FEATURES UPON CONVERTING A CONVENTIONAL CAR INTO AN ELECTRIC CAR

Assoc. Prof. Rachev S. PhD [1], Assist. Prof. Lyubomir Dimitrov PhD [1], Assist. Prof. Dimitrina Koeva PhD [1]
Technical University of Gabrovo [1], Republic of Bulgaria

sratchev@mail.com

Abstract: *Paper deals with specifics of converting a conventional car into an electric one. The main stages of the conversion process are dealt concise but thorough. The findings are the basis for launching a large scale project with the necessary duration and financing, as a result of carrying out the necessary development activities and experiments will proceed to the development of a prototype, which will ultimately be realized. The overall focus is on research and application in the students' learning process.*

KEYWORDS: *MOTOR DRIVES, ELECTRIC MACHINES, TRACTION MOTORS, INDUCTION MOTORS, ENERGY CONVERSION, BATTERIES, GEARS, STEERING SYSTEMS, ELECTROHYDRAULICS, AUTOMOTIVE COMPONENTS*

1. Introduction

The trend towards creating and producing environmentally friendly and energy-saving cars in the world has become irreversible. This trend is constantly accelerating by the depletion of the raw materials of liquid fuel and natural gas as well as by global warming and environmental pollution caused by the rising consumption of these raw materials. An alternative to solving this problem is the *conversion* of various models of classic cars with internal combustion engine (ICE) in electric vehicles (EV).

Conversion of conventional cars with ICE to EV is not new - conversions have been made for a long time. In short, the reason for doing so is the desire for clean and alternative moving at a lower cost. Like most things, conversions have equipment/cost levels. Incidentally, it is precisely the subject of the conversion that is the main reason for the creation of the Electric Vehicles Industrial Cluster (EVIC) 8 years ago (registration on 25th November 2009) [21].

Conversion is a aggregation of all kinds of works and activities, the necessary new technical and software tools, mounting and complete parts, assemblies and constructions, which define and perform the conversion of an automobile with an ICE in a 100% EV (electric powered vehicle). In the world there has long been a system for converting available cars into EV. For conversion, training aids have been developed, courses are being conducted, complete kits are provided for the retrofitting itself in different ways of selecting the technical means. There are options for alternating current (AC) or direct current (DC) drive system. Typically AC systems are of higher voltage and give faster performance, but they can cost 2-3 times more than a simpler and proven DC system. Each system requires a motor, controller, batteries and charger. An additional advantage is that when converting, the equipment and functions most suited to the user's needs can be selected.

Regarding vehicle efficiency, it can be said that a thorough and accurate study of the advantages and disadvantages of all types of transport vehicles is a particularly important and interesting but difficult to solve problem [7]. Numerous studies to determine the optimal spheres for the use of particular types of transport, even under certain restrictive conditions, have shown that the task is difficult to solve, not least because of lack of accurately formulated and user-friendly assessment criteria. This allows in many cases to influence the final results.

Conventional vehicles with an ICE are, as an option, cheaper to buy. But the consumables - oils, filters, belts, clutch, brake linings, antifreeze, spark plugs, etc. have to be taken into account. In EV, the only consumables are batteries (and after a considerable amount of time), brake linings, and possibly some bearings. Many of the mechanical parts in conventional cars are missing in EV - for example, they do not have an exhaust system. On the other hand, On the other hand, batteries can be a problem. In EV, normal charging up to 100% of capacity (230V AC / 8-14A) lasts 6-11 hours, and fast charging up to 80% of the capacity (400V DC / 95A) - about 30 minutes. Most manufacturers give them a warranty of 8 years or 100000 km, and it will not be a problem and a mileage of 150000 km. The latest models feature rechargeable batteries that last up to 250000 km and even 300000 km.

Over time and increasing mileage, it is certain that batteries become increasingly worn, which has an adverse effect on the maximum range of the EV. Autoproducers do not put restrictions on the number of quick charges, but advise adherence to the slow charge at the current level of technology. There is no point in focusing so much on fast charging and long endurance, because 95% of the trips are less than 50 km long, and the urban environment is better to focus on practical solutions around homes, offices and parking lots [18].

