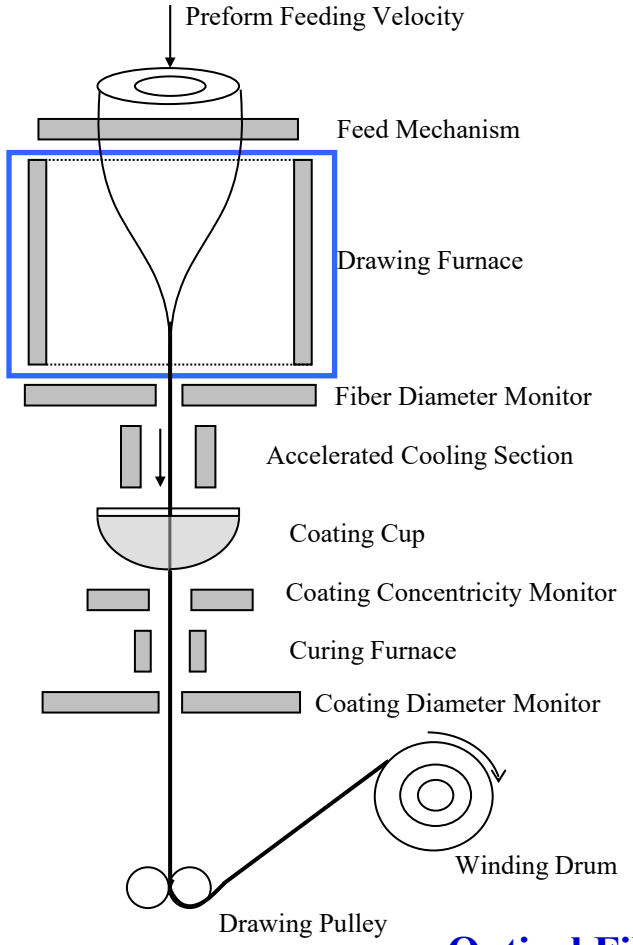
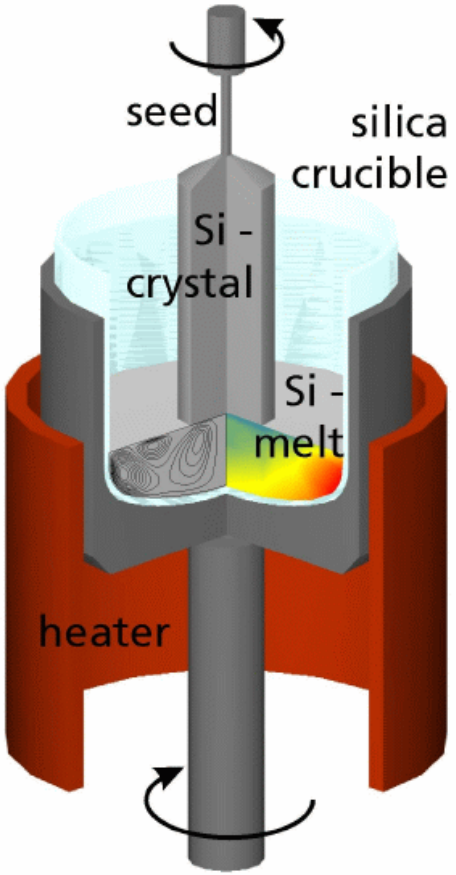
Optical Fiber Drawing and Czochralski Crystal Growing



