A Fundamentally Better Way to Dry

CANNABIS AND HEMP

Microwave Drying Technology from Cellencor

Cellencor
High Power Microwave Solutions

Microwave Dryers for Cannabis and Hemp

Drying freshly harvested hemp has been a vexing problem for large scale THC/CBD processors. Traditional drying systems are not well suited for hemp because of high drying temperatures or slow process rates. Microwave dryers have been used for many years to dry fresh herbs and botanicals on a large scale. Cellencor has tailored this technology to the specific requirements of high volume processing.

Benefits of Microwave Drying Systems

- **Speed :** Like your home microwave oven, microwave drying is much faster than any other method
- **Low Temperature Drying**: Because microwave energy selectively targets water molecules, the temperature of the biomass during drying remains at about 120^{o} F. This protects the natural qualities of the cannabinoids, terpenes and other essential molecules. THC/CDB levels are not reduced.
- **Uniformity**: The mixing action of the dryer assures highly uniform moisture content of the dried hemp.
- **Consistency:** Advanced sensors and sophisticated computer control assures uniformity from batch to batch, even with varying composition and moisture content of the raw biomass input.
- Scalability: Systems are configurable with a wide range of process capacities.
- **Ease of Operation:** Operation is fully automatic with simple operator controls.
- **Efficiency:** Microwave dryer typically are much more energy efficient than convection and steam dryers.
- **All Electric:** Powered by 480 VAC electric power, no natural gas is needed. Can be powered by diesel generator sets for remote "on the farm" sites.

The Equipment

The main components of a microwave hemp drying system consist of:

Horizontal Paddle Mixer/Dryer: This is a vessel with a number of large paddles attached to a large horizontal shaft running across the mixer body. The paddles constantly circulate the product during drying, resulting in extremely high uniformity and eliminating hot and cold spots. There is a fill valve on the top and a discharge valve on the bottom of the body. The paddles also assist during loading and unloading operations. The entire mixer assembly is made from T304 stainless steel and is FDA food grade with CIP capability. Smaller units are available for laboratory or pilot scale use.

Microwave Generators: One or more microwave generator provides energy to the dryer. The number of units required depends on the mixer size and required drying speed. Both traditional magnetron and new technology solid state generators are available.

Sensors and Controls: The dryer is equipped with sensors which provide real-time measurement of load weight, temperature, and moisture content. These feed into dedicated a computer which precisely controls the drying cycle. The control computer also includes a simple touch screen user control panel. Loading unloading, operations, and synchronization with material handling equipment is also provided.

Solid State
Microwave Generator

We offer the finest equipment in the industry. Cellencor integrates complete systems using top quality components for industry leading manufacturers. Our microwave hardware is custom manufactured in the USA to our specifications by our partner companies.

Safety

Systems are engineered to the strictest OSHA and HHS standards for microwave leakage and are continuously computer monitored using numerous safety interlocks and sensors. Microwave components are all stainless steel, wash down capable, and are FDA compliant for human food processing. Microwave energy is non-ionizing (i.e., not radioactive) radio waves that operate on the same band as your cell phone.

Installation and site requirements

Microwave drying systems can usually be installed quickly, with a minimum of site preparation. A typical installation takes a week or two, depending on the system size. The basic site requirements are: 480 volts three phase electric service with a load center; a supply of cooling water; and a simple low-temperature exhaust duct and blower system. Microwave systems are controlled by a computer with an easy to use touch screen operator panel. Installation includes training your staff in operating, safety, and maintenance procedures.

Estimating System Process Rates

Cellencor can engineer a system configured to your exact needs. In general, the throughput of a microwave dryer is determined by:

- the moisture content of the incoming biomass
- the capacity (volume) of the mixer/dryer
- the amount of microwave energy available

Mixer/dryers are available in sizes from 25 to 500 cubic foot capacity. Solid state microwave generators are available in 50 and 100 kilowatt models; magnetron generators are available in 75 and 100 kilowatt models. For larger systems, multiple microwave generators are used. A 100 kilowatt generator delivers about 340,000 BTU/hr., and about 95% of this energy is applied to the material being dried.

