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Thermal Analysis of Laptop Battery Using Composite Material

R.Arunkumar
Assistant Professor Department of Electrical and Electronics Engineering
Alpha College of Engineering and Technology, Puducherry, India

Abstract: *The main objective of this paper is to reduce the heat produced in the Battery. A composite material is placed over the battery to absorb the heat produced in the internal cells and outer casing. The temperature of the battery is analyzed using ANSYS15.0 software. The simulation result is compared with the cooling methods of cooling fans, heat sinks and fins. According to the simulation result, the proposed method is better effective in cooling the batteries. Overheating in laptop leads to failure of hardware components and decrease the lifespan of the computer. This thermal management of laptop battery using composite material reduces the temperature up to 47℃ with better thermal efficiency. Due to the reduction of temperature in the battery, there is a considerable reduction in charging time of the battery and also it avoids the fast discharging in batteries.*
Keywords: *Composite material, cooling fan, heat sink, temperature*

I. Introduction

A Battery is a device consisting of electrochemical cells which convert chemical energy into electrical energy. It is basically classified into two types primary and secondary. In primary batteries, a chemical reaction takes place at only once, this action cannot be reversed and the battery is discarded. While in secondary batteries, the chemical reaction can be reversed and the battery is rechargeable. They can be recharged by passing an electric current through them. In the modern world, secondary battery plays a vital role in hand phones, laptops, and remote control applications and in hearing aids. Nowadays the use of secondary batteries becomes very common in electrical drives due to the shortage and increase in the price of petroleum products.

Especially in secondary batteries, the lithium ion (Li-ion) batteries are very popular due to the generation of higher voltage than other types of cells, can be made into convenient shapes and sizes, less weight, high energy density, and less self –discharge [1-2]. The main drawback in the secondary battery is the heat production in the internal cells of the battery. The heats produced in the battery reaches up to 60℃ in the normal working condition and do not have a proper heat transfer or cooling method to reduce the temperature. This heat inside the battery spreads over the internal cells and also it reduces the lifetime of the battery [3-4] and sometimes even leads to an explosion of batteries. The heat produced in the laptop battery not only affects the battery and also leads to several problems and damage in motherboard, hard discs etc. Hence this paper deals with the reduction of temperature produced in the battery using the composite material. This material significantly reduces the temperature inside the battery by absorbing the heat produced inside the battery.

II. Composite Material

Composite material [5] is a material with two or more base materials with different physical and chemical properties, when they are combined they produce a different unique characteristic from the base material. Composite materials are chosen as the cooling material to be placed over the laptop battery casing. The materials chosen for analysis are I. Copper II. Aluminum III. Carbon fiber

S.No	Material	Density	Thermal Conductivity	Emissivity
01.	COPPER	High	Good	Low
02.	ALUMINIUM	Moderate	Moderate	Low
03.	CARBON FIBER	Low	Moderate	Moderate

Table 1: Material Comparison Table

III. Design Of Battery In Cad

The tabulation below shows the dimensions of the laptop battery. Using the tabulated parameter values the battery is designed in AutoCAD software.

S.no	Specifications	Dimensions
1	Size of battery (mm)	X:270.40mm Y: 27.40mm Z.49.30mm
2	Size of each unit cell (mm)	43*8*26.8
3	Size of core region (mm)	20.63 (diameter)
4	Thickness of the case (mm)	2063
5	Weight (kg)	0.36kg (0.79 lb)
6	Voltage	11.1 Volts

Table 2 Dimensions of Battery Model

Using the tabulated battery parameters value shown in table 2, the battery is designed using AUTOCAD designing software.