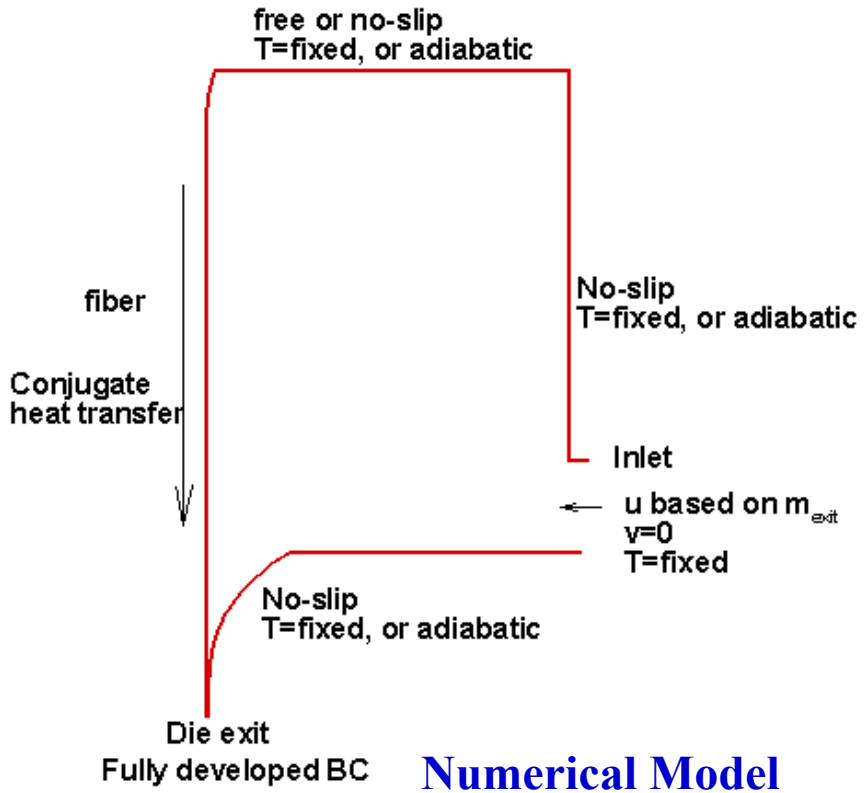
Optical Fiber Drawing



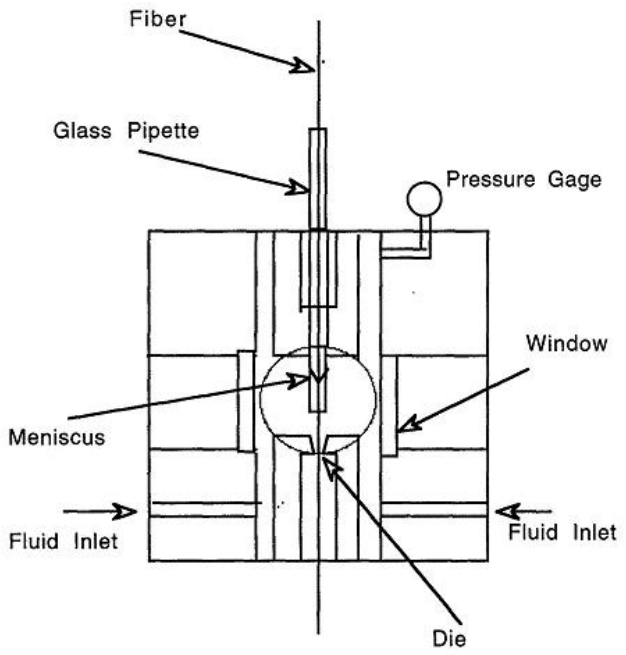
Crystal Growing

RUTGERS
School of Engineering

An Optical Fiber Coating Applicator



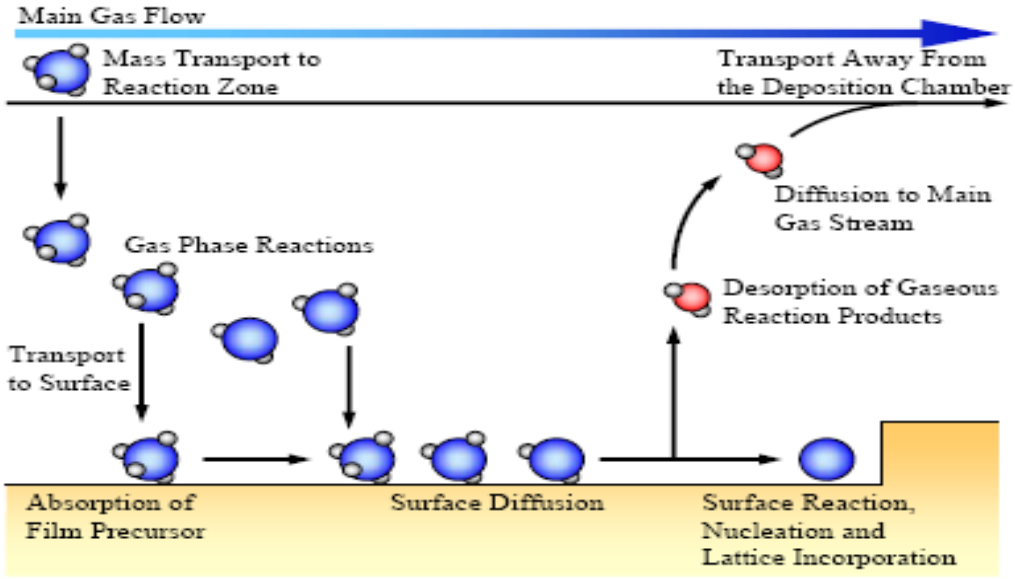
Numerical Model

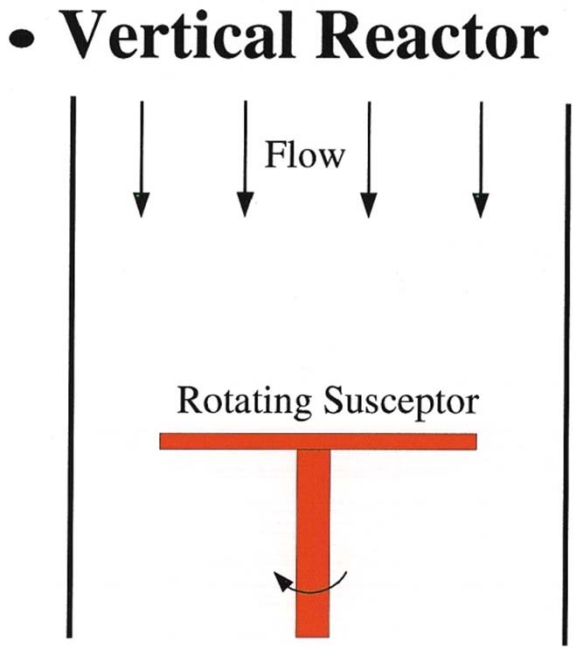


Experimental System

RUTGERS
School of Engineering

Chemical Vapor Deposition

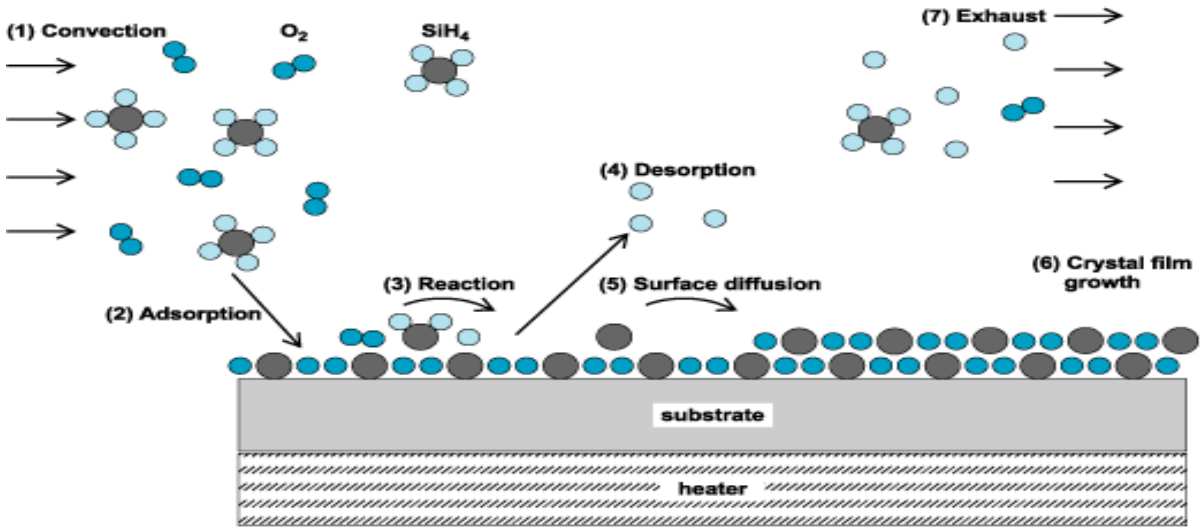


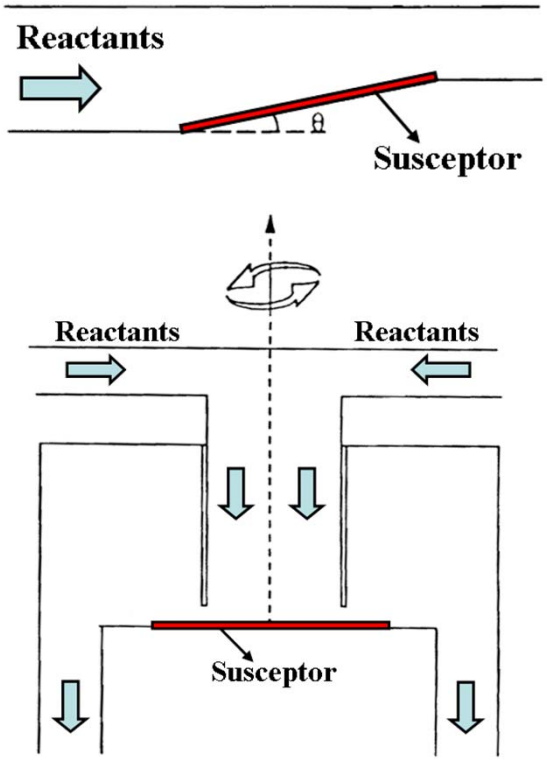


- **Chemical Transformations and Deposition at Micro/Nanoscale**
- **Boundary Conditions and System at Macro/Engineering Scale**
