Ferrite
Microwave Technologies

Why Choose Microwave Technology?

The History, Science and Benefits

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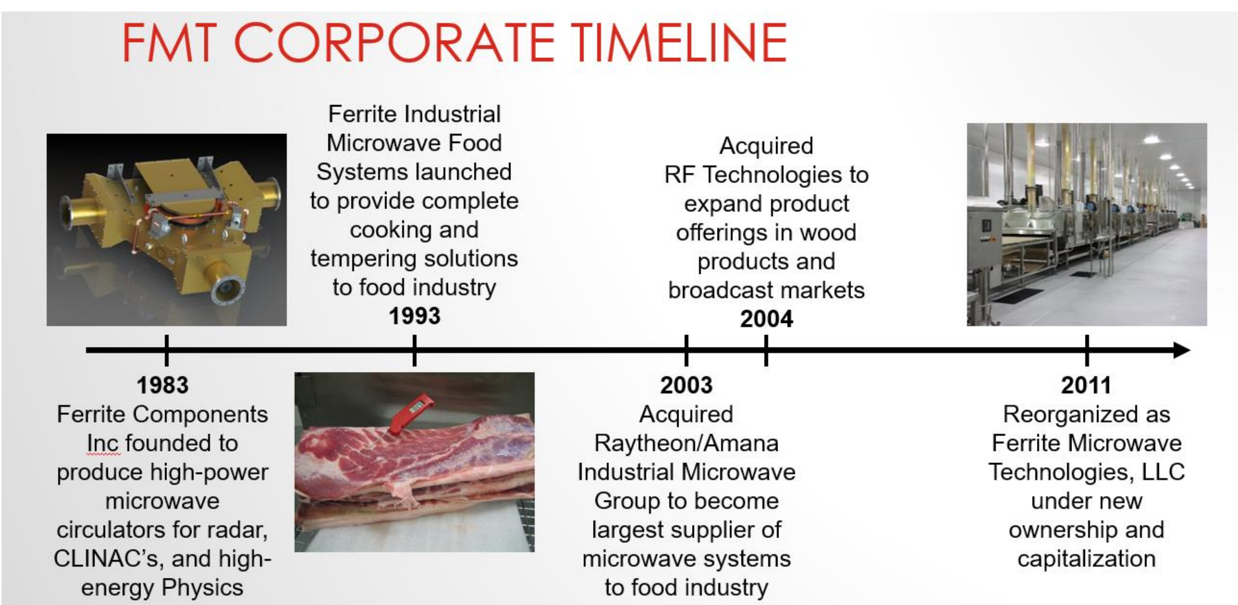
Introduction

Microwave energy has gained in popularity within a variety of industries since the home microwave first enjoyed widespread adoption in the 1960's. Raytheon, the company that invented the home microwave when they began selling the "Radarange" in 1947, would go on to manufacture the first Single Mode dryer in 1965. They would continue to pioneer new industrial microwave processes with the development of the first Continuous Tempering System at 25kW in 1970 and the first 25kW microwave generator in 1972. Many of FMT' founders got their start on the Raytheon team developing these revolutionary processes. Ferrite Microwave Technologies (FMT) would go on to eventually purchase that same business unit and we are proud to continue innovating and pushing the boundaries of the science.

With the advent of large scale microwave drying and tempering technology, microwave cooking moved from home kitchens to large food processing plants. As safety concerns were alleviated by improved technology and cost concerns by increased efficiency, industrial microwave applications expanded. There are many other non-food applications for industrial microwave systems that utilize microwave properties for drying and heating. Examples include timber processing, coal drying and bio-waste treatment. New applications are being tested and proven every day.



How It Works – The Basics

Microwaves are a form of electromagnetic energy. The electromagnetic spectrum contains everything from DC voltage to visible light and beyond (see Figure 1). Microwaves devices utilize a wide variance of these frequencies between 300 MHz and 3,000 MHz (see Figure 2). Home microwaves operate at a frequency of 2,450 MHz in the US and use far less power than an industrial microwave which most often operates at a frequency of 915 MHz. The longer the wavelength (read: the lower the frequency), the deeper a microwave can penetrate material. This is critical to ensuring uniform energy distribution.

