Direct Contact Ultrasonic Drying

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Drying with no heat!

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Industrial Drying

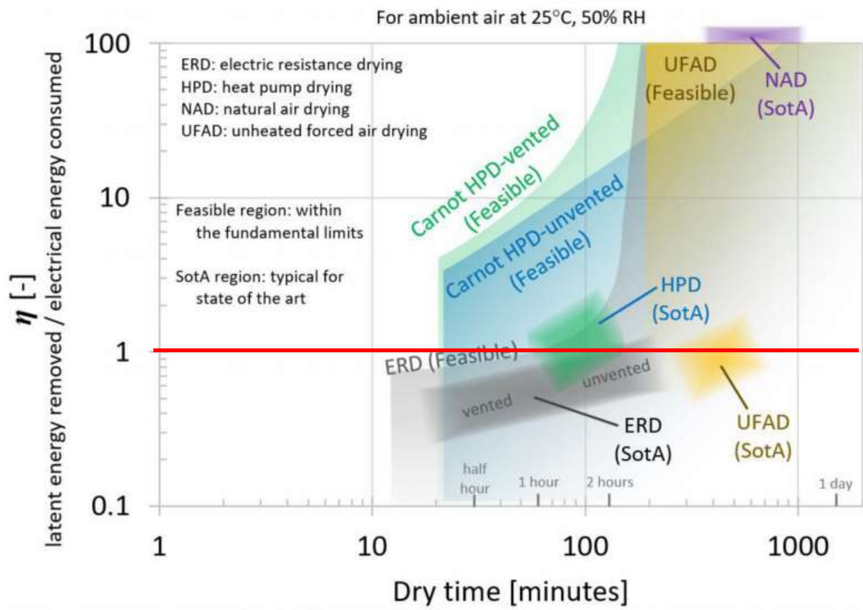
- Drying can be done for **free! But …**

- The **challenge** is in the strict industrial drying **requirements**:
  - Drying speed
  - Extent of drying
  - Product quality
  - Disinfection requirements
  - Wrinkles
  - Required heat to promote certain chemical reaction/bonding

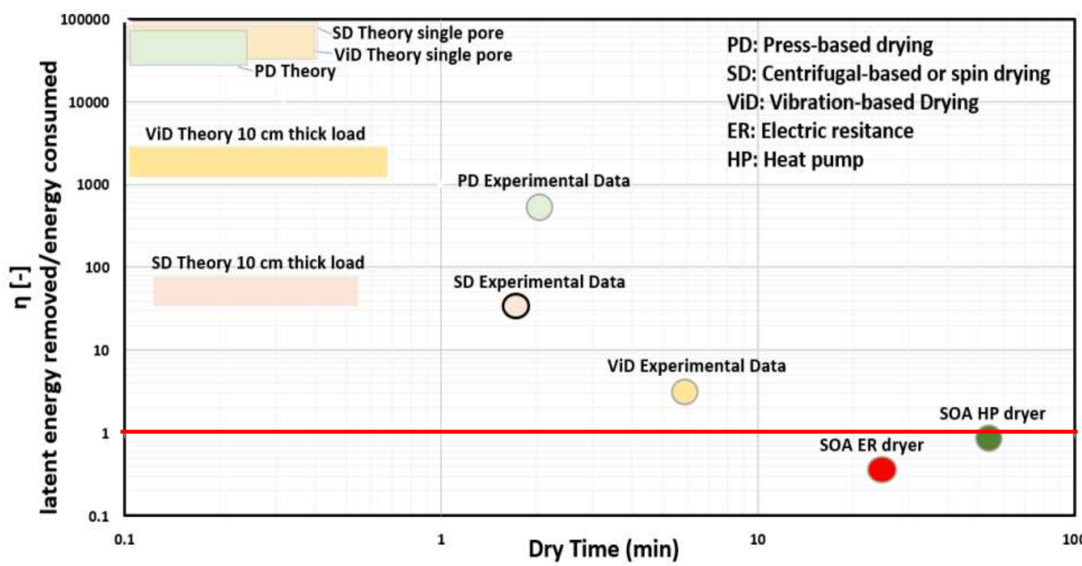
- The process requirement is where discussion should start

