CENTER FOR ADVANCED RESEARCH IN DRYING

A National Science Foundation Industry University Cooperative Research Center

Dehydration of Moist Media with Airborne Ultrasonic Waves

Presenter : Mehrnoush Dardashti
Advisor : Jamal Yagoobi

Impact of Drying

- **Industrial DRYING accounts for 1.25% of the total energy used in the USA which is 1.2 quads of energy every year.**

- Around 0.5 quads of energy can be conserved by improving drying processes. This equates to reducing CO2 emissions by 204,736,567,033 kg/year.

- The United Nations announced for 17 Sustainable Development Goals, specifically focusing on "industry, innovation, and infrastructure" and "responsible consumption and production".

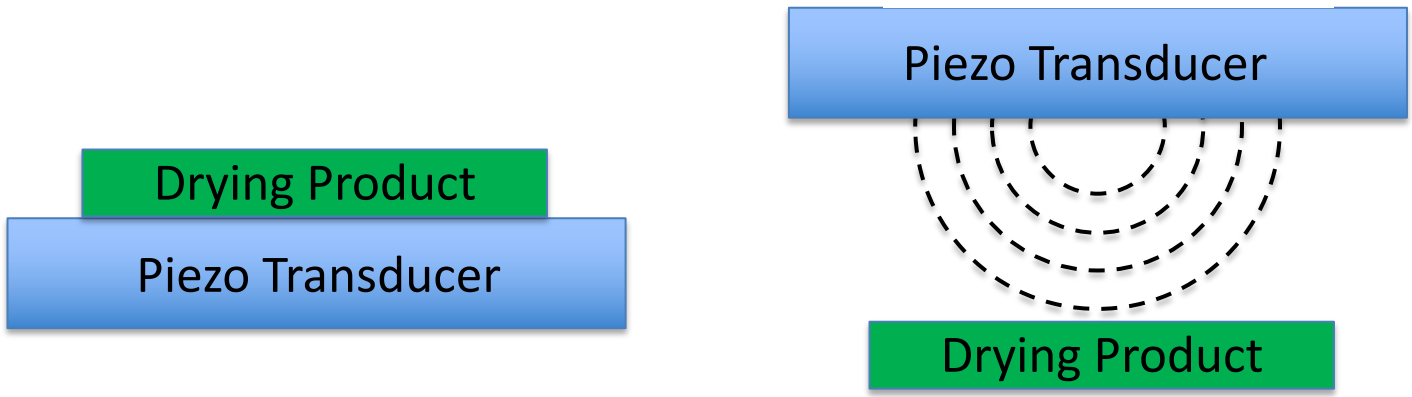
- Industries such as food & agriculture, pulp & paper, chemicals, textiles, and biopharmaceuticals all depend on inefficient drying technologies.

Drying

- Conventional and non-conventional drying methods:
  - Sun drying
  - Tunnel drying
  - Spray drying
  - Drum drying
  - Freeze drying
  - Microwave drying
  - Electrotechnology drying
  - Laser drying
  - Heat pump drying
  - Radio frequency
  - Impingement drying
  - Infrared drying
  - Ultrasonic drying

Introduction to Ultrasonic Drying

- Acoustic waves of which frequencies are higher than the upper limit of the human hearing range, usually around 16 or 20 kHz, are called ultrasound.