Energy efficiency is extremely important information on the consumption of electricity from power grid to travel kilometer of the road. It is obtained as the ratio of distance traveled per unit of electricity consumed [4].

In 2009, the company "Koortech" Ltd., Varna started its activity in the retrofitting (converting) of vehicles with ICE in fully electric [23]. Several separate built-in kits have been developed, depending on the type of vehicle, desired mileage and dynamics. For the first time in Bulgaria, new generation rechargeable batteries are used. Thanks to their high energy density and low weight, converted cars justify their investment. The drive chain consists of the following elements: a drive motor, computer for controlling the drive motor (modulator), a built-in charger - DC/DC converter, an internal high voltage charging cable, an internal high voltage quick charge cable, independent cable for normal charging of the car, computer for controlling the battery.

The company Caproni PLC, Kazanlak also has a successful car conversion - Opel Corsa in this case [19].

According to some estimates, it is precisely in the conversion that a market niche can be sought for rapid realization of technological solutions.

Some reasons for conversion as a step towards electromobility are:

- No large financial resources are required.
- There will be an opportunity to collect a serious database of tests and applied innovations when installing one or more electric motors.
- Quick return on investment.
- The implementation can be based on Bulgarian products - electric motors, cable network, regulators, rechargeable batteries.

Furthermore, EV can be modularly updated. If a better engine, controller or some more efficient batteries are found, new technologies can be adapted gradually when they become available. In addition, there will be an opportunity to control the project (the converted vehicle and the selected components); as well as the ability to quickly diagnose and fix problems.

In order to make the best decisions, the requirements must first be identified.

The weight of an EV is paramount for any design, but high acceleration will dictate a type of approach to design and gear ratios, while high mileage design pushes things in a different direction.

The conversion bonus is the structure that comes with a whole body, chassis, suspension, steering and braking system, designed, developed, tested and safe, proven to work together. There is also another bonus for the body - bumpers, lights, glazed windows, etc., which are already pre-approved and tested to meet all safety requirements.

Conventional models of cars in recent years are ideal for conversion - not only because of the lower cost according to new vehicles with full depreciation, but cars with 40000 to 100000 kilometers traveled are suitable because in the vehicle the kinematic circuits, brakes and wheels / tires generate less friction (bends and edges wear, gaskets are inserted, etc.) and they roll/ turn around more easily.

When converting a conventional car into an EV, a 8-step procedure can be followed [21]:

1. Choosing a donor car and components.
2. Preparing the donor car for conversion.
3. Technological solutions for rechargeable batteries.
4. Design of the electrical system.
5. Technological solutions for component assembly and technical documentation.
6. Delivery and production of components.
7. Mechanical and electrical mounting. Tests and adjustments of the EV.
8. Preparation of documentation and registration of the EV.

After the conversion, the car should have a certificate from the Technotest JSC (independent private company with accredited testing laboratory for road vehicles) and registration in Traffic Police as an EV.

Performing preparatory work on the 8 steps listed may be the basis for launching a large-scale project with the necessary duration and funding. As a result of carrying out the necessary development activities and experiments to proceed to the production of a prototype, the latter is ultimately realized. This is also related to specialized forms of education - master's degree, engineering, professional, and so on training.

In connection with the above, there is a compliance with one thematic area of the Republic of Bulgaria's Innovation Strategy for Smart Specialization 2014-2020, as follows: Thematic area ‘Mechatronics and Clean Technologies’, where the following priority axis has been identified: • Clean technologies focusing on transport and energetics (storage, saving and efficient energy distribution). There is also full compliance with the Economic Strategy of Bulgaria, where as a third defined priority are laid down ‘Eco and energy saving technologies’ and with the first priority direction of the Strategy for development of science in Bulgaria till 2020, which is: ‘Energy, energy efficiency and transport. Development of green and eco-technologies’.

2. Choosing a donor car

Firstly, a lightweight construction is required.

An important indicator for modern vehicles is the mass per unit of power, which is determined by the dependence [1]:

$$g = M/P, \qquad (1)$$

where

M the mass of the vehicle, kg;

P the rated power of the vehicle, kW.