Drying

Thermal Methods



Mechanical Methods

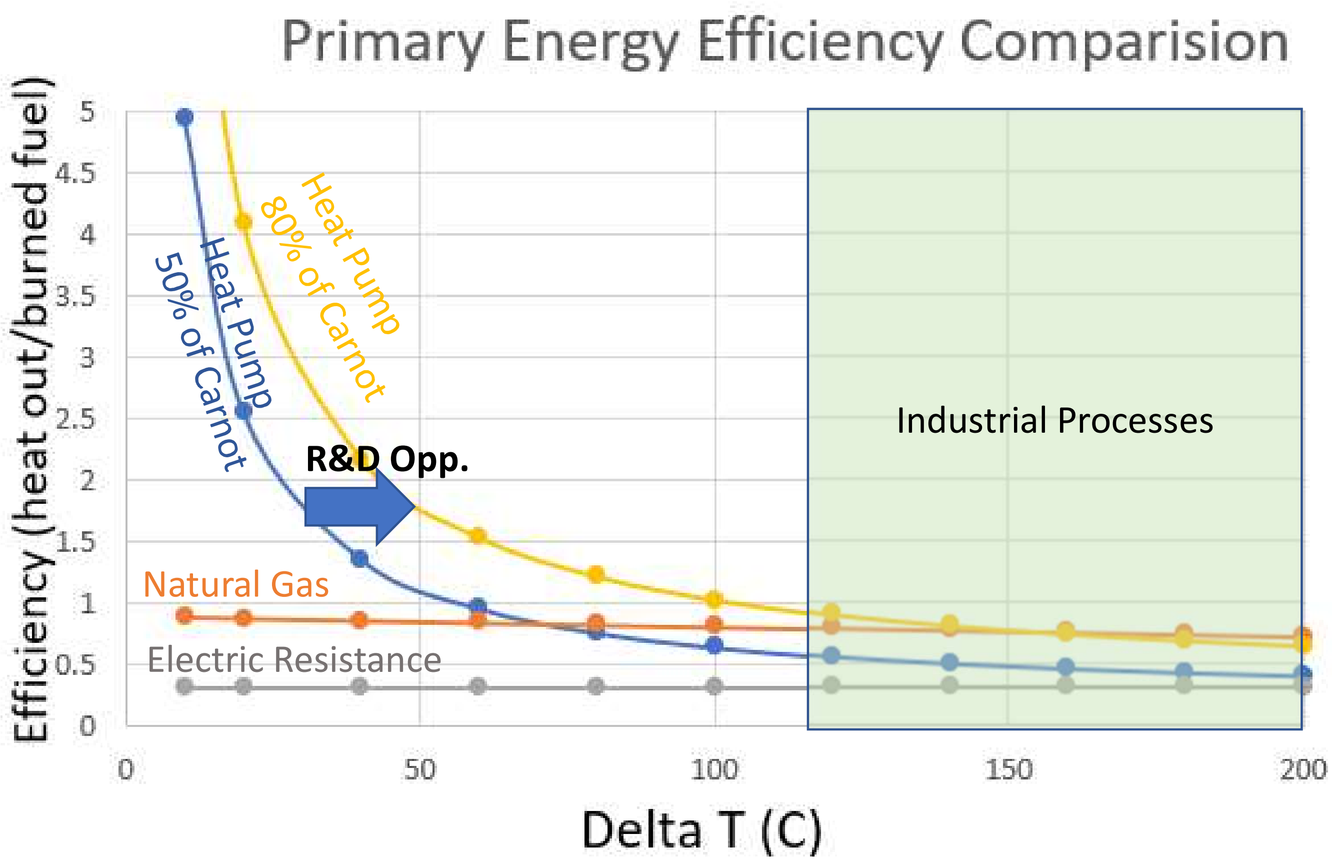


- Surprisingly, all the drying methods (including electric resistance drying) can have efficiency > 1 under certain conditions!!
- Generally speaking, **mechanical drying can have orders of magnitude higher efficiency**… **but**… **with many restrictions**
- Disappointing **0.35** efficiency multiplier should be added to all the above numbers if using electricity vs. gas (in terms of primary energy or CO_2 emission)

