# Lithium-Ion Battery Thermal Management System Using PID controller

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**Abstract:**High vehicle emission resulting in rising the air pollution day by day has challenged and driven the automotive industry to explore for alternate and more environment friendly technology. The transition of the automobile sector in near future towards green energy solutions has also spurred the technological improvement in this industry. In order to achieve this requirement, Electrical Vehicles (EVs) have emerged as the finest answer accessible till now. It has become highly popular due of the zero pollution and higher wheel-drive efficiency. The car has some restrictions in terms of performance, cost, longevity & battery safety. The EVs feature lithium-ion batteries built to satisfy the drive power requirement. In order to maximize the vehicle performance, thermal control of the batteries becomes highly crucial. The battery thermal management system (BTMS) has vital significance in controlling the thermal behaviour of the batteries. Several cooling methods are employed for battery thermal management systems such as air-cooling system, liquid cooling system, direct refrigerant cooling system, phase change material cooling system, and thermo-electric cooling as well as heating system The present study explains the battery thermal management using the coolant i.e., liquid cooling system & proves the battery performance at various situations. The study evaluates the thermal heat load demand of the battery with respect to various ambient circumstances and optimize it accordingly. Typically, the cooling systems are intended to address the thermal heating of the battery for both high & low ambient temperatures. This article exhibits the association between many parameters to its thermal performance. The complete system has been tested and performance were validated in the laboratory.

Keywords: Lithium-ion battery model, PID controller, cooling system, thermal management

## I.INTRODUCTION

Because of the growing concern over pollution produced by conventional energy consumption, renewable energy sources have grown in popularity over the last few decades all over the world. However, the integration of renewable energies into the electrical grid is becoming more challenging due to natural, economic, and technical constraints [1]. [2] The battery energy storage system (BESS) is being touted as a major answer to the difficulty of integrating renewable energy into the grid. With their superior characteristics and performance of high energy efficiency and density, wide operating temperature range, greater rate of charging, longer cycle life, and lower self-discharge rate, lithium batteries have the potential to remain competitive in the global market. During the charging and discharging process, a lithium-ion battery undergoes a large number of electrochemical processes. When charging and discharging a big battery pack, the heat that accumulates during the operation might cause the battery pack's temperature to rise, accelerating the electrochemical reaction. This has the potential to shorten the battery's life and compromise its charging ability and safety. There is also a risk of battery damage due to mechanical abuse, overcharging, and short circuits in high heat conditions. Lithium-ion diffusion capacity in the battery may decrease when the temperature is low [7]. For this reason, it is possible that the electrochemical balance of a battery pack will become unbalanced, leading to variations in charging and discharging rates, state of charge (SOC) differences between nearby cells, and capacity loss [8]. It is therefore vital to have a battery thermal management system (BTMS) in order to ensure optimal battery performance [9]. Batteries in BTMS have a heating and cooling system that maintains a specified temperature in the battery storage system in cold climates, and these systems work together to keep the battery storage system operating at an optimal temperature while charging and discharging. Many battery heat management systems have been studied and developed. Amenable ambient air circulation is utilised to perform the heat transfer in an air-based cooling system. When using an air-based temperature control system, there is no need for an isolation between the cells and the coolant media. However, because this cooling system uses the outside air for cooling reasons, an additional filter must be installed to prevent and filter out the dust from the environment. In addition, compared to other cooling systems, this air-based system has a lower heat capacity. Passive, moderate, and aggressive liquid-based cooling systems are used for battery thermal management systems in liquid cooling systems. Until the liquid coolant and ambient air reach equilibrium temperature, the heat transfer process in a passive system takes place at the heat exchanger. It is important to note that the cooling effect is largely dependent on the temperature of the ambient air, so a low ambient air temperature results in a large and sufficient cooling effect. In an active system, two heat exchangers are employed to cool the battery. In this way, the battery coolant used for the battery pack is always maintained at a cool temperature and is not affected by the ambient temperature. In spite of this, it is difficult to maintain due to the intricate system structure and the likelihood of liquid leakage [10,11]. Most hybrid electric vehicles now use refrigerant-based cooling systems, which eliminate the drawbacks of both air- and liquid-based cooling systems. A pre-existing refrigerant cycle is used to integrate the battery pack. Due to the lower heat capacity of refrigerant when compared to liquid, it is not appropriate for high charge and discharge rate applications. Other than that, this system has a high price tag and a safety concern for R134a, a highly-flammable chemical. Battery packs with extensive charge-discharge cycles require a strong controller that can maintain a uniform temperature throughout the operation of the battery pack. Temperature monitoring and control systems in the thermal management system have received a lot of attention because the thermal impacts might alter the kinetic movement and transport phenomena of the electrochemical system of lithium batteries [13-15]. It is the PID (Proportional-Integral Derivative) controller that provides a solution to the practical application control difficulties in industries [16].