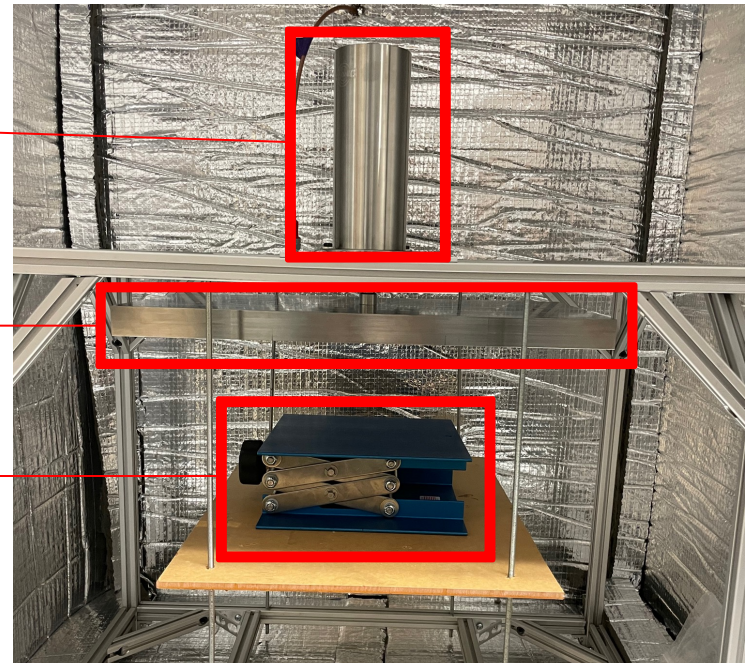


Direct Contact Ultrasound V.S. Airborne Ultrasound

Airborne transducer

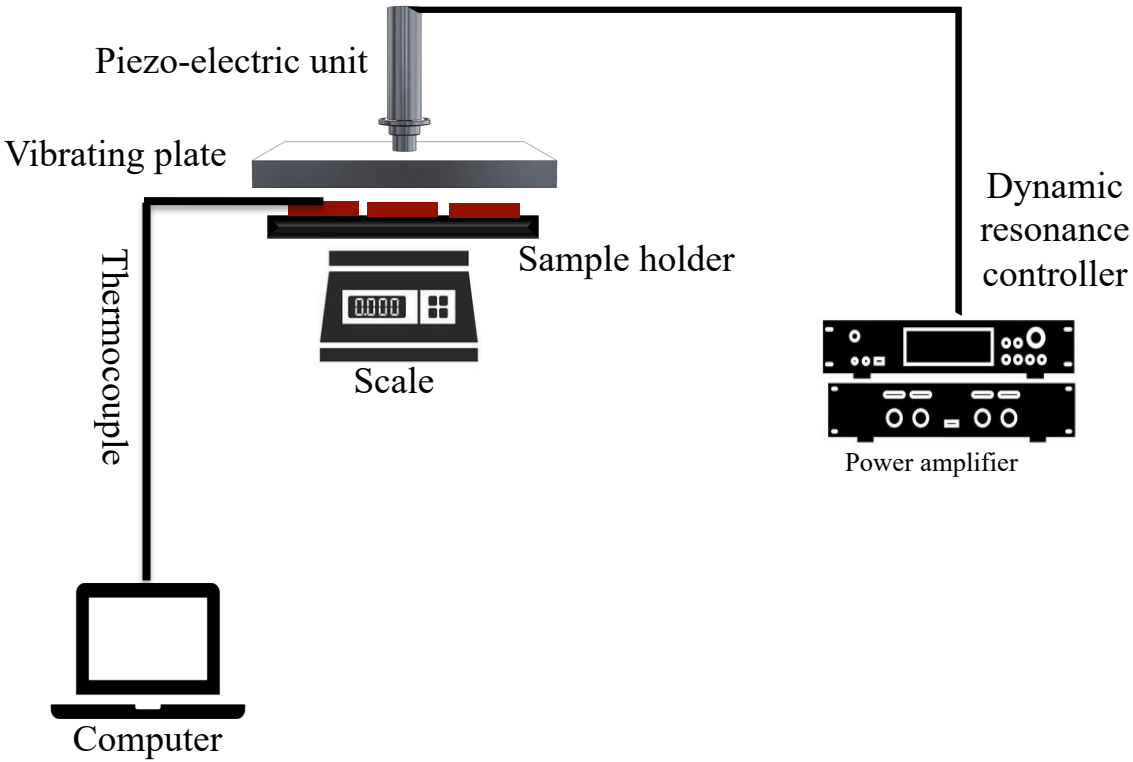
- Airborne power ultrasonic transducer with a rectangular plate radiator
- Maximum Power = 225W
- Frequency = 21 kHz
- Dimensions of the titanium plate :

