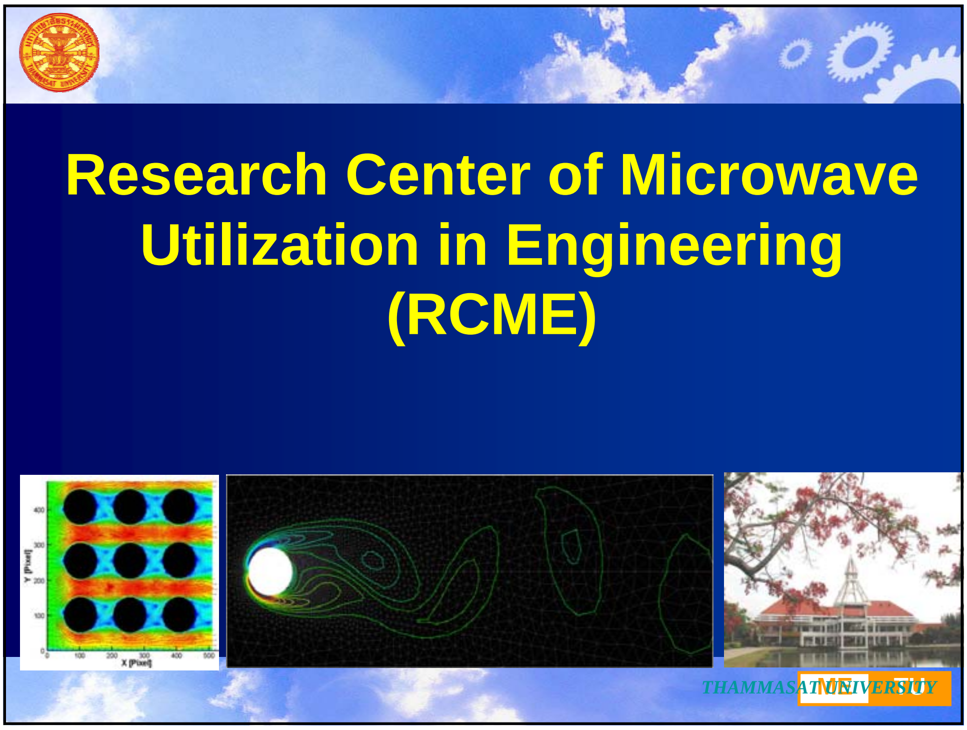


Research Center of Microwave Utilization in Engineering (RCME)

THAMMASAT UNIVERSITY

สาหรับตัวผม ผดุงศักดิ์ รัตนเดโช เน้น

วิจัยพื้นฐาน วิจัยประยุกต์ และทำควบคู่
ทุน สกว สภาวิจัย สวทช
ตีพิมพ์ในวารสารวิจัยระดับนานาชาติที่มีมาตรฐานสูง
สร้างสิ่งประดิษฐ์และนวัตกรรมที่ใช้ประโยชน์กับสังคมไทยได้
และสามารถจดสิทธิบัตรได้
ให้บริการทางสังคม
ผลิตนักศึกษา ปริญญาตรี โท และ เอก ที่มีคุณภาพ

RCME RESEARCH CENTER OF MICROWAVE UTILIZATION IN ENGINEERING

RCME Members

5 Ph.D Researchers

15 Ph.D Students

5 Master Students

6 Bachelor Students

Research Area:

Basic Research/Applied Research

(1) Development Mathematical Modeling/Numerical Technique for Solving Heat and Mass Transport in Highly Complex System

- Conventional Methods
  - Finite Volume Method (FVM)
  - Finite Differnce Time Domain (FDTD)
  - Transfinite Interpolation-PDE Mapping Method
- Statistical Methods
  - Lattice Boltzmann Modelling
  - Monte-Carlo Modelling

(2) Theoretical Analysis in Multiphase Flow-Phase Change Problem (Porous Media, Biomaterial, Tissue-Membrane, etc.)

