HIGH TEMPERATURE PROCESSING OF POWDERS USING MILLIMETER-WAVES

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The microwave specific feature, which is instantaneous, volumetric heating of all kinds of dielectric materials, has high potential for industrial applications. It allows a reduction of processing time and therefore energy consumption in comparison to conventional heating where energy is deposited to the materials surface and transferred to the volume by thermal conduction. This benefit is most distinctive for materials with low thermal conductivity such as polymers, glasses, powders or powder compacts. For specific materials which show low dielectric loss or which require homogeneous heating the application of frequencies higher than the wide spread industrial frequency of 2.45 GHz can be beneficial, since power absorption is increasing with frequency and the realization of a homogenous field distribution is easier. The benefits of a compact gyrotron processing system operating in the millimeter-wave (mm-wave) range at 30 GHz have been demonstrated on various high temperature processes with inorganic powder materials.

Alumina is a material widely used for the production of abrasives, fibers or technical ceramics. It exists in various modifications. While the α-alumina is the modification most interesting for technical applications conventional production processes usually end up in the γ-alumina phase. This powder has to be transformed into the α-phase by a subsequent calcinations process at temperatures of more than 1100 °C. Since powder materials have extremely low thermal conductivity, the conventional process suffers from strong thermal gradients during the heating cycle. Therefore, the conventional process is time consuming and going along with grain growth. The potential of mm-wave technology has been investigated in this field in collaboration with Baikowski Chimie, France.

Another powder material under test has been Kaolin which is a mineral widely used in ceramic, paper and chemical industries as an additive which gives specific properties to a large variety of products. To influence such characteristics and to develop new applications the kaolin has to be modified in an appropriate way. The use of microwaves has a high potential in this field. For example the dehydroxylation reaction into the metakaolin was found to happen more effective under microwave irradiation. This obviously demonstrates the potential of microwaves on selective heating of such layered minerals at the hydroxyl groups which are located in-between the layers of 0,7 nm thickness.

Due to its good thermal shock resistance and its thermal load capacity fused silica is a material of high technical interest. The production of high purity fused silica is a huge challenge which is done by melting of natural silica sand of high purity or synthetic silica. Since softening temperature is at about 1700 °C and the melting temperature is above 2000 °C, contamination of the high purity material is a severe problem in the conventional process. By application of microwave technology this problem can be solved because no heating elements, hot walls or electrodes for plasma discharge are needed. Microwave energy can be transferred directly into the powder volume where is it transformed into heat by dielectric absorption. Since dielectric loss of this type of material is extremely low the application of microwave frequencies within the mm-wave range is indispensable. Experimental investigations which have been kindly supported by the Quarzschmelze Illmenau GmbH, Germany in will be presented.