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IMPROVED METHODS FOR NONWOVEN FABRIC DRYING

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Abstract

Two methods of nonwoven fabrics drying, microwave energy and radio frequency energy, are now available as well as a new method of fabric moisture measurement and control for conventional dryers using the difference in two temperatures.

Introduction

Today we want to talk about two different methods of nonwoven fabric drying as well as a new method of moisture measurement and control for conventional dryers. The first method uses microwave energy for drying. The second uses radio frequency energy for drying. The third method is a system which uses the difference in two temperatures for moisture measurement and control.

The microwave system is made by Industrial Microwave Systems, Inc. (IMS) of Morrisville, NC. IMS is represented in the NAFTA territory (the United States, Canada, and Mexico) by Batson Yarn and Fabrics Machinery Group, Inc., an affiliate of Louis P. Batson Company of Greenville, SC.

The radio frequency system is manufactured by RF Systems, Inc. of Vicenza, Italy. RF Systems has over 300 dryers installed world wide and recently received an order from Michelin in France as well as an order for 30 systems for China. RF Systems also is represented in the NAFTA territory by Batson.

The temperature differential system is called DELTA T and is made by Drying Technology, Inc. of Silsbee, Texas. Drying Technology as well is represented in the NAFTA territory by Batson Yarn and Fabrics Machinery Group, Inc.

Equipment

The IMS Microwave Drying System

The IMS patented microwave drying system was developed by two Duke University professors in 1997. Six patents have been issued and others are pending. Test systems have been evaluated at Russell Corporation in Alexander City, AL and Lorber Industries in Los Angles, CA.

The first production system was installed at one of the world's largest producers of underwear in December of 2000. This is a pre-dryer for multiple strands of tubular knit fabrics used to make tee shirts. Speed increases of 20 to 50 percent have been achieved as well as simultaneous uniform drying of different widths of fabric. Another system is being used in the Textile School at Georgia Tech to dry single strands of yarn at 500 yards per minute.

Other drying systems are installed or being installed in a fiberglass fabric finishing operation, another tubular knit plant pre-dryer in California, a non-woven blanket drying operation in Mexico, and chemical and food processing.

The microwave system has a generator which produces microwave energy at a frequency of 915 Megahertz and a wave length of about 13 inches. It has a control panel and a microwave applicator in the form of serpentine wave guides producing a uniform field without hot spots. The wave guides are designed to give adequate dwell time for the moisture in the product. The wave guides can accommodate fabrics, carpets and non-woven materials up to two inches in thickness and up to 20 feet or more in width. The product to be dried passes through the wave guides in a direction perpendicular to the energy flow.

There is a smaller system like the one at Georgia Tech which produces microwave energy at 2450 Megahertz with a wave length of about five inches. This system can accommodate products up to three-fourths of an inch in thickness.

With the microwave system, the microwave signal penetrates the fabric and heats the water molecules to evaporative temperature (212 degrees F.) without heating the fibers above about 140 degrees F. When the moisture is gone, the heating essentially stops. The water molecules are bi-polar and react with the microwave energy. The fibers are non-polar and do not react to any great degree with the microwave energy. Thus, the more moisture present, the more heating takes place. There is an air handling system to remove the evaporated moisture.

Drying control is accomplished by using different power settings. The moisture variation in the product is evened out by the fact that the wetter areas attract more microwave energy. In addition, different size generators can be provided ranging from 100 Kilowatts (kW) up to 800 kW or more. Moisture differences in certain portions of the product across the width or along the length are evened out.

Drying can be targeted for the standard moisture re-gain of four percent for nylon or seven and one-half percent for cotton. Additional moisture can provide an economic benefit since some products are sold by the weight of the finished product.

The system can be used as a pre-dryer or post-dryer on relaxed goods and as a pre-dryer on tentered goods. It is very effective as a post-dryer on carpets since it is very difficult to remove the moisture in the tufts down in the backing with conventional hot air drying.

The microwave system is very efficient. For example, it requires about 115 Kilowatts of electrical energy from the power source to produce 100 Kilowatts of microwave power for drying. The transfer of energy into the product is highly coupled giving a loss of only one to three percent. So the overall efficiency is 82 to 84 percent. Conventional gas-fired or steam dryers have an efficiency of 20 to 40 percent depending on the age and design.

Primary Advantages of the Microwave System

Primary advantages of the microwave system are continuous uniform drying of the product, increased speed, and reduced energy consumption. More information on this system is available on the Industrial Microwave Systems, Inc. web site: www.Industrial Microwave.com or call Max Cochran, Product Manager, Batson Yarn and Fabrics Machinery Group, Inc. at 864-242-5262.

The RF Systems, Inc. Radio Frequency System

The RF Systems, Inc. radio frequency dryer is similar to the microwave dryer except that it uses a more conventional heating tunnel with electrodes inside. The frequency is lower, 27 Megahertz, which gives a longer wave length of 36 feet. Therefore the input and output openings can be larger without any danger of radiation energy leakage. The RF Systems dryers can accommodate thicker products such as thick nonwoven fabrics or skeins and cones of yarn, even when the yarn is on dye tubes or dye springs.

The radio frequency technology (as well as microwave technology) is based on the fact that when a dielectric or insulating material like water is put into an electrical field, its molecules have a polarization which means a deformation and an orientation according to the electrical field. If the field is alternating (oscillating), the direction of the polarization inverts at each inversion of the electrical field. Molecules of water have to move with the same frequency as that of field, dissipating energy due to inter-molecular friction: this energy represents what is named dielectric loss. This transforms itself into heat and increases the water's temperature eventually allowing passage into steam which discharges into the ambient and is carried away by the air handling system. The higher the oscillations, the bigger will be the power absorbed into the material. The radio frequency energy at 27 megahertz provides 54 million inversions per second.

RF Systems was founded to manufacture radio frequency dryers for the drying of textile nonwovens and fibers in the form of loose fibers, cones, cakes, hanks, etc. In 1990 RF Systems was the first company to design and industrialize high power air-cooled radio frequency generators (85 Kilowatts) with performance superior to those obtained by existing radio frequency dryers on the market. Today RF Systems is one of the world leaders in the production of radio frequency dryers with both air and water cooled generators. The choice between air or water cooling depends on the application, the climate conditions, and the requirements of the customer. Power available is from 0.5 to 85 kW.

Power is delivered to the product by means of the electrode. The electrode, which is a combination of the best existing solutions, is one single rectangular element composed of aluminum bars with uniform voltage profile. Movable electrodes allows more drying flexibility compared to traditional systems with fixed electrodes and a more efficient transfer of the power onto the goods to be dried. The power regulation is obtained by means of variation of the distance between the two electrodes. For special applications with a single product with fixed dimensional characteristics (for example strips of fabrics), RF Systems offers a fixed electrode with power regulation by means of a variable capacitance coupling circuit.

The power density of the equipment is a very important factor for the final quality of the product. For each application there is an optimal value (from 2 to 20 kW/sq. meter). Low values are generally required for the textile industry. The dryers are designed to match a value between 3 to 18 kW/sq. meter according to the quality and the forms of the fibers to be dried.

RF Systems expertise lies not only in the radio frequency techniques, but above all in their applications in many fields such as textiles, food, wood, etc. RF Systems is very innovative and, over the years, has secured a large number of patents in this field and is proud of its capability to develop novel and innovative applications to match the customer's requirements for new solutions.

The RF Systems equipment is also very efficient in converting electrical energy from the source into radio frequency drying energy at a rate of 80 percent.

Primary Advantages of the Radio Frequency System

Primary advantages of the RF system are also continuous uniform drying for thicker products, increased speed, and reduced energy consumption. More information on this system is available on the RF Systems, Inc. web site: www.rfsystems.it or call Max Cochran, Product Manager, Batson Yarn and Fabrics Machinery Group, Inc. at 864-242-5262.

Drying Technology Inc. Delta T System

The Drying Technology, Inc. temperature differential system, called Delta T, is installed in about 300 plants mostly in the USA with some in England and South America. The system is measuring and controlling moisture in textiles, fibers, plywood, veneers, food, pet food, coffee and chemical plants. It can be used on carpets, fabrics and on fibers not already in bales such as bleached cotton, rayon, fiberglass, and nylon.

With the Delta T system, the measurement method involves using the temperature difference of the air before and after contacting the product. Here, the greater the difference in temperature, the greater the moisture remaining in the product. The system consists of two or more temperature probes and a desktop PC or industrial PC connected to an existing (or provided) Programmable Logic Controller (PLC) or other input/output logic devices. The PC runs the patented Delta T software which has been developed over many years starting back in 1985 by Mr. John Robinson. The system uses standard RTD or thermocouple sensor probes which are commonly used in ovens. These sensors are normally installed and maintained by plant personnel. Ovens already require one or more sensors to control the burners or steam flow. Spare sensors are usually kept in the supply room. At least one additional sensor is installed to measure the temperature differential. The new sensor is located about two-thirds to three-fourths of the way through the oven, typically in the third zone of a four-zone dryer. The Delta T system is used on relaxed dryers, tenter frames, loop dryers, tumble dryers, fluid bed dryers, coaters, and flow through dryers.

This patented moisture control technology incorporating "inside the dryer" temperature sensors reduces product moisture content distribution. The result is increased production and reduced energy consumption. Many times the product is being over dried, "just to make sure," due to a lack of accurate and consistent moisture measurement. In this case the product speed through the dryer can be increased thus increasing production and reducing unit cost for energy or the dryer temperature can be reduced thus directly saving energy.

The Delta T is an improved method for controlling the moisture content of textiles from dryers. Standard, off-the-shelf, temperature sensors are used for measuring moisture content inside a dryer utilizing the patented Delta T control model:

$$\mathbf{M = K_1(\Delta T)^p - K_2/S^q}$$

relating the moisture (**M**) to: (1) the temperature drop (**ΔT**) of hot air after contact with the wet product; and (2) the dryer speed or production rate (**S**). Hot air flowing over or through the product is cooled by evaporation. This drop in temperature (**T1 - T2 =ΔT**) is a relative measure of the moisture content. The constants $\mathbf{K_1}$ and $\mathbf{K_2}$ and exponents **P** and **Q** are unique to each product and to each dryer and are determined at the time of installation, start-up, and calibration.

Conventional dryer controls measure the moisture at the exit or dry end of the dryer. They assume uniform moisture content of the textiles entering the dryer. The actual inlet moisture content may vary significantly. The Delta T system senses these variations inside the dryer and makes the necessary corrections before the product exits the dryer.

Primary Benefits of the Delta T System

- Provides uniform and precise control of fabric moisture.
- Maximizes production and reduces energy consumption.
- Yields drying uniformity shift-to-shift and product-to-product.
- Is applicable to a wide range of dryers, both continuous and batch.
- Is easily programmed to control drying of all fabric styles, blends, and finishes.

- System may be modified to control resin curing.
- Eliminates resin pre-cure by preventing over drying.

Additional information on Drying Technology, Inc. and re-prints of many articles about the Delta T system can be found on the web site: www.moisturecontrols.com or call Max Cochran, Product Manager, Batson Yarn and Fabrics Machinery Group, Inc. at 864-242-5262.