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Weighted Sum Model (WSM) based Selection of Battery in Electric Vehicle.

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ABSTRACT: — Battery-powered electrical Vehicles area unit beginning to perform a significant role in the automobile sector. There exist many categories about batteries discovered in this development in electrical vehicles, for which to determine the fulfills most beneficial essential features, from totally various perspectives, like energy storage efficiency, valuable characteristics, expense amount, and protection. This study confers the liberty of an electrical Vehicle employs 4 different varieties of batteries: lithium-ion (Li-Ion), Lead Acid, Nickel Metal hydride (Ni-MH), and Nickel-cadmium (Ni-CD), all of them should continuous electrical energy storage capacity. Since the battery area a very important role in the completion of an electric vehicle, so it is required to find out the most beneficial or optimal performance of the batteries with the list specifying. So by using the WSM method we found that the ranking status for the battery for Lead-acid is second, for Nickel-cadmium (Ni-CD) is third, Nickel-Metal hydride (Ni-MH) is fourth and for Lithium-ion is first.

Keywords: — Battery, Charging efficiency, Discharge rate, Electric Vehicle (EV), Life Span, Minimum cost, Normalization, Self -Discharge rate, Weighted Sum Method (WSM).

1 INTRODUCTION.

Electric vehicle (EV) is the most demanding vehicle in the automobile sector. The main purpose of this electric vehicle is to overcoming nursery gas (GHG) effusions. EV enough perforation in the transportation section is required to reduce that number. As a city transportation mode, it is useful. The power sector goes through an ever-changing section wherever renewable sources area unit getting energy for a charge. As a vehicle, an energy unit is low, straightforward control, including doesn't have the fuel prices connected with standard vehicles.

Hybrid Electric vehicles (HEVs) and Electric vehicles (EVs) have largely considered as the hopeful explications to substitute the common internal combustion (IC) engine-based vehicles, also modern times have noticed an expeditious growth of EV and HEV technologies. Batteries are largely employed because of the energy stores for HEVs and EVs until the profits like special energy density, low atmosphere contamination, and continued living time. The battery needs specific responsibility in Electric Vehicle utilization. Battery electric vehicles can assist in studied fossil fuel utilization and nursery gas ejections. Especially in factory or company charging relieve some reduction of renewable sources, when implementing charging possibilities to long route passengers [1]. The main shortage of the EV is a battery-based storage system, in the modern phase of expansion that performs the electric vehicle small permissible to purchasers. Comparatively small cycle periods, huge responsiveness to ambient states, environmental dangers, and almost insufficient output power are simply some of the shortage from modern battery technology [2]. On the high requirement for fossil fuels in the global markets together with the difficulty of environmental difficulties produced by an improved number of internal combustion engine vehicles, there is enhanced importance in the study and improvement of batteries utilized in hybrid and electric vehicles [3]. The battery according to specific and adequate test standards, so that clients with different needs can choose. In the similar tests of electric vehicles, the power battery completion detection system has many symbols, such as battery cycle stability, battery over-discharge [4]. Inappropriate actions such as over-current, over-voltage, or overcharging and releasing will produce notable protection issues to the battery, noticeably stimulate the method, and still cause ignition and discharge [5]. The battery administration method performs a required function in securing the stability also execution of battery. A designed charging system order preserves battery next loss defines temperature distinctions as improve the performance of energy transformation. Slow charging has a real impact on the availability of EV utilization, but charging is fast resentfully lead to high energy waste and warmth growth [6]. Extensive temperature variety additional leads to the fast battery also likewise generate heating instead of super-cooling, which finally decrease the battery service life [7]. The total energy savings by co-optimization range from 5.3% to 24.2% for energetic driving on a cragged field. Meanwhile, on a similarly flat road, the advantage of co-optimization is a smaller amount essential. Even so, co-optimization reached a 0.5%-5.3% reduction in total energy loss as compared to incessant optimization [9]. Optimization-based design is a major complicated so, necessitate more complicated numerical effort and experience however, they prepared to produce optimal administration according to a particularized cost use and similar restrictions [10]. The power variation of the fuel cell held restrained inside 250 W/s in three standard road conditions, which expects helpful to elongate its lifespan. Meantime, the submitted EMS nearly saves up to 4.4%, 2.6%, and 2% hydrogen in relating to the EMS based on an indefinite check under three drive cycles, severally [12]. The multi-objective sunflower optimization algorithm is improved to together optimize two objective functions and obtain the optimal parameter description and determine the status of cost [13]. The maximum evaluation failure of capability established by sampled real EVs is shorter than 4%. Based on the modern cloud data, the evaluation process can precisely determine the ability of the energy battery in EVs and recognize the growth forecast [14]. If the EV battery has attained their performance of life in the vehicle, they furthermore should sufficient energy used in additional applications as Fixed energy storage applications. Remanufacturing at the battery level has advantages on both modules and cell levels and shorter time is needed and several cost [15]. The increase in discharged and charged power in an encouraging state begins to an addition of 7.77% in stored energy of electric vehicles aggregator further it is decreased 23.32% in the real problem in relation to the numerical problem. The robust optimization technique shows the ability of the suggested design in electricity store cost contingency in association with the deterministic appearance [19].