  $43.3 \times 23.4 \times 3.15\ cm^3$



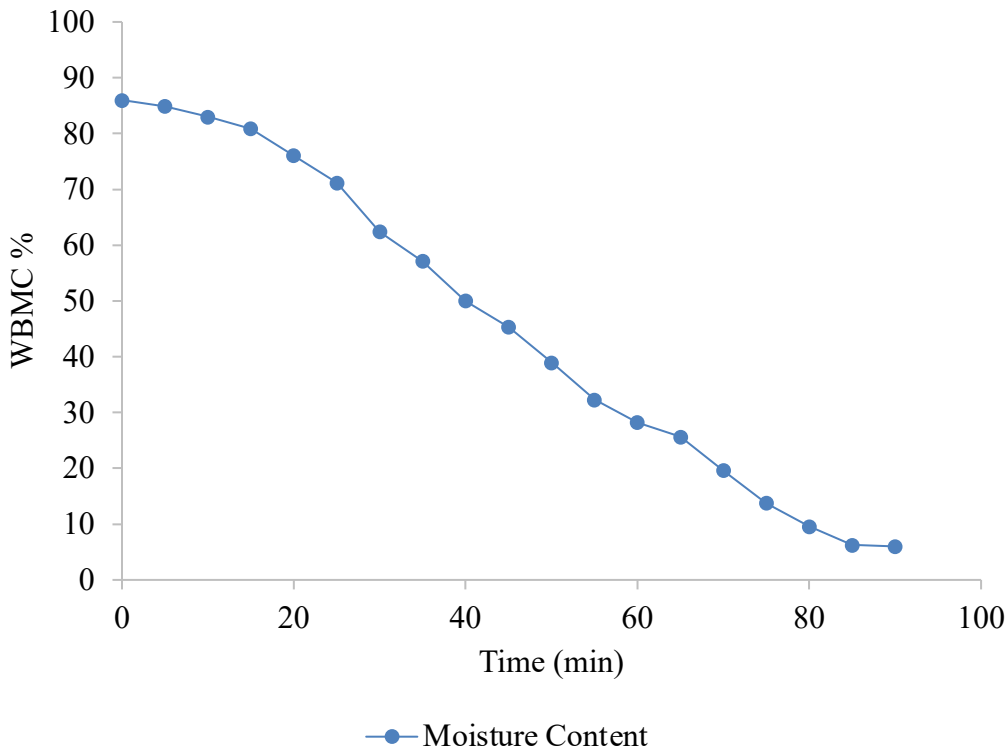
Experimental setup

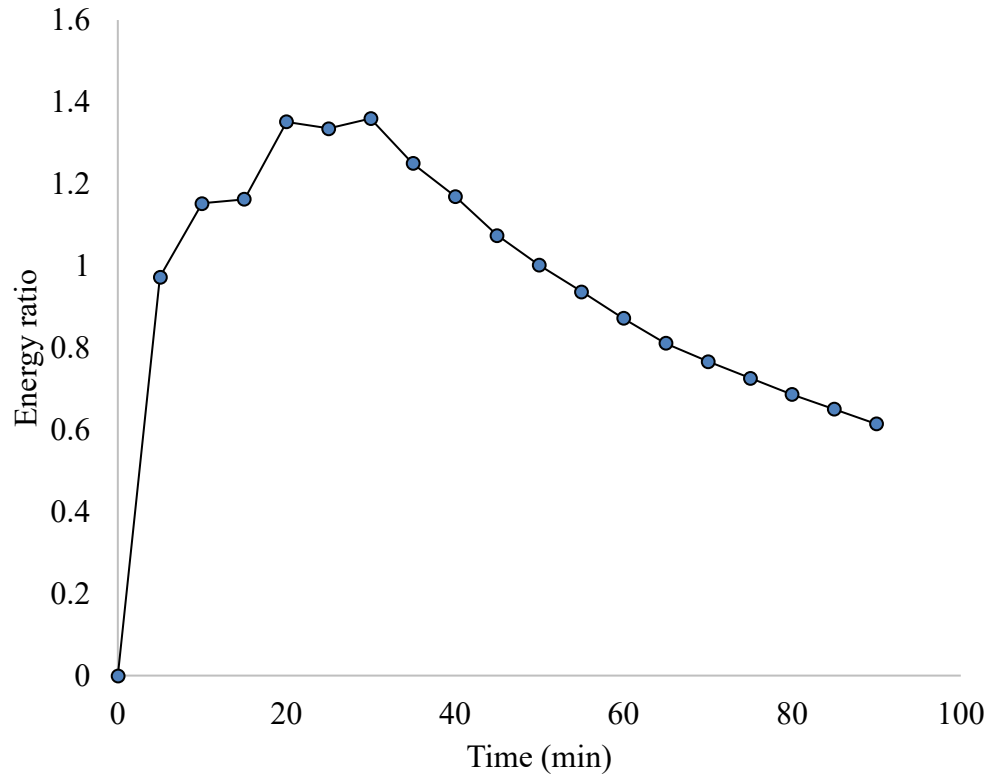
- Using Strawberry as a sample