- **Desire High Deposition Rates, with Uniform, High Quality, Film**
- **Minimum Loss of Reacting Gases**

RUTGERS
School of Engineering

Chemical Vapor Deposition

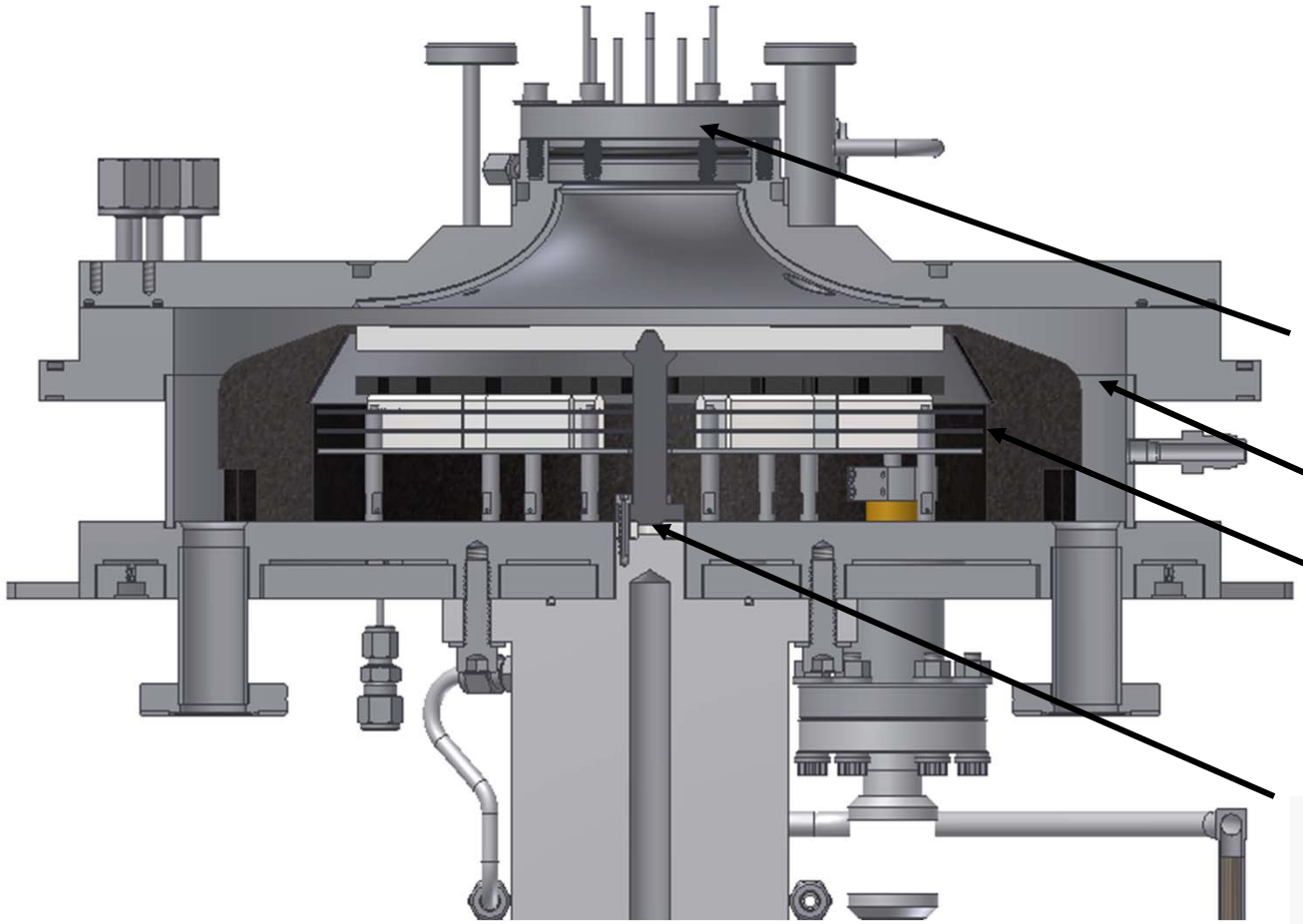




Desire High Deposition Rates, with Uniform, High Quality, Film

RUTGERS
School of Engineering

Industrial CVD Reactor for Gallium Nitride (GaN)



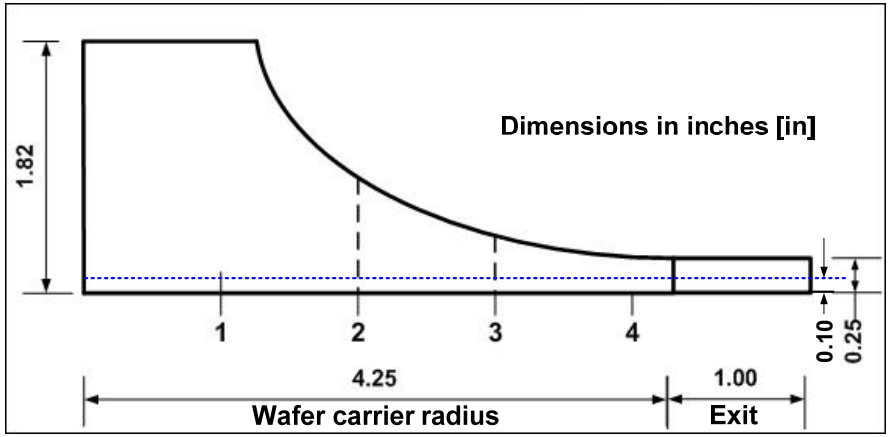
Adjustable Proportional Flow Injector (APFI)

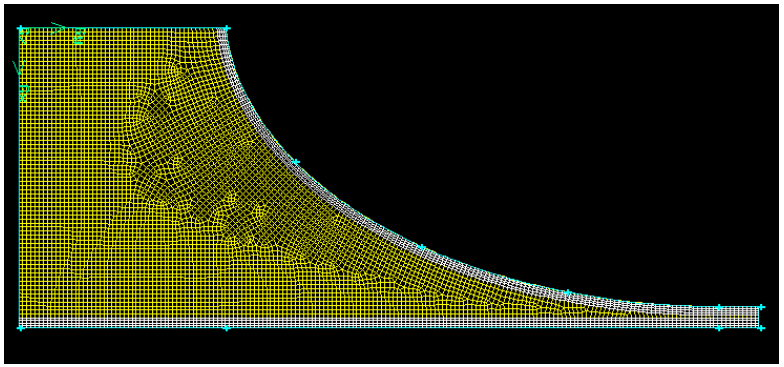
Upper flow guide (UFG)

Lower flow guide (LFG)