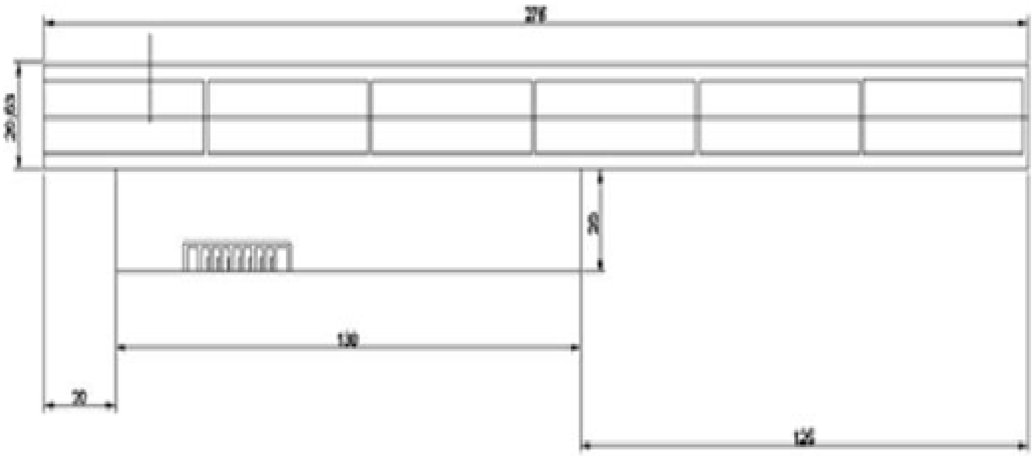

Fig1 Six Cell Laptop Battery Wireframe View

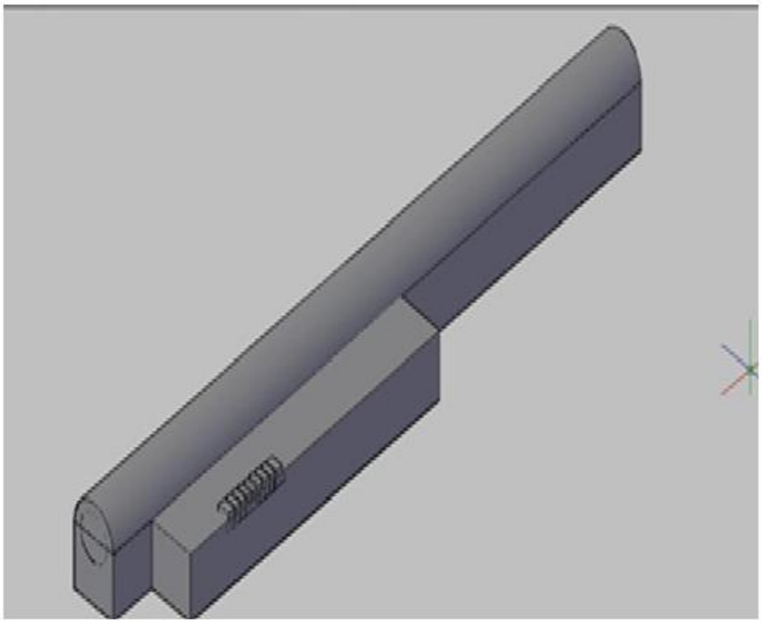

Fig 3 Laptop Battery in 3D Front View

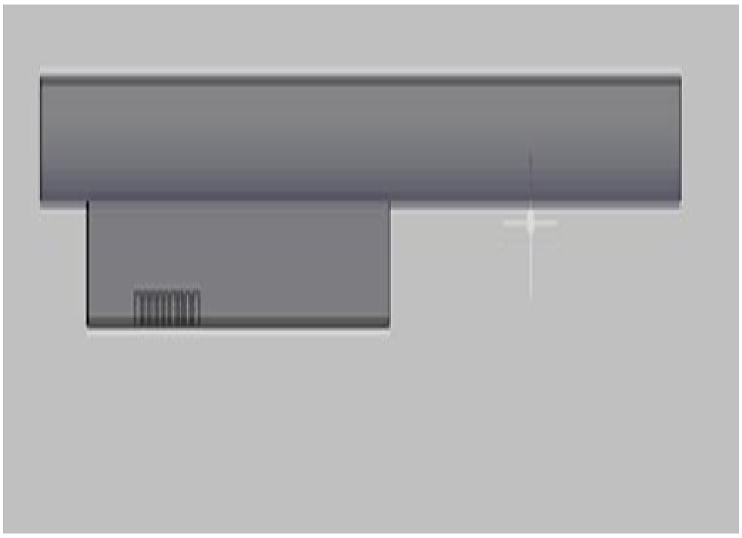

Fig2 Laptop Battery in 3D Isometric View

IV. Boundary Conditions Assigned For Battery

The boundary condition assigned for battery to analysis the heat transfer over the casing.