Output data are also set acceleration and desired mileage.

The converted car will be able to move both in the original version with an ICE - the same (or better, due to the high torque of the electric motors at angular speeds close to zero) acceleration and speed, but with lower mileage provided by rechargeable batteries.

The key is in simplicity. Everything that requires power from the engine is not desirable. Hydraulics and ESP are not as necessary as electric windows and seat heating. Excessive weight should also be avoided because it will cause an unnecessary load on the already heavy vehicle after putting on batteries and an electric motor.

It is necessary to pay attention to the presence of a vacuum pump that allows the braking system to function properly and this is extremely important for road safety.

It is important to say that the original gearbox plays an important role in the performance of the system and its preservation is advisable - because of the gearbox number, the motor will not be loaded too much. It is also essential to limit the revolutions of the electric motor to about 6500 rpm (despite the possibility of higher speeds) because most ICE operate within this maximum range, the transmissions are tuned to it and are highly likely to be damaged , if they have to work with the range of revolutions of the electric motors. Standard automatic gearboxes are not particularly suited to electromobility conversions because they require a number of expensive modifications to withstand the load on the electric motors.

There is a concept with which an EV can be driven by means of electromotors mounted in its wheels and this solution is really elegant. Even if this is not the most appropriate word, such a system will certainly eliminate energy-dissipating devices such as transmissions, drive shafts and differentials, which would allow for a more modular approach to propulsion and would save extra space for devices storing or producing energy [22].

An important component is the steering system. Electromechanical servo drive is appropriate. Electromechanical power steering is electrically adjustable, depending on the speed supporting steering effort, which works only when the driver needs it. This control does not include any hydraulic elements. It acts on the principle - by turning the wheel of the car, it does not spin the front axle directly, but rotates the mechanism of a machine that rotates the front axle.

Electromechanical is called because at the bottom of the steering rack there is an electric motor mounted with a control unit that boosts/drives the rake. The advantage over an electro-hydraulic power steering is that the vehicles equipped with it consume less energy in the end (the standard pump in the car always rotates with electro-hydraulic power steering).

The servo motors are equipped with speed and rotor position sensors relative to the stator. Typical of servomotors is the minimum start-up time to set revs and the minimum braking time. This means instantaneous achievement of the electronically controlled revolutions, as well as termination of the action. The torque is transmitted through a torsion shaft that is incorporated into the steering system. Electromechanical servo drive acts on the principle of current variation. For example, when turning the steering wheel, the force is transmitted through the torsion shaft. The torque sensor detects this variation and transmits it to the control electronics and the electric motor is doing this instantly.

3. Preparing the donor car for conversion

Removing the entire drive system. The engine, the radiator, the fuel tank, the starter, the exhaust system and the fuel pipes are removed from the car. Without compromising safety, the other components can also be removed to reduce weight. In addition, from a car costing only €500, you can get decent money from unnecessary components.

Somehow, the electricity has to reach the wheels, so the original transmission of the car is preserved. About the way the gearbox engages the engine and the way it is fully attached to the chassis - because the original gearbox is mounted to the engine, and with a couple of tampons in different places holding onto the passenger compartment, removing the ICE gearbox hangs.

An adapter plate made of solid aluminum to connect the motor to the transmission has to be made. First you have to make a template and make sure that the input shaft of the transmission and the output of the electric motor will fit perfectly. You need a little welding to connect the two shafts. A toothed adapter must be mounted on each shaft, which means that the motor and the transmission will be able to connect mechanically to each other to transmit power to the wheels. A number of mechanical problems can also arise, especially in the connection between an electric motor and a transmission. If they are not well aligned, the vibrations and shaft oscillations can lead to a serious mechanical problem.

The wide variety of the practical types of EV determines the exceptional variety of traction motors [7]. They can be classified by several features, the more important of which are:

– depending on cooling: with independent, inherent or mixed ventilation or convection;

– according to the way of suspension: for immediate, bearing-axle, bearing frame or special suspension;

– according to the way of transmission of the torque from the drive motor shaft to the motor axles: for individual, group or special drive of the axles or wheels.