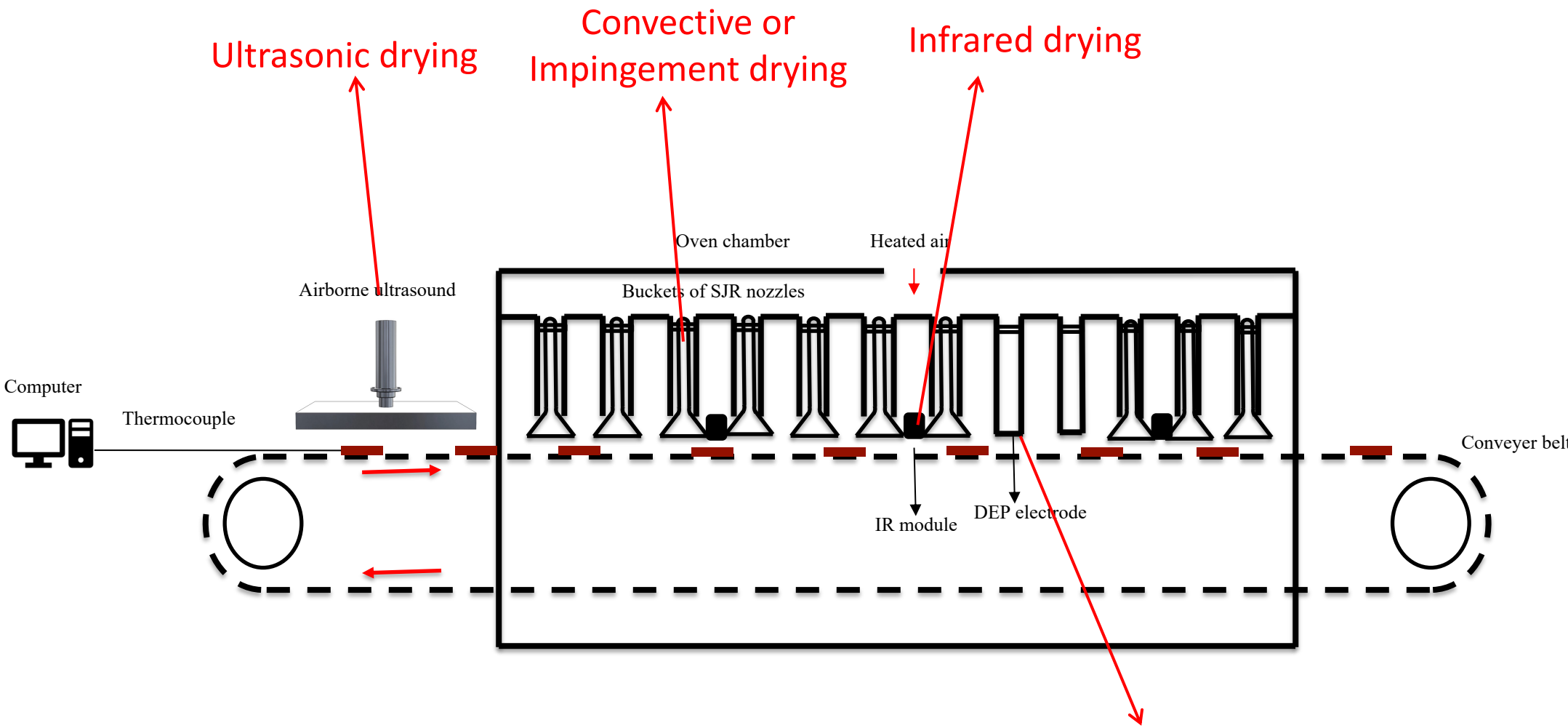
Experimental results

- Operating conditions: Applied power to transducer= 200W – Distance from the plate= 5mm – Sample thickness= 3mm