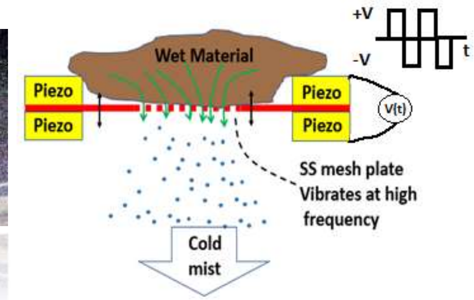
Authors: Ayyoub Momen, Kyle Gluesenkamp, Viral Patel

Concerning environmental impact and CO_2 emission: The <u>primary energy efficiency</u> is a figure of merit

Thermodynamic Limitations



We Invented The “Direct Contact Ultrasonic Drying”



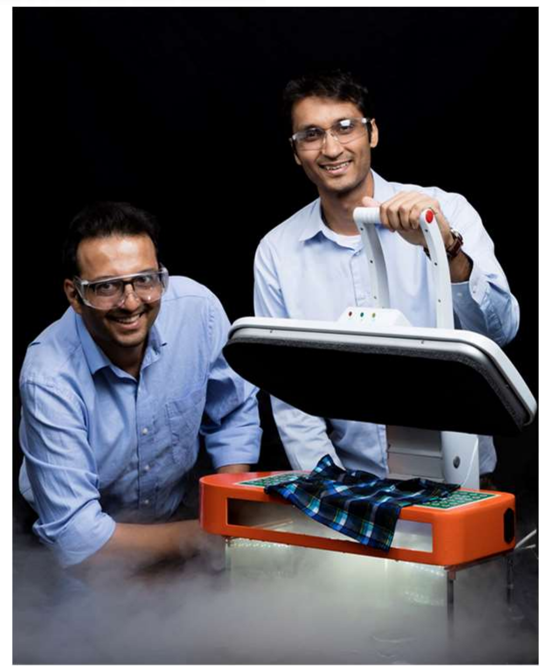
Our technology uses piezoelectric elements to shake (vibrate) wet material at a high frequency resulting in moisture removal in the form of cold mist that can be captured.

Pros:

- **5-10X improvement in energy efficiency**
- **2-10X faster drying rate can be achieved**
- **Unlike thermal drying, it works even better for thicker material**

Cons:

- **Unlike generic thermal drying, customization based on the material is required.**



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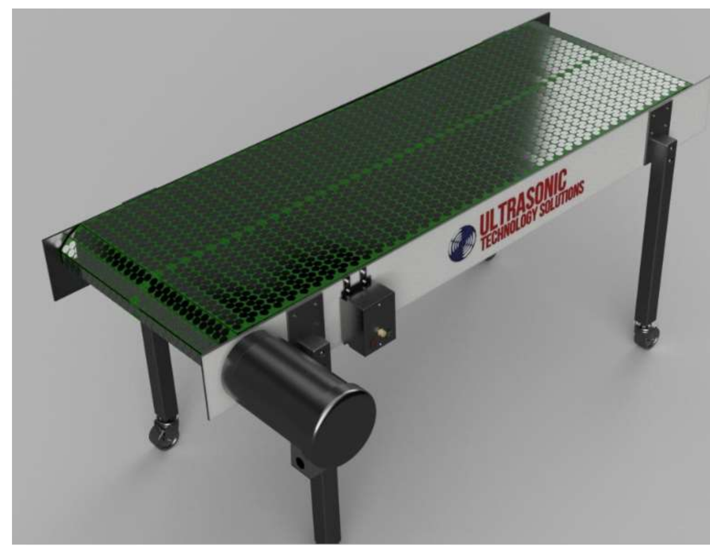
Primary Market: Textile and hospitality industry