Industrial microwave systems require much more power than domestic systems and therefore almost always utilize a stand-alone microwave generator. The microwave energy is then transmitted to a cavity of varying type for application to the material being treated. For example, pictured left is a small batch tempering system FMT produces, the MIP-4. Included in the photo is a standard 75 kW GET2024 generator.

Figure 1: The Electromagnetic Spectrum

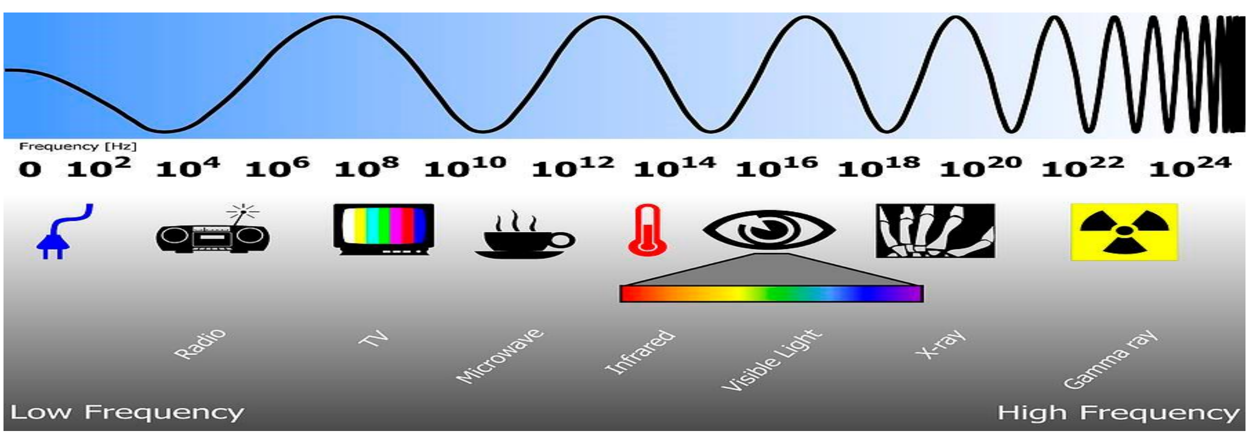


Figure 2: Frequency Ranges And Their Uses

Name	Frequency range	Name Origin	Common uses
VHF	30 to 300 MHz	Very High Frequency	FM radio, television broadcasts
UHF	300 to 3000 MHz	Ultra High Frequency	Television broadcasts, Microwave oven, Microwave devices and communications, radio astronomy, mobile phones, wireless LAN, Bluetooth.
L Band	1 to 2 GHz	Long	Military telemetry, GPS, ATC radar
S Band	2 to 4 GHz	Short	Weather radar, surface ship radar, microwave ovens, microwave devices/communications.
C Band	4 to 8 GHz	Compromise (between S and X)	Long-distance radio telecommunications
X Band	8 to 12 GHz	X for crosshair (used in WW2 for fire control radar)	Satellite communications, radar, terrestrial broadband, space communications,
Ku Band	12 to 18 GHz	Kurtz Under	Satellite communications
K Band	18 to 26.5 GHz	Kurtz (German for short)	Radar, satellite communications, astronomical observations, automotive radar
Ka Band	26.5 to 40 GHz	Kurtz Above	Satellite communications

Benefits Over Conventional Heating Methods

According to the University of Nottingham, the benefits of microwave heating allow for processing times of certain materials to be 1000 times faster using microwave heating over conventional heat sources.[i] These claims are likely based on very absorptive material with a high dielectric loss tangent.[ii] However, even materials that do not absorb microwaves very well are excellent candidates for drying. In drying applications, the aim is to only evaporate the water in the material bed. Therefore, in such cases, it can actually be an advantage for the base material to have a low dielectric loss tangent. That way, the water will be evaporated with minimal impact to the surrounding material and also consume less total energy to achieve the desired evaporation.

