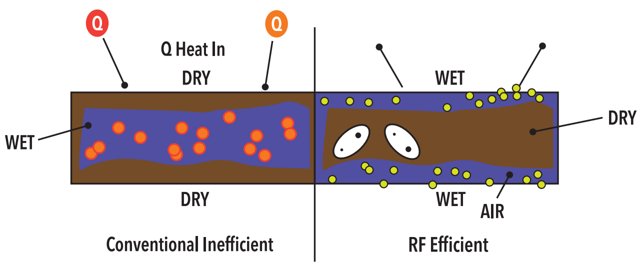
PSC Heating & Drying with Radio Frequency
A Litzler Company

Radio Frequency Basics

Faster and more consistent drying is a common goal for today's manufacturers. The use of Radio Frequency (RF) drying can offer many benefits over conventional drying, including faster line speeds, more consistent moisture levels, lower drying temperature, and smaller equipment. By replacing conventional dryers with PSC Radio Frequency dryers, manufacturers have changed from batch processes to continuous processes resulting in drying times reduced from 24 hours to 90 minutes and from 12 hours to 30 minutes!

Differences Between Radio Frequency and Conventional Heating

Conventional heating (i.e. conduction, convection, radiant) has a heat source on the outside and relies on transferring the heat to the surface of the material and then conducting the heat to the middle of the material. Radio Frequency heating is different; it heats at the molecular level so it heats from within the material and heats the middle as well as the surface.



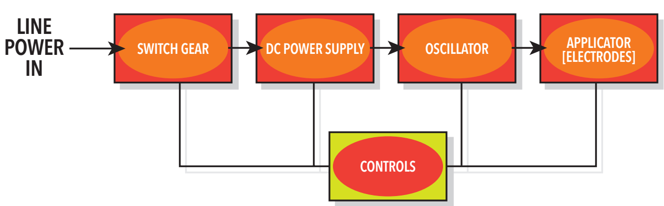
Radio Frequency vs. Conventional Diagram

A conventionally dried product is hot and dry on the outside and cold and wet on the inside. This is not efficient because the dry outer layer acts as an insulating barrier and reduces the conduction heat transfer to the middle of the product. This dry outer layer can cause quality problems, such as surface cracking, a skin on coatings and uneven solids dispersion through wicking of sizing and additives from the middle to the surface.

With Radio Frequency drying, the heating is from within so there is no hot, dry outer layer. The product is heated throughout so the water in the middle will be heated and will move to the surface. In general, because of the heat losses at the surface, Radio Frequency dried products are hot and dry on the inside and cooler and wetter on the outside. The combination of two technologies, using the Radio Frequency heating to heat the inside and move the water to the surface where conventional methods are effective at removing it, offers some great potential benefits.

Diagram of Radio Frequency Equipment Schematic

A basic schematic of a Radio Frequency dryer is shown below. The dryer receives standard power (i.e. 480V, 60 Hz) through the Switchgear. In the Power Supply section, line voltage is stepped up to high voltage AC through a transformer and then changed to high voltage DC through rectifiers. In the Oscillator section, high voltage DC is changed to high frequency, high voltage Radio Frequency energy and transmitted to the applicator or electrodes where it is applied to the work. All of this is controlled by a modern control system.



Radio Frequency Equipment Schematic

The key to effective application of Radio Frequency energy for drying is the right applicator, or electrode design. Traditionally, heating was accomplished by creating a uniform electric field between two parallel plates. This approach is capable of heating thicker materials uniformly because a high voltage gradient can be established in the material. However, it does not work well for thin materials such as webs. In order to establish a high voltage gradient in a thin web material, the plates must be very close together which can cause arcing between the plates.

For thin materials, the stray field electrode design was developed. This design creates an electric field between alternating parallel rods that gives a higher voltage gradient in the web for faster heating. A variation on this electrode design for thicker webs is the staggered stray field design. This allows for more uniform heating of thicker webs. This has also been used for thin beds of ceramic powders. As a general rule, materials under 1/4" (6mm) thick use the stray field design, materials 1/4" - 1/2" (6mm - 12mm) use the staggered stray field design, and materials over 1/2" (12mm) use the parallel plate design. In all of these electrode designs, the material can be either self-supporting or can be transported on a conveyor.

Materials have a major effect on the success of Radio Frequency heating. Some materials heat very well and some do not heat well at all. The key measure of "heatability" is the loss factor of the material. The loss factor is a material property that determines how well the material absorbs the Radio Frequency energy. If the material has a high loss factor, it absorbs energy quickly and thus heats quickly. If a material has a low loss factor, it absorbs energy slowly and thus heats slowly. In general, polymers tend to have low loss factors and thus do not heat well. Water, on the other hand, has a high loss factor so it heats rapidly. This is why Radio Frequency lends itself to drying so well, it heats the water quickly but does not heat most base materials.

It is important to remember every material reacts differently and loss factors (the ability to absorb Radio Frequency energy) can change with frequency and temperature. A material that does not absorb Radio Frequency energy at room temperature might absorb the energy at higher temperatures. This is especially important in a composite product with a high loss factor material (RF heats rapidly) and low loss factor material (RF heats slowly). As the high loss factor material is heated by the Radio Frequency energy, it will heat up the low loss factor material through normal conduction. If this heat raises the temperature of the low loss factor material to where it now absorbs Radio Frequency energy, both products are heated and could be overheated. In rare cases, this can lead to a runaway situation where as the temperature increases, it absorbs more energy, which increases the temperature, which increases the energy absorbed, and it continues until the material overheats.

In most cases, the product can be heated faster than the solvent can be removed so the heating rate must be scaled back to get the right balance of heat transfer and mass transfer. If the heat transfer rate is too high, steam will be generated which can damage the product.

The complexity of the interaction between materials and the Radio Frequency field is why it is critical to consult with an expert in Radio Frequency drying and conduct trials on your product.