Battery Technology for E-Mobility

.November 28-December 2, 2022

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Overview

E-Mobility is the need of the time dictated mainly due to environmental issues. Automobile industry is facing presently its biggest transition its history from IC Engine to battery operated car. Li-Ion Batteries due to its high energy density have made it now possible to drive around 1 km for 1 kg Battery weight. Battery Energy density is the main focus in development of E-Mobility. In next 5 years solid state batteries will be the state of art. It would be soon followed by Li- Oxygen batteries. These new Batteries have 3 times more energy density then present Li-Ion Batteries. Challenges of E-Mobility have also raised great demand on batteries in terms of power density, fast charging and battery life.

Battery technology is at present one of the most important development area. Companies are investing their major R&D Budget in development of super batteries. Battery production is very energy intensive process. Battery raw materials are extracted under unfriendly working conditions. There is a need for environmentally friendly battery production and extraction of raw materials to boost future E-Mobility. There are immense potentials for the improvement in battery manufacturing. Participants will get detailed insight into present and future battery production technologies.

Till battery operated car reaches its peak development and infrastructure necessary for that is developed, hybrid vehicle is seen as transition solution. Hybrid vehicle has advantages of higher efficiency, possibility of brake recuperation and CO_2 emission free drive. Hybrid car needs in addition to IC Engine also high power density batteries. Battery technology is equally important for hybrid car as much as for pure electric car.

Present lecture focusses on present and future battery technology, battery manufacturing and hybrid concepts. It would help industries to prepare for transition to E-Mobility. Institutes and students will get deep insight into the battery technology. This will help them to carry out new research in exciting and very fast growing area of battery technology. E-Mobility is going to create new business models where India could play dominant role.

.Modules	**Battery Technology for E-Mobility : (28th Nov. to December 2, 2022)**
You Should Attend If…	• You work on battery technology for transportation sector, energy storage or a related field (Industrial R & Ds, academic institutions, Govt institutions) • You teach in an educational institution • You are a researcher in energy storage or a related field • You perform numerical simulations / studies involving batteries for transportation sector • You are a student wanting to learn the design, manufacturing of automobile batteries
Fees	The participation fees for taking the course is as follows:

	Participants from abroad : Rs. 25000 **Industry : Rs. 10000** **Academic Institutions / Government organisations : Rs. 5000** **Full time Students : Rs. 4000** The above fee includes all instructional materials, refreshments during breaks in the programme, and 24 hours free internet facility. Lodging and Boarding are NOT included in the fees. The participants are requested to bring their own laptops. *On-Campus accommodation will not be available for outstation participants.* **A certificate of participation will be issued to those participants who register as above.**

The primary objectives of the course are as follows:

- Exposing participants to the fundamentals of E-Mobility and electro chemistry
- Giving detailed overview on different batteries with focus on Li-ion batteries
- Understanding battery materials, causes of battery aging and thermal runaway.
- Battery safety, fast and intelligent charging and Battery management system will be explained.
- Battery manufacturing and all process from raw material extraction to battery recycling will be discussed in detail.
- Future Battery concept like solid state battery, Li-Sulphur and Li-Oxygen batteries will be discussed in detail. Fuel Cell as second alternative to emission free driving will be also shown

Last and not least principle of hybrid vehicle and Innovation in E-Motor will be discussed

The Faculty

Dr-Ing. Kartik D. Jamadar, Volkswagen AG, Germany

Dr. Kartik is working from last 12 years with Volkswagen AG in Germany. He is presently working in the development of Li-Ion Battery. He is responsible presently for development of Li-Ion Battery plant in Germany. He has already finished developing one 0.5 GW Plant and is now planning for next 16 GW plant.

Prof. Prashant P. Date

Department of Mechanical Engineering IIT Bombay

Prof. Date's research interests lie in manufacturing processes, electric vehicles, sustainable manufacturing, Light weighting and manufacturing process design.

Contents

Module A: Need for E-Mobility and Battery types

Lecture 1 (60 Min): Challenges of E-Mobility (Lectures by Prof. Date)

Lecture 2 (90 min): Need for E-Mobility (Lecture by Dr. Kartik Jamadar)

Introduction to greenhouse effect, CO_2 emission rules PM10 particle Emission, NOx limits, automobile companies strategies, three main approaches to E-Mobility (Battery, Fuel Cell and synthetic fuel).

Lecture 3 (60 min): Principles of Electrochemistry (Lecture by Dr. Kartik Jamadar)

CU-Zn Volta Cell, standard hydrogen cell, Redox principle, Selection of anode and cathode materials, Role of solid electrolyte interface, diffusion of Li-Ion, problem with over charge voltage, Problem with under discharge voltage and Li plating.

Lecture 4 (60 min): Battery types (Lecture by Dr. Kartik Jamadar)

Different secondary (rechargeable) batteries like lead, Ni- Cadmium, Ni metal hydride and Li-Ion Batteries will be explained. Batteries will be compared with respect to energy and power density (Ragon Diagram).