Cannabis/Hemp Properties

The moisture content can vary considerably depending on the variety, location, climate, and even the time of day it is harvested. A reasonable average value for estimating is 75%. The density of the biomass determines how much material can be loaded into a given sized mixer/dryer. It is affected by the nature of the cannabis/hemp (flower/bud/leaf proportion) and how it is cut and chopped. The weight of the biomass itself causes compression which increases loaded density with larger mixer/dryers.

Example Process Rates and Times

For a given amount of biomass, the drying time will depend on the amount of microwave power available and the moisture content of the biomass. A 2 hour cycle time is generally is a good balance between drying speed, moderate drying temperature, and equipment cost. The tables below illustrate performance of various size mixer/dryers configured with sufficient microwave power for 2 and 3 hour drying cycle times. These examples assume flowers and leaves chopped to 10 mm.

PROCESS RATES AND EQUIPMENT SIZE – 2 HOUR CYCLE TIME
DRYING FROM 75% TO 10%

Mixer Capacity (cubic feet)	25	50	100	200	400
Wet input per load (lbs.)	300	700	1,600	3,600	8,000
Dry output per load (lbs.)	85	200	450	1,000	2,240
Dry output per 24 hrs. (lbs.)	**1,000**	**2,400**	**5,400**	**12,000**	**26,880**
Microwave power required (kW)	50	100	200	500	1,100

PROCESS RATES AND EQUIPMENT SIZE – 3 HOUR CYCLE TIME
DRYING FROM 75% TO 10%

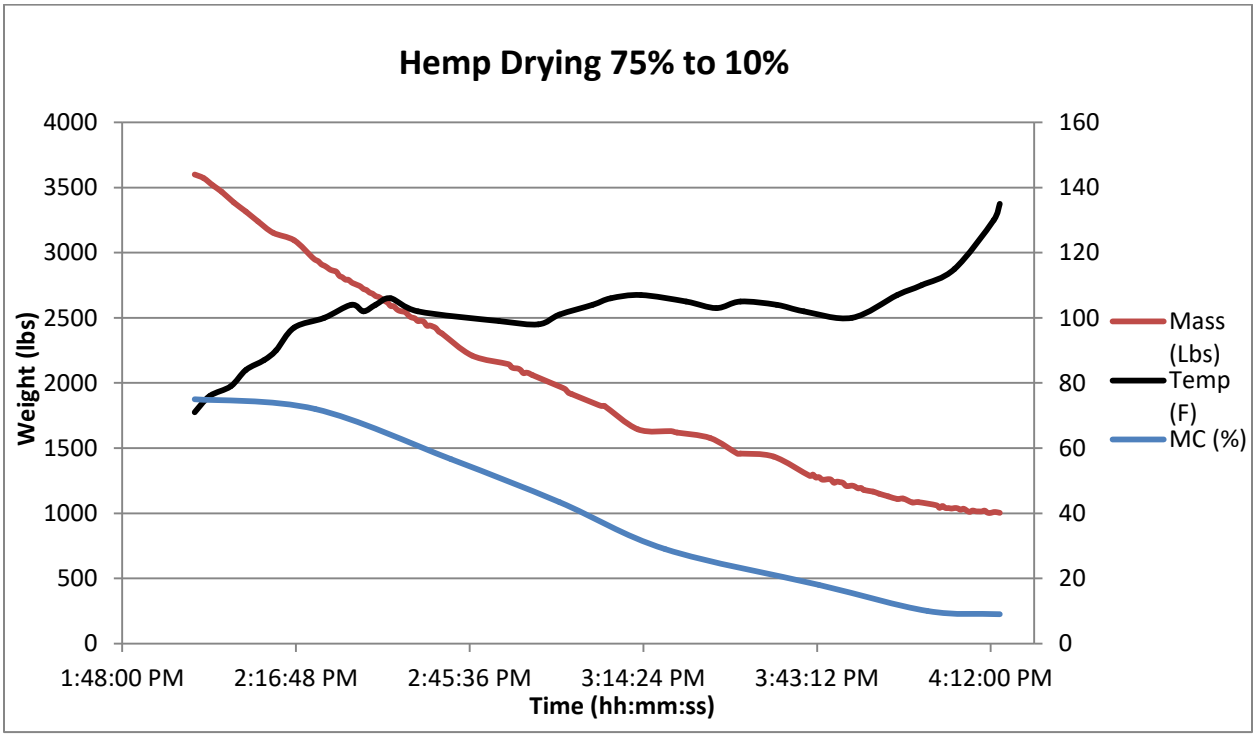
Mixer Capacity (cubic feet)	25	50	100	200	400
Wet input per load (lbs.)	300	700	1,600	3,600	8,000
Dry output per Load (lbs.)	85	200	450	1,000	2,240
Dry output per 24 hrs. (lbs.)	**680**	**1,600**	**3,600**	**8,000**	**18,000**
Microwave power required (kW)	25	64	110	350	750