(3) Microwave Heating (Theory and Experiment)

(4) Experiment in Thermal Processes

(5) Biomechanics

List of World Class-International Journals Published (>60 Papers)

- Int. J. Numerical Method for Engineering
- Int. J. Materials Science
- ASME Journal of Heat Transfer
- International Journal of Heat and Mass Transfer
- International Communications in Heat and Mass Transfer
- Drying Technology International Journal
- Applied Math. Modelling
- Numerical Heat Transfer Part B - Fundamentals
- IEEE Transactions of Microwave Theory and Techniques
- ASME J. Manufacturing Science and Eng.
- Chemical Engineering Science
- Computers&Chemical Engineering
- AIAA Journal of Thermophysics and Heat Transfer
- AIChE J.

etc

Patents: >10 Items

Research Collaboration

Cornell University, USA.
University of California, Riverside, USA.
Nagaoka University of Technology, Japan
University of Nottingham, U.K
University of New South Wales, Australia
Etc.

Grants

- **CHE**
- **TRF**
- **MTEC**
- **ITAP-NSTDA**
- **NRC**
- **Private Company**
- **Etc.**

Electromagnetic Field Analysis

Maxwell's Equations (TE$_{10}$ Mode)

$$\frac{\partial E_y}{\partial z} = \mu \frac{\partial H_x}{\partial t}$$

Magnetic Permeability

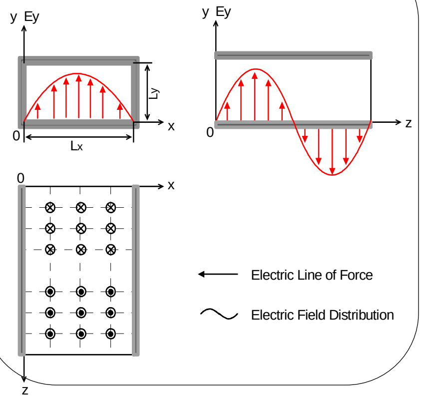
$$\mu = \mu_0 \mu_r$$

$$\frac{\partial E_y}{\partial x} = -\mu \frac{\partial H_z}{\partial t}$$

$$-\left(\frac{\partial H_z}{\partial x} - \frac{\partial H_x}{\partial z} \right) = \sigma E_y + \varepsilon \frac{\partial E_y}{\partial t}$$

Electric Conductivity **Permittivity** $\varepsilon = \varepsilon_0 \varepsilon_r$

Electric Field Distribution in TE$_{10}$ Mode



Microwave Absorption

$$Q = 2\pi \cdot f \cdot \varepsilon_0 \cdot \varepsilon_r (\tan\delta) E_y^2$$

Electric Field

Microwave Frequency

Modeling Formulations

Fluid Transport Eqs.

Pressure

X-Momentum

$$\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} + w\frac{\partial u}{\partial z} = -\frac{1}{\rho}\frac{\partial p}{\partial x} + \nu\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial z^2}\right)$$

Z-Momentum

$$\frac{\partial w}{\partial t} + u\frac{\partial w}{\partial x} + w\frac{\partial w}{\partial z} = -\frac{1}{\rho}\frac{\partial p}{\partial z} + \nu\left(\frac{\partial^2 w}{\partial x^2} + \frac{\partial^2 w}{\partial z^2}\right) + g\beta(T - T_\infty)$$

x-Velocity z-Velocity Kinematics Viscosity Coefficient of Thermal Expansion

Continuity Eqs.

$$\frac{\partial u}{\partial x} + \frac{\partial w}{\partial z} = 0$$

Heat Transport Eq.

$$\frac{\partial T}{\partial t} + u\frac{\partial T}{\partial x} + w\frac{\partial T}{\partial z} = \alpha\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial z^2}\right) + \frac{Q}{\rho \cdot C_p}$$

Microwave Absorption

Thermal Diffusivity

Specific Heat Capacity

Modeling Formulations

Fluid Flow Eqs.