Tutorial 1 (30 min): Quiz based on lectures in first Module (Tutorial by Dr. Kartik Jamadar)

Second day : 4,5 hours lectures + 1 Tutorial of 30 min

Module B: Li-Ion Battery

Lecture 5 (90 min): Working Principle of Li-Ion Battery (Lecture by Dr. Kartik Jamadar)

Li Batteries with solid Lithium as anode, problems with Li Solid battery, Li-Ion battery evolution, electrolyte and lithium salt, role of separator, different anode and cathode materials like LTO, LCO, LMO, NMC, NCA and LFP

Lecture 6 (60 min): Battery Aging and Thermal Runaway (Lecture by Dr. Kartik Jamadar)

Fundamentals of battery aging, break up of solid electrolyte interface (SEI), expansion – contraction rate of Graphite and Silicon, thermal Runaway, Battery explosion, nail penetration test, safety mechanisms inside battery.

Lecture 7 (60 min): Battery Management system (BMS) and High Speed Charging (Lecture by Dr. Kartik Jamadar)

Role of BMS in battery safety, passive and active BMS, different charging mechanism, role of material chemistry in high speed charging, Different charging strategies, Battery cooling and warming methods.

Lecture 8 (60 min): Future Battery Technology (Lecture by Dr. Kartik Jamadar)

Battery Roadmap, Future Li-Ion Batteries, solid state batteries, Silicon in anode, Li-S and Li-O Batteries, Dual ion transfer batteries, Dual ion battery, 800 V Battery system, Energy density comparison of future battery strategies

Tutorial 2 (30 min): Quiz on Lectures in Module B (Tutorial by Dr. Kartik Jamadar)

Third Day : 4,5 hours lectures + 1 Tutorial of 30 min

Module C: Battery production, Recycling, Raw Materials sources

Lecture 9 (120 min): Battery production (Lecture by Dr. Kartik Jamadar)

Mixing of active materials, electrode manufacturing processes like coating, calendaring, slitting, later trimming, electrode assembly, collector welding, electrolyte filling, battery formation and End of life test. Problems during manufacturing, power and investment requirements.

Lecture 10 (90 min): Manufacturing of Battery Module and Battery System (Lecture by Dr. Kartik Jamadar)

Battery module and system production, battery standards, Dedicated platforms for Battery electric car, recycling of battery, battery raw material sources, supplier, of row martials, battery cost breakup and future raw materials like CNT and water based cathode.

Lecture 11 (60 Min): Fuel Cell (Lecture by Dr. Kartik Jamadar)

Principle of hydrogen fuel cell, manufacturing of fuel cell, hydrogen tank design, infrastructure for hydrogen, role of Hydrogen in E-Mobility, thermal and electrical energy distribution and efficiency of fuel cell.

Tutorial 3 (30 min): Quiz on lectures in Module C (Tutorial by Dr. Kartik Jamadar)

Forth Day : 4,5 hours lectures + 1 Tutorial of 30 min

Module D: Hybrid Vehicle and E-Motor

Lecture 12 (120 Min): Hybrid Vehicle (Lecture by Dr. Kartik Jamadar)

Hybrid vehicle constellations, advantages of hybrid concept, brake recuperation, motor in wheel, efficiency of hybridization, range extender, battery requirements for hybrid vehicle, planetary drive, Dedicated hybrid transmission and different hybrid strategies:

Lecture 13 (60 min): Is Green Energy really Green? (Lecture by Dr. Kartik Jamadar)

Tank to Wheel (TtW), Well to Wheel (WtW), life cycle analysis of electric and hybrid car, power sources and energy mix, energy management system, synthetic fuels like power to gas and power to diesel.

Lecture 14 (90 min): E-Motors (Lecture by Dr. Kartik Jamadar)

Fundamentals of E-Motor, reluctance force and Lorenz force, DC Motor, synchronous motor, induction motor, reluctance motor, efficiency comparison, field weakening, Innovation in E-Motor, Power density comparison, permanent magnets properties, high speed motor, cooling principles, rotor and stator materials.

Tutorial 4 (30 min): Quiz on lectures in Module D (Tutorial by Dr. Kartik Jamadar)

Fifth Day: : 5 hours lectures + 1 hour Tutorial

Lecture 17 (90 min): Power Electronics and inverter principle

Principle of Inverter, AC-DC Converter, high voltage DC-low voltage DC Converter

Lecture 18 (90 min): Solar Photovoltaics as Sources of Power for Electric Vehicles (Lecture by Prof P. P. Date)

Solar Energy as an alternate source of energy to charge batteries, to run the vehicle, will be discussed.

Lecture 19 (90 Min): E-Mobility prospects for India (Lecture by Prof- Date)

India Emission Rule, Power scenario, Power sources, charging infrastructure, Raw material scenario

Lecture 20 (60 Min): Supporting technologies for Battery Development and directions of research

Tutorial 5 (30 min): Discussion