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Role of Lithium Ion Battery Technology for Penetration of Electric Vehicles

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Abstract :

The Electric Vehicles (EV's) operated on Lithium Ion Batteries are gaining the attention across the world .The technological development of Lithium Ion Battery in terms of Specific Energy meeting the safety, cost and life requirements will be key for larger and quicker penetration of EVs.

Currently Lithium Ion battery chemistries such as LMO, LCO, LFP , NMC and NCA are competing with each other. The most critical factors for technological development of Lithium Ion battery will revolve around Specific Energy (Wh/Kg) , Safety and Costs. The role of Technology Development in addressing these challenges is Critical. The paper discusses various types of battery chemistries, their advantages and disadvantages, highlights the role and impact Specific Energy plays in technology development of Lithium Ion batteries and attempts to project future scenario for various battery chemistries.

Keywords*: Electric Vehicles (EVs), Specific Energy, EV Battery, Lithium Ion Battery Technology and Penetration of EVs.*

Introduction:

EV industry is currently facing challenge in terms of expectations of the vehicle buyer with respect to key factors such as Range in Km per Charge, the Charging Infrastructure, the

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Speed, the Comparable higher Costs of an EV and the Life of the batteries. Among these factors, the two most critical factors, as far as EV battery is concerned, are Range per km and Cost per KWh of the battery. The range per km depends on the Specific Energy (Wh/kg) of the battery . The cost of the battery is directly linked to the capacity of the battery (KWh).

The technological development of various Lithium Ion Battery chemistries such as LMO, LCO, LFP , NMC and NCA in terms of Specific Energy meeting the safety , cost and life requirements will be key for larger and quicker penetration of EVs. The paper highlights these aspects and attempts to predict the future scenarios.

Lithium Ion Batteries - Over view of Technological Options and Expected Future Scenarios

The crux of the success of the Lithium Ion Battery operated EVs lies in the performance of the battery in terms of range per charge expressed in kms operated per charge. In one of the survey conducted in Belgium for Consumer attitudes towards battery electric vehicles only 10.4% of the sample was satisfied with a range lower than 200 km. If, through technological improvements, the driving range would improve to 300 km, 400 km or 500 km, the percentage of satisfied consumers would increase to respectively 32.6%, 49.5% and 71.1%[1].

The specific energy expressed in Wh/kg determines the range of the Battery. Higher Specific Energy leads to higher range per charge. In simple terms, the electric motor along with fully charged Lithium Ion battery in an EV resembles the IC engine along with fuel tank full of gasoline or diesel . It is therefore key to assess the available Lithium Ion Battery chemistries and how they compare with each other.

Historic and continuing investments in Li-ion battery technologies are leading to batteries that perform better against multiple attributes, especially specific energy and cycle life. The resulting improvements in EV range and price will foster rapid, near-term acceleration of consumer adoption. Specific Energy is one example of a continual performance improvement that has compounding effects on the value proposition of Advanced Battery Technologies[2].

The development of Lithium Ion batteries for Specific Energy started in real terms in year 2010, when the specific energy in the range of 100-200 Wh/kg was achieved , with current levels at about 300 Wh/kg. For Electric vehicles to be better placed in terms of range per charge at par with IC engine vehicles, the specific energy of above 400 Wh/kg needs to be achieved . It is expected that these levels will be reached by year 2025 . This technological development is vital for EVs to succeed in the years to come.

The types of various Lithium Ion battery chemistries, currently in vogue are discussed below:

The early type of commercially used battery chemistry is Lithium Manganese Oxide **(LMO)** due to the low cost. The lifetime of LMO is, however limited which is a disadvantage. LMO has a specific energy of 140 Wh/kg.

Lithium Cobalt Oxide **(LCO)** is another early type of battery chemistry having a medium cost and better specific energy but has some safety concerns. LCO has a specific energy of 200 Wh/kg.

