# Comparing Microwave to Conventional Heating & Drying



The mechanism for drying with microwave energy is quite different from that of conventional drying. In conventional drying, heat is transferred to the surface of the material by conduction, convection or radiation, and into the interior of the material by thermal conduction. Moisture is initially flashed off from the surface, and the remaining water diffuses to the surface. This is often a slow process in conventional drying, and the diffusion rate is limited, requiring high external temperatures to generate the temperature differences required.

In conventional or surface heating, the process time is limited by the rate of the heat flow into the body of the material from the surface as determined by its specific heat, thermal conductivity, density and viscosity. Surface heat is not only slow, but also non-uniform with the surfaces, edges and corners being much hotter than the inside of the material. Consequently, the quality of conventionally heated materials is variable and frequently inferior to the desired result.

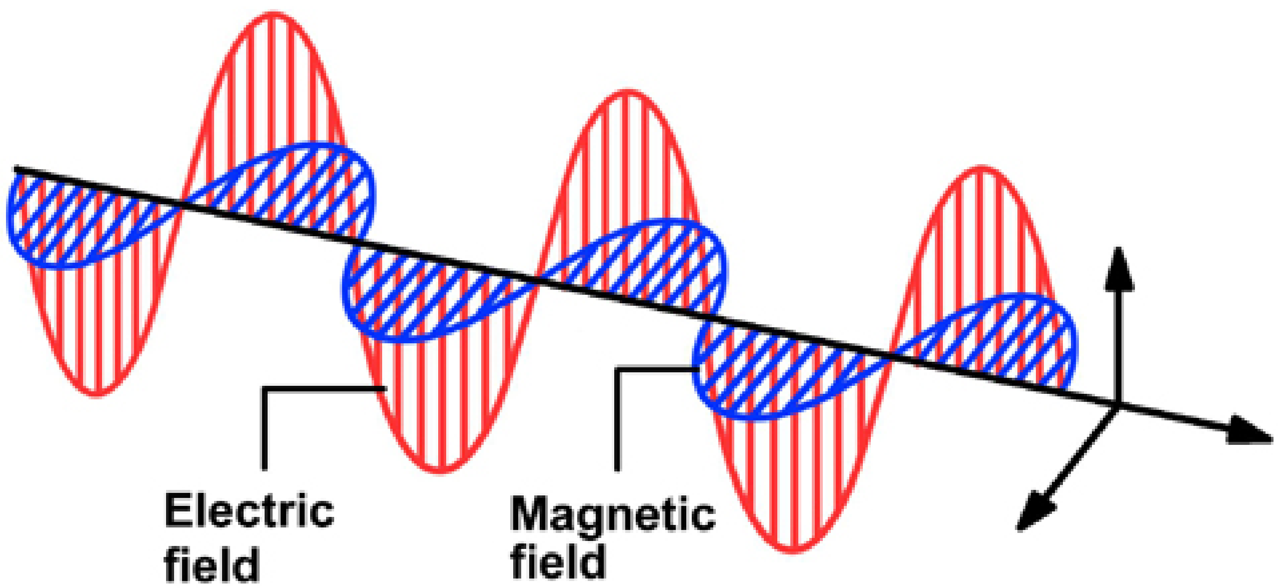
Microwaves are not forms of heat, but rather forms of energy that are manifested as heat through their interaction with materials. Microwaves initially excite the outer layers of molecules. The inner part of the material is warmed as heat travels from the outer layers inward. Most of the moisture is vaporized before leaving the material.

If the material is very wet and the pressure inside rises rapidly, the liquid will be removed from the material due to the difference in pressure. This creates a sort of pumping action, forcing liquid to the surface, often as vapor. The result is very rapid drying without the need to overheat the atmosphere, and perhaps cause case hardening or other surface overheating phenomena.

**Mechanism of Heating**

Microwave energy does not heat the room — only the desired material — without harmful greenhouse gas emissions from the heat source. The energy is mainly absorbed by a wet material placed in the cavity. Water, fat and sugar molecules in food materials absorb energy from the microwave in a process called electromagnetism, a phenomena associated with electric and magnetic fields, and their interactions with each other, and with electric charges and currents.

Microwaves are electromagnetic waves having a wavelength (peak-to-peak distance) varying from 1 millimeter to 1 meter. 1GHz = 1,000 MHz. Frequency of microwaves lies between 0.3 and 3.0 GHz. A domestic microwave operates at 2,450 MHz (a wavelength of 12.24 cm). Approximately 90 percent of American homes have microwave ovens. Industrial/commercial microwave systems typically operate at 900 MHz (a wavelength of 32.68 cm). This range allows more efficient penetration of the microwave through the material.