2. Battery Electric Vehicle (BEV)

Battery electrical Vehicles conjointly acknowledged as BEVs and supplementary known as EVs, are fully-electric vehicles with reversible battery and not the internal-combustion engine. Battery electrical vehicle collect electricity aboard including high-capacity battery packages. The battery power is operated to drive the electric motor and everyone aboard electronics. BEV's don't release harmful discharges also uncertainties generated by classical gasoline-powered vehicles.

BEV's are the best variety of electron volt from a general prospect, electric power from one supply the electrochemical battery to power the one supplementary electrical motor. Basically, one motor is connected to the front shaft by an easy one or two speed cases; however, there are many alternative doable modifications within the driveline constructions. Electric vehicles with individual batteries to provide power to drive trains are related to BEVs. BEVs have to be constrained uniquely on this energy keep into the battery pack; thus description of some vehicle depends on the battery storage directly. Usually, the BEV will cover a 90– 250 km on one charge. These limits depend upon the driving situation, vehicle arrangements, road situations, environment, battery variety, and life. The charging period depends on the charger shape, it is the foundation of the operational power. The advantage of BEVs is its easy installation, development, availability. They don't escape gas (GHG), don't generate noise, and hence helps the environment.

The battery is made of many cells that are formed of modules, which is a service and arranged into a set. This is done in several types doing parallel and series connection in a group of this cell. EV electric motors essentially perform at hundred volts, indicating a minimum of about 101 cells is needed. Though, some agencies have many but small cells, up to tens thousand, configured in a compact array with parallel-series connections. Subsequently, it deserves seeing that one theory of BEV is to have the battery pack be quickly detachable and swappable. This permits toward elongated drive span into the performance of battery swap locations and classification for customers to consume preferably than own their batteries. Figure 1 explains a basic arrangement for BEVs.

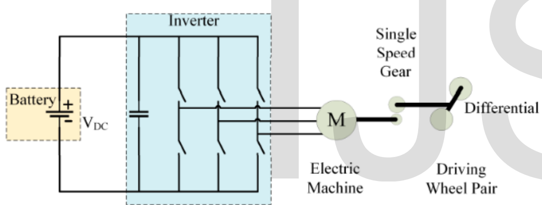

FIGURE 1:-BATTERY ELECTRIC VEHICLE CONFIGURATION.