Capillary Pressure $p_c = p_g - p_l = \frac{\sigma}{\sqrt{k/\phi}}\left[0.325(1/s_e - 1)^{0.217}\right]$

Liquid

$$u_l = -\frac{kk_{rl}}{\eta_l}\left(\frac{\partial p_g}{\partial x} - \frac{\partial p_c}{\partial x}\right), \quad w_l = -\frac{kk_{rl}}{\eta_l}\left(\frac{\partial p_g}{\partial z} - \frac{\partial p_c}{\partial z} - \rho_l g\right)$$

Gas

$$u_g = -\frac{kk_{rg}}{\eta_g}\frac{\partial p_g}{\partial x}, \quad w_g = -\frac{kk_{rg}}{\eta_g}\left(\frac{\partial p_g}{\partial z} - \rho_g g\right)$$

$$k_{rl} = s_e^3, \quad k_{rg} = (1 - s_e)^3$$

Air

$$u_a = u_g - \rho_g \frac{D_m}{\rho_a}\frac{\partial}{\partial x}\left(\frac{\rho_a}{\rho_g}\right), \quad w_a = w_g - \rho_g \frac{D_m}{\rho_a}\frac{\partial}{\partial z}\left(\frac{\rho_a}{\rho_g}\right)$$

Vapor

$$u_v = u_g - \rho_g \frac{D_m}{\rho_v}\frac{\partial}{\partial x}\left(\frac{\rho_v}{\rho_g}\right), \quad w_v = w_g - \rho_g \frac{D_m}{\rho_v}\frac{\partial}{\partial z}\left(\frac{\rho_v}{\rho_g}\right)$$

Vapor Diffusion Coeff. $D_m = \frac{2\phi}{3-\phi}(1-s)D$

Mass Transport Eqs.

Liquid+Vapor $\phi\frac{\partial}{\partial t}\{\rho_l s + \rho_v(1-s)\} + \frac{\partial}{\partial x}(\rho_l u_l + \rho_v u_v) + \frac{\partial}{\partial z}(\rho_l w_l + \rho_v w_v) = 0$

Air $\frac{\partial}{\partial t}\{\rho_a\phi(1-s)\} + \frac{\partial}{\partial x}(\rho_a u_a) + \frac{\partial}{\partial z}(\rho_a w_a) = 0$

Heat Transport Eq.

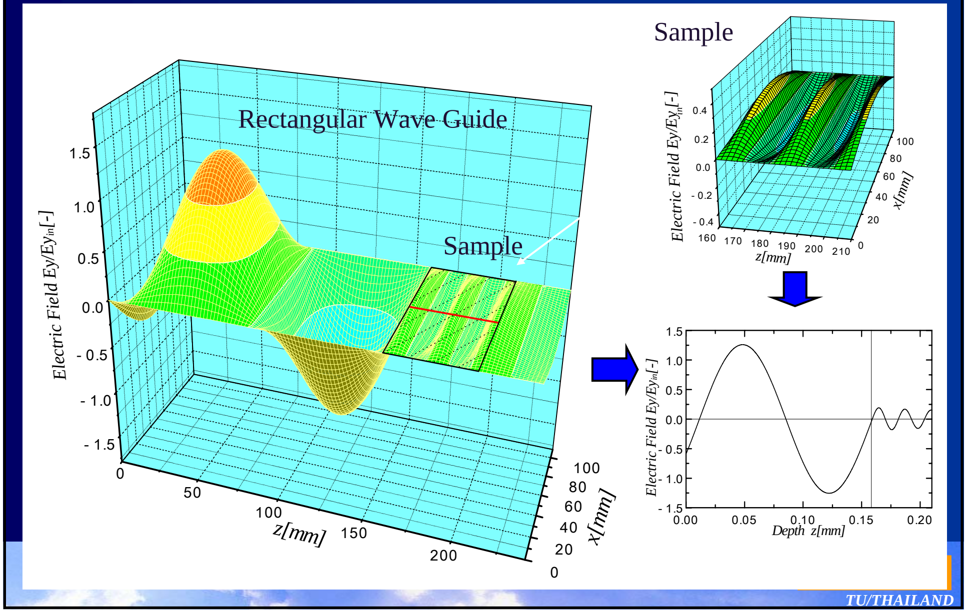
$$\frac{\partial}{\partial t}\left[\{\rho_l c_{pl}\phi s + \rho_g c_{pg}\phi(1-s) + \rho_p c_{pp}(1-\phi)\}T\right] + \frac{\partial}{\partial x}\{(\rho_l c_{pl} u_l + \rho_g c_{pg} u_g)T\} + \frac{\partial}{\partial z}\{(\rho_l c_{pl} w_l + \rho_g c_{pg} w_g)T\}$$
$$= \frac{\partial}{\partial x}\left\{\lambda_{eff}\frac{\partial T}{\partial x}\right\} + \frac{\partial}{\partial z}\left\{\lambda_{eff}\frac{\partial T}{\partial z}\right\} - h_{lv}\dot{n} + Q$$