Example of the Process Requirements:

- Typical process speed ~ 1 m/s
- Mechanical drying up to 85% RMC is easy with press drying
- Every 5% additional drying has $30-40k/yr. energy saving value per machine

Our machine:

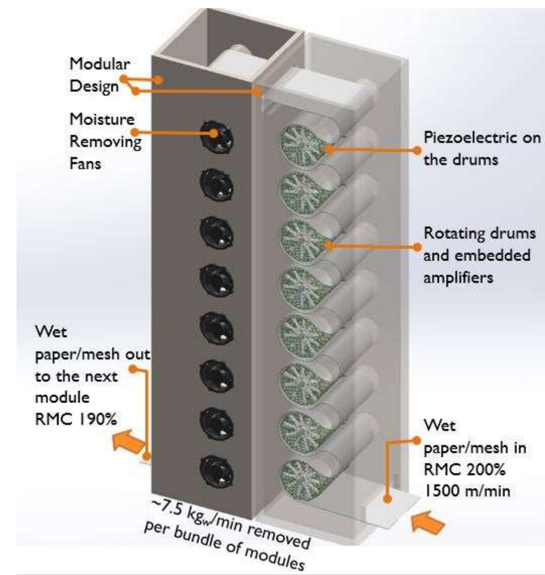
- One module dry from 85% down to 60%
- Two modules dry from 85% down to 50%
- ROI < 20 months

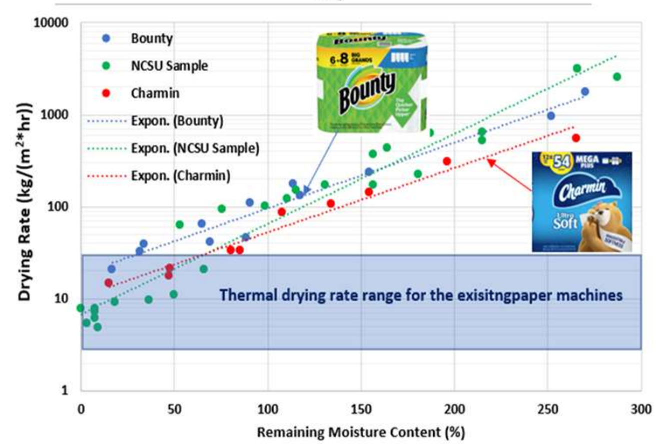


Longer term goal: Paper and Pulp Industry

Requirements:

- The **3rd largest** consumer of industrial energy.
- The **new** TAD technology (introduced in 1960's and patent expired in 1990's) machine cost **$250-800M**
- We **cannot sell** a totally new dryer machine in the U.S. market (you may in China!!)
- Only **retrofittable** solutions are acceptable (i.e. Tissue pre-dryer)
- **Process speed up to 6000 ft/min (75 mph)-> Residence time <0.5s thus T>440F**
- Market acceptance takes 10-15 years
- U.S market demands for premium products made through TAD process (TAD 9800kJ/kg_{water} compared to LDC 7500 kJ/kg_{water})





Projected machine performance on a sample plant:

- Drying from 22 to 50% consistency
- *Energy savings 473,400 kWh*
- *Payback period of 19 months*
- *Ongoing operational energy saving of $2,097,000/yr.*

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The proposed standard metrics for apple-to-apple comparison among technologies

- Efficiency:

  Primary energy based efficiency:

  $\eta_{primary}$= Latent heat removed (kJ/kg)/primary energy (kJ/kg)

  *Gas to electric multiplier needs to be pre-defined (i.e. 33%)

  i.e. The current heat pumps are barely below 1

- Drying Rate:

  $kg/m^2.hr$

- Dryness:

  Either consistency or remaining moisture content