Multi-segment, low thermal conductivity spindle

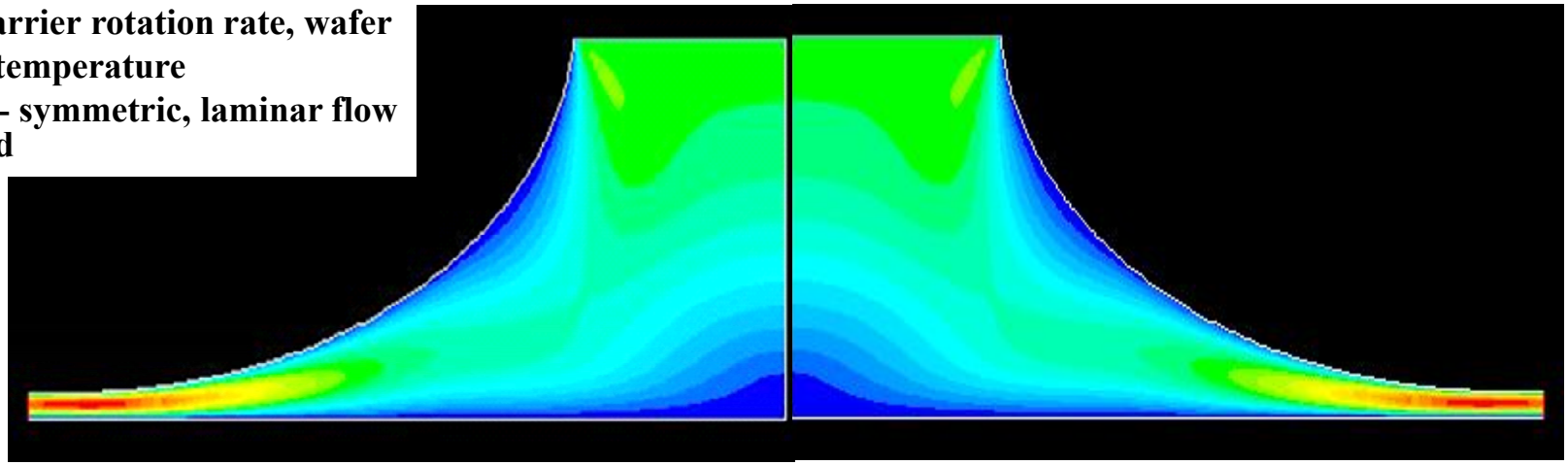
Analysis of Flow Field



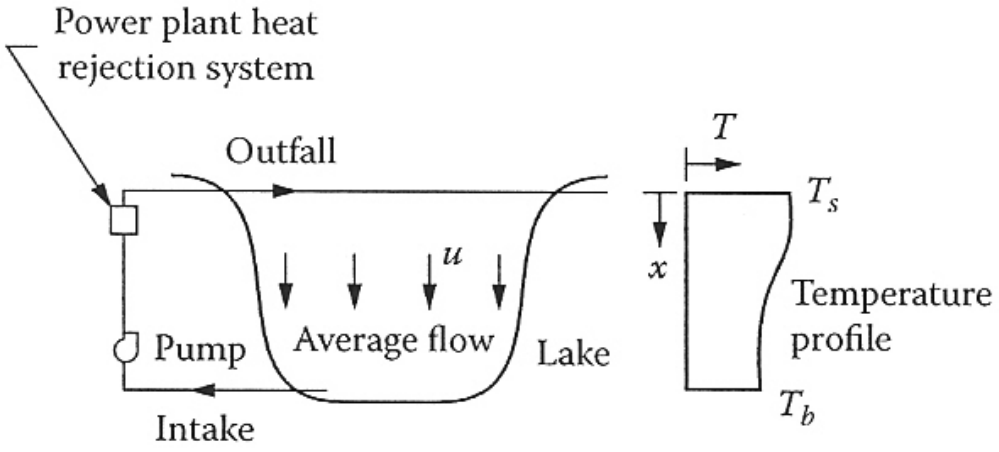


Factors – gas flow rate, pressure, wafer carrier rotation rate, wafer carrier temperature

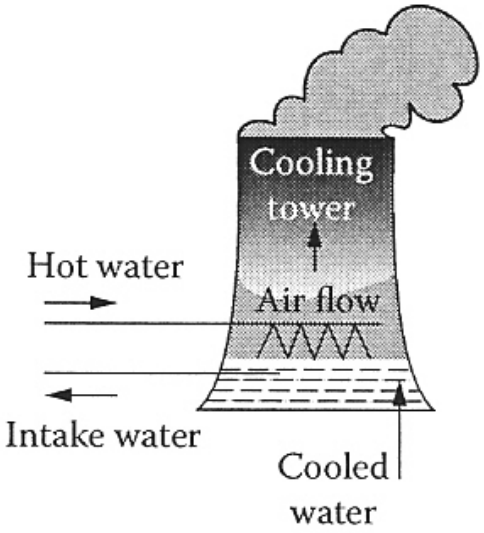
Results - symmetric, laminar flow field



Heat Rejection from a Power Plant to a Lake and a Cooling Tower



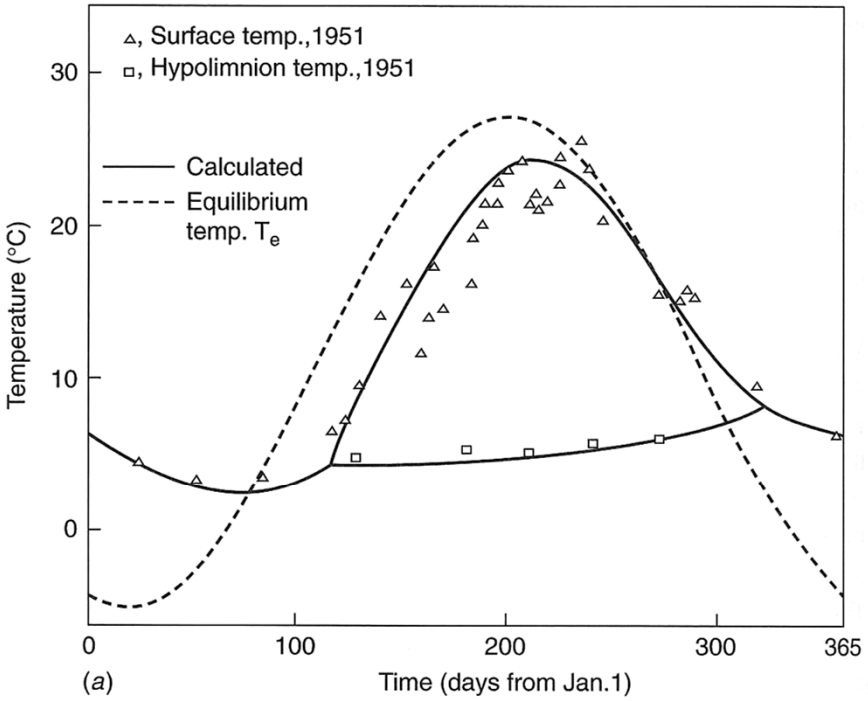
(a)

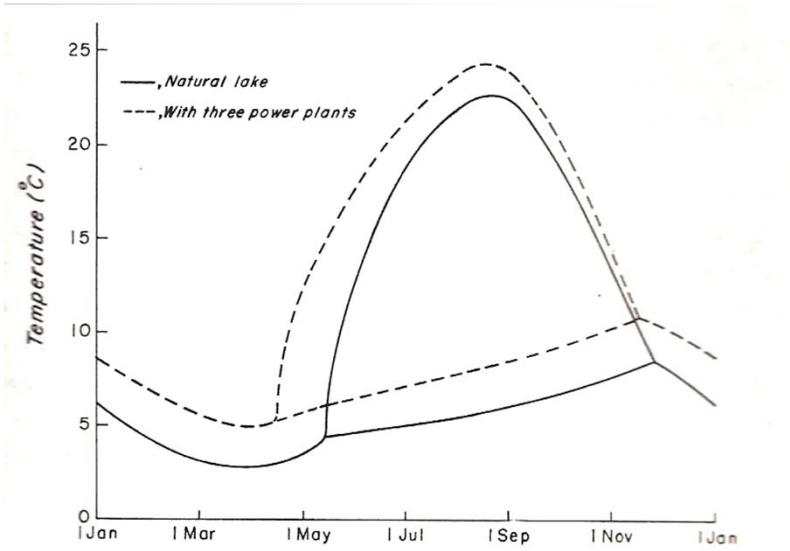


(b)

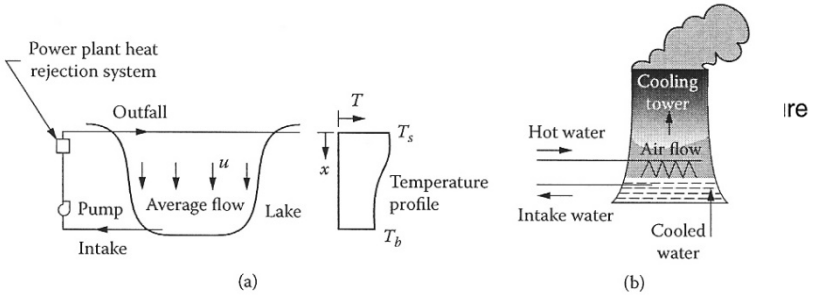
RUTGERS
School of Engineering

Environmental Effect of Thermal Discharge to a Water Body





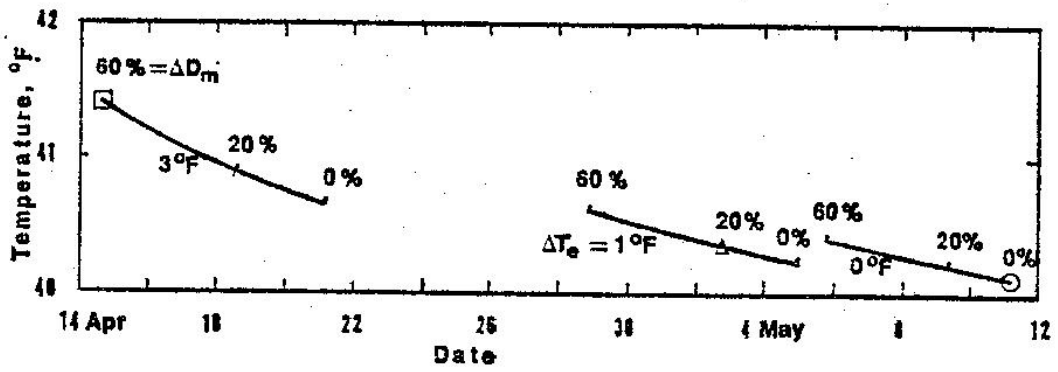
$$\int_0^{365} q''_{surface}\,dt = Q_{rejected}$$



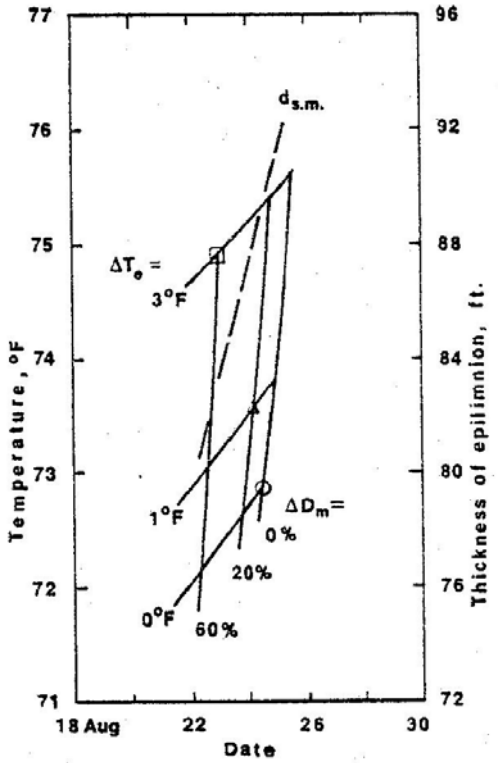
Relatively small temperature changes
Effect on natural cycle
Effect on transport processes
Effect on bio-organisms