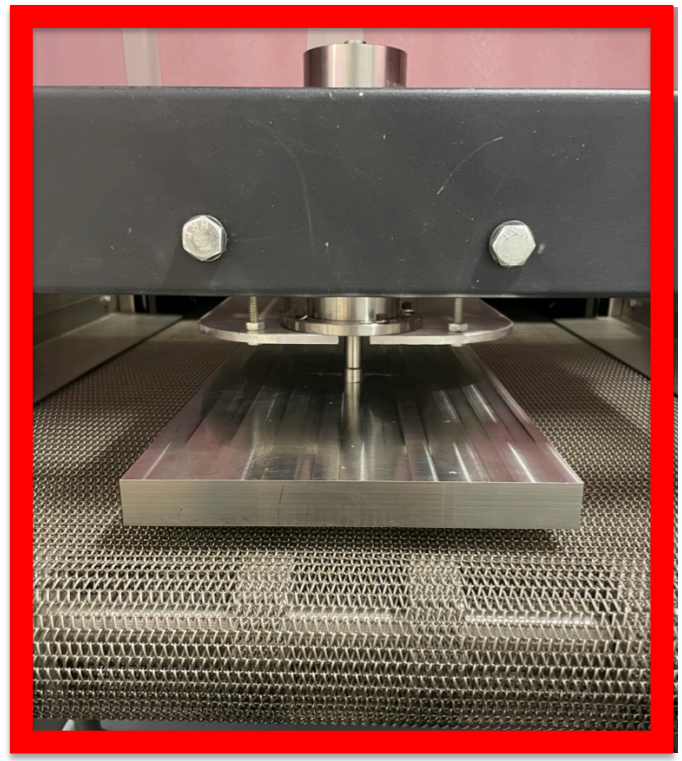


Fully electrified drying oven (Smart Dryer)