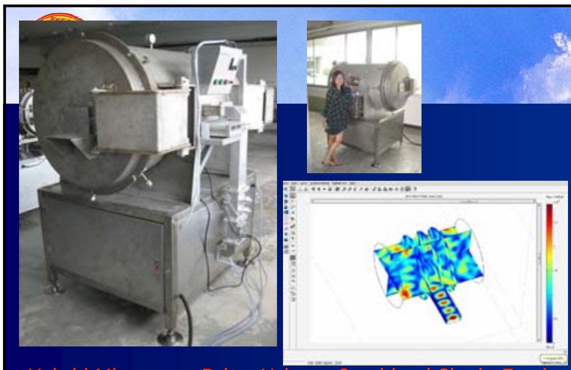
Microwave Absorption

Latent Heat of Evaporation

$$\lambda_{eff} = \frac{0.8}{1 + 3.78\exp(-5.95s)}$$

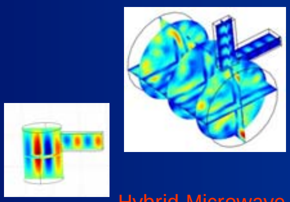
Electric Field Distribution Inside a Rectangular Wave Guide





Hybrid Microwave Drier Using a Combined Single-Feed High Power Magnetron and Vacuum System

Microwave Vacuum Drier Unit



Hybrid Microwave Drier Using a Combined Unsymmetrical Multi-Feed Low Power Magnetrons and Vacuum System