RUTGERS
School of Engineering

Effects of Heat Rejection from a Power Plant to a Lake



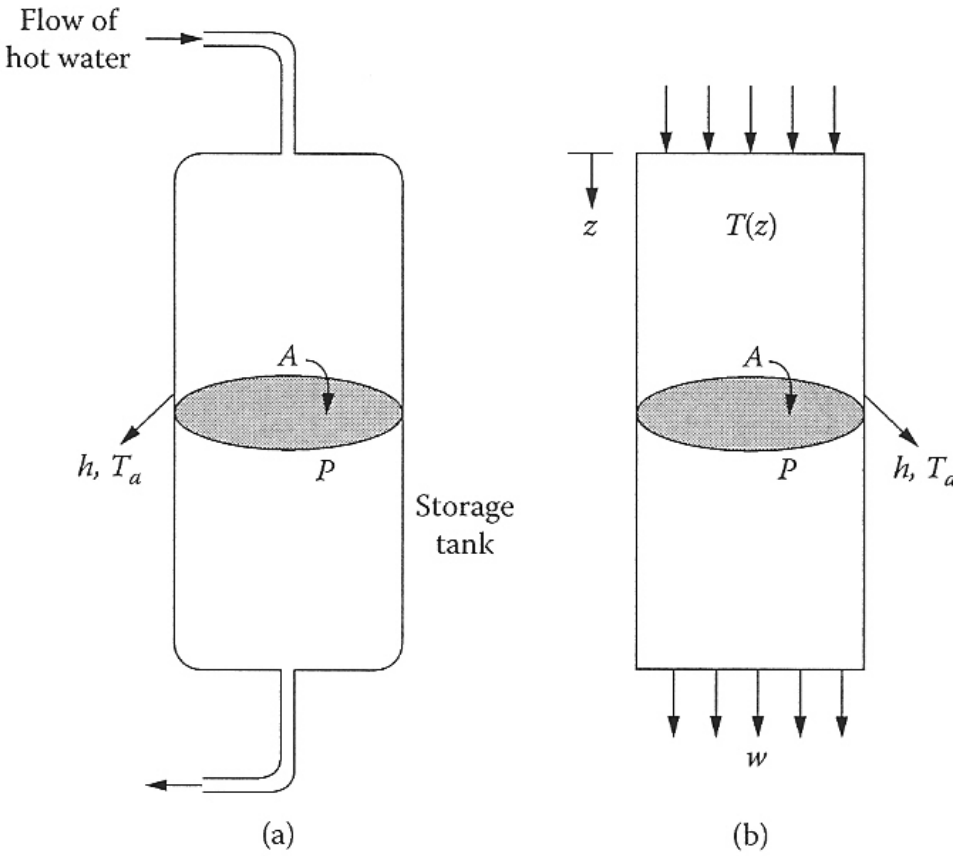
Onset of stratification



Summer maximum and epilimnion depth

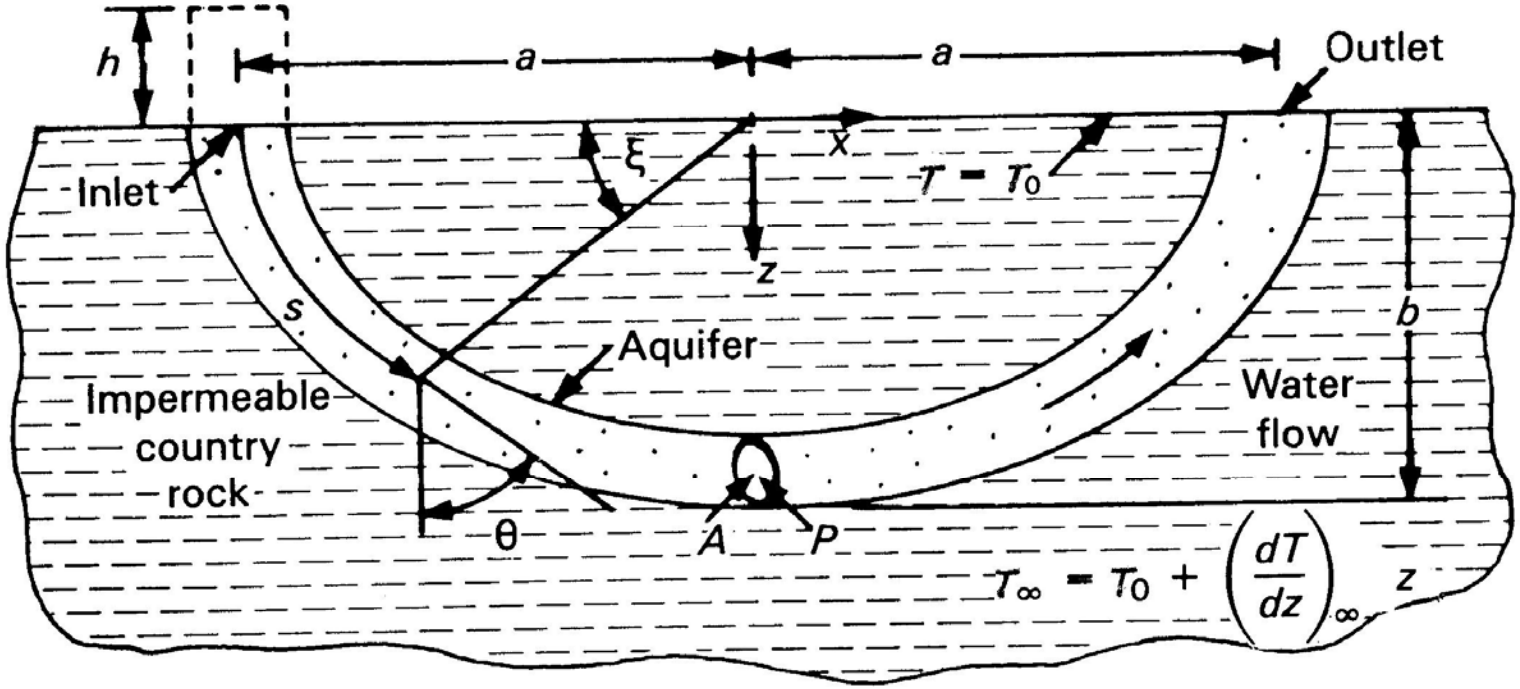
RUTGERS School of Engineering

Energy Storage as Sensible Heat



RUTGERS
School of Engineering

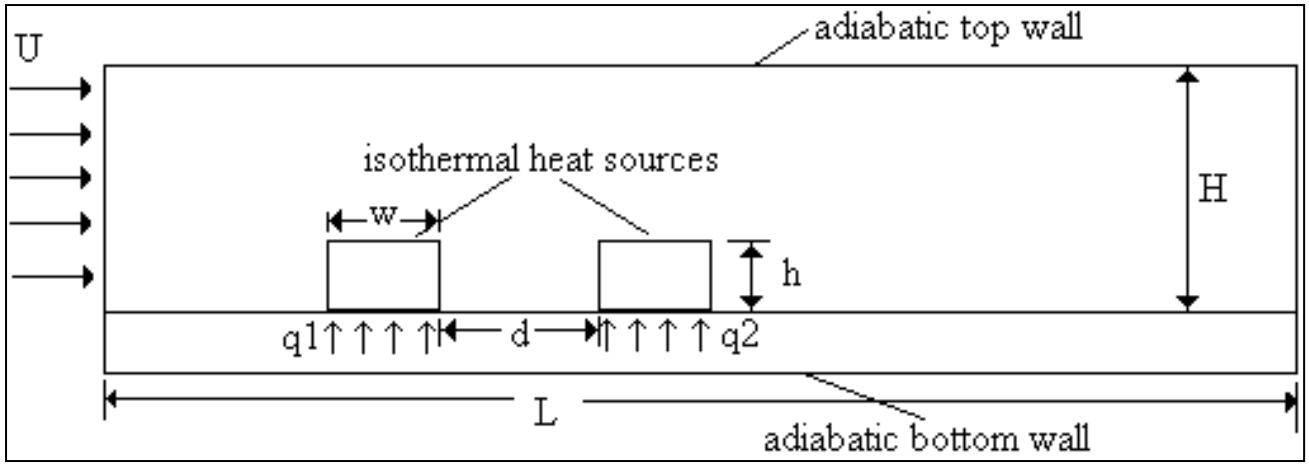
Schematic of an Open-Loop Thermosyphon (the Aquifer)



From Torrance (1979)

RUTGERS
School of Engineering

Numerical Modeling of Air Cooled Electronic System



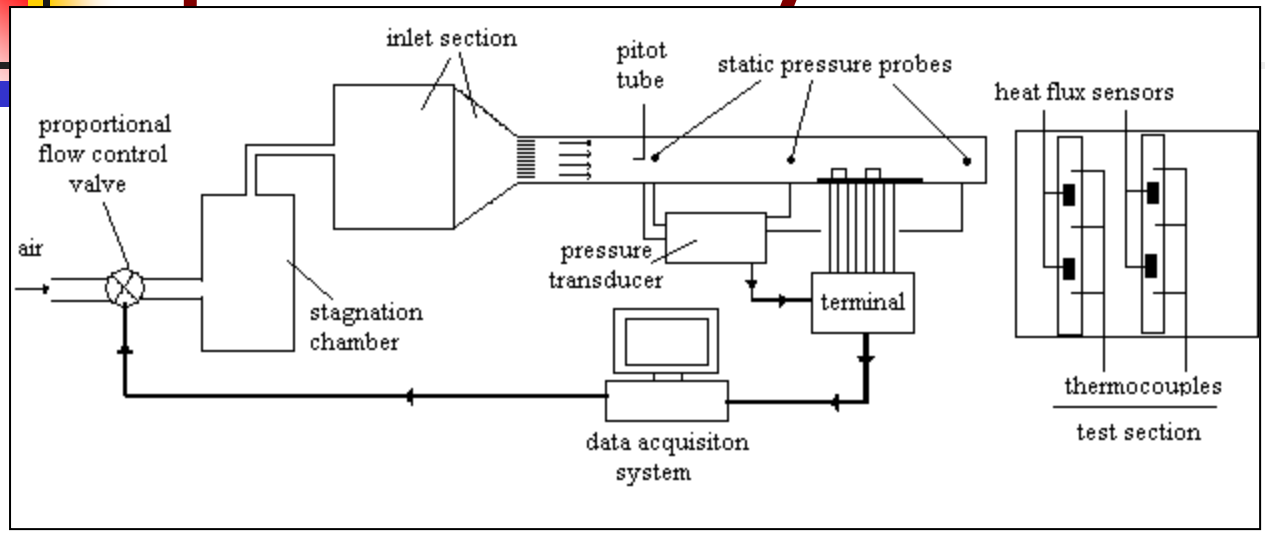
$$\nabla \cdot \vec{V} = 0$$

$$\frac{\partial \vec{V}}{\partial \tau} + \vec{V} \cdot \nabla \vec{V} = -\nabla P + \frac{1}{Re} \nabla^2 \vec{V} - \frac{Gr}{Re^2} \theta \vec{g}$$

$$\frac{\partial \theta}{\partial \tau} + \vec{V} \cdot \nabla \theta = \frac{1}{RePr} \nabla^2 \theta$$

