Review Paper on Fault Detection Techniques In EV Charging

Lovish kumar[1], DR. Jaimala Gambhir[2]
[1]Dept of Electrical engineering
[2]Associate professor, Dept of Electrical engineering
[1, 2] Punjab engineering college, Chandigarh,India

Abstract- *For charging the electric vehicles in a more rapid and convenient way on a large scale development, the usage of the public charging piles is at a rapid rate. To charge piles, there is much usage of the traditional fault detection procedures that results into the low speed of detection efficiency. This paper represents several kinds of issues related to charging faults of batteries in electrical vehicles (EVs), and the available techniques used to detect these faults. After reviewing the current scenario, this paper represents the techniques that were used for detecting the faults in the EVs and make electrical vehicles more efficient. The study concludes that now-a-days, technology is advancing in a fast speed making artificial intelligence and machine learning popular for the charging of electrical vehicle.*

Keywords- Fault detection, electric vehicle charging piles, ELM algorithm, multi-fault diagnostic , etc.

I. INTRODUCTION

As energy and universal climatic issues are rising rapidly, the electric vehicles have clear benefits over the need of saving energy and reducing emission because of that they are getting developed at a fast rate [1]. Everywhere in the world, the manufacturing of electric vehicle has got immense help from governments because of big-scale construction. Due to development and operation of a huge number of electric vehicles charging machinery, the focus is mainly on the problem of charging reliability and security [2].

Limited by day to day environments, productivity and numerous different components, the electric vehicle charging tool is continuously enhancing to the direction of public [3]. Accordingly, people charging heap is additionally significant. Lately, the interior construction plan of charging heap has gotten more sensible, along associated capacities are progressively being enhanced. Its general pattern is for growing cleverly and effectively [4].

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Notwithstanding, because of the huge count of charging heaps being put available and the absence of the board faculty, the charging heaps are inclined to different delicate faults. Most of the deficiency location techniques depend on experimental judgment, and presently there are not many strategies recognized by the technology of machine learning and AI. The restricted deficiency identification of charging heaps or piles has been suggested. The prior strategies were to distinguish disappointments by manual review and setting up scientific or analytical model. These models and techniques could be utilized to pass judgment on the disappointment of charging heaps partly[5].

Since fault detection is a crucial part of electrical vehicles, various methods for fault detection have been studied and developed. the rest of the paper is organized as the section 2 represents the types of the faults those generally occur in batteries, section 3 provides the review of few fault detection techniques in domain of electrical vehicles with the outcomes of these techniques. Finally the conclusion is given in section 4.

II. TYPES OF FAULTS IN BATTERY SYSTEMS

After reviewing the literatures it is concluded that the battery faults are categorized into two types internal and external faults. In this section some of the faults from both categories are discussed.

A. Internal Battery Faults

Because the functions inside a Li-ion cell are quiet not understood entirely, internal battery issues are hard to identify. Few instances of internal battery issues are overcharge, over-discharge, internal and external short circuit, over-heating, accelerated deterioration and thermal run-away. Accelerated degradation and thermal runaway are deadliest over other issues that affect the battery operation because they can considerably influences the Li-ion battery application as well as can hurt the consumer directly [7]. The unusual reaction of battery operations such as voltage drop, SOC drop, temperature rise, increase in internal resistance, and physical transformation like inflation are used for the identification of internal issues.

B. External Battery Faults

If tabs are connected with a low resistance path, an external short circuit can occur [6]. The electrolyte leakage from cell inflation resulting from gas production because of side reactions when it gets overcharged is also one of the reasons [8]. The reason behind occurring of it can be water immersion and collision distortion. If an external heat- leading component makes a connection with the positive and negative ends concurrently then an external short circuit especially occurs, which causes an electrical linking of electrodes [9]. According to the study, it is concluded that because of an external short circuit, the Li-ion diffusion within negative electrode causes restricted current, and heat produced by the electrolyte degeneration in the positive electrode is accountable to the occurring of thermal runaway. An external short circuit is also the reason behind extreme release of the energy which is kept in a cell.

Fig 1 shows a summary of various faults in a battery system with the possible causes of these faults.

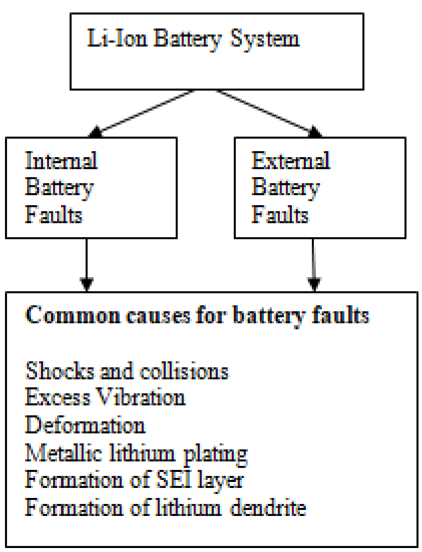

Fig 1: Different types of battery faults and their causes

Fault Diagnosis Using Machine Learning

The majority of fault monitoring systems are focused on objective judgment, and a very few solutions are available using Artificial intelligence so far. Manual testing and the development of a numerical simulation were the traditional technique for identifying failures. To some degree, such techniques and prototypes could be used to determine the failure of charging piles, however the precision of the decision is low. Likewise, even as quantity of charging piles grows and equipment structures become more complex, it becomes more hard to detect faults by using methods described above. Machine learning and deep learning advancements are commonly utilized and have also become a major research area. Pattern recognition, image classification, and a variety of several other areas benefit greatly from that kind of approach, that employs a Neural Network to learn features and identify them.