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Optical Fiber Optics

Network Analyzer System

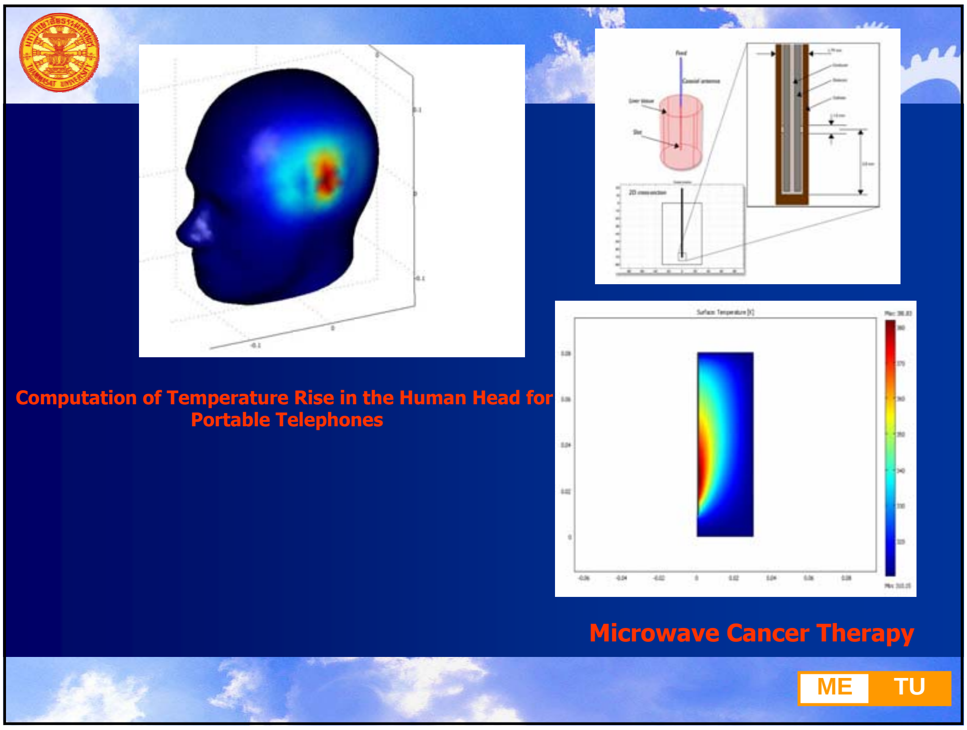
Microwave-Rectangular Waveguide System

Digital Readout MW leakage Detector

Microwave Spouted Bed Drier

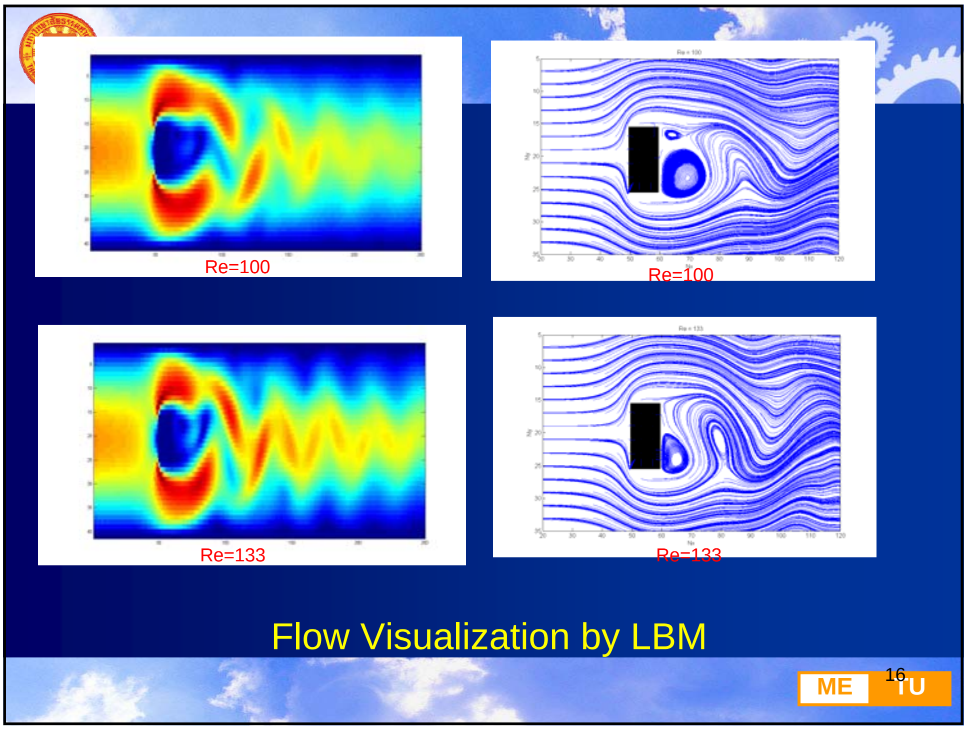
Microwave Pyrolysis Unit

Hybrid Microwave Drier Using a Combined Unsymmetrical Multi-Feed Low Power Magnetrons and Continuous Belt System