## III. PROPOSED SYSTEM

To keep the temperature of the battery at an appropriate level, we use a combination of liquid and air cooling. Pumps force the liquid and air into the heat exchange system. However, the temperature control in our model is significantly faster than that of a typical refrigerator because of the forceful injection of air and liquid into the heat exchange system. This improves the heat absorption process.

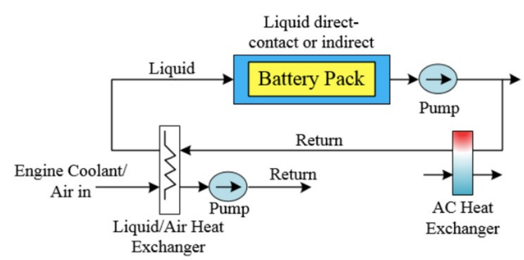


Fig.1 Proposed Lithium-ion battery pack thermal management system

### Operation

Cold plates with cooling channels surround the battery packs, which allow the liquid that cools them to circulate below them. The Cooling Unit receives the heat absorbed by the cooling liquid. In order to keep the batteries, cool, the Radiator employs air-cooling. To reduce the temperature of the overheated batteries, the refrigerant system is employed. The amount of heat flow taken from the cooling liquid is used to describe the refrigeration cycle. Drive cycle or quick charge scenarios are used to mimic the system, with varying temperatures for the environments.

## III.CONTROL PROCESS

A temperature controller is a device that measures the difference between a setpoint and a measured temperature and is used to control temperature. A temperature sensor is attached to the controller's output, which can be used to drive a fan or refrigeration system.

A temperature control system relies on a controller that accepts a temperature sensor such as a thermocouple as input to accurately control the process temperature without requiring extensive operator involvement. As soon as the setpoint is reached, it sends a signal to a control element, which it then uses to adjust the temperature.

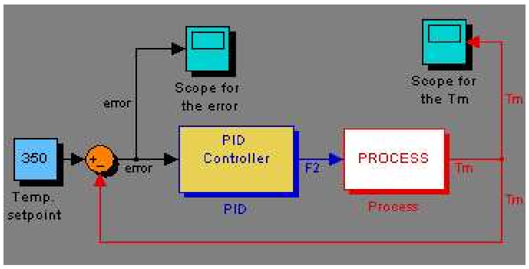


Fig.2 Temperature controller

Step 1: We determine the battery's optimal operating temperature.

Step 2: Using a thermocouple to gauge the battery's real temperature.

The PID control system receives the measured valve in step three.

In step 4, the PID controller compares the battery's actual temperature to the battery's desired temperature, and if there is a discrepancy, the controller identifies an error.

Step 5: Using a controlled variable, the controller tries to reduce the mistake as much as possible.

Step 6: The temperature of the battery should be measured and sent back to the PID control system.

To get the battery temperature to its ideal range, this operation must be repeated from 5°C to +45°C.

## IV. WORKING OF PID CONTROLLER

A common function on most process controllers is PID temperature control, which is used to increase the process's precision. It is feasible to keep the process temperature as close as possible to its setpoint by employing PID temperature controllers, which use a formula to determine the difference between the desired temperature setpoint and the present process temperature.

In contrast to on/Off temperature controllers, PID temperature controllers use a proportional-integral-derivative (PID) method to manage the temperature. As a result, there will be frequent overshoots and lag, which will have an impact on the final product's quality.

