Features of operation of electromobile transport in the conditions of Russia

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Abstract

Electric cars in Russia are used in large cities. It is preferable to commercial use, since the lack of it is currently charging infrastructure on the territory of the enterprise can create a rapid charging station and arrange proper maintenance of an electric vehicle. Another argument in favor of the purchase of an electric vehicle - comfortable car loan program in the Russian market. Advantages of electric vehicle in Russia compared to a car with an internal combustion engine: - Reduction of harmful emissions in operation, by transferring them to a higher level (electric vehicles themselves do not emit harmful substances, but most of the electricity is produced by thermal power plants, the efficiency is higher than the efficiency of the internal combustion engine); - Low noise (motor runs very quietly, mostly noise coming from the wheels of a moving car and air currents flowing around it); - Electric multiple times cheaper to run (besides electric vehicle can be charged at the nightly rate). Disadvantages: - Limited cruising range (100 - 150 km for conventional electric vehicles, 200 - 300 km for class "lux"); - A long time to recharge the battery (7 - 8 hours of charging from a household network, about half an hour - to express the charging station); - High cost of acquisition, the main component of which is the price of batteries. An important role in the development of electric vehicles in Russia plays implementation of an appropriate charging infrastructure - charging stations. The main problem of electric vehicle - specific Russian conditions, among which are the harsh winters with low temperature conditions, bumpy road surface. Keep in mind that during the winter when using heaters real running electric significantly reduced.

Keywords: electric car, electric motor, energy store, infrastructure, operation

1 Introduction

Use of electromobile transport [1] in Russia is faced with some peculiar problems. The main factor making the Russian operating conditions unique is cold climate and difficult road conditions, such as snow on the roadway. Such conditions adversely affect the characteristics of electromobile transport. To solve this problem, we propose to make changes in the design of such vehicles.
2 Climatic conditions in Russia

Russia spans a vast territory of the Eurasian continent and has a wide variety of climatic zones. In the northern territories the winter period reaches 300 days and air temperature drops below -50 °C, which requires routine use of additional equipment in vehicles to ease engine start, heat up operation fluids and ensure more efficient heating of the vehicle cabin. If we consider central Russia, the typical winter conditions last for at least six months. In the south, winter lasts for not more than 40 days and the temperature rarely falls below -5 °C. The number of days per year with an average temperature of 0 °C or less is 171 days on average for the Russian Federation as a whole, i.e. 47% of the year. Therefore, vehicles are operated at low and at times extremely low temperatures. Such conditions make it difficult to use even a vehicle equipped with an internal combustion engine, not to mention electric ones.

Note, that performance indicators claimed by the manufacturers of electric vehicles, such as driving range and battery charging time, are often focused not on the realities of Russia but rather on the Central European climatic zone, excellent road and charging infrastructure. Nevertheless, these figures become the criteria of electric transport applicability for daily life. The above-mentioned specific conditions existing in Russia will undoubtedly affect the originally stated performance values.

One of the most essential elements of electric transport operation are high-voltage batteries, but their performance is highly dependent on the way how and in what environment the vehicles they are installed in are operated. Currently the most popular type of batteries for electric vehicles is lithium-ion batteries. They have many advantages compared to other types of batteries: high energy density (capacity), low self-discharge and maintenance-free operation.

3 Test of electric cars in winter conditions

The testing center of "NAMI" conducted bench tests of the effects of ambient temperature on the operational performance of an electric vehicle. The test vehicle was an electric Nissan Leaf car. The power of its electric motor is 80 kW, and the capacity of the rechargeable Li-ion battery is 24 kWh. Its declared maximum driving range is 160 km. The bench tests were based on the method outlined in UNECE Regulations No. 101-00, which implies simulation of a combined driving cycle (urban-rural). The tests [2] provided data for an assessment of the electric vehicle's driving range sensitivity to changes of ambient temperature, external loads caused by rolling resistance and extra stress on the on-board electrical network created by energy consuming devices. As a result of the test it was found that a drop of ambient temperature from +25 to -7 °C reduces the driving range by 9% and further up to 44%, when extra energy is consumed by additional equipment, shown in Figure 1.