Overall heat transfer coefficient (U)

$$U = \frac{Q}{A[T_a - T_b]}$$

Where

'U' = overall heat transfer co-efficient (W/m^{2}k)

Here

$Q_c = Q = 0.0923$

A= Area of laptop battery=43675mm^2

$$U = \frac{0.0923}{43{,}675(45-40)}$$

$$U = 4.22\times 10^{-7}$$

Average Nusselt number

$$Nu = \frac{hL}{K}$$

$$Nu = 0.664(Re^{0.5} Pr^{0.333})$$

$$= 0.664(\,{10^{12}}^{0.5}(0.065)^{0.333})$$

$$Nu = 267.2\times 10^{3}$$

V. Material Parameter Used In Battery

In the below table 3 tabulation, The materials which are present inside the laptop battery are listed below from S.No 1-10 and the next remaining 11-13 are the composite materials which are going to be used In the analysis for the battery.

SL.NO	MATERIAL	DENSITY	HEAT CAPACITY	THERMAL CONDUCTIVITY	EMISSITIVITY
1.	CARBONACEOUS ELECTRODE	1347.33	1437.4	1.04	
2.	LICOO2	2328.5	1269.21	1.58	
3.	AL FOIL	2702	903	238	
4.	CU FOIL	8933	385	398	
5.	PP SEPARATOR	1008.98	1978.16	3344	
6.	AL-2024	2770	875	170	0.25(OXIDIZED) 0.4(ROUGH)
7.	S.S.AISI-304	7900	477	14.6	
8.	LIQUID ELECTROLYTE	1129.95	2055.1	0.60	
9.	COPPER	8940	385	398	
10.	MAGNESIUM	1770	1000	96	
11.	ALUMINIUM	2710	900	210	
12.	COPPER	8940	385	398	
13.	CARBON FIBRE	1780	1678.3	21-180	

Table 3 Material Parameters

The designed laptop battery and its parameter values are imported in ANSYS 15.0 software. The laptop battery with its side view is shown below,

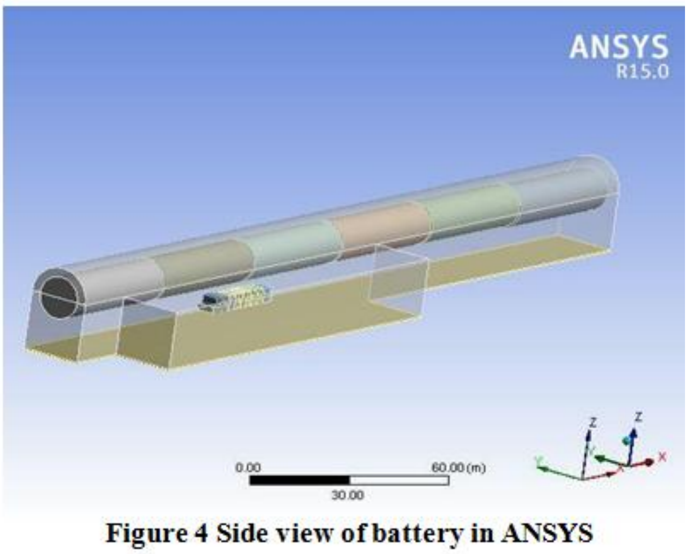

Figure 4 Side view of battery in ANSYS

From the figure, it is seen that the battery temperature is increased from 31℃ and reaches up to 57℃

RESULT IN ANSYS WITH MATERIAL ALUMINIUM

The simulation is performed by assigning the boundary conditions of the Aluminium material. The simulated result is shown below

