Marathwada Mitra Mandal's College of Engineering

Final Year Project

Liquid and Solid Cooling System of Electric Vehicles

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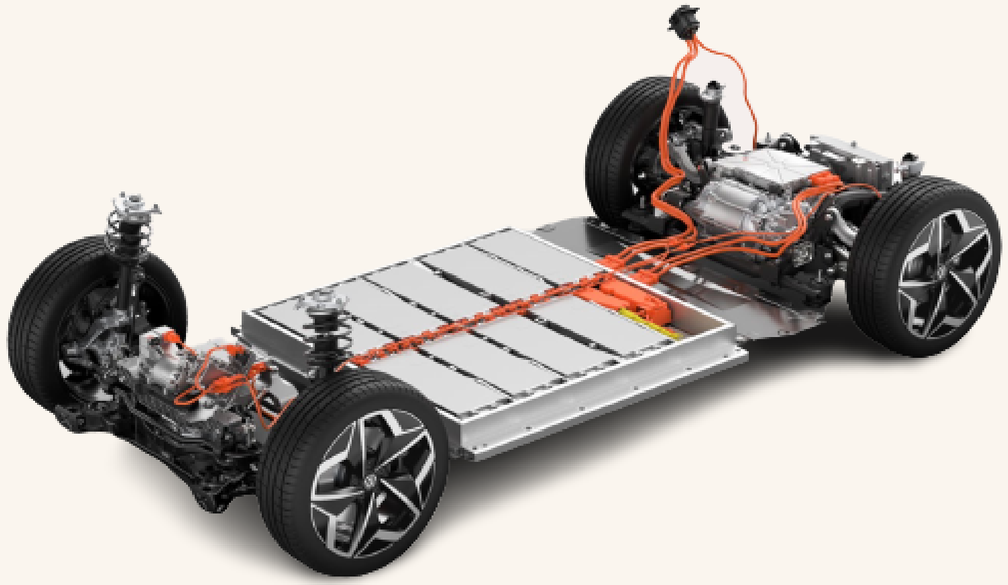
Overview

- Introduction
- Statement of the Problem
- Objectives
- Review of Literature
- Framework
- Methodology
- Scope and Limitations
- Results
- Implications and Recommendations
- References

Introduction



- An electric vehicle (EV) is a vehicle that uses one or more electric motors for propulsion. It can be powered by a collector system, with electricity from extravehicular sources, or it can be powered autonomously by a battery
- In the 21st century, EVs have seen a resurgence due to technological developments, and an increased focus on renewable energy.
- Electrical energy is a high grade energy as compared to the conventional fuels (ICE). Hence , the efficiency of EVs is higher.
- Compared to internal combustion engine (ICE) vehicles, electric cars are quieter, have no exhaust emissions, and lower emissions overall.

Statement of the Problem

Damage caused to Motor and Battery of Electric Vehicles due to Heating

Back to Overview

- In Traditional EVs there is excessive heat generation due to high Atmospheric temperature, overcharging and short circuit.
- Most of the EVs use Air cooling system but it is not sufficient to maintain the temperature below the Ignition Temperature.
- In electric vehicles, the discharging of battery generates heat. The more rapidly you discharge the battery, the more heat it generates.

Objectives:

Development of an Effective Cooling System for EV's

- To overcome the problem of Fire Hazard
- To reduce the load of Cooling on the Components
- To increase the Performance of the Battery and Motor.

Back to Overview

Review of Literature

Back to Overview

Air cooling system:

- Air cooling generally uses the principle of convection for transfering the heat away from the battery pack.

Liquid cooling system:

- Liquid cooling system primararily uses the Water-Glycol mixture to dissipate the heat from the components.

- Liquid coolants have higher heat conductivity and heat capacity (ability to store heat in the form of energy in its bonds) than air, and therefore performs very effectively.

Review of Literature

(Authors: GangZhaoa, XiaolinWanga, MichaelNegnevitskya, HengyunZhangb,
Elsivier, 31 July 2021)
A review of air-cooling battery thermal management systems for electric and hybrid electric vehicles:

- It is found that with the help of advanced computational numerical simulations and sophisticated experiments, the air-cooling efficiency is greatly improved by introducing new concepts of battery packs, innovative designs of the cooling channel, and novel thermally conductive materials.