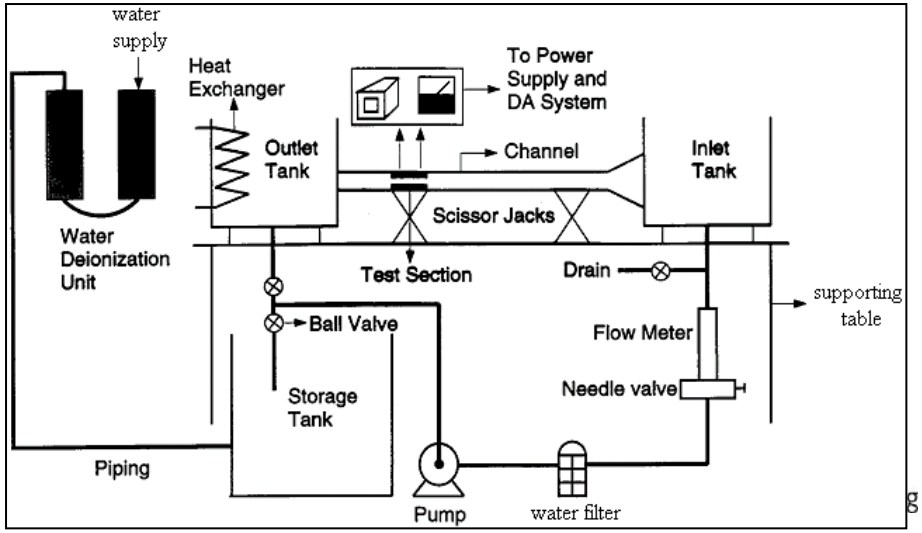
RUTGERS
School of Engineering

Experimental Systems

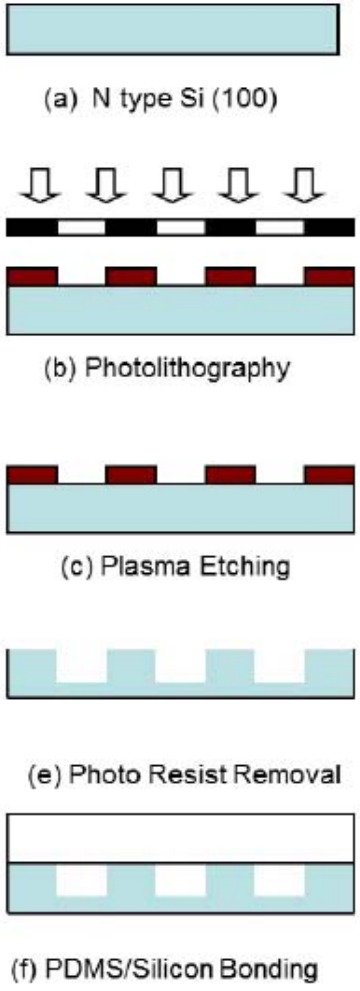


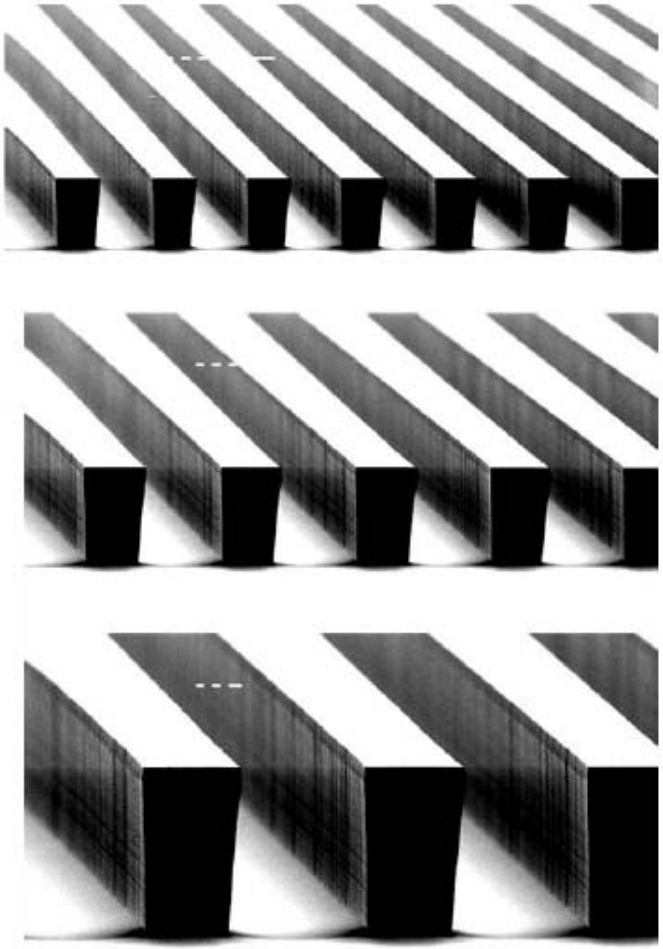
Air Cooling System

Liquid Cooling System

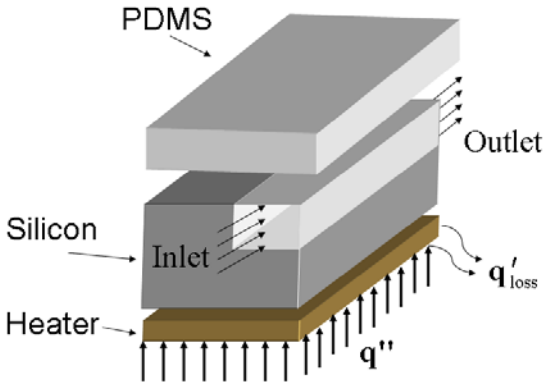


Microchannel Heat Sinks: Different Scales in Different Components



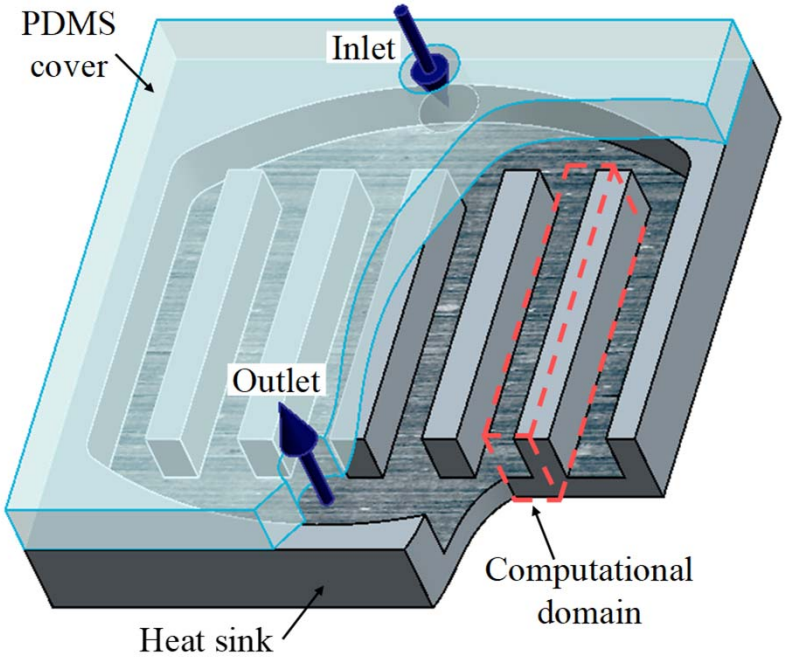


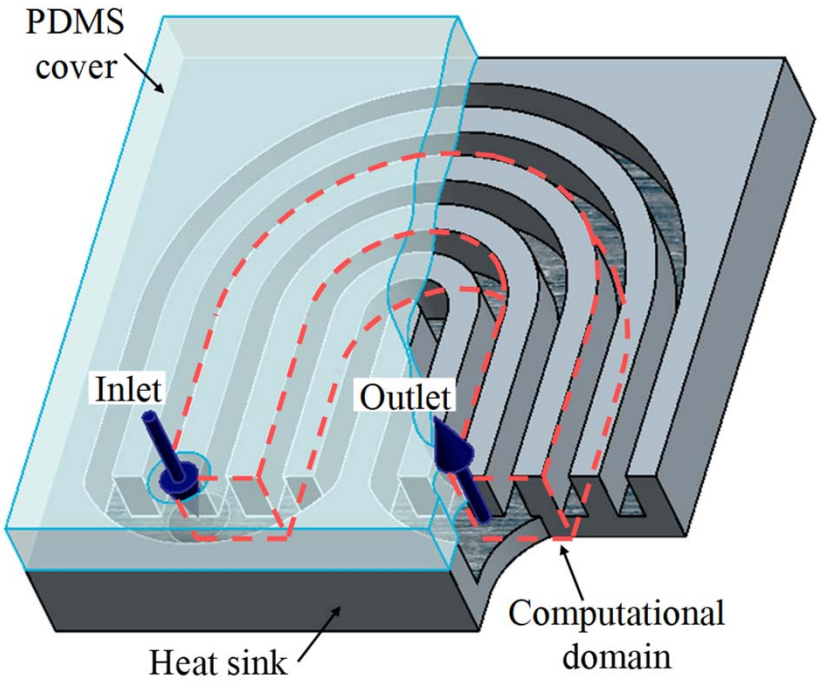
Plasma Etching



RUTGERS
School of Engineering

Schematic of Straight and U-Shaped Microchannels



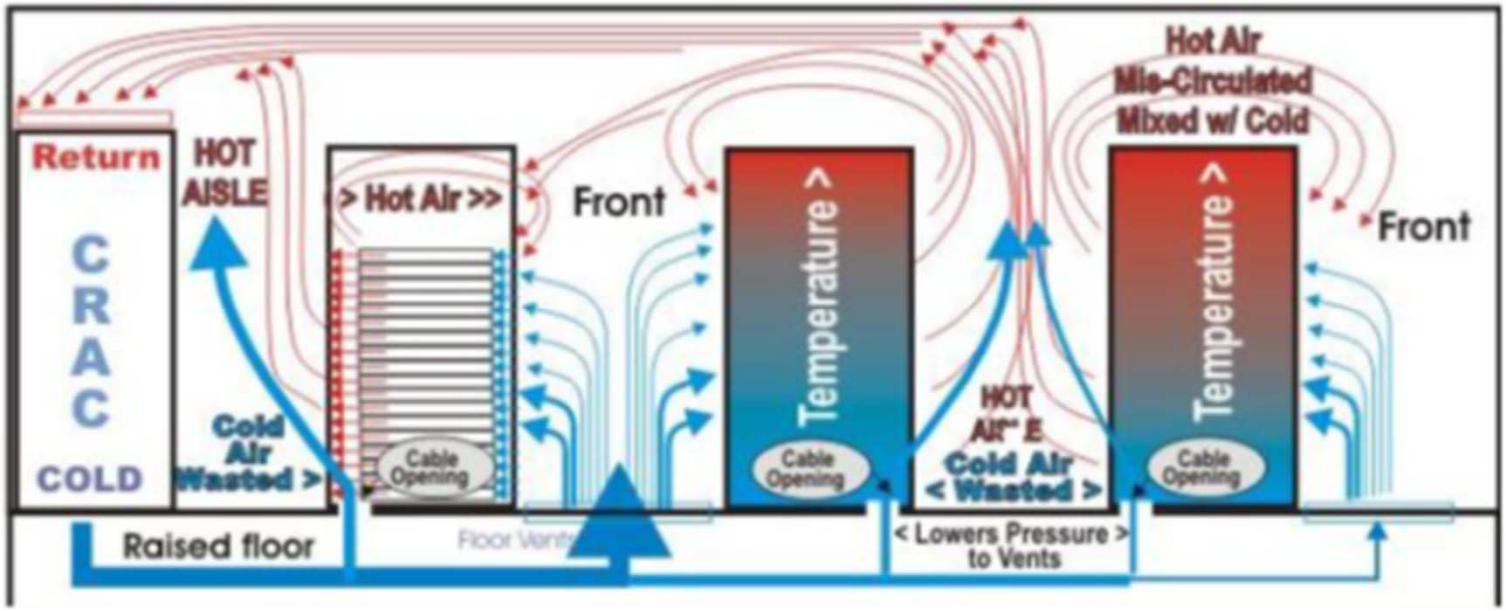


RUTGERS
School of Engineering

A Typical Data Center

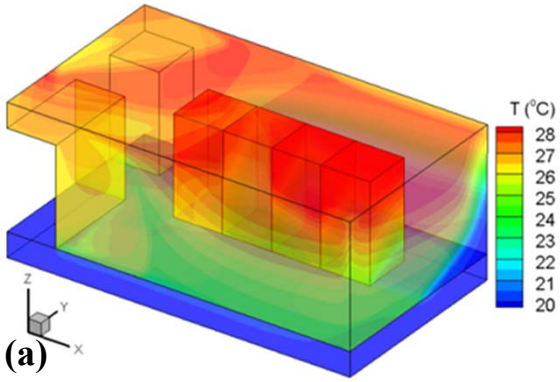
RUTGERS
School of Engineering

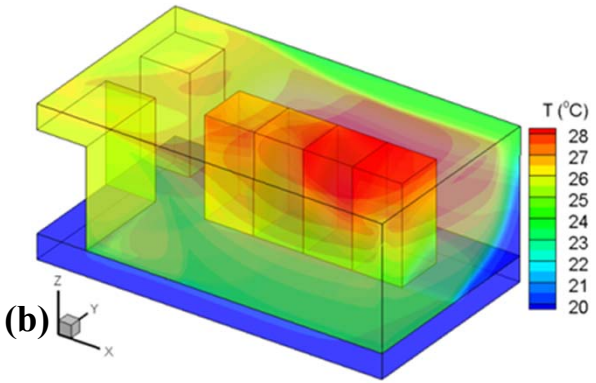
Three-Dimensional CFD Data Center Model



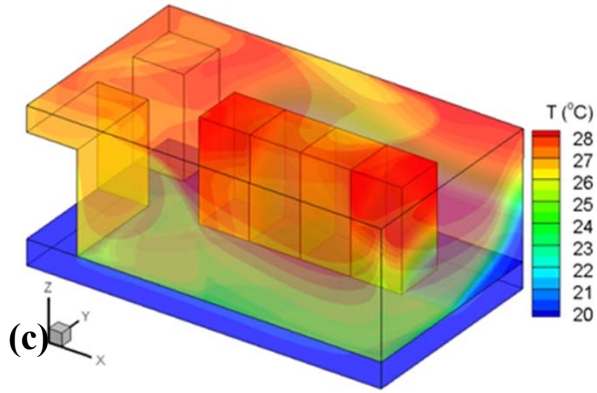
RUTGERS
School of Engineering

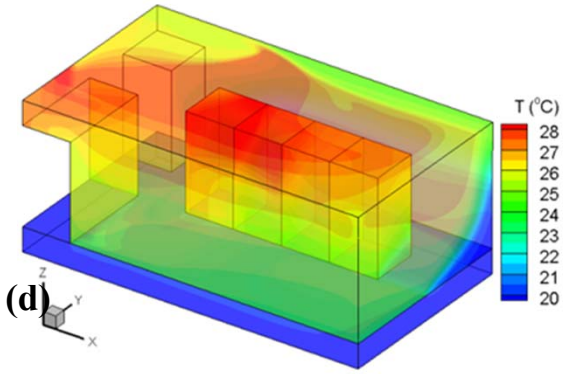
Temperature Distribution in the Data Center Room with 50% Utilization





(a) A and C racks are operating, flow rate 4650CFM (b) A and C racks are operating, flow rate 5650
(c) A and D racks are operating, flow rate 4650CFM (d) A and B racks are operating, flow rate 4650CFM



