ANALYSIS OF A LITHIUM-ION BATTERY COOLING SYSTEM FOR ELECTRICVEHICLES USING A PHASE-CHANGE MATERIAL AND HEAT PIPES

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ABSTRACT

Lithium-ion power battery has become one of the main power sources for electric vehicles and hybrid electric vehicles because of superior performance compared with other power sources. In order to ensure the safety and improve the performance, the maximum operating temperature and local temperature difference of batteries must be maintained in an appropriate range.

In thesis the modeling in CREO parametric software and analysis done in ANSYS. the model designed with different type of heat pipe shapes and analyze the heat pipe with different mass flow inlets (30, 20 & 50L/min).

In this thesis CFD analysis to determine the pressure, velocity, heat transfer coefficient, mass flow rate and heat transfer rate for the different designs of heat pipe and different mass flow inlets

1. INTRODUCTION

1.1 Hybrid Electrical Vehicles (HEVs)

Hybrid Electric Vehicles (HEVs) are the first steps to make the transition possible to the fully electrification of the automotive sector in the future. In principle, there are two energy sources in HEVs: the conventional internal combustion engine (ICE), which uses mainly gasoline or diesel operates in combination with an electric motor generally powered by battery or a combination of battery and electrical double-layer capacitors (EDLCs). The HEVs have the advantage of reducing the fuel consumption and emissions. The electric motor allows energy recovery to the battery system during braking, provides additional power to assist the ICE during pick power demand, and then allows reducing the size and power of the ICE.

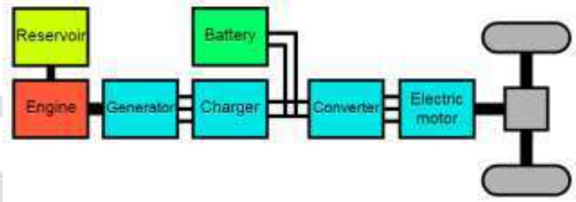
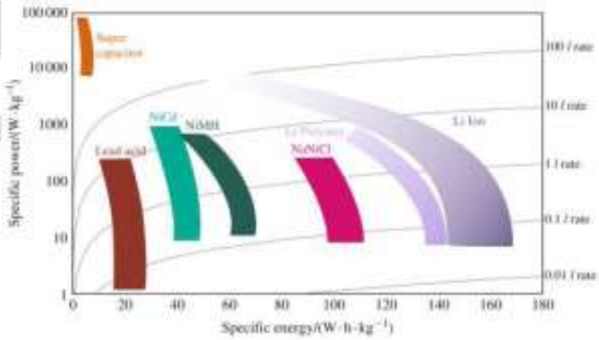


Fig: Series hybrid topology

Lithium-ion battery
Lithium-ion battery (LIB) has received considerable attention for traction uses due to the higher energy density (70-170 Wh/kg), power capabilities, lowest standard reduction voltage (Eo=-3.04V) and low atomic mass compared to previous battery technologies. Figure 1.8 shows the relationship between various types of secondary batteries in a Ragone plot. The required amount of energy stored in PHEVs and EVs is much higher than for HEVs in order to be able to travel long distances in all electric range. In the 2000s, the LIB is considered as one of the most promising solutions for environment-friendly transportation such as HEVs, PHEVs and EVs.



Specific energy and specific power of different battery types
Basically, LIB includes different components (cathode, anode, separator and electrolyte)
and work according to the so-called "extraction/insertion" process. The LIB cells are configured in various shapes such as coin, cylindrical, pouch and prismatic as shown in Figure . The basic working principle of the LIB is described in Figure 1.10. During charging lithium-ions are extracted from the cathode and migrate via the electrolyte into the

anode. The reverse mechanism occurs during discharging

2.LITERATUREREVIEW

Towards an Ultimate Battery Thermal Management System: A Review Mohammad Rezwan Khan *, Maciej Jozef Swierczynski and Søren Knudsen Kær

The prevailing standards and scientific literature offer a wide range of options for the construction of a battery thermal management system (BTMS). The design of an innovative yet well-functioning BTMS requires strict supervision, quality audit and continuous improvement of the whole process. It must address all the current quality and safety (Q&S) standards. In this review article, an effective battery thermal management is sought considering the existing battery Q&S standards and scientific literature. The article contains a broad overview of the current existing standards and literature on a generic compliant BTMS. The aim is to assist in the design of a novel compatible BTMS. Additionally, the article delivers a set of recommendations to make an effective BTMS.