(Authors: MohsenAkbarzadeh, JorisJaguemont, TheodorosKalogiannis, DanialKarimi,JiachengHe, LuJincPengXie, JoeriVan Mierlo, MaitaneBerecibar,
Elsivier,
1 March 2021)
A novel liquid cooling plate concept for thermal management of lithium-ion batteries in electric vehicles:

- A novel liquid cooling plate embedded with PCM for battery thermal management.
- An innovative liquid cooling plate (LCP) embedded with phase change material (PCM) is designed for electric vehicle (EV) battery thermal management.

Review of Literature

(Authors: ZhonghaoRao, ZhenQian, YongKuang, YiminLi
August 2017)
Thermal performance of liquid cooling based thermal management system for cylindrical lithium-ion battery module with variable contact surface:

- A novel liquid cooling based thermal management system for the cylindrical lithium-ion battery module with variable contact surface is designed.
- The cooling system relies on aluminum block which can effectively transfer heat from battery to cooling water. A battery module with six cells along flow channel is chosen to study the effects of aluminum block length and velocity on the thermal performance in the way of simulation.

(Authors: L.W.Jin, P.S.Lee, X.X.Kong, Y.Fan, S.K.Chou
January 2014)
Ultra-thin minichannel LCP for EV battery thermal management:

- The oblique fin maintains boundary layer to be re-developed periodically.
- The injection of secondary flow accelerates the heat propagation into fluid core.
- The temperatures on the oblique fin are lower than those on the straight channel.

Review of Literature

(Authors: ChunrongZhao, Antonio C.M.Sousa, FangmingJiang
February 2019)
Minimization of thermal non-uniformity in lithium-ion battery pack cooled by channeled liquid flow:

- A numerical study with the aim of analyzing the effectiveness of cooling channels to reduce thermal non-uniformity in lithium-ion battery packs of electric vehicles.
- The cooling system relies on aluminum block which can effectively transfer heat from battery to cooling water. A battery module with six cells along flow channel is chosen to study the effects of aluminum block length and velocity on the thermal performance in the way of simulation.

(Authors: S.Panchal, R.Khasow, Dincer, M.Agelin-Chaab, R.Frasera, M.Fowler
25 July 2017)
Thermal design and simulation of mini-channel cold plate for water cooled large sized prismatic lithium-ion battery:

- A comparative study of the temperature and velocity distributions within the mini-channel cold plates placed on a prismatic lithium-ion battery cell using experimental and numerical techniques.
- The study was conducted for water cooling methods at 1C and 2C discharge rates and different operating temperatures of 5 °C, 15 °C, and 25 °C.

Review of Literature

(Authors: Chaitanya Pandya, Dhrunil Timbadia
June 2021)
A Detailed Review on Cooling System in Electric Vehicles:

- The temperature rise is the major factor that influences the functioning of Lithium-ion batteries (Lilon). To refine the heat efficiency of the battery there are various methods to dissipate the heat. Selecting a correct cooling technique for a Li-ion battery module of an electric vehicle (EVs) and deciding an ideal cooling control approach to maintain the temperature between 5C to 45C is necessary.
- Maintaining an optimal temperature is essential as it increases safety, reduces maintenance cost, and increases the service life of the battery pack.

(Authors: SNaokiNitta, FeixiangWu, Jung TaeLee, GlebYushin
June 2015)
Li-ion battery materials: present and future:

- A comparative study of the temperature and velocity distributions within the mini-channel cold plates placed on a prismatic lithium-ion battery cell using experimental and numerical techniques.
- The study was conducted for water cooling methods at 1C and 2C discharge rates and different operating temperatures of 5 °C, 15 °C, and 25 °C.

Review of Literature

(Authors: Tao Chen
June 2020)
Research on Electric Vehicle Cooling System Based on Active and Passive Liquid Cooling:

- Compared with internal combustion engine automobile, the battery capacity and motor conversion efficiency for electric vehicles (EV) are limited, which means it requires lower energy consumption.
- To this aim, EV needs more complex thermal management system and higher thermal management requirements.
- This paper proposes an active and passive liquid cooling-based system cooling scheme. Coolant circulation's components model and refrigerant circulation's components model are built..