3. Batteries for BEV's.

Batteries are the most important key power supply toward EVs for a large time; although, as time has passed, entirely various battery technology has been developed furthermore utilized this method remains transpiring to accomplish the defined performance goals. The excellent battery descriptions are lead-acid, Ni-CD, Ni-MH, Na/S, Li-ion, and Li-polymer batteries. Lithium-ion batteries are being operated everyplace recently. It displaced the lead-acid equivalent plus shifted a prime technology. Nature will balance by the experience the commercial EVs. Higher battery technologies are recognized previously, still, they're not occurring proceeded due to the excessive prices connected including their examination and improvement; therefore it will be equivalent that, lithium battery can overlook the EV.

Battery type	**Lead acid**	**Ni-CD**	**Ni-MH**	**Lithium-ion**
Life span (cycle)	250	1000	450	1800
Charging efficiency	72.5	80	65	85
Self-discharge rate (%/month)	5	20	30	6.5
Cost (rs/kwh)	20474.26	21311.50	Avg-57084.385	Consumer electronic - 41861.875 Vechicle:- 114168.75

Table 1:- characteristics of EV's Battery

In above table there are some beneficial and non- beneficial parameters are present. Some beneficial are long life span , higher specific energy rate, higher specific power rate , higher charging efficiency, low self discharge, higher energy density, high power density, high nominal voltage, etc. The value of below table are refers from above table.

Beneficial	**Battery type**	**Non-beneficial**	**Battery type**
Long life span	Ni-CD- 1000, Lithium-ion – 1800	**Short life span**	Lead acid - 250, Ni-MH – 450
High charging efficiency	Ni-CD - 80, Lithium-ion – 85	**Low charging efficiency**	Lead acid - 72.5, Ni-MH – 65
Low self – discharge	Lead acid - 5, Lithium-	**High self-discharge**	Ni-CD - 20, Ni-MH -30

rate	ion – 6.5	**rate**	
Minimum cost	Lead acid – 20474.26	**High cost**	Ni-CD - 21311, Ni-MH - 57084, Li-thium-ion – 114168

Table 2:- Beneficial and non-beneficial parameters

One issue with several certain bits of knowledge of battery evaluations toward vehicles is that they got to analyze the BMS or a lot of typically unique “balance of plant” required supporting the utilization of individual battery in the vehicle. This can be particularly necessary within the situation of Lithium-ion batteries, which gives vital demands to cooling and are receptive to overburdening. The BMS may be an essential value thing for exceptional batteries, performing because the combination element for battery and vehicle systems, though studies don't represent the range to that they combine the prices of the BMS also the battery package.

4 Methodology

This study aims to the optimization of Electric vehicle battery. In the current analysis, for battery selection, Weighted Sum Model (WSM) Method is used. The introduction of the WSM method is as follows.

4.1 Introduction of WSM

The WSM or weight sum model is perhaps the simplest among the methods commonly used in for multi-criteria decision making. The WSM method consist of three phases are the following:-

1] Normalizing the decision matrix

2] Designating the weight vector

3] Calculating the overall rate for each choice.

The WSM method has 4 steps are the following:-

Step 1:- Design of decision matrix and weight matrix

For a MCDM problem consisting of *m* alternatives and *n* criteria. Let D = X_{ij} be adecision matrix, where X_{ij} € R

$$D = \begin{bmatrix} x_{11} & \dots & x_{1j} & \dots & x_{1n} \\ \vdots & & \vdots & & \vdots \\ x_{i1} & \dots & x_{ij} & \dots & x_{in} \\ \vdots & & \vdots & \ddots & \vdots \\ x_{m1} & \dots & x_{mj} & \dots & x_{mn} \end{bmatrix}$$

The weight vector may be expressed as,

$W_j = [W_1 \ \dots \ W_n]$, where $\sum_{j=1}^{n} (W_1 \dots \mathbf{Wn}) = 1$

Step 2:- Normalized of decision matrix

$$n_{ij} = \begin{cases} \dfrac{x_{ij}}{\max x_{ij}} & | j \in B \\ \dfrac{\min x_{ij}}{x_{ij}} & | j \in C \end{cases}$$

Where n_{ij} is normalized value of the i^{th} alternative for the j^{th} criterion .max x_{ij} and min x_{ij} are the maximum and minimum value of x_{ij} in the j^{th} column for benefit (B) and cost criteria (C) respectively.