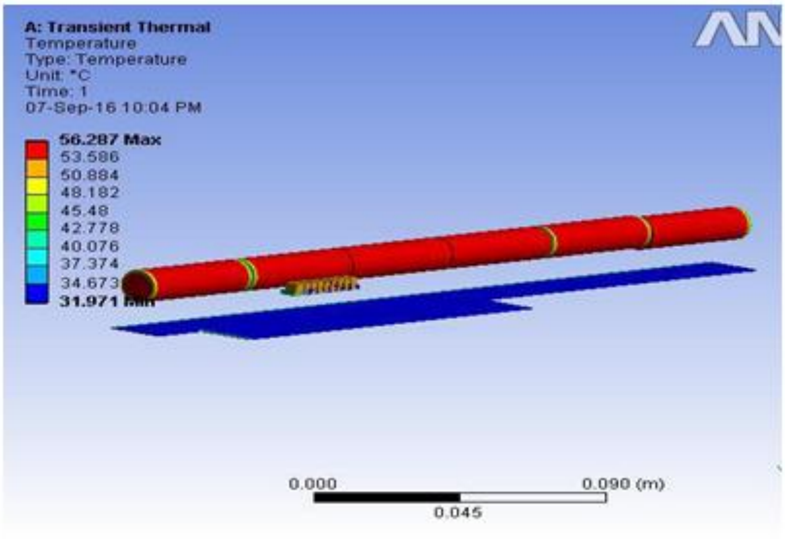

Figure 5 Simulated result of carbon fibber material in ANSYS

RESULT IN ANSYS WITH MATERIAL CARBON FIBER

The simulation is performed by assigning the boundary conditions of the carbon fiber material. The simulated result is shown below

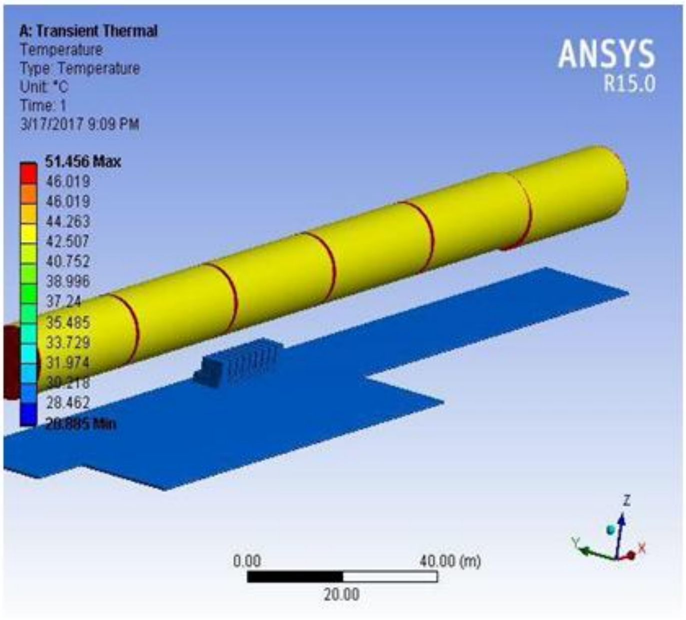

Figure 6 Simulated result of Aluminium material in ANSYS

From the figure of Aluminium, it is seen that the battery temperature is increased from 20℃ and reaches up to 51℃

RESULT IN ANSYS WITH MATERIAL
COPPER

The simulation is performed by assigning the boundary conditions of the Copper material. The simulated result is shown below

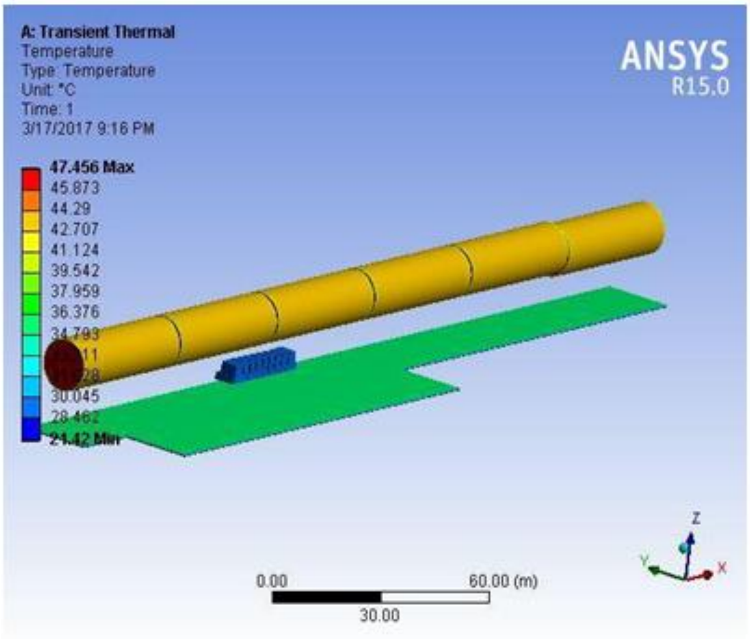

Figure 7 Simulated result of copper material in

From the figure of copper, it is seen that the battery temperature is increased from 21°C and reaches up to 47°C
The below graph represents the temperature vs charging time of the materials that have been analyzed for thermal management.

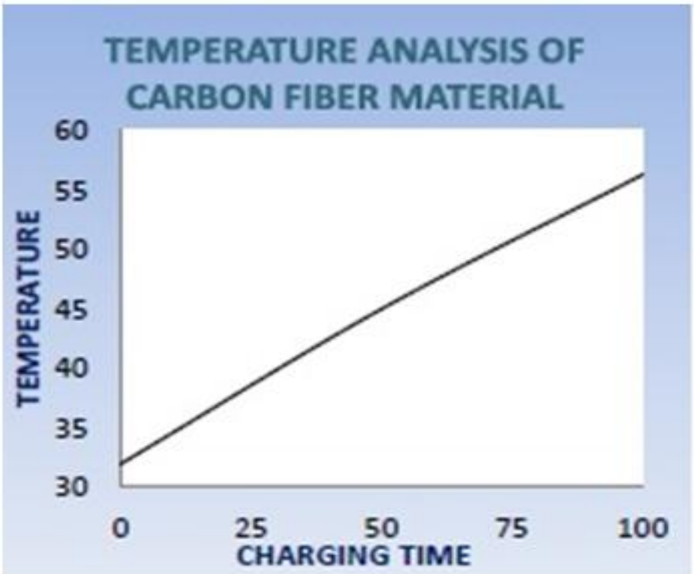

Figure 8 Temperature vs charging time of carbon fiber

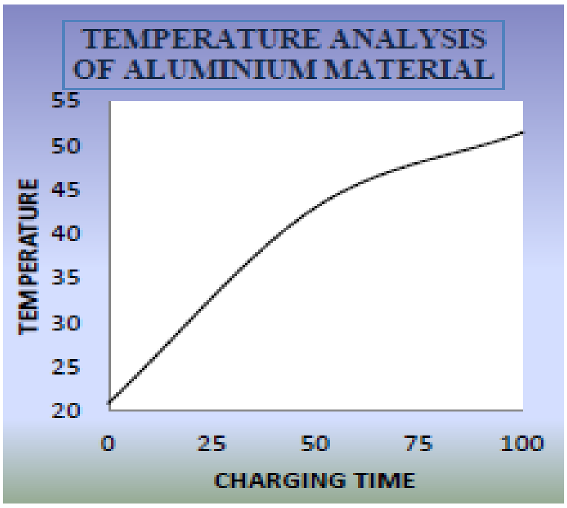

Figure 9 Temperature vs charging time of Aluminium

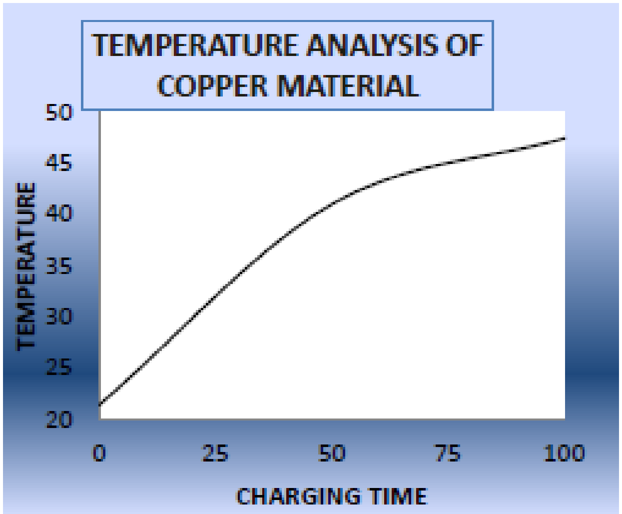

Figure 10 Temperature vs charging time of copper material

VI. Result Comparison

SL.NO	MATERIAL	% SOC	% SOC	% SOC
01.	COPPER	21.42 ℃	41.239℃	47.456℃
02.	ALUMINIUM	20.885℃	43.01 ℃	51.456℃
03.	CARBON FIBER	31.971℃	45.10 ℃	56.287℃

Table 4 Comparison of materials with respect to SOC

VII. Conclusion And Future Work

From the results and output, it has been concluded that, Using copper as a material above the casing reduces the temperature significantly than other two materials i.e. carbon fiber and Aluminium. It also has high density and a good conductivity. So, using copper material is the best choice to reduce the temperature in a battery. A comparison of the composite materials with the analysis is done. The future work deals to still reduce the temperature by using both the combinations of fins and composite materials.

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