The traction motors can be classified according to the type and size of the supply voltage, the type of EV for which they are intended, the rated power, the degree of protection, the insulation class, etc.

Comparison of different motor design is done in [3].

At present, for the purpose of better efficiency, and due to their known advantages, mainly AC electric motors are used in EV.

Although scientist Nikola Tesla wrote and discussed the use of EV with the alternate (induction) motor until 1904. in [16], when the EV is already contained in the traffic in the United States a decade ago founded the company bearing his name, Tesla Motors, which is producing very interesting and modern sports EV.

In contemporary EV the choice of propulsion (traction) motor is not only related to the price/quality criterion. Frequently defined are the specific weight-overall dimensions indicators, as these motors have to fit in a certain volume and have satisfactory electromagnetic and mechanical performance [15].

Depending on the purpose of the EV, the maximum efficiency value of the electric motor is selected at a certain load. This is achieved at the expense of an appropriate choice of the ratio between the variable (electrical) and the constant (mechanical and magnetic) losses of the electric machine [1].

Creating an optimal custom motor for electric vehicles requires that multiple electro and mechanical components are designed and tested together as a system. All of the parameters to be optimized have to be considered simultaneously. It is necessary to account for the dynamic interactions between the components, as well as all the necessary parameters to determine optimal solutions [12].

4. Designing (preliminary) calculations

Determination of the total weight of the electric vehicle [6]

The total weight of an EV G is determined by the number of passengers using the formula:

$$G = G_0 + G_T = (1 + k_T)G_T \tag{2}$$

where

$G_0 = k_T G_T$ the own weight of an EV;

G_T the load capacity of the EV (the weight of the payload, together with the passengers and the driver);

$k_T = \dfrac{G_0}{G_T}$ the coefficient of load of the EV.

The load capacity of an EV is determined by the number of passenger seats through the formula:

$$G_T = G_P z + G_L \tag{3}$$

where

G_P the weight per 1 passenger, which is assumed on average at 0.75 kN;

z the number of passenger and driver seats;

G_L the luggage weight, which is taken up to 0.5 kN.

The following values can be used for EV:

$k_T = 2.5 \div 3.5$.

Selection of the electric motor and gear ratio of the transmission box [6]

The key to a better EV is more efficient propulsion.

The electric motor of the designed electric vehicle is selected according to the set maximum speed. The power required to ensure movement is determined by the formula:

$$P_{V\max} = \frac{F_k V_{\max}}{3.6\eta_E \eta_M} = \left(fG + k_a S \frac{V_{\max}^2}{13} \right) \frac{V_{\max}}{3.6\eta_E \eta_M} \tag{4}$$

where

F_k motive force, N;

$V_{\max}$ set maximum speed, m/s;

η_E efficiency of the electric motor;

η_E mechanical efficiency of the transmission;

f coefficient of the movement resistivity, takes values [0.012÷0.08] depending on road conditions (pavement)

k_a coefficient of the aerodynamic drag, kNs^2/m^4, takes values $[2\div3]10^{-4}$ kNs^2/m^4;

S front area, m^2, takes values [1.5÷2.8] m^2.

After selecting the electric motor, the gear ratio of the transmission box is determined by the formula:

$$i_T = \frac{\omega_N r_k}{V_{\max}} \tag{5}$$

where

ω_N rated angular speed of the electric motor, rad/s.

After determining the gear ratio of the transmission box, a check has to be carried out to overcome the maximum angle of inclination $\alpha_{\max}$, which must be set at the beginning. The check can be made by bringing the total resistance force from the path F_k to the shaft of the electric motor.

$$M_{\alpha_{\max}} = \frac{F_k}{\eta_M i_T}\left(f \cos\alpha_{\max} + \sin\alpha_{\max} \right)G. \tag{6}$$

The following condition is required

$M_{\alpha_{\max}} < M_{\max}$.

The last variable is the maximum torque of the electric motor shaft.

If this condition is not met, a more powerful electric motor must be used or the gear ratio to be increased at the expense of the maximum movement speed.