(https://www.dober.com/electric-vehicle-cooling-system
June 2015)
The importance of battery thermal management:

- An evaluation of which cooling system is the most effective
- The requirements for liquid coolants in different systems
- Given that liquid cooling is the most efficient and practical method of cooling battery packs, attention needs to be given to the type of coolant used in these systems.

Review of Literature

(Authors: Wamei Lin , Jinliang Yuan , Bengt Sunden
Nov. 2011)
Review on Graphite Foam as Thermal Material for Heat Exchangers

- The thermal conductivity of graphite foam is four times that of copper.
- The density of graphite foam is only 20% of that of aluminum.
- Thus, the graphite foam is considered as a novel highly conductive porous material for high power equipment cooling applications.

News References:

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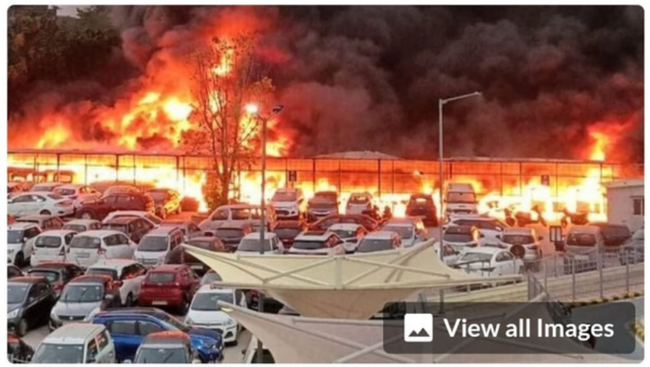
Fire at EV parking in Delhi, nearly hundred cars and e-rickshaws gutted

The fire broke out at the parking for electric vehicles near Jamia Nagar Metro station on Wednesday morning. No casualties have been reported in the incident.

By : Updated on : 08 Jun 2022, 13:16 PM



A fire broke out at the parking for electric vehicles near Jamia Nagar Metro station on Wednesday morning.

RENEWABLES

EV battery explosion claims life in Nizamabad, two injured

READ ON APP

Synopsis

Adding fuel to concerns around electric vehicle battery safety, a case of battery explosion has been reported. An 80-year-old man died while his wife and grandson suffered burn injuries when the battery of an electric scooter exploded in their hou...