Theoretical Modelling Methods for Thermal Management of Batteries Bahman Shabani and Manu Biju *

The main challenge associated with renewable energy generation is the intermittency of the renewable source of power. Because of this, back-up generation sources fuelled by fossil fuels are required. In stationary applications whether it is a back-up diesel generator or connection to the grid, these systems are yet to be truly emissions-free. One solution to the problem is the utilization of electrochemical energy storage systems (ESS) to store the excess renewable energy and then reusing this energy when the renewable energy source is insufficient to meet the demand. The performance of an ESS amongst other things is affected by the design, materials used and the operating temperature of the system.

3. PROBLEM DESCRIPTION:

The objective of this project is to make a 3D model of the Lithium-ion power battery and study the CFD and thermal behavior of the steam boiler by performing the finite element analysis.3D modeling software (CREO) was used for designing and analysis software (ANSYS) was used for CFD and thermal analysis.

The methodology followed in the project is as follows:

- Create a 3D model of the steam Boiler assembly using parametric software CREO.
- Convert the surface model into Para solid file and import the model into ANSYS to do analysis.
- Perform thermal analysis on the Lithium-ion power battery assembly for thermal loads.
- Perform CFD analysis on the existing model of the surface steam boiler for Velocity inlet to find out the mass flow rate, heat transfer rate, pressure drop.

4. INTRODUCTION TO CAD/CAE:

Computer-aided design (**CAD**), also known as **computer-aided design and drafting** (**CADD**), is the use of computer technology for the process of design and design-documentation.

4.1. INTRODUCTION TO CREO PTC CREO

Previously called Pro/ENGINEER, is three-D modeling software used in mechanical engineering, design, production, and in CAD drafting service firms. It became one of the first three-D CAD modeling programs that used a rule-primarily based parametric system. Using parameters, dimensions and capabilities to capture the conduct of the product, it may optimize the development product in addition to the layout itself.

Part design, Assembly, Drawing& Sheet metal.

4.2. INTRODUCTION TO FINITE ELEMENT METHOD:

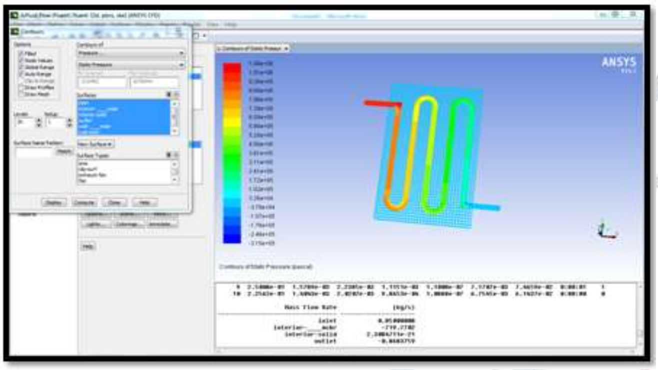
Finite Element Method (FEM) is also called as Finite Element Analysis (FEA). Finite Element Method is a basic analysis technique for resolving and substituting complicated problems by simpler ones, obtaining approximate solutions Finite element method being a flexible tool is used in various industries to solve several practical engineering problems. In finite element method it is feasible to generate the relative results.

5. RESULTS AND DISCUSSIONS:

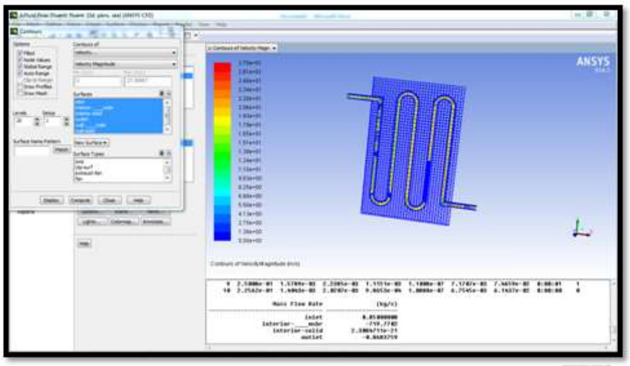
5.2. CFD ANALYSIS OF LITHIUM-ION POWER BATTERY