Lithium Nickel Manganese Cobalt Oxide **(NMC)** is a combination of LCO, LMO and nickel and is gaining popularity due to its high lifetime as well as its high specific energy . The technological development of this type of chemistry is oriented towards higher use of Nickel

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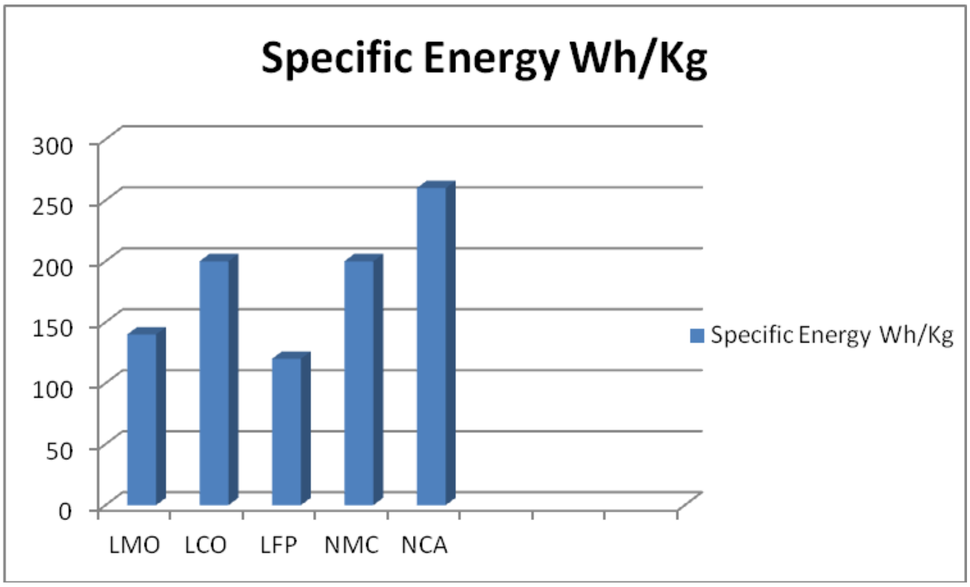
which leads to increased Specific Energy . NMC has a specific energy of 200 Wh/kg. NMC is costly .

Lithium Iron Phosphate **(LFP)** has excellent lifetime properties and is safer. LFP has a specific energy of 120 Wh/kg.

Lithium Nickel Cobalt Aluminum Oxide **(NCA)** is recently developed battery chemistry having high specific energy but their are safety concerns, which are being addressed. NCA has a specific energy of 260 Wh/kg.

Although NCA and LFP are expected to have higher life span then NMC it is yet not clear as to how fast these battery types will age across a range of temperature conditions[3].

The graphical representation for the Specific Energy details of the battery chemistries discussed above is given below :



We have seen from above that although multiple battery chemistries are available, no single battery chemistry scores in all critical aspects. Today, these battery chemistries are competing with each other to emerge as winner. Going ahead, it is expected that there will be a close contest between LFP, NMC and NCA battery chemistries. Considering the Specific Energy & Range issues, the battery technologies, particularly LFP , NCA and NMC are expected to develop further as we move forward[4] . It is further expected that by 2030, lithium iron phosphate (LFP) batteries will have the largest share of LIBs used in electric vehicles[5]

Conclusion:

The crux of the success of the Lithium Ion Battery operated EVs lies in the performance of the battery in terms of range per charge expressed in kms operated per charge . The specific energy expressed in Wh/kg determines the range of the Battery. The battery costs are also directly linked to capacity of the battery expressed in KWh. Various battery chemistries such as LMO, LCO, LFP , NMC and NCA are competing with each other with LFP, NMC and NCA are surging ahead as they offer the advantage in terms of range per charge, safety and costs. The technological development too , is currently oriented towards these three battery chemistries to bring it at par with performance & costs of IC engine. It is expected that there will be a close contest between LFP, NMC and NCA battery chemistries. It is further expected that by 2030, lithium iron phosphate (LFP) batteries will have the largest share of LIBs used in electric vehicles.

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