AI techniques are providing much more reliable and effective ways to deal with the limitations of the conventional diagnosis method as computational capacity and data storage become more available. The general process for machine learning algorithm to detect faults in EVs is given below;

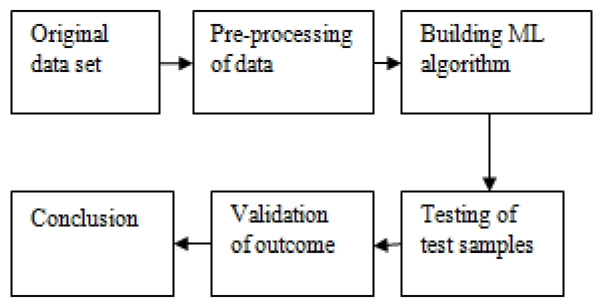

Fig 2 General machine learning model for detection

In Fig 2, the process demonstrate the procedure of machine learning approaches for detection purpose. In the initial phase the dataset from different sources, or recorded in real time is processed, the next phase is preprocessing of the dataset as sometime few values get skipped, or in form those became complex for machine to understand, normalization of the values etc. Once the dataset is preprocessed, the initialization of machine learning object is to be done. where learning algorithm is to mention, training dataset is to give. Training phase is next part of the process and when the training is done the testing of the test samples is to be done for the detection. To perform the analysis validation of the outcome with actual results is to be done so that the a conclusion can be given regarding the precision of the network.

Intelligent diagnostic approaches, like support vector machine (SVM), decision theory, neural network, fuzzy logic, and diagnostic methods based on deep learning technology, provide greater efficiency for fault classification of complicated processes than conventional methodologies. Other than these a number of approaches are provided by the researchers in recent years those are discussed in next section.

III. FAULT DETECTION TECHNIQUES

The greater part of the current BMS could just analyze basic faults, for example, overcharging of battery, over temperature, over release. The cause is that the deficiency determination in the framework of battery has two uncommon challenges [10]. Firstly, numerous deficiencies in the battery framework are secretive in nature and hard to distinguish. Some minor flaws such as inward short out and beginning connection issue can't be analyzed by straightforward edge analytic techniques with restricted actual boundary, i.e., arrangement current, cell voltage and testing point temperature. Also, a few flaws with comparable electrical and warm attributes are inclined to misdiagnosis, for example, diagnosing sensor deficiencies as shortcomings of cells. A number of methods are given by in few past years that provides solution of detection of faults.

Boulaid Boulkroune et al. [11], This paper's researchers explore the problems of actuator fault detection and isolation (FDI) and sensor failures that impact the side behavioral patterns of autonomous vehicles. Quick recognition of the faulty actuator or sensor is extremely important for vehicle dynamics whereas it is also regarded as a major phase in the vehicle control design strategy for fault tolerance. Yaw rate and lateral acceleration sensor errors along with steering system actuator and motor torque errors were also checked. A vigorous unknown input spectator and H/H error detection filter are chosen whereas it was also used for the residual signals generation, in order to reduce the effects of model uncertainty, perturbations and sensor noise. The evaluation algorithm was used by researchers to detect and isolate the faulty signal based on the generalized probability ratio test (GLRT).

Waad Rtibi et al. [12], In this paper, authors proposed the rotor-field-oriented control of induction motor (IM) based electric vehicle (EV) system. The five-level H-bridge inverter supports the induction motor. The multilevel inverter was controlled with the help of PDC-PWM (Phases Disposition Carrier- Pulse Width Modulation). The reliability and stability plays significant role in this system so, in this paper the authors also focused on detecting and locating the faults in the system and then replace the damage part with new one. A practical algorithm was used to tracking the fault and detaches it by replacing the damaged cell with a new cell. The detection and correction of defected cell is very easy because the process of localization was based on based on present calculations of its value and THD percentage. The required corrections can be realized by executing the suggested algorithm with the help of MATLAB/Simulink.

Quanqing Yu et al. [13], In this paper, researchers identified a prototype for electric vehicles relying on the strategy of sensor fault classification for lithium batteries. In this technique, the Unscented kalman filter (UKF) was used to measure the State of Charge (SOC) of battery in real-time. The ampere-time integration method can estimate the amount of charge/discharge of battery for certain time duration. So the capability of the cell was determined from its ratio of the amount of SOC change to the amount of charge or discharge over a given time interval. The sensor failure was identified from the variation in between power used for SOC estimation and the expected capacity. This suggested technique for detecting the fault of the sensor was proved by the dynamic stress test.

