Applied Thermal Management

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Course Overview

In this course, we discuss thermal management of industrial systems. The course will start with an introduction to what is involved in thermal management, why it is important, and discuss different aspects of thermal management in selected industrial applications, namely:

i. Electric Vehicles
ii. Autonomous Self Driving Systems
iii. Consumer Electronics
iv. Datacenters and Supercomputers

After the introduction, the course will discuss the steps of thermal management in industry and its different aspects from a practical perspective.

Textbook

There is no textbook required for this course. Course material will be based on multiple textbooks and industry standards; all course notes and public references will be posted.

Pre-requisite

- MIE210 Thermodynamics (or equivalent)
- MIE312 Fluid Mechanics (or equivalent)
- MIE313 Heat and Mass Transfer (or equivalent)
- Computational Fluid Dynamics (ANSYS Icepak is preferred)

Learning Outcomes

We will introduce applied concepts and best design practices as related to thermal management in high-tech industries. Students will learn a systematic approach to product design from concept to architecture to design and validation.

The course aims to prepare the students for a job in industry as a thermal/mechanical design engineer.

Academic Rationale

The main goal of this course is to bridge the gap between the fundamental knowledge of thermal sciences provided in core curriculum of mechanical engineering (Heat Transfer, Fluid Mechanics, Thermodynamics) and practice of thermal design in industry. Relevant examples from high tech industry will be incorporated in the course material to provide relevant examples to the students.

MIE 1242 : Applied Thermal Management:
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Week	Lecture Topic	Evaluation Milestones

1
(Sep 10)
	Introduction to Thermal Management
	1) what is involved?
	2) Why is it important?
	3) Examples
	    a) Electric Vehicles
	    b) Autonomous systems
	    c) Consumer Electronics
	    d) Datacenters and supercomputers
	
	Final Project – Introduction	

2 **(Sep 17)**	**Process of Product Design** 1) Concept 2) Architecture 3) Life Cycle Assessment 4) Design and optimization 5) Validation 6) Manufacturing 7) Quality Control 8) ISO 9001 Standard	

3
(Sep 24)
	Fundamentals of Fluid Flow & Heat Transfer
	1) Fluid Flow
	    a) Internal viscous flow
	    b) Flow networks
	    c) Fan affinity laws
	2) Conduction
	    a) Steady state
	    b) Transient
	    c) Spreading resistance
	    d) Non-Fourier heat Transfer
		HW-1

4
(Oct 1)
	Fundamentals of Fluid Flow & Heat Transfer - continued
	3) Convection
	    a) Forced
	    b) Natural
	4) Boiling
	5) Thermal network and 1D modelling
		Due date for HW-1

5
(Oct 8)
	Different Types of Cooling Solutions
	1) Environment (no heatsink)
	2) Passive
	3) Active
	    i) Air cooled
	    ii) Liquid cooled
	        (1) Single phase
	            (a) Closed loop
	            (b) Immersion
	        (2) Two phase
	            (a) Closed loop
	            (b) Immersion
	
	Final Project – review milestones	

6 **(Oct 15)**	**Heat Transfer Enhancement** 1. Fin enhancement 2. Heatpipe 3. Vapor Chambers 4. 3D vapor chambers 5. Thermosyphon 6. Heat spreaders (Graphite, Graphene, CNTs, …) 7. Thermoelectric cooling **Review of Final Project**	HW-2
7 **(Oct 22)**	**Industrial Examples** 1) Consumer: Hot-to-touch limit and skin temperature for hand-held devices 2) Datacenters: Coolant selection for a liquid cooled system 3) AI: Heatsink optimization based on first principals 4) Fan Acoustics and Affinity Laws	Due date for HW-2 Bonus Project
8 **(Oct 29)**	**Reading week – no class**	
9 **(Nov 5)**	**Thermal Interface Materials** 1. Why needed and how used 2. Thermal contact resistance 3. Different types of TIM 4. Characterization (ASTM, ISO) 5. Reliability testing and common issues 6. Hands on experience	HW-3
10 **(Nov 12)**	**An introduction to Supercomputers' cooling** 1. Architecture 2. Infrastructure 3. Efficiency and Total Cost of Ownership **Review of Final Projects**	Due date for HW-3
11 **(Nov 19)**	**Acoustics in Engineering Systems** 1. General introduction 2. Sounds Measurement 3. Sound quality 4. Live demonstration	HW-4
12 **(Nov 26)**	**Reliability of Thermal Management Systems** 1. Review of reliability concepts 2. Typical reliability tests 3. Acceleration factor 4. DFMEA	Due date for HW-4
13 **(Dec 3)**	**Presentation on Final Project**	Final Project Reports Due by EOD Friday Nov. 29