



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering

Level: PG

Subject Code : ME02000561

Subject Name : Energy storage and Battery Thermal Management

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Fundamental knowledge and understanding of battery technology, thermodynamics and Electrochemical behavior. Basic knowledge of thermal management design, energy storage systems and safety regulation.
Rationale:	The course “Energy Storage and Battery Thermal Management Systems” is designed to provide comprehensive knowledge and practical skills related to performance, life, safety, energy efficiency, cost efficiency of various energy storage systems used in EV. The course covers the design, development and optimize performance of battery thermal management systems.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT level
1	Understand energy storage technologies, their applications and importance.	U
2	Compare energy storage system for vehicles.	A
3	Demonstrate energy storage system for vehicles.	R
4	Analyzing energy storage and thermal management systems.	N

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Tutorial / Practical		
				ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150



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Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Energy Storage System Overview: Scope of energy storage, needs and opportunities in energy storage, Energy storage in the power and transportation sectors. Importance of energy storage systems in electric vehicles. Thermal storage system: heat pumps, application of phase change materials for heat storage-organic and inorganic materials, efficiencies, and economic evaluation of thermal energy storage systems.	8	20
2.	Chemical storage system: Hydrogen, methane etc. application of chemical energy storage system, advantages and limitations of chemical energy storage, challenges, and future prospects of chemical storage systems. Electromagnetic storage systems: Double layer capacitors with electrostatically charge storage, superconducting magnetic energy storage (SMES), concepts, advantages and limitations of electromagnetic energy storage systems, and future prospects of electrochemical storage systems.	8	24
3.	Electrochemical storage system: Batteries: Working principle of battery, primary and secondary (flow) batteries, battery performance evaluation methods, major battery chemistries and their voltages- Li-ion battery& Metal hydride battery vs lead-acid battery. Supercapacitors: Working principle of supercapacitor, types of supercapacitors, cycling and performance characteristics, difference between battery and supercapacitors, Introduction to Hybrid electrochemical supercapacitors Fuel cell: Operational principle of a fuel cell, types of fuel cells, hybrid fuel cell-battery systems, hybrid fuel cell-supercapacitor systems.	11	24
4.	Thermal Management for Batteries: Thermal control in vehicular battery systems: battery performance degradation at low and high temperatures, Passive, active, liquid, air thermal control system configurations for HEV and EV applications -	18	32



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Battery Heat Transfer. Introduction to battery modeling: tracking current demand, voltage, and State of Charge as functions of time for given drive cycles, Development of thermodynamic relationships for cell heat generation, Lumped cell and pack models for transient temperature response to drive cycles, Model parametric study results. Thermal Management Systems: Overall energy balance to determine required flowrates, Determination of convection and friction coefficients for air and liquid systems in various geometric configurations: flow around cylinders, flow between plates, flow through channels - Development of a complete thermal system model and parametric study results - Temperature control and heat transfer using phase change materials - Thermal Management of Power Electronics.		
Total	45	100

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	25	30	25	--	--

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Frank S. Barnes and Jonah G. Levine, Large Energy Storage Systems Handbook (Mechanical and Aerospace Engineering Series), CRC press (2011)
2. Ralph Zito, Energy storage: A new approach, Wiley (2010) Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013.
3. Pistoia, Gianfranco, and Boryann Liaw. Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost. Springer International Publishing AG, 2018.
4. Robert A. Huggins, Energy storage, Springer Science & Business Media (2010) Michael Nikowitz, "Advanced Hybrid and Electric Vehicles: System Optimization and Vehicle Integration", Springer International Publishing, 2016.
5. "Vehicle thermal Management Systems Conference Proceedings", 1st Edition; 2013, Coventry Techno centre, UK



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6. Younes Shabany, "Heat Transfer: Thermal Management of Electronics Hardcover" 2010 , CRC Press.
7. T. Yomi Obidi, "Thermal Management in Automotive applications", 2015, SAE International.

(b) Open-source software and website:

1. E-materials available at the website of NPTEL- <http://nptel.ac.in/>
2. MATLAB (Trial version): Software is useful for simulation and analysis of electrical systems

Suggested Course Practical List: If any

1. Demonstrate Thermal Energy Storage Systems.
2. Demonstrate Chemical Energy Storage Systems.
3. Demonstrate Electromagnetic Energy Storage Systems.
4. Demonstrate Thermal Energy Storage Systems.
5. Construction of Different Electrochemical batteries.
6. Demonstrate Fuel Cell.
7. Demonstrate Supercapacitor.
8. Simulation of thermal battery management systems

List of Laboratory/Learning Resources Required:

- Necessary instruments, kits and apparatus are to be provided for conducting above said practical in a group of maximum four students.
- Simulation software like MATLAB as demanded by the course

Suggested Project List:

The following project ideas are designed to provide practical experience and deeper understanding of the concepts covered in the " Energy storage and Battery Thermal Management " course. These projects aim to address real-world challenges and innovations in the field of Energy storage and Battery Thermal Management.

Project 1: Design and Development of a Battery Thermal Management System

Project 2: Simulation and Analysis of Battery Thermal Management System

Project 3: Comparison of various Energy storage systems



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Suggested Activities for Students: Engaging students in practical activities is crucial for enhancing their understanding and skills in the field of electric and hybrid vehicles. Here are suggested activities that can complement the theoretical learning and laboratory experiments:

1. Field Trips and Industry Visits:
2. Guest Lectures and Expert Talks:
3. Technical Workshops and Hands-on Training:
4. Design and Innovation Challenges:
5. Research Projects on Emerging Technologies:
6. Case Studies and Problem-Based Learning:
7. Simulation Exercises:
8. Public Awareness Campaigns:
9. Hackathons and Prototyping Events:
10. Internships and Industry Projects:

These activities are designed to complement classroom learning and laboratory experiments, providing students with a holistic educational experience in the field of electrical and hybrid vehicles. They promote practical skills development, critical thinking, and preparation for future careers in the evolving automotive industry.

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