S. Bhagyalekshmi et al. [14], in this paper, authors presented solar powered electric vehicles which can be used for detecting major defects in railway tracks with greater precision. This system is very accurate and cost effective. Conventionally, the manually operated cart is used for this purpose but this vehicle is automated and controlled with the help of Raspberry Pi. To detect the faults like horizontal split, broken rail and broken base, Image processing is used in this system. The Ultrasonic sensor is used to find the faults like misalignment of tracks and crushed head. In addition to this, Vibration sensors are also introduced in this system to detect faulty areas in railway track. So, this system made the rectifying process very simple by providing the detailed information of faults. The GSM module and Raspberry Pi were used to introduce the framework. An effective communication process between the system and the control room was necessary for the system to operate systematically. This system is eco-friendly as it works on solar energy which is renewable resource of energy.

K. Bouibed et al. [15], This paper was focused on the identification and correction of faults in sensors and actuators in automated electric vehicles. So, the authors of this article proposed two model based techniques in order to resolve these issues. In reconstructing the state vector and the device effects, the first technology utilizes sliding mode observers and the conclusions drawn from this comparison was regarded as residual. Another method depends on nonlinear analytical redundancy (NLAR) and was used to remove the unknown condition and factors so that it becomes possible to achieve the relationship among all the known variables. The main purpose of authors is to show the interest of these two techniques for detecting sensor and actuator faults of electric autonomous vehicles. So, it was concluded from the simulation results that the sliding mode observer was more adequate to detecting sensor faults and the method of NLAR was better for detecting actuator faults.

Yakoub SAADI et al. [16], The purpose of the researchers of this paper was to find out and trace regularly the open circuit defects in the electronic power converter in association with four phases 8/6 Switched Reluctance the system which was used in an electric vehicle drive train. The designed approach was on the basis of spectral analysis which uses the FFT algorithm over a periodic sliding window as total referral torque given via velocity controller and evaluated current of every phase. The updated technique, which produced an open circuit defect over a system load torque in a certain stage of the converter/ Switched Reluctance Machine, was eventually verified on the simulator of an electric machine. Besides, to identify beyond one open circuit defect, this methodology could be expanded. In locating open circuit defect regularly and in control unit of electric machines, this scheme could be helpful.

Yongzhe Kang et al. [17], This study focused on an online multi-fault diagnostic technique. This approach was based on the proposed method of correlation coefficient and the redundant calculation circuit of crossed style. Each sensor in the measurement circuits calculates the voltage total of two neighboring cells and one link component without raising any hardware cost. The correlation coefficient approach was used for the reason of capturing the fault signatures as well as measuring the fault grade. By defining the correlation coefficient of adjacent voltages with fault flags, these two methods could be used to distinguish cell faults from all other faults. For distinguishing voltage sensor faults and link faults, the correlation coefficient of the adjacent voltage difference and current could be used. With the aid of the multi-fault diagnostic process, false fault detection could be prevented and so this approach further ensures high reliability to normal measurement errors and temperature change, health status and SOC inconsistencies. The theoretical and experimental results show that is method is very useful for fault detection.

Xinming Gao et al. [18], The author suggested an error detection protocol for the charging pile based on the ELM method in this article. This method constructs data for common charging pile characteristics, unlike the conventional charging pile fault detection model, and develops a classification prediction frame work that relies on the algorithm of the Extreme Learning Machine (ELM). Experimental findings show that the precision of the frame works is 83 percent, with high performance, good practicability, and simple to popularize.

Table 1: Analysis table of different fault detection approaches

Author Name	Publication Year	Work Done
Boulaid Boulkroune et al.	2019	Explored actuator's fault detection and isolation issues and sensor failures affecting the side behavior of automated vehicles
Waad Rtibi et al.	2019	An algorithm is used to tracking the fault and detaches it by replacing the damaged cell with a new cell
Quanqing Yu et al.	2019	Proposed a the Unscented kalman filter based technique to measure the State of Charge of battery.
S. Bhagyalekshmi et al.	2019	Presented solar powered electric vehicle capable of detecting faults by use of image processing
K. Bouibed et al.	2010	Proposed two model based technique for detection and correction of sensor and actuator faults on the electric autonomous vehicles
Yakoub SAADI et al.	2019	The designed approach uses the FFT algorithm to find out and trace regularly the open circuit defects
Yongzhe Kang et al.	2020	This paper is focused on the method of an online multi-fault diagnostic
Xinming Gao et al.	2020	Machine learning ELM algorithm for detection of fault in charging piles of an electrical vehicle

The above table provides the brief research works done by different authors in domain of fault detection technologies in area of electrical vehicles.

IV. CONCLUSION

The electrical vehicles will be the new normal in the future. The electrical vehicles have seen a great advancement in recent times. But at present time, there are several kinds of faults in electrical vehicles which are explained in this paper. Basically, the conventional techniques have low efficiency, low precision rate, less detection efficiency etc. And the need of the hour is resolving the faults appearing in recent development. In order to fix the issue of low efficiency and reduced accuracy rate of charge fault detection, few methods are being implemented, but improvements are still possible. Advanced learning algorithms used by artificial intelligence or machine learning will be the focus for future advancement in electrical vehicles.

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