Microwave heating is most efficient on liquid water, and much less on fats and sugars and frozen water where the molecules are not free to rotate. Depending on water content, the depth of initial heat deposition may be several centimeters or more with microwave ovens, in contrast to grilling, which relies on infrared radiation, or the thermal convection of a convection oven, which deposits heat shallowly at the food surface.

Historically the biggest constraint to using microwave energy for industrial processing has been the inability to heat the material with uniform energy distribution. If you have non-uniform heat distribution, the result is underexposed and overexposed material in the same batch or continuous process. Our innovative solution provides agitation that stirs the material, exposing the mass to uniform heat distribution.

Marion Mixers has joined forces with Applied Microwave Technology (AMTek) to design and manufacture mixer vessel-heating systems with microwave technology for the processing industries.

Marion Mixers has more than 70 years of experience in custom-design manufacturing of horizontal and vertical mixing equipment in numerous industries. AMTek specializes in microwave systems, primarily for the food industry. Our unique combination of a microwave and a mixer in one piece of equipment has solved one of the biggest challenges of the microwave industry — the ability to achieve uniform heat distribution. This is accomplished with the unique paddle-style agitation within the mixer vessel and AMTek's patented microwave systems.

**Energy Savings**

There was a time when electrically powered systems were considered too costly to operate for high-power applications. Today, with the rising costs of oil and gas, this is no longer necessarily true. There is significant interest today in the potential energy saving from a microwave heating system. The offsets to the current cost of electricity include the increased speed of drying, the direct coupling of energy into the material and possible lower drying temperatures.

Processors that use steam, gas or electric heating systems are aware of the high costs of running these systems. Consider the energy-saving benefits of microwave heating vs. conventional heating:

1. Slashed energy consumption by up to 50 percent.
2. Reduced man-hours and downtime involved in cleaning.
3. Minimized ancillary equipment, such as heated jackets, boiling pans and heating vessels.
4. Smaller heating and/or cooking footprint.
5. Less warm-up and cool-down time.
6. No heating of the room, only the material.

**Economics of Microwave Systems**

Several criteria for successful microwave drying systems are related to reduced cost. Cost saving may be realized through:

1. Energy savings.
2. Faster batch processing.
3. Operational efficiencies.
4. Increased throughput.
5. Labor reduction.
6. Reduction in heat load in the plant.
7. Reduced maintenance costs.
8. Reduction in product fouling.
9. Less floor space needed.

In addition, with the challenges of the current economic climate, as well as growing concerns about carbon footprints, many manufacturers are looking for ways to reduce operating costs and cut down on energy consumption. Conversely, with microwaves, heating the volume of a material at substantially the same rate is possible. This is known as volumetric heating. Energy is transferred through the material electromagnetically, not as a thermal heat flux. Therefore, the rate of heating is not limited and the uniformity of heat distribution is greatly improved. The microwaves heat the product at the surface and deep into the product until the microwave energy is absorbed.

A common misconception is that microwave heating is always more expensive than heating by conventional techniques. Of course, the actual answer depends on the application. In some cases, microwaves can be used 50 percent more efficiently than conventional systems, resulting in major savings in energy consumption and cost. Imperfect heating causes product rejections, wasted energy and extended process times that require large production areas devoted to ovens. Large ovens are slow to respond to needed temperature changes, take a long time to warm up, and have high heat capacities and radiant losses. Their sluggish performance makes them slow to respond to changes in production requirements, making their control difficult, subjective and expensive.

**Applications, Functions & Industries**

Our equipment is capable of performing multiple applications, including heating, drying, tempering, cooking on multiple-stage recipes that thaw, cook and simmer in the same vessel aided by programmable process control. Possibly eliminate some permits and do away with your troublesome boilers with costly insurance.

Microwave technology is a viable commercial alternative to traditional cooking and heating methods, and is now being seriously considered by many food, drink and pharmaceutical producers. Our equipment is ideal for cooking foodstuffs, such as gravies, sauces, chilies, soups, syrups, eggs, puddings, fruit juice, salad dressings, canned and packaged fruits and vegetables and much more.

Uniformity of heating with precise temperature control is also important to many other industries, including chemicals, plastics, minerals, textiles and a variety of other industrial processes.

*For more information, please visit* www.marionmixers.com *[1].*

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