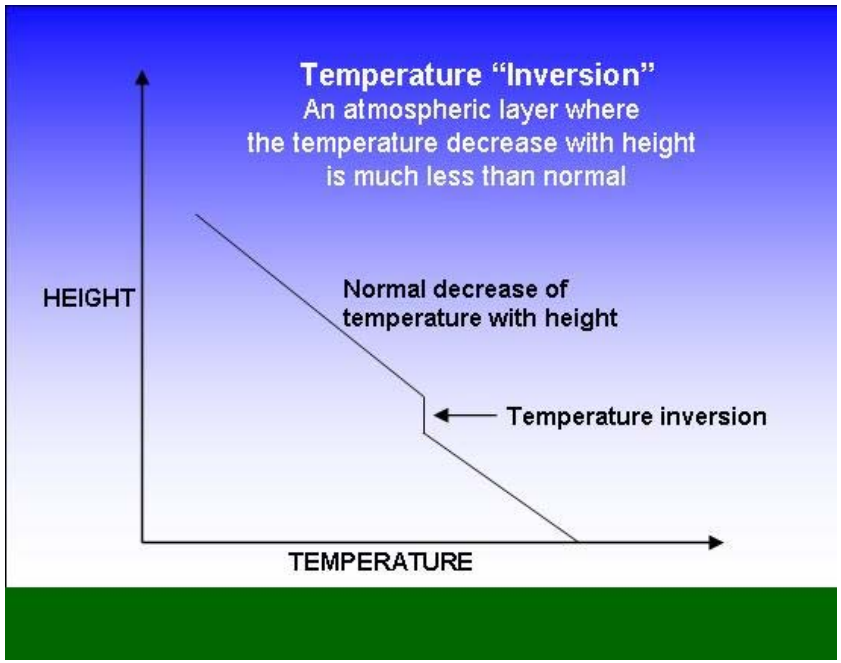


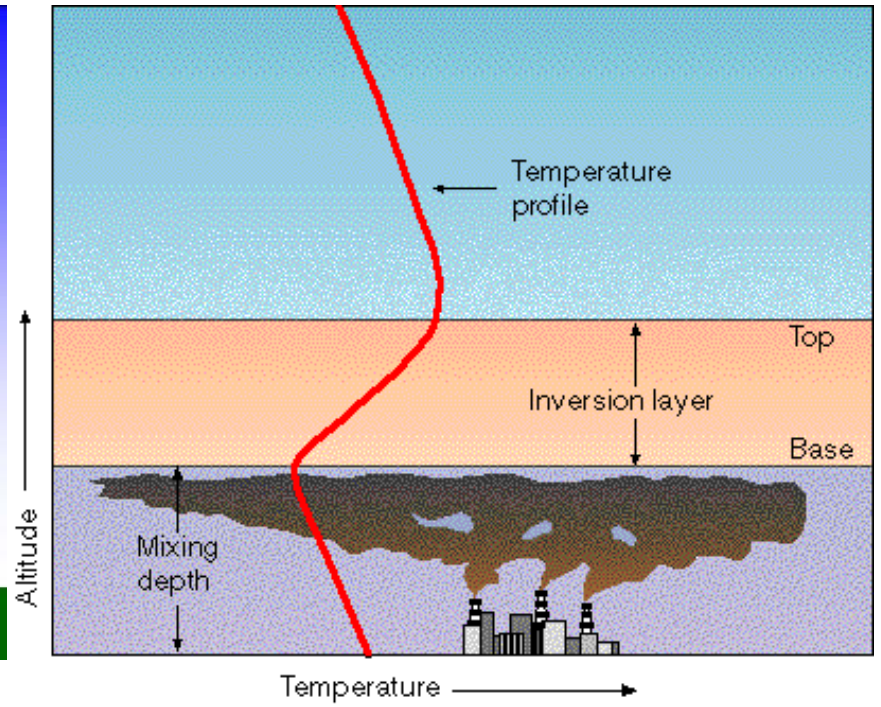
RUTGERS
School of Engineering

Temperature Inversion

RUTGERS
School of Engineering

Temperature Inversion

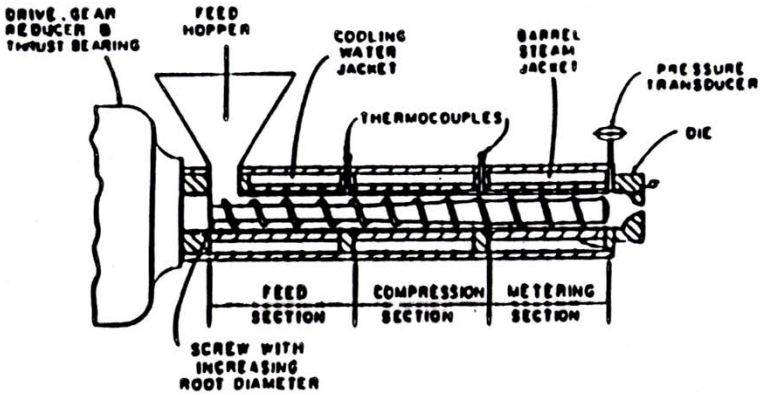




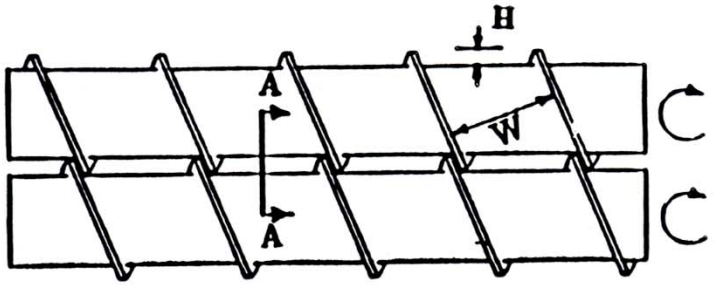
RUTGERS
School of Engineering

Single- and Twin-Screw Polymer Extruders

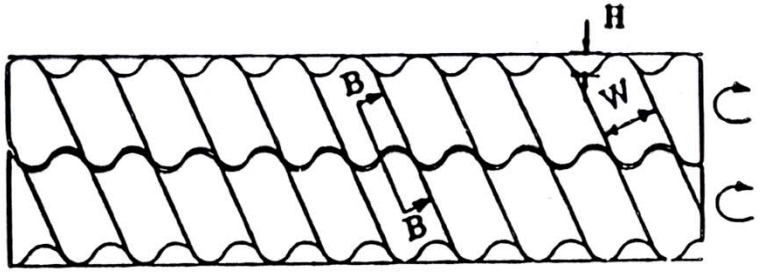
Schematic of a single screw extruder



Schematic of twin-screw geometries

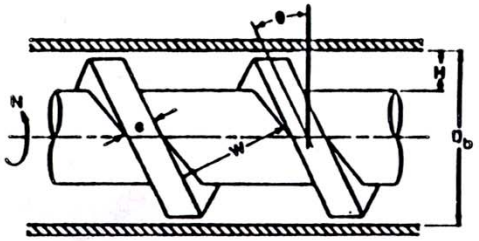


Tangential (finite gap between screws)



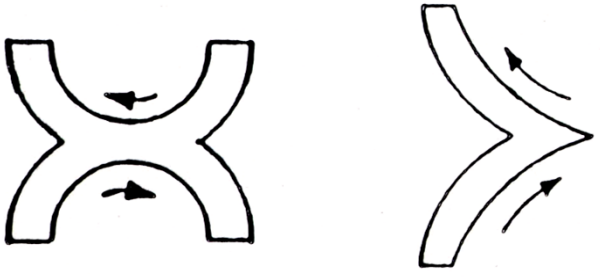
Self-wiping (no gap between screws)

Schematic of a single screw with shallow rectangular channel



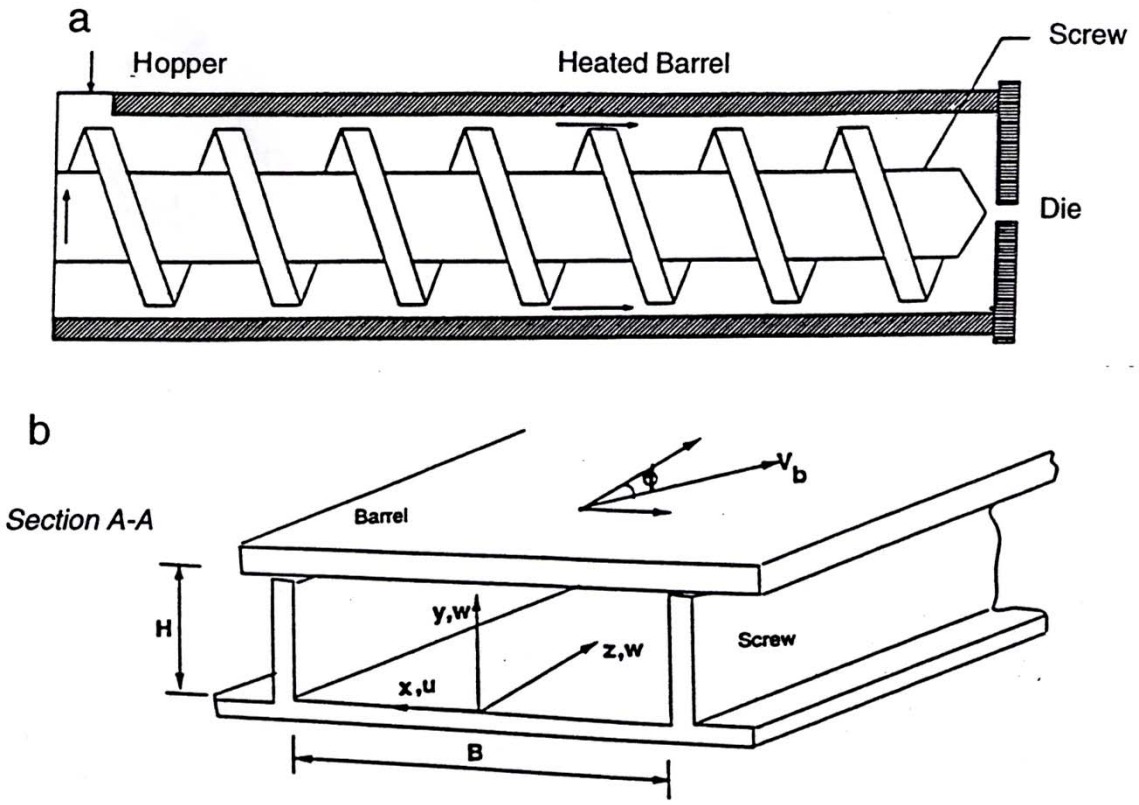
Schematic of a single screw with curved channel

Cross Sections



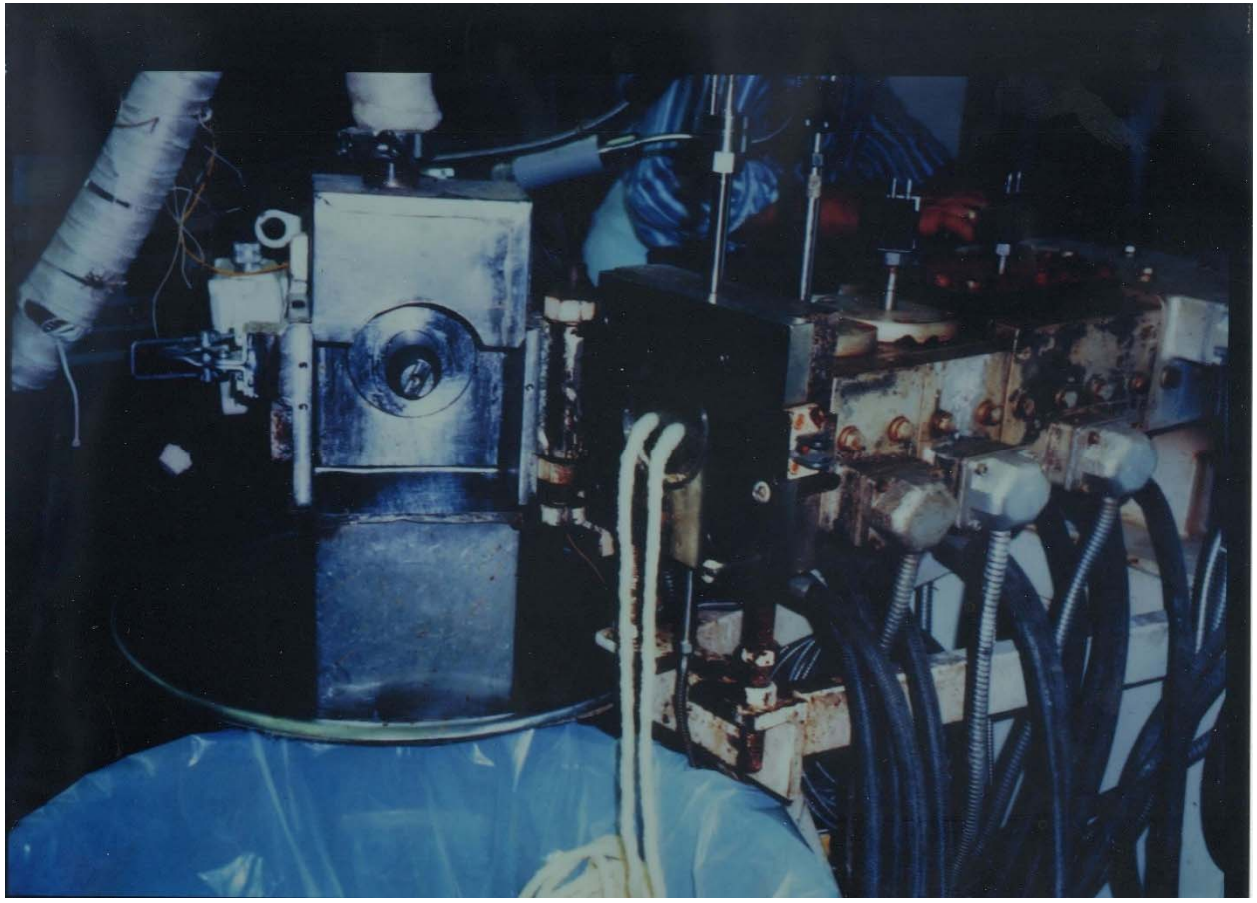
RS
ıgineering

Sketch of Single-Screw Polymer Extruder



RUTGERS
School of Engineering

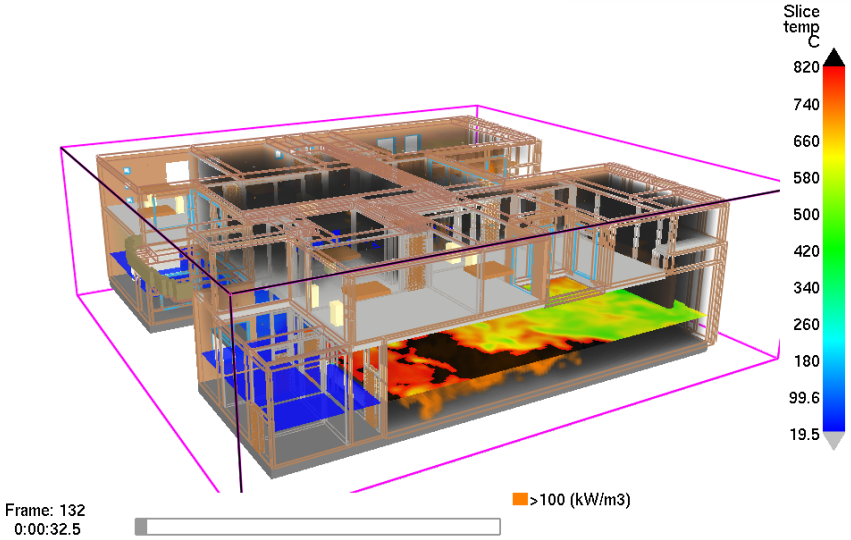
Twin-Screw Food Extruder



- Feed Hopper
- Rotating Screw
- Extruder Channel
- Heating/Cooling Arrangement
- Die

