs.

The calculations showed that the intensities of [illegible] microwave pellet [illegible] decrease the breakdown field strength. Volatile materials such as water, fluorides, and NO_x would not significantly reduce the breakdown field strength from that of clean air conditions. It is recommended, however, that off-gases should be swept from the microwave field to prevent them from becoming predominant or

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