To deal with process interruptions such as the opening of an oven door, temperature controllers with PID are more effective. The change in temperature can subsequently have an impact on product quality. A correctly tuned PID temperature controller will compensate for disturbances and return process temperature to the setpoint, but it will cut power as temperature approaches the setpoint to avoid overshooting and destroying the product with excessive heat.

## IV.SIMULATION RESULTS

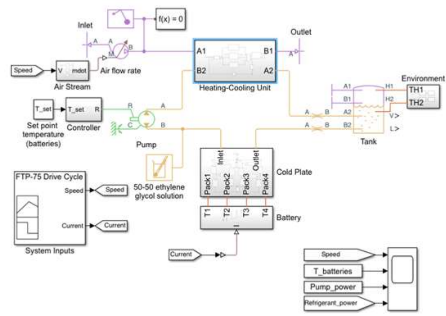


Fig. 3Simulation diagram of battery cooling system

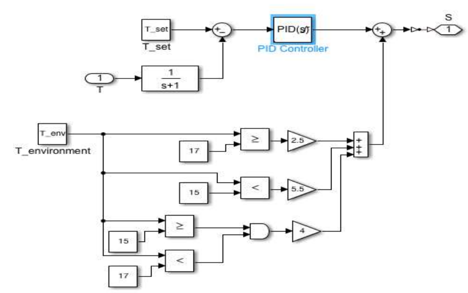


Fig.4PID controller subsystem

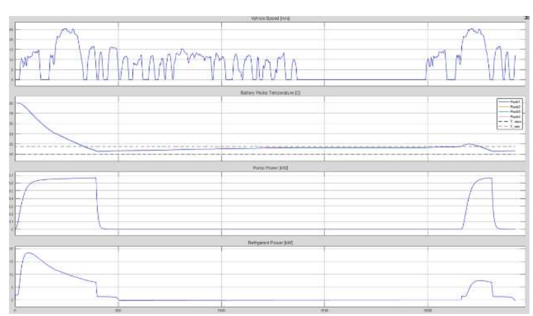

Fig.5 Vehicle speed, Battery packs temperature, Pump power and Refrigerant power

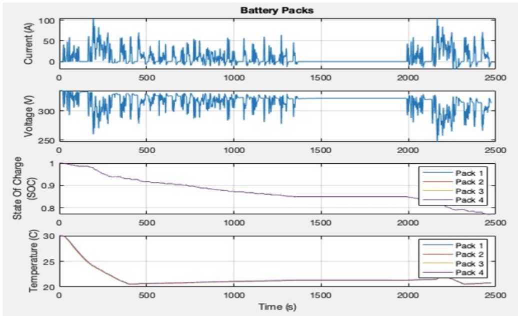


Fig.6 Battery current , Voltage , SOC and Temparature

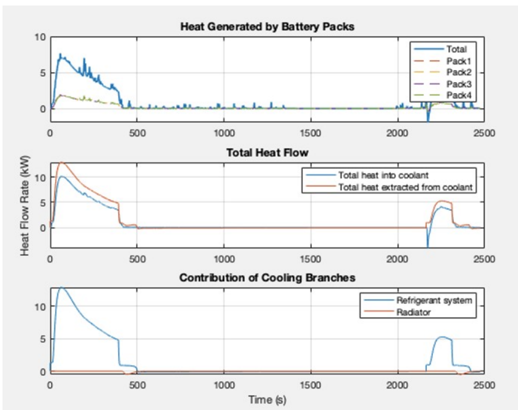


Fig.7 Battery performance wave forms

## CONCLUSION

There are four modules in series-parallel configuration in the battery pack that are controlled by a PID controller in this study. The PID-based temperature control method and its implementation are discussed. Electrical vehicles will run more efficiently if the batteries are properly cooled. As a result of a combination of air and liquid cooling, we are able to maintain the battery operating temperature. Battery's battery life and efficiency will be improved as a result. The results of the proposed PID controller for heating and cooling subroutines are shown along with the results.

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