By ET Online

Apr 21, 2022, 11:12 AM IST

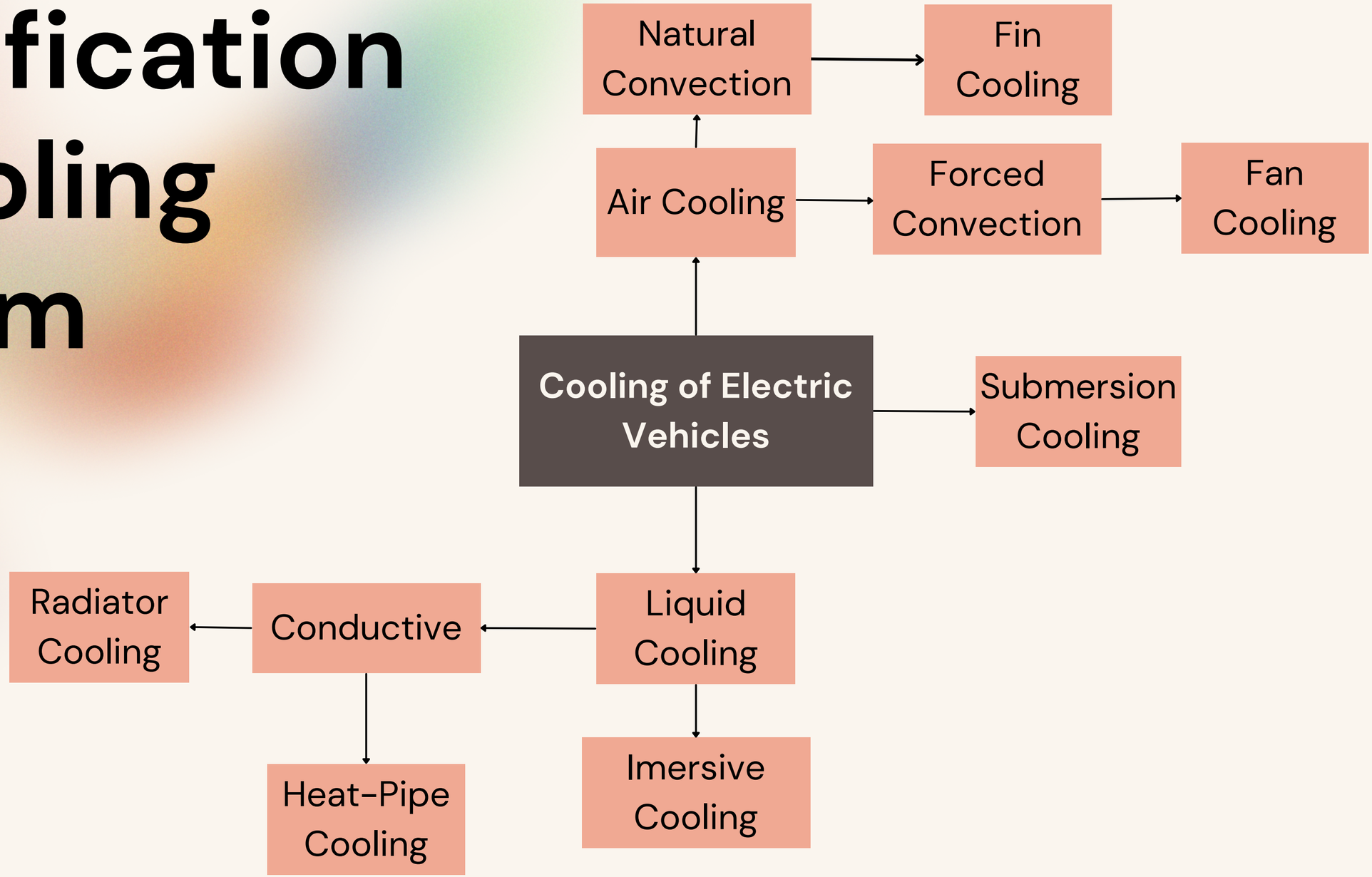
HOME » BUSINESS

Explained: Why India Is Witnessing Electric Vehicles Explosions

Union Minister Nitin Gadkari announced on Thursday that any EV company found to be negligent with customer safety will be penalized heavily. He also issued orders to recall the defective electric vehicles.

EV Fire.

Classification of Cooling System



Back to Overview

AIR COOLING

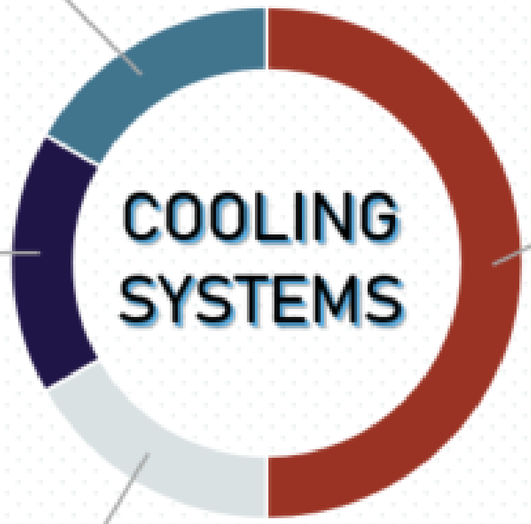
Simple and easy, yet relatively crude System needs 2 to 3 times more energy than other solutions.
Not most effective solution.

FAN COOLING

Adds about 40% extra weight of cell. This weight outweighs the cooling benefits.
Not a practical solution.

PHASE CHANGE MATERIAL

Can satisfy requirements at expense of system volume. Material cannot transfer heat away once collected.
Not a practical solution.



LIQUID COOLING

High heat capacity and efficiency. Compact, easy-to-arrange structure. Delivers best performance.