![Figure 1 - Effect of ambient temperature and supplementary equipment on the driving range and energy consumption](image)

The figures obtained during the bench test are confirmed by similar results from road tests carried out on a snowy road with different load on the on-board electrical network and vehicle load. The state of the road surface, which heavily affects the amount of energy spent to clear the way, also affects the driving range, shown in Figure 2. Our studies have shown that under the worst driving conditions (on loose snow) the driving range is 14% less than during driving on dry asphalt. The presence of ice on the road reduces the driving range by 9%. Compacted snow reduces the running distance before full battery discharge by 5%. Thus, the task of maintaining normal operation environment for the batteries is extremely important. The results of the studies of battery charge dependence on temperature changes [3] are shown in Figure 3. It can be seen that the charging power reaches its maximum in the temperature range between +20 and +40 °C. In
order to avoid thermal problems and achieve better battery performance, it is necessary to maintain the ideal temperature range, which influences the battery charge level and its life cycle, shown in Figure 4.

![Figure 2 - Effect of the road surface condition on the driving range and energy consumption](image)

![Figure 3 - Dependence of battery charge on the temperature changes](image)

![Figure 4 - Life cycle at temperature difference](image)

The diagrams demonstrate the dependence of driving range on ambient temperature, but energy consumption depends to an even greater degree on the number of activated supplementary systems (heating, lighting, light-signaling devices, etc.), which are essential for driving comfort and safety. It is in the mode with active supplementary systems that the most intensive energy consumption is observed, which significantly reduces the vehicle's driving range, virtually eliminating the possibility of traveling more than 50 km at low temperatures.

Similar tests to identify shortcomings of electric vehicles in winter, were carried out by Tesla Motors [4]. Tests of Tesla Model S in Minnesota showed that the ambient temperature below zero, certainly affects the battery and vehicle's power. The test revealed that the power of Model S is reduced by 20% at -10 °C and average amount of snow. At the same time, the battery charge will last for a shorter stretch of the road. Operating Guidelines for Tesla Model S in winter are as follows: electric vehicle should be stored in a separate heated garage to preserve battery life; it should not be left in hard frost without the motor running; cold start after a relatively long stop (about 30 minutes) is not recommended; starting-up and warm-up is best done while connected to the electric power grid; models with air suspension are preferable, because of the ability to adjust clearance; recommended minimum allowed operation temperature is -15 °C.

4 Possible solutions

It is obvious that Russian versions of electric vehicles designed by foreign manufacturers require special equipment. Even stock cars with internal combustion engines are often equipped with special "Russian package", which includes wheel suspension with different characteristics, exhaust after treatment systems less sensitive to the quality of the fuel, and so on.

To prepare a vehicle for operation in areas with cold climate additional onboard equipment should be installed, especially heating systems, powered not only and not so much by batteries, but by other sources of energy, lighting devices with lower power consumption, etc.

The problems of introducing electric vehicles are associated with significant investments in research (especially concerning the development of highly efficient energy sources), creation of designs and preparation of their production, building the necessary infrastructure. There are a number of specific requirements concerning electric vehicles, which are related with limited driving range for a drive cycle (80-150 kilometers per charge), hill-climbing restrictions, relatively low acceleration dynamics, expensive infrastructure (first of all the network of charging points for batteries, warm boxes for storing EVs during winter), etc.
A partial solution to the above problems, it offered by Range Extender system, which would support supplementary systems of the car and increase the equivalent battery capacity, therefore, increasing the driving range of the electric vehicle.

This system consists of a small ICE of low capacity, which actuates an electric generator and has no kinematic connection with the drive wheels. When a certain level of traction battery discharge is reached, the ICE is automatically started and charges the battery while running in the optimal mode. The Range Extender system is shown in Figure 5.

Figure 5 - Range Extender system (1. Range Extender module; 2. fuel tank; 3. energy storage device; 4. inverter; 5. reversible electric machine 6. reduction gear with the main gear)

The Range Extender system provides high economic and environmental performance being reasonably compact, and is preferable in the design of a hybrid vehicle [5] with high electric mileage, which is often necessary.

Range Extender system has a number of advantages:
1. It is small in weight and size but can significantly increase the distance traveled on one filling.
2. It has a wide range of layout solutions.
3. Relatively high efficiency.
4. Possibility of running ICE in economically and environmentally optimal modes.
5. Possibility of driving long distances exclusively on electricity.
6. Relatively simple controls.

Figure 6 shows different Range Extender systems from several manufacturers.

Figure 6 - Range Extender systems of different manufacturers

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References

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