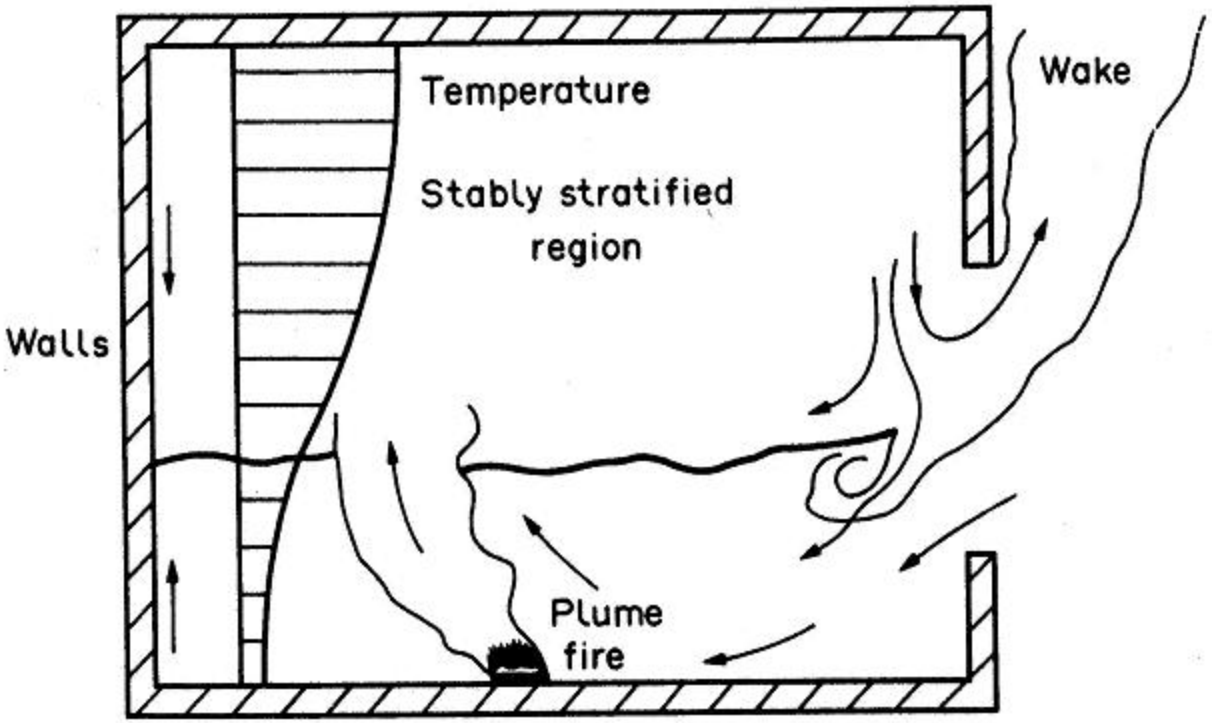
RUTGERS
School of Engineering

Safety Issues with Fires, Explosions and Other Accidents



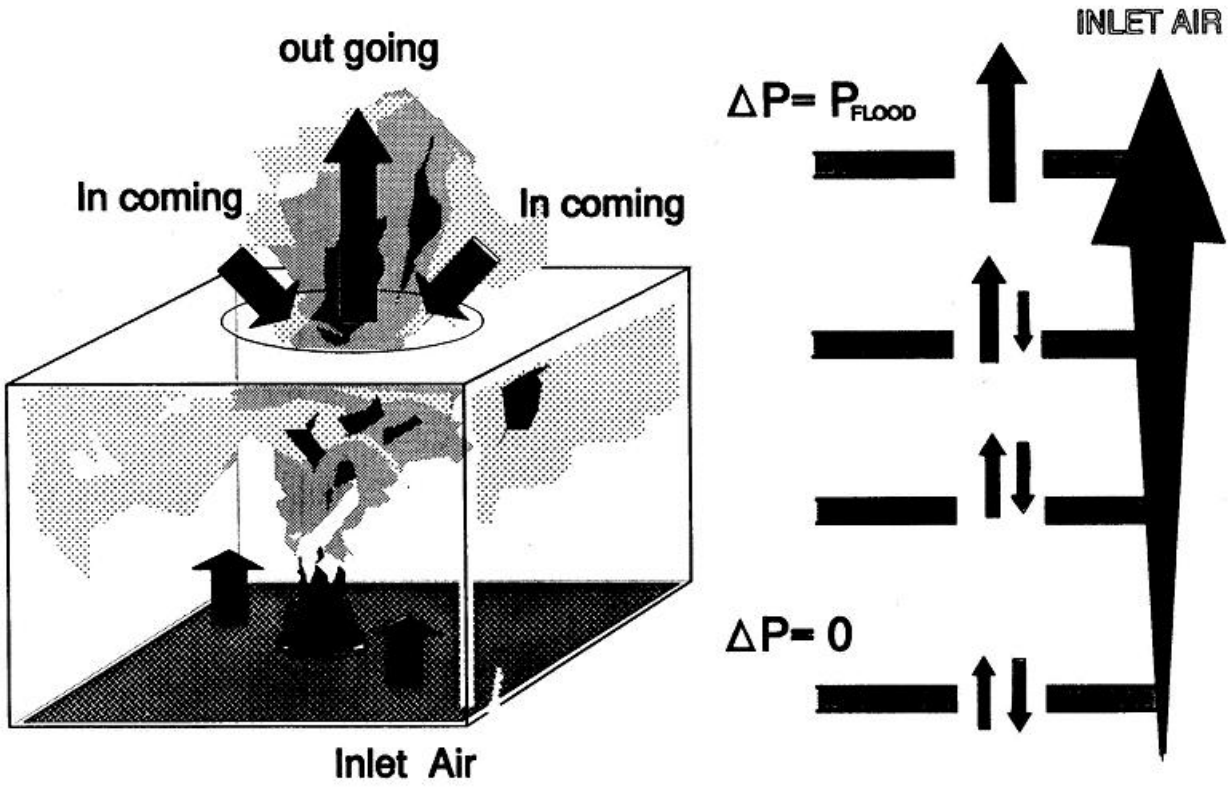
RUTGERS
School of Engineering

A Typical Room Fire



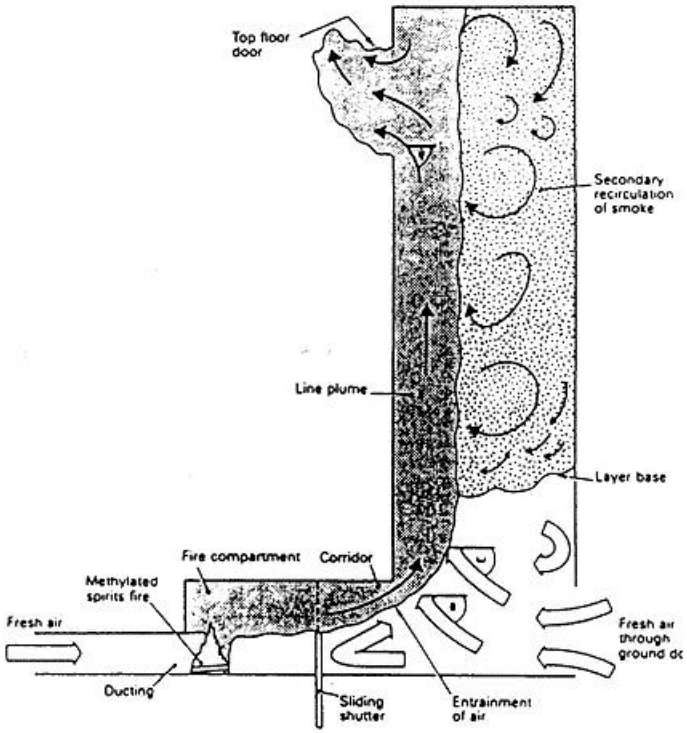
RUTGERS
School of Engineering

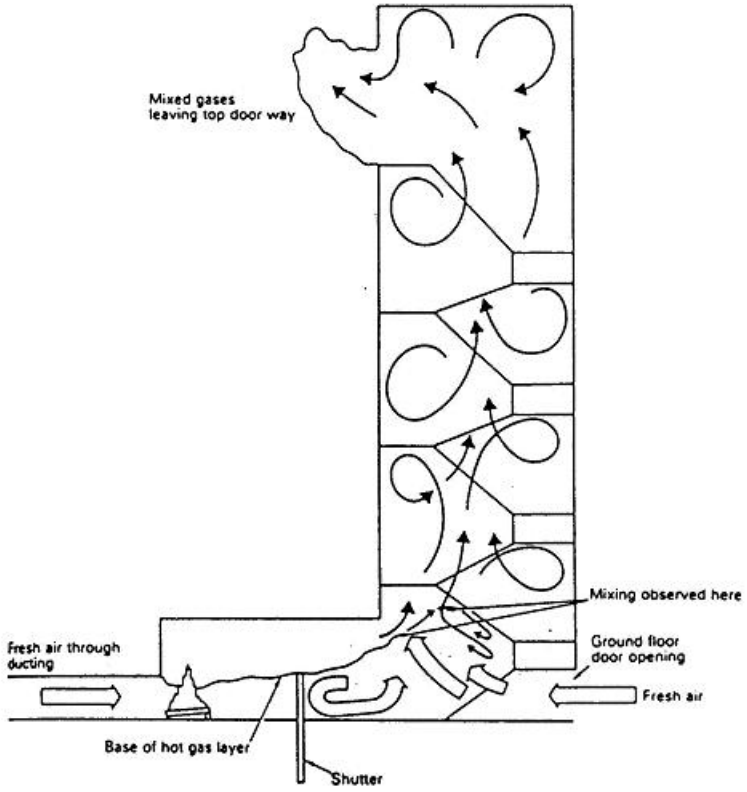
Flow in an Enclosure with a Single Horizontal Vent



RUTGERS
School of Engineering

Flows in a Vertical Elevator Shaft and in a Stairwell





From Marshall (1986)

RUTGERS
School of Engineering

The Optimization Problem

MAXIMIZE

- **Efficiency/Effectiveness**
- **Heat transfer rate**
- **Product quality: Uniformity, purity**
- **Productivity: Rate of production, speed**

MINIMIZE

- **Energy and material losses**
- **Pressure drop**
- **Entropy generation**
- **Defects: Voids, impurities**
- **Costs: Capital, operating costs**

RUTGERS
School of Engineering