DIRECT

Battery is submerged directly into the coolant. Requires coolant to be low- to no-conductivity to maintain vehicle safety. Not yet commercialized for electric vehicle use due to continuing R&D.
Has excellent cooling potential.

INDIRECT

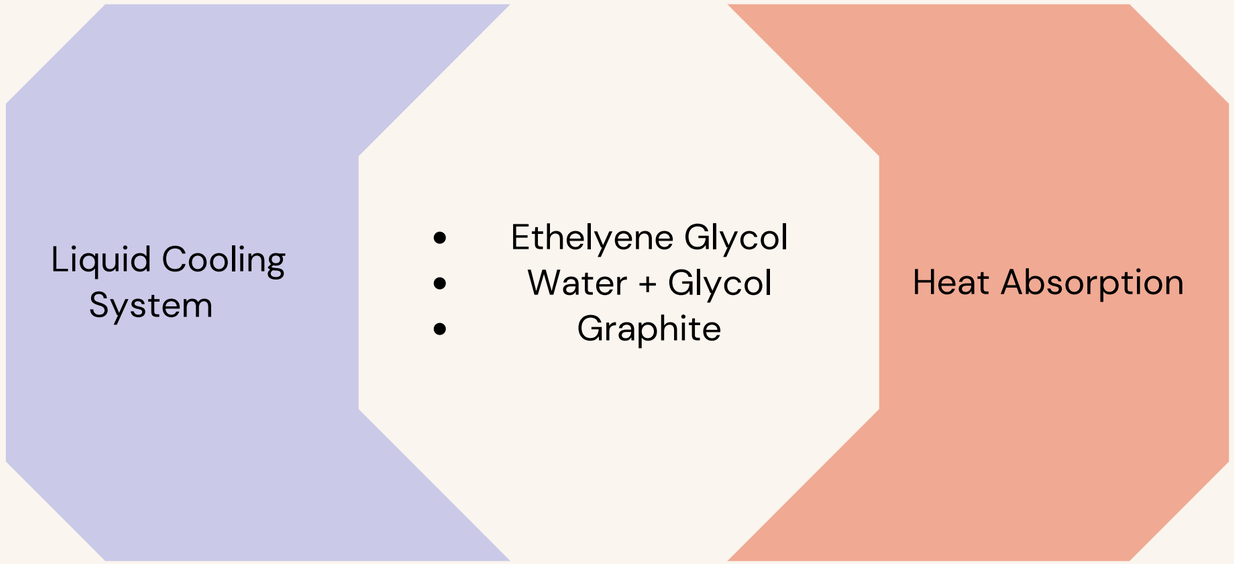
Coolant circulates through a system of pipes, similar to cooling system currently found in the internal combustion engine. Requires a high heat capacity coolant with corrosion inhibitors.
Most promising cooling system on the market.

Methodology

Back to Overview

Literature Study	• Studying the concepts needed to understand the Basics of the EV
Data Gathering	• Data collection from various sources such as Research Papers, Testing labs, etc.
Research Design and Methods	• Virtual model Creation using CAM and CAD softwares such as SOLIDWORKS and CATIA
Simualtion	• Simulation of model using Simulation softwares such as MATLAB or SIMULINK.
Analysis	• Usage of Analysis Softwares such as ANSYS

Framework



- Usage of graphite coating on the crucial components such as battery and motor to resist them from reaching the ignition temperature.
- Autonomous liquid cooling system that is capable to sensing the temperature and cool the components also in standby mode while restricting the usage when not needed.

Back to Overview

Engineering Paramerters

Graphite:

- Cp : 706.9 J/ Kg*K
- Thermal Conductivity : 120-240 W/m°K
- Coefficient of Thermal Expansion : -8.717× 10-6 /K

Battery:

- Operating Temperature : 20-40 °C
- Ignition Temp: 2000°C

Scope and Limitations

Back to Overview

Scopes:

- The safety and performance of battery-powered electric vehicles are integral to their viability and acceptability.
- While advancements have been made in electric vehicle batteries that allow them to deliver more power and require less frequent charges,
- One of the biggest challenges that remain for battery safety is the ability to design an effective cooling system.