Drying Profiles

Because microwave energy selectively targets water molecules, the temperature of the biomass during drying remains at about 120^{o} F throughout the drying cycle. This is well below the vaporization temperature of the essential oils and terpenes, so virtually no loss will occur.

The mixing action of the dryer provides extremely uniform heating without hot spots, so is no burning or overheating. The cannabis/hemp retains its natural green color.

The graph below shows the drying cycle of a 200 cubic foot mixer/dryer equipped with 400 kilowatts of microwave power.



Decarboxylation

Minimal conversion of THC-A to THC or CBD-A to CBD occurs during the microwave drying process. The amount of conversion is mostly based on the material temperature while drying, which usually is between 120 and 180 F. An additional heating step added to the end of the drying cycle can produce 95%+ decarboxylation. This is a software controlled option.

A Plant Tour

This Cellencor-designed large scale drying plant is located in a remote location in Arizona where thousands of acres of hemp are cultivated for CBD oil production. The plant is equipped with a 400 cubic foot mixer/dryer with a processing capacity of about 24 tons per day of fresh hemp. The plant is pre-configured for installation of two additional dryers in the future. After drying, the hemp is pelletized and packed in bulk bags, which are then transported to an extraction facility.

The mixer dryer is installed on a steel mezzanine for easy access and to allow bottom discharge of dried product to a conveyor system.

This is a top view of the mixer/dryer, showing the loading port, exhaust duct, and waveguide which delivers microwave power from the generators.

This system is powered by eight Crescend Technologies 50 kilowatt solid state microwave generators. These units have extremely high reliability and minimal maintenance, which is especially important at this remote site.

Freshly cut, chopped and screen hemp is dumped from an end loader into this intake hopper, which feeds a conveyor that loads the dry/mixer from the top.

Hemp in the dryer/mixer after drying, just before unloading.

The dryer's discharge conveyor carries the hemp to a bulk bag loading station.

About Cellencor

Cellencor is a unique company dedicated to high power microwave engineering. Since 2007 we have assisted many companies, large and small, to apply microwave technology in innovative and sometimes revolutionary new processes. Our clients cover a wide range of industries including food processing, agriculture, advanced materials, energy and much more.

Our multidisciplinary staff has expertise in electrical engineering, mechanical engineering, software development, and materials science. We use advanced computer aided design tools including Solidworks for 3D CAD design, and COMSOL Multiphysics for electromagnetic and thermal modeling. We have a fully equipped test laboratory for pilot level testing and material evaluation. We can also work closely with other engineering firms that have specialized skills in mechanical engineering, plant design and project management.

The systems we design utilize the highest quality equipment from leading manufacturers. This includes microwave applicators, microwave generators, sensors, and process control computers.

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