Conventional heating is achieved through conduction, convection or radiation and heat is applied to the surface of the material. In the case of drying applications, this causes any surface moisture to evaporate quickly. The remaining water in the material surfaces slowly as the heat is conducted from the surface of the material toward the center. Heat dissipates as it travels inward, which equates to relatively high external temperatures to ensure the center of the material gets hot enough to meet the required threshold. Much of the heat utilized is wasted heating the air around the material. Depending on the size of the heating cavity, the energy costs can add up very quickly. Time is also an important factor as the whole process of heating a material usually requires a ramp-up and cool-down period in order to safely handle material. Also, the disparity in temperature between the surface and center of the material can cause quality problems and make it difficult to control the final temperature. In processes where exposure above a certain temperature is a problem, the resulting material loss is expensive.

Microwave heating and drying, known as volumetric heating, solves many of these problems. Volumetric heating is highly energy efficient because it acts only on the material in question, not the air around it. Microwaves have up to 95% conversion efficiency from electricity to microwave energy.[iii] Heating in this manner allows users to heat the full volume of the material at a constant rate. Such heating is usually more cost effective than conventional methods and almost always much quicker. Microwave heating works *fast*. Tempering that may have taken several days in a thawing room can be done in a matter of minutes.

Benefits Summary:

Benefit	Result
Energy efficiency	Direct cost savings
Decreased process time	Greater throughput
Uniform temperature	Less product loss and higher process quality
Precise control	Customizable settings to fit different material
Decreased equipment footprint	Indirect cost savings, large drying ovens and tempering rooms become unnecessary

Common Concerns

Often the largest concern potential users have when considering implementing microwave systems is safety. Because, after all, isn't microwave energy dangerous?

The answer is yes, but not as dangerous as a conventional oven or virtually any other piece of industrial equipment. In closed batch systems, door sensors with automatic shutdowns ensure that while the system is running users are not exposed to electromagnetic energy. In the case of a continuous belt-fed tempering system chokes and leak detectors wired with automatic shutoffs ensure the same level of safety. The

FDA limits the amount of leakage 5 cm from the source to 5mW per square centimeter, far below what is dangerous to people and in operation the industrial microwave system poses no more of a health hazard than your home microwave oven. Also, microwaves are a form of non-ionizing radiation which means that they create no lasting effect (as opposed to ionizing radiation like that emitted from radioactive materials, which can permanently change exposed materials). That means when you turn off the system, everything is exactly as it was except the material you treated which is now the desired temperature.

Arcing, the effect you've seen in your home microwave if you accidentally leave a fork in, occurs from time to time for a variety of reasons. However, all systems manufactured by FMT and leading competitors feature arc detectors that shut the system down at the first sign of trouble. All these safety measures ensure that industrial microwave systems are as safe, if not safer, than other industrial machinery.

Applications

The efficient use of microwave technology provides the most benefit to processes involving dehydration, sterilization, tempering (thawing), boost heating and cooking. The technology can be used either in conjunction with, or in place of, conventional heating methods to maximize energy efficiency and minimize process time and waste. The specific gains will depend highly on the material in question. When trying to decide whether microwaves will work in your business, it is important not to think that testing in a normal kitchen microwave will be a good enough litmus test. Though a first trial in the microwave you have available is a good place to start, testing the material at higher power levels and lower frequency will be necessary to prove the use case. If you would like to test your material to see how it will react, we would be happy to test it if you send it to us. Our engineers can also use computer modeling to predict outcomes when provided with the relevant material properties.

Microwaves Are A Safe, Efficient Alternative

Perhaps it is time to rethink your drying and heating application. Microwave technology is safe, energy efficient and fast. Though the upfront investment can be costly, we often find those costs are far offset by improved throughput, lower energy costs and less product waste.

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References

[i] For a full explanation, please see the University of Nottigham's website. Source: http://www.nottingham.ac.uk/research/groups/industrial-microwave-processing/research.aspx

[ii] In this paper, we are focusing on the basic principles of microwave heating and the benefits it yields to those who implement it in their process. If you would like more information about how different material properties affect efficiency, please review some of our other published resources.

[iii] Source: http://www.nottingham.ac.uk/research/groups/industrial-microwave-processing/research.aspx