Step 3:- Weighted normalized decision matrix

$W\, n_{ij} = w_j\, n_{ij}$

Step 4:- Ranking of alternative

$S_i^{WSM} = \sum_{j=1}^{n} w_j\, n_{ij}$

Where S_i^{WSM} is the ranking score of i^{th} alternative , w_j is the weight of the j^{th} criterion. The alternative are then ranked in the descending order with the highest S_i^{WSM} being ranked highest.

The data set for this WSM method are as follow:

DATA SET				
Battery Type	**Life span**	**Charging Efficiency**	**Self dis-charge**	**Cost (Rs/kwh)**

			rate	
Lead acid	250	72.5	5	20474.26
Ni-CD	1000	80	20	21311.5
Ni-MH	450	65	30	57084
Lithium-ion	1800	85	6.5	41861

Table 3 :- Parameters of battery for WSM method

5 Result

As we describe the WSM method for an electric vehicle, we applied it to the above battery type as shown in table 3 with their parameter. From table 3 we will find the solution of the WSM method for an EV battery.

5.1 Normalization of Decision matrix.

From table 3 we will find the normalization of battery. The result of normalized matrix is given in the below table.

Normalized Matrix				
Battery Type	**Life span**	**Charging Efficiency**	**Self dis-charge rate**	**Cost (Rs/kwh)**
Lead acid	0.13889	0.85294	1.00000	1.00000
Ni-CD	0.55556	0.94118	0.25000	0.96071
Ni-MH	0.25	0.76471	0.16667	0.35867
Lithium-ion	1	1	0.76923	0.4891

5.2 Weighted Normalized decision matrix.

The weighted normalized decision matrix is can solve by step 3 in the WSM method. By using the design matrix. We will keep weight factor overall is 0.25 as shown in below table. We will find the solution of step 3 as follow.

Weight				
Battery Type	**Life span**	**Charging Efficiency**	**Self dis-charge rate**	**Cost (Rs/kwh)**
Lead acid	0.25	0.25	0.25	0.25
Ni-CD	0.25	0.25	0.25	0.25
Ni-MH	0.25	0.25	0.25	0.25
Lithium-ion	0.25	0.25	0.25	0.25

Weighted normalized decision matrix				
Battery Type	**Life span**	**Charging Efficiency**	**Self dis-charge rate**	**Cost (Rs/kwh)**
Lead acid	0.03472	0.21324	0.25000	0.25000
Ni-CD	0.13889	0.23529	0.06250	0.24018
Ni-MH	0.06250	0.19118	0.04167	0.08967
Lithium-ion	0.25	0.25	0.19231	0.12228

5.3 Preference score & Rank.

By using the WSM method for EV battery we can calculate the preference score of each battery. Based on Rank we are said that which battery is optimal for using in Electric Vehicle.

Battery Type	Preference Score	Rank
Lead acid	0.74796	2
Ni-CD	0.67686	3
Ni-MH	0.38501	4
Lithium-ion	0.81458	1

Based on the rank position of battery which we calculated on the basis of the WSM method we are said that the Lithium-ion battery is optimal for use in Electric vehicles.

6 Conclusion

From this study, we examine Lithium-ion, Ni-MH, Ni-CD, lead-acid batteries from the analysis of this battery for batter selection by the WSM method. The lithium-ion battery can be utilized in the electric vehicle which fulfills best all the nearly most necessary characteristics mentioned in the abstract. From the result, we can see that lithium-ion battery in the normalized matrix is optimal comparatively other battery types. By the Weighted sum method, we conclude that the lithium-ion battery is the optimal battery based on their Rank.

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