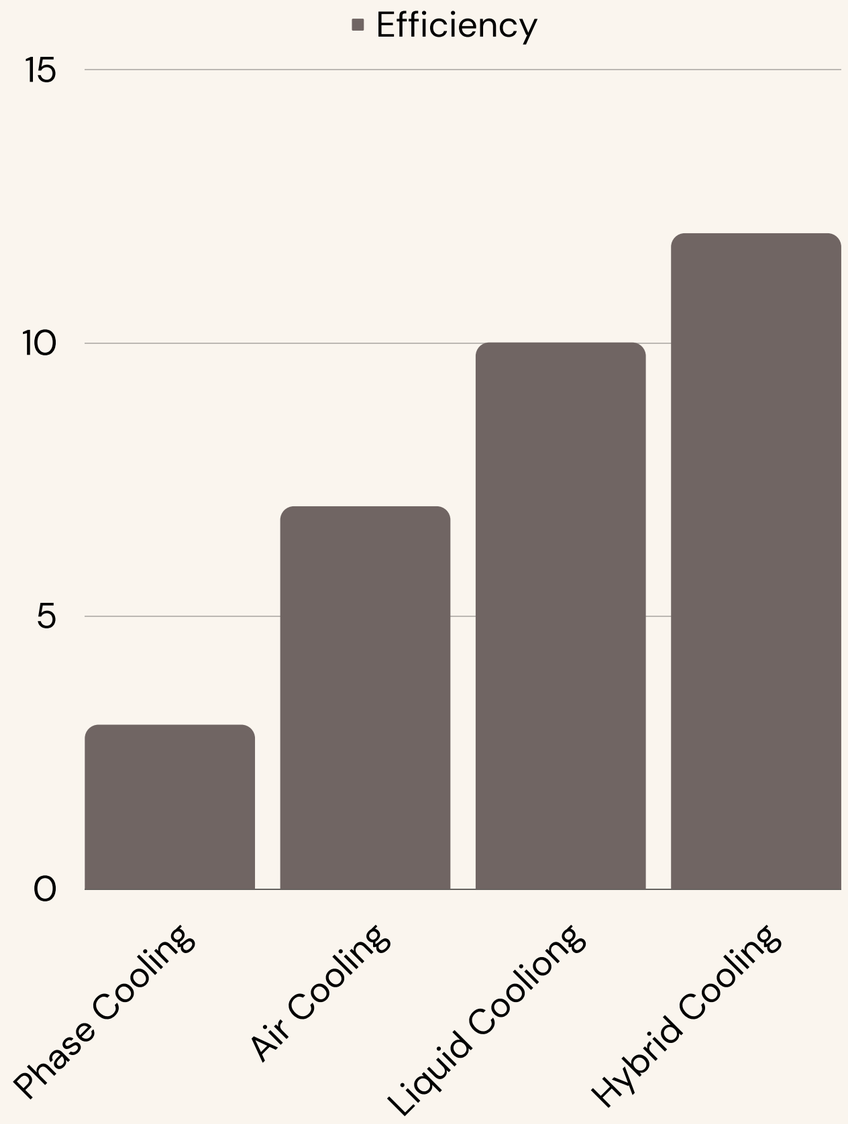
Limitations:

- Initial Costing is High
- Maintenance of Liquid Coolants

Upgrades:

- Coating of Graphite
- Autonomous working conditions

Back to Overview



Results

- The Efficeincy of the System is observed to be Increased.
- Due to the addition of Graphite the components have to face less load due to controlled temperature regulation.

Implications and Recommendations

Back to Overview

Theoretical and Methodological Issues

Heating of Battery and Motor resulting to Failure
High load Consumption
Fire Hazard

Practical Implications

Usage of Thermocouple Sensor
Graphite Coating

References

Back to Overview

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- Researchgate.com
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- Times of India
- The Economic Times
- Hindustan Times
- IRJERT
- ELSEVIER
- Thermal Management of Electric Vehicle Battery Systems
- Electric vehicle technology explained by James Larminie

Back to Overview

Thank You!

Thank you for Your Time!