MASS FLOW INLET -50L/min

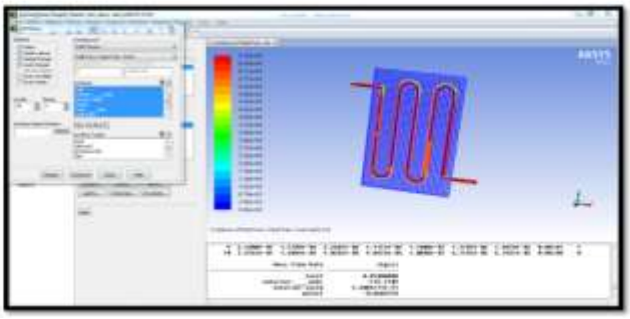
PRESSURE



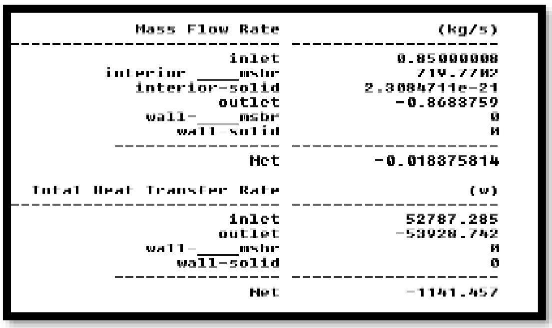
VELOCITY



HEAT TRANSFER COEFFICIENT



M ASS FLOW RATE & HEAT TRANSFER RATE



Mass Flow Rate	(kg/s)
inlet	0.85000008
interior- ____msbr	719.7782
interior-solid	2.3084711e-21
outlet	-0.8688759
wall- ____msbr	0
wall-solid	0
Net	-0.018875814

Total Heat Transfer Rate	(w)
inlet	52787.285
outlet	-53928.742
wall- ____msbr	0
wall-solid	0
Net	-1141.457

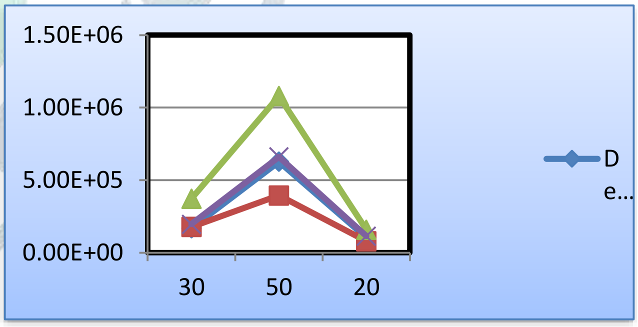
6. RESULTS AND DISCUSSIONS

CFD ANALYSIS RESULT TABLE

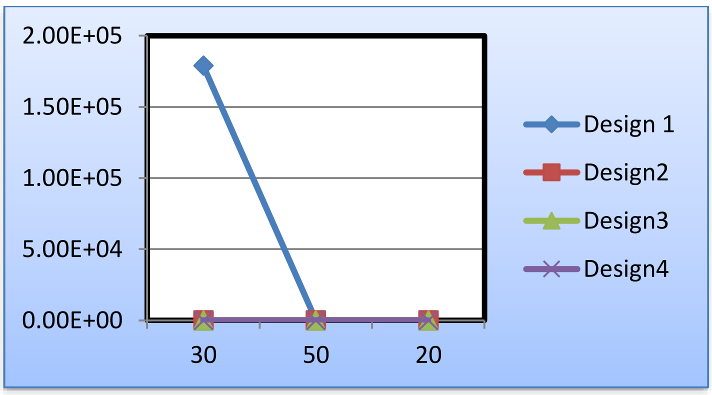
Design	Mass flow (L/min)	Pressure(Pa)	Velocity (m/s)	Heat transfer coefficient (w/m2-k)	Mass flow rate(kg/s)	Heat transfer rate(W)
Design 1	30	1.69e+05	1.79e+05	7.98e+04	0.00054436922	33.761719
	50	6.27e+05	3.56e+01	1.15e+05	0.0026317	163.46484
	20	1.04e+05	1.19e+01	5.94e+04	0.0023104	143.42773
Design2	30	1.77e+05	1.39e+01	6.90e+04	0.0039595	245.73242
	50	3.95e+05	2.31e+01	9.73e+04	0.0035874	222.87109
	20	7.87e+04	9.19e+00	5.20e+04	0.000649631	40.185547
Design3	30	3.71e+05	1.65e+01	4.32e+04	0.004757	295.22461
	50	1.08e+06	2.75e+01	6.79e+04	0.018375	1141.457
	20	1.59e+05	1.09e+01	3.03e+04	0.00259035	161.08789
Design4	30	1.96e+05	1.25e+01	4.3e+04	0.00680541	422.917
	50	6.60e+05	2.09e+01	6.72e+04	0.00096654	59.7304
	20	1.14e+05	8.34e+00	3.01e+04	0.001507	93.37109