Computation of Temperature Rise in the Human Head for Portable Telephones

Microwave Cancer Therapy



Re=100

Re=100

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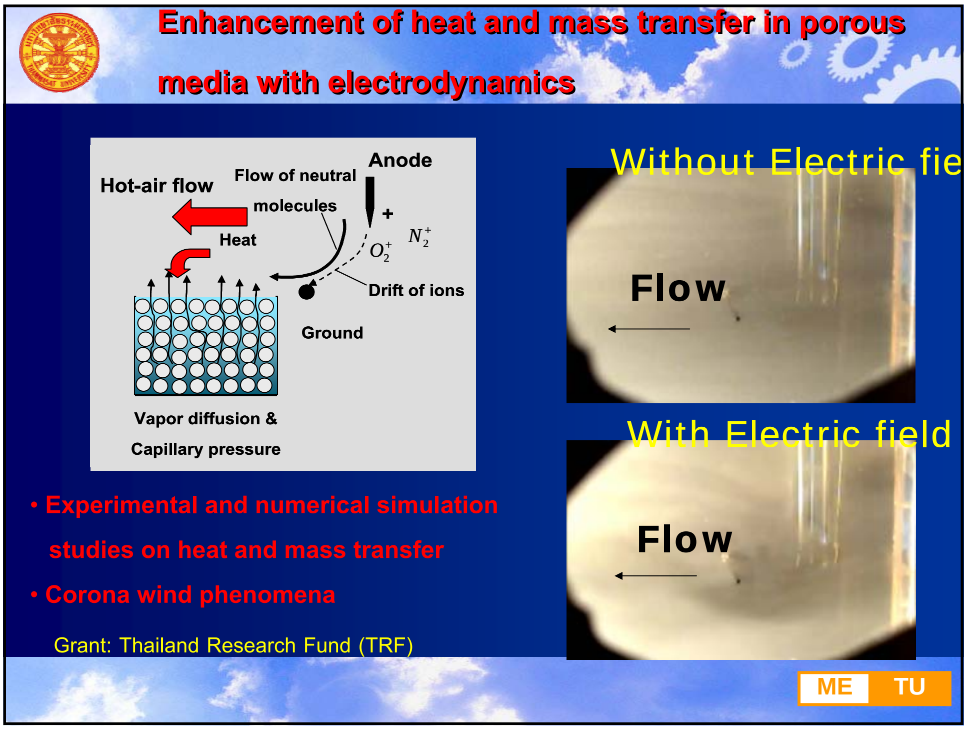
Re=133

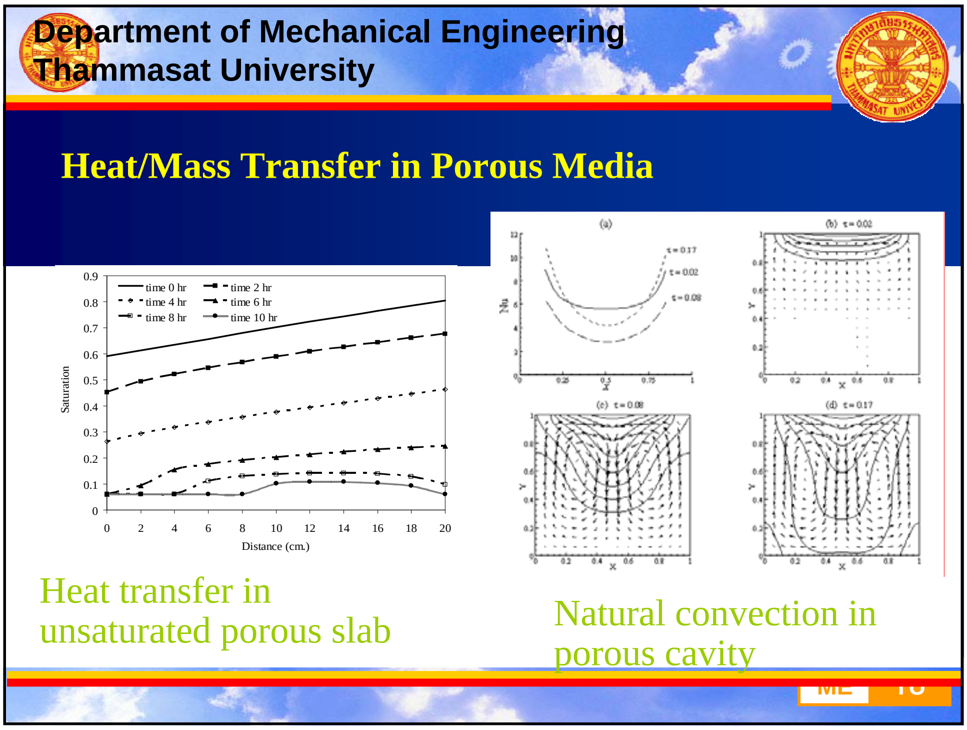
Flow Visualization by LBM



Enhancement of heat and mass transfer in porous media with electrodynamics

- Experimental and numerical simulation studies on heat and mass transfer
- Corona wind phenomena

Grant: Thailand Research Fund (TRF)



Heat/Mass Transfer in Porous Media

Heat transfer in unsaturated porous slab

Natural convection in porous cavity

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Question?

Good Luck

Enough!