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Rapid Wave Microwave Technology for Drying Sensitive Products

Microwave drying will play an increasingly important role in attempts to achieve shorter delivery times and reduce warehouse capacities.

Drying is an important part of the production process. In some cases, it determines the rate or duration of production. Drying times of 10-14 days are common in the ceramic industries. Therefore, the drying process often is subject to scrutiny in attempts to optimize a production process. Conventional drying methods offer little room for acceleration. A remedy, however, is at hand in the form of a familiar technology: the microwave. Drying with microwave technology is both fast and gentle on the product. These qualities assure it a place among drying techniques of the future. Microwave drying will play an increasingly important role in attempts to achieve shorter delivery times and reduce warehouse capacities. This acceleration is possible because of the physics of microwave technology; i.e., the propagation and the characteristics of the electromagnetic waves. In certain cases, the microwave can even enhance the material. In the early 1990s, Linn High Therm GmbH began its work in the field of microwave heating. A pass-through microwave oven was developed to meet the demand for industrial dryers.

Conventional Drying

In the conventional heating process, typical heat sources are gas, resistance or infrared heating elements. All of these are located in close proximity to the material to be heated. Energy is applied to the surface of the material by radiation and convection, and must penetrate the inside in order to achieve uniform heating of the material. The thermal conductivity and heat resistance of the material mainly determines the heating process. Sensitive materials often will not allow high temperatures. If the material has poor thermal conductivity, an extension of the process is unavoidable. Conventional heating technologies, therefore, are subject to strict limitations in the manufacture of many products. There is no need to rewrite the laws of physics in order to extend these limitations. We must simply turn our attention to radio or radar technology.

Radar Technology

Microwaves are electromagnetic waves (e.g., those used in radio, television and radar technology). Different applications demand different frequencies and power densities. For example, a frequency range of 88-108 MHz is used for VHF radio. Mobile telephones use higher frequencies, e.g., ~1900 MHz, whereby the power output is ~2W. Three main frequencies are available for microwave technology, although there may be deviations depending on regulations in different countries. The highest frequency is 28 or 30 GHz. At this frequency, low-cost industrial application on a large scale does not appear possible. The lower frequency of 915 MHz involves certain technical complications. Its use is justified only in certain applications. The lowest-cost frequency is 2.45 GHz. This frequency is already used universally in household microwave ovens. Most of us use this technology without actually knowing how the heating process functions. The conversion of electromagnetic energy into thermal energy is realized because of the electromagnetic characteristics of materials. It depends principally on the material, temperature and frequency. Generally, when one frequency is used for the heating process and the temperature-dependency of the characteristics is not known, an observation can be made only in terms of the material itself. Three parameters-conductivity, permeability and permitivity-are required to describe any material. Permitivity is often referred to as the dielectric constant and dissipation factor. The decisive factor for the conversion of energy is the imaginary component of the dielectric coefficient (= dissipation factor X dielectric constant). This is often wrongly equated with the dissipation factor. The relationship is shown in Eq. 1.

Continous microwave belt furnace Mobile test furnace
4,5 m / 8 kW.

Microwave reversing belt furnace
5.3 m / 4.8 kW.

$$\varepsilon_r = \varepsilon' \qquad \tan\delta = \frac{\varepsilon''}{\varepsilon'} \qquad \varepsilon = \varepsilon' - j \cdot \varepsilon'' \tag{1}$$

where ε_r = dielectric constant; $\tan\delta$ = dissipation factor; ε = dielectric coefficient (DC); ε' = real component of the DC; and ε'' = imaginary component of the DC.

Inverse Temperature Profile

The inverse temperature profile of microwave drying is an advantage-higher vapor pressure builds within the material, and drying takes place from the inside out. Some of the vapor condenses on the colder surface and keeps the surface damp. When vapor no longer comes from the inside, the surface begins to dry. Because water generally converts the most energy, the energy conversion on the inside is lower, and depending on the drying substance and the degree of drying (the microwaves pass on unweakened), this energy can be used somewhere else. This allows effective drying with the elimination of all water pockets. The course of the drying process may be different due to the varying energy intake of the materials to be dried. There is no real difference above a humidity content of >15%. In this case, the water determines the course of the process. In the 5-15% humidity range, the substance to be dried plays an increasingly important role. If the material, itself, is capable of converting microwave energy, the temperature of the material can rise. The temperature-dependency of the dielectric coefficient, therefore, determines the process. In certain chemicals, this can separate the chemically bonded water. It is necessary to carry out material tests to ensure that the necessary temperature can be achieved. Below 5% humidity, microwave drying can become ineffective as the moisture content decreases.

A Rule of Thumb

To determine the power required for microwave drying, the rule of thumb is that a microwave output of l kW is required to evaporate l kg of water per hour. This rule applies as long as initially there is sufficient moisture.

References

A. C. Metaxas and R. J. Meredith, Industrial Microwave Heating, Power Engineering Series, No. 4. Peter Peregrinus Ltd., U.K.

What´s hot in Kilns & Furnaces

Pass-Through Microwave Oven

Continous microwave belt furnace
e. g. for building material industry
15 m / 60 kW

The pass-through microwave oven of the MDBT series is used for drying. A modular structure was chosen for this oven so that it can be extended at any time without major complications. The microwave generators (magnetrons) are arranged in a spiral around the longitudinal axis of the cylinder chamber to achieve a more uniform distribution of the field. The conveyor belt is led over floor plates that are equipped with secondary radiators (slot antennae). These have the effect of concentrating the field. The inlets/outlets are lined with a special absorber material in order to comply with allowed values for leaked radiation. Depending on the size of the opening, further absorber zones may be integrated to effect a further radiation reduction. In the case of larger openings, additional absorber curtains are used. The magnetrons used are air-cooled, whereby the heated cooling air flows into the oven and can absorb moisture. The moist air is then drawn out of the oven by a suction system. This passthrough microwave oven can be fitted with a microwave output of: < 100 kW.