Smart Dryer

Soundproof insulation

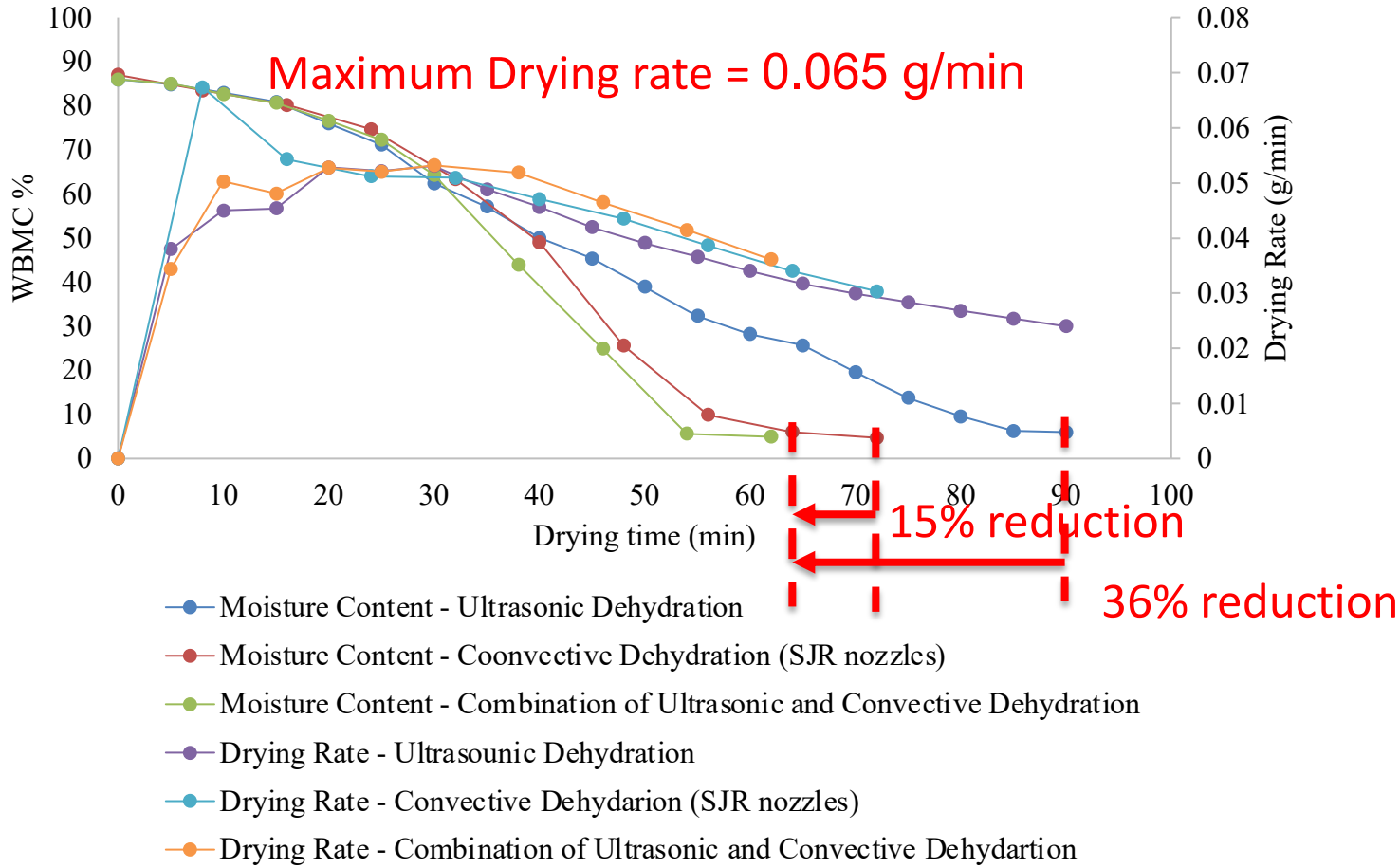


Non-contact transducer

Smart dryer

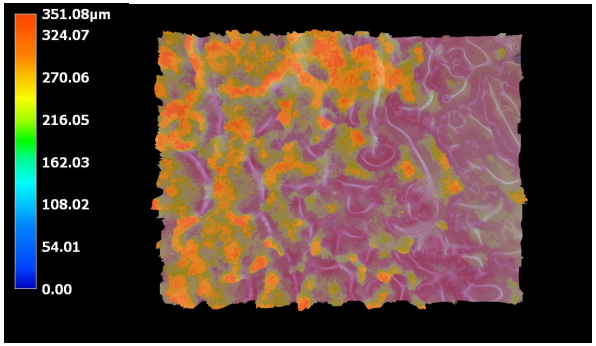
Experimental results

- Operating conditions: P= 200W - Distance= 5mm - Thickness= 3mm – Air V_{exit}=5.3 m/s - belt speed = 0.006604 m/s, Air Temperature = 50°C

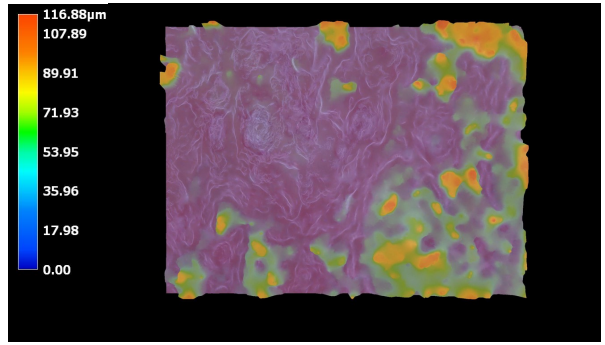


Quality measurements

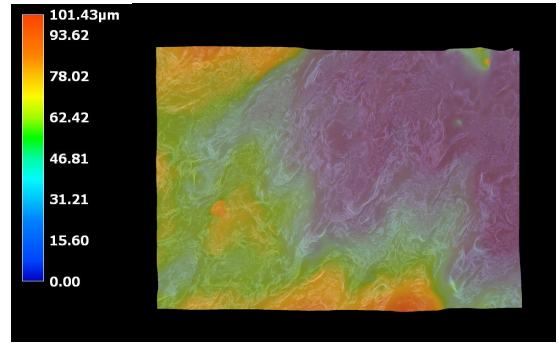
- Color
- Water activity
- Microstructure → ESEM photos and surface topology
- Rehydration ratio and texture analyzing by measuring tensile strength



Fresh sample		
parameters	Value	Unit
Sa	69.59	μm
Sz	351.08	μm
Sq	82.14	μm



Ultrasonic Drying		
parameters	Value	Unit
Sa	19.48	μm
Sz	116.88	μm
Sq	23.82	μm



Convective Drying with SJR nozzles		
parameters	Value	Unit
Sa	15.96	μm
Sz	90.75	μm
Sq	19.88	μm

Conclusions

- Combination of different drying methods such as SJR nozzles, airborne ultrasonic waves, and Infrared showing promising results in terms of both energy consumption and product quality

- Investigate on different controlling parameter to optimize the process for energy consumption and product quality

For more information contact:

Professor Jamal Yagoobi (jyagoobi@wpi.edu)
Mehrnoush Dardashti (mfamildardashti@wpi.edu)

https://www.dryingresearch.org/