GRAPHS

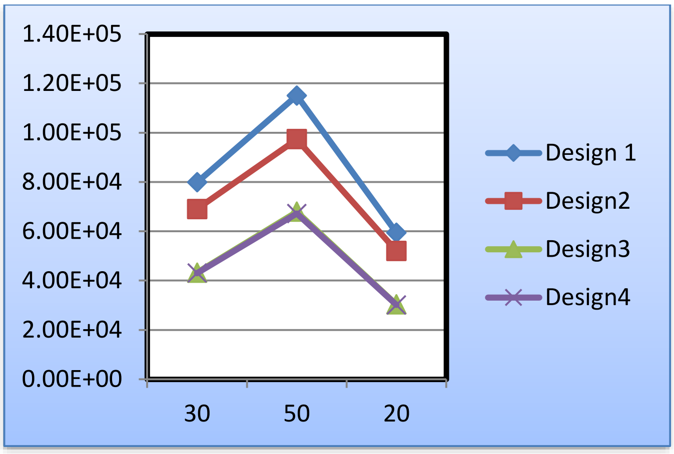
PRESSURE PLOT



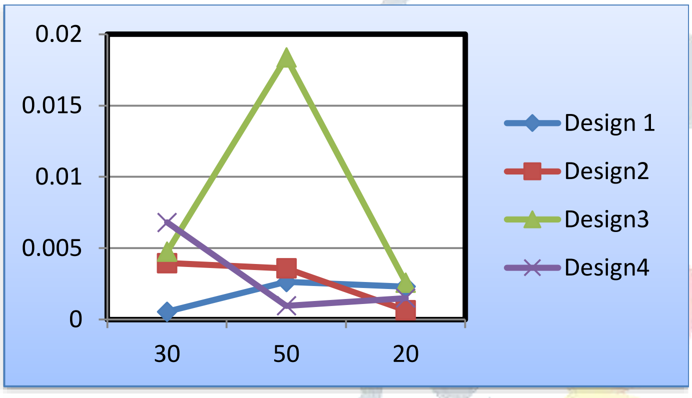
Velocity plot



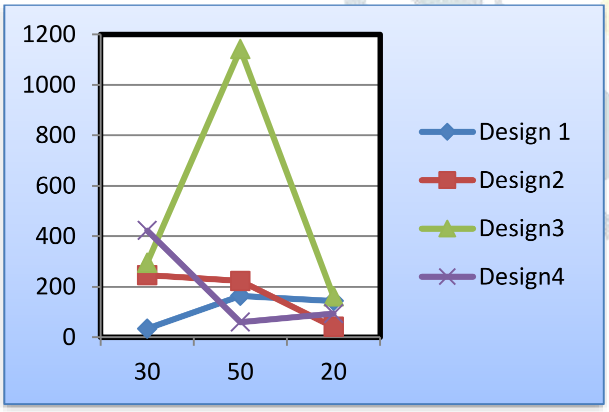
HEAT TRANSFER COEFFICIENT PLOT



mass flow rate



heat transfer plot



7. CONCLUSION

Lithium-ion power battery has become one of the main power sources for electric vehicles and hybrid electric vehicles because of superior performance compared with other power sources.

In thesis the modeling in CREO parametric software and analysis done in ANSYS. the model designed with different type of heat pipe shapes and analyze the heat pipe with different mass flow inlets (30, 20 & 50L/min).

by observing the CFD analysis mass flow rate, heat transfer rate, heat transfer coefficient values are increases by increasing the mass flow inlets and heat transfer rate more at design3.

so, it can be concluded the design 3 is better model for Lithium-ion power battery cooling system.

REFERENCES

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