The following technical data are important for the electric drive of EV:

Motor Technical Data
Rated power, kW
Peak torque, Nm
Battery voltage, V (one of the preferred values is 144 V)
Nominal speed, rpm
Speed range, 0-xxxx
Efficiency, %
Insulation class, (for example F-class)
Protection (IP 54 prefered)
Cooling (natural air)
Overall dimensions: Φ and length, mm
Weight, kg

Inverter technical data
Max. Capacity, kVA
Input voltage, DCV
Output voltage, V
Current rating, A
Ambient temperature (for example -25-60°C)
Peak current, A
Efficiency, %
Protection (IP 54 prefered)
Cooling (forced air)
Weight, kg

The electric motor undergoing research in [4] and a major component in the electric drive of an EV, obtained by the conversion of Opel Corsa, is induction type with a double-cage rotor manufactured by Caproni JSC, Kazanlak [19]. This motor has the following technical data:

Purpose - electric motor for mounting on electric vehicles; Mode of operation – continuous duty S1; Rated power: 16.5 kW; Rated voltage: 135 VAC; Rated rotational frequency: 2600 min^{-1}*; Number of poles pairs: 2p=4; Frequency of supply voltage: 86 Hz; Rated torque: 61 Nm; Rated current: 94.5 A; Rated efficiency: 92.5%;* $\cos\varphi_{ном}$*: 0,81; Degree of protection: IP21; Insulation class: F; Weight: 104 kg; Temperature sensor: KTY84/130; Sensor bearing SKF – number of impulses 80; Battery voltage:144 VDC.*

5. Batteries and controller

The number and size of the batteries depend on the selected motor. For example, if it is for the 72 V voltage the car will need six 12 V batteries. For lithium batteries, each cell has a rated voltage of 3.2 V. Given that batteries are heavy, weight distribution is essential. It is recommended to place two-thirds of the batteries in the boot, and the others under the hood to the motor. The batteries are connected, and an electric charge plug can be placed in place of the tank cap. The location of the batteries is chosen to be charged both on the electric vehicle and on the outside, while at the same time ensuring a uniform distribution of the mass of the whole EV and achieving a fairly good center of gravity [17].

The controller is required to adjust the power from the batteries to the motor, indicating the current value in amps. It uses a potentiometer to provide electric current and power regulation. It connects to the accelerator and provides the connection between batteries and an electric motor. The prospects for controllers are in the new ways to regulate the performance of traction motors.

Depending on the size of the motor and the amperage of the controller, a single mileage can be expected with one charge when driving at normal urban speeds. The acceleration can be quite impressive, taking into account the lower total weight of the EV. However, the maximum speed is usually limited (for example up to about 100 km/h) due to the motor's rotation speed.

Parameters to check the performance of an EV are battery capacity and mileage with one charge.

Electric vehicles must be equipped with charging ports to which special cables with standardized terminals are connected. Charging is done by plugging into a standard power outlet or in a dedicated charging station (power box). Standard charging takes 4-8 hours, and there are also fast charging stations that shorten the charging time to 15-30 minutes. Also tested are wireless charging technologies where a built-in EV receiver captures an electromagnetic field emitted by a transmitter.

Besides recharging, most EV also have another source of energy: they themselves, in view of the available possibility of recuperation of electricity to the source under different conditions and modes of operation. In fact, during the speed reduction phases, the motor could function as a generator and transform the vehicle's kinetic energy into electricity that recharges the batteries. Mechanical assemblies greatly reduce the efficiency that an electric vehicle is supposed to have - which is its main advantage. And if the batteries are not charged during braking, the main advantages of this type of drive are lost. In addition, rechargeable batteries can be charged electrically by the sun, wind and other renewable energy sources [8].

Problems arise from the cost of replacing batteries at certain years. Expenditures also include worn suspension due to the increased front axle weight.

If the weight is raised above the norm, because of more batteries (to extend the mileage), the EV will not be certified by the Technotest JSC.

6. Design of the electrical system

For small currents and high voltages, much smaller losses can be achieved both in wires and batteries and in the power elements of the regulator.

Everything in an EV is subject to maximum energy savings. All lights could have LEDs, making them 11 times more economical than standard lamps, and their efficiency is the same.

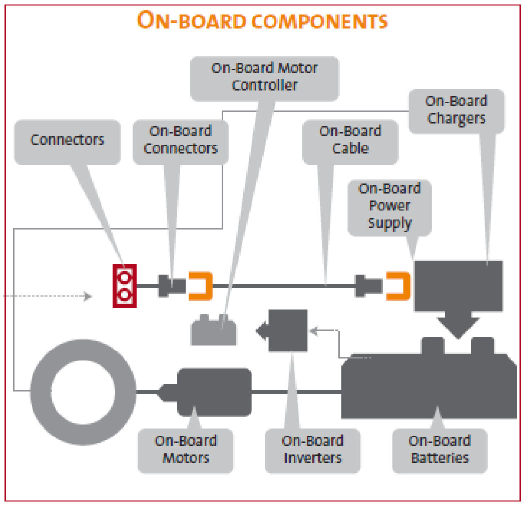

Fig. 1 *EV on-board components. [14]*

Battery Management System – controls through CAN interface charging, balances batteries, monitors motor speed and temperature. It shows everything on a touch screen display..

Converter - converts the relatively high voltage from the main batteries to 13.5 V for a 12 V battery charge (not always needed) to power the electrical devices in the car.

Contactors – 2 pieces contactors - to switch-off the high voltage from the main battery.

Fuses, Cables, Terminals

The power cables should pass in the shortest way (not the entire length of the car) so that the losses are not fairly large [20].

Mounting photovoltaic modules on the top of the EV.

From the perception of energy efficiency exhibitions, it can be concluded that no PV modules with a power above 50 W/m^2 are available. The efficiency is not high, but the price is more important. And protection from mechanical damage and theft. Apart from the cost of an investment, there is no other cost, no matter how much electricity it gets, it is still beneficial. The question here is that for every installed watt, we have to pay around €2 total costs. How long will the investment return?

7. Tests and adjustments of the EV

Full and accurate study of the advantages and disadvantages of all types of transport vehicles a particularly important and interesting but difficult to solve problem [7].

The theoretical drawings related to electric traction are of interest. Electric traction studies and investigates the forward movement of electric vehicles. In particular, it deals with the following issues: formation of motive and braking forces; forces of movement resistivity, cohesive forces and their influence on the motive and braking properties of EV, the reciprocal link between these forces and their relationship to acceleration, speed, distance gone and running time, electrical-traction characteristics of EV, methods to determine the electric energy consumption for the movement of the EV on a given area, determining the heating of the traction motors of the EV when moving on a given area, etc. [2].

The main task is to determine the variations of the starting current and voltage during the transient processes [5].

Running processes affect the change of current at a change in angular velocity ω. The presence of a controller reduces the flow of high value currents, yet their values are significant [9, 10, 11].

The starting current of the motor may result in an unacceptably high torque which may cause unacceptable accelerations of the EV and unacceptable mechanical stresses in the power kinematic transmission [13].

8. Conclusions

The results obtained could be of great practical importance when considering to start and possibly implement the EV by converting conventional car.

There is more and more talk about the benefits (and deficiencies) of electric vehicles.

By participating in the process of popularizing electric mobility in Bulgaria, we give a boost to every new step with one main goal - developing a new direction and changing the way of movement related to the realized efficiency. Because efficiency goes hand in hand with the benefits.

References

1. Balgaranov L. Electric transport, Sofia, 2009, ISBN 954-12-0103-2. (in Bulgarian)
2. Balgaranov L. Electric transport, Technical University - Sofia, 1991. (in Bulgarian)
3. David G. Dorrell; Andrew M. Knight; Mircea Popescu; Lyndon Evans; David A. Staton. Comparison of different motor design drives for hybrid electric vehicles, Energy Conversion Congress and Exposition (ECCE), 2010 IEEE, Atlanta, GA, USA.
4. Dimitrov L., S. Rachev. Mathematical Model of Electric Vehicle with Induction Motor. