New Microwave Technology for Uniform Heating, Drying, and Curing Coatings and Laminants

Prepared for: AIMCAL

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Agenda

- About IMS
- Microwave vs Conventional heating
- Uniform Microwave Heating
- Planar Drying Systems™
- Advantages of Microwave Heating
- Examples
IMS

- An industrial heating & drying technology company
- Founded in 1997 by two Duke EE professors
- Located in Research Triangle Park, NC
- 45,000 s.f. facility
- Patented microwave technology for continuous processes
  - Uniform exposure of planar materials
  - Uniform heating throughout a cylindrical region
- Commercial sales in textiles, chemicals, paper & food processing
- Acquired by Laitram, LLC, September 2003
Microwaves
Microwaves vs. Conventional

• Faster
• Easier
• Smaller
• More Efficient
Microwave vs. Conventional Heating

- Conventional heating → external via thermal transfer in convection heat (i.e. Outside – In)
- Microwaves heat throughout the product or volumetrically
- Heating at the molecular level, preferentially by polarity
Conventional Microwave Heating

- Traditional microwave technology generates non-uniform heating
The IMS Difference

• IMS’ patented technology enables the performance and economic benefits of microwaves to be translated to industrial applications by uniformly heating continuous processes
Planar Drying System – How It Works

- Material flows through a horizontal slot in the side of the waveguide where it is exposed to microwave energy.
- MW energy is launched into the waveguide, traversing perpendicular to the material flow.
Creating Uniform Energy Distribution

- Uniformly exposes planar materials to microwave energy by compensating for attenuation and aligning hot spots.
Significance to Planar Applications

- Selective absorption properties
  - Generates a uniform moisture profile across multiple strands or non-uniform moisture profiled webs
  - Reduced substrate temps
- Maximized efficiencies
  - Reduced energy usage
  - Increased process speeds
- Precisely controllable
  - Less wasted time & energy
    - Instant on/off
    - No warm up or cool down
  - Improved quality
  - Instantaneously variable power output
- Electro-technology
  - No on site emissions
- No moving parts
  - Reduced maintenance & labor
- More compact
  - Smaller footprint
Moisture Leveling Case Study

• Protocol
  — Started with a roll of dry, heavyweight paper
  — Each edge was then soaked in 8” of water
  — The center section remained dry
  — The sheet was then run in continuous fashion for two revolutions through an IMS prototype dryer

• Results

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Infrared Temperature Image with Dye
Benefit Analysis

- Final moisture reduction from 10% to 4% represents a disproportionate 20% to 25% of drying time & energy, reducing process speeds and creating quality issues.
- IMS post-drying eliminates loss of efficiency & speed.

**Figure 10.** Overall moisture regain versus drying time for carpet samples with different areal densities (see legend). These data were measured with the laboratory through-air dryer using an airflow rate of 20 m/min and an air temperature of 116°C.
Planar System-Horizontal Pre Dryer

- Drying multiple strands of tubular knits 120” wide, 6’ in the machine direction (118% speed increase on fleece)
Planar System-Horizontal Pre or Post Dryer

- Pre-drying multiple strands of tubular knits (93% speed increase on heavyweight knits)
Planar System-Horizontal Post Dryer

- Post drying of printed nonwoven blankets w/ < 15% ink coverage
Planar System - Vertical

- Total drying of woven fiberglass from 30% to 0.2% @ 180 ft/min
Planar System-Horizontal Stand Alone

- Total drying of polyurethane foam from 45% to 1% @ 34 ft/min
Performance Comparison of IMS to RF

Why do you have a microwave oven at home and not an RF oven?
- Microwaves have a shorter wavelength and therefore can:
  - Operate in a cavity or “box” without the need for additional components such as electrodes or platens
  - Be absorbed by thinner materials like foods more efficiently
  - Accommodate a more universal range of products/processes without mechanical adjustment

Arcing
- With microwaves, in the unlikely event of an arc there is no damage to the material
- With RF, arcing occurs from electrode to electrode through the material causing product damage and increasing the likelihood of thermal incidents (fire)
Performance Comparison of IMS to RF

• Uniformity
  — IMS’s patented technology results in total uniformity throughout the volume of material processed
  — RF is known to generate edge effects or distortion of the energy field that causes side-center-side moisture variations
  — Due to the wavelength, RF has difficulty “coupling” to materials at low moisture levels dramatically reducing process speeds

• Efficiency
  — 95% to 99% of the microwave energy generated is converted to heating in IMS systems

• Power consumption
  — 100 kW IMS system pulls 115 kW from the wall (15% loss)
  — RF typically pulls twice its output power from the wall (50% loss)
Performance Comparison of IMS to RF

• Operation/adjustments
  — IMS systems have no moving parts (other than the conveyor) and are totally automated with minimal or no operator interface
  — RF systems typically require the adjustment of electrodes or platens depending on process variations

• Controllability
  — IMS systems can incorporate a process input signal to vary output power instantaneously resulting in maximum energy efficiency and precise final moisture control
Industrial Microwave Systems

Processing at the Speed of Light
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