MICROWAVE INTERACTIONS IN THE MELTING OF METALS

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ABSTRACT

The microwave oven in your home is a highly efficient appliance for cooking. But place a fork or aluminum foil in the oven and sparks fly. Doesn't metal reflect microwaves? Yet, microwaves are the higher frequency cousin of radio waves. It is well known that an induction furnace is commonly used for the heat treatment/melting of metals. At higher electromagnetic frequencies, lasers and incoherent infrared also melt metals, so why not microwaves? Actually, you do heat metals with your microwave. That fork or aluminum foil can get very hot.

Recent developments in the processing of ceramics have provided a new paradigm in the processing of metals. The use of non-wetting ceramic crucibles has reduced the chemical interactions. This reduces slag as well as inclusions. The process is environmentally green and cost effective for a number of high value metals. A companion poster paper will address the chemical cleanliness of microwave cast metals.

Microwaves heat via: 1) dipole rotation and collisions, 2) ionic current and resistance, 3) electronic current and resistance and 4) other nonlinear processes. By controlling the form of microwave heating along with appropriate thermal insulation, very high temperatures can be achieved with relatively low microwave power. The heat treatment, sintering, melting and casting of solid and powdered metals such as aluminum, various steels, copper, and numerous other metals have been demonstrated[1-4].

One aspect of the new paradigm for microwave melting of metals is the heating efficiency. But skin depth of microwaves in metals is small, how can it be efficient? Certainly heating a susceptor in the central region is thermally efficient. But how does a metal heat at low temperatures (< 600 C)? At high temperatures (> 1200 C), blackbody heating is significant, but the gray body coefficient for most metals is low, typically less than 0.35.

Mechanisms involved in the heating processes will be discussed. This includes indirect heating of dielectrics (hybrid heating), direct heating, plasmas, and a few secondary phenomena. Comparisons with inductive, resistive, and combustion furnaces will illustrate the differences with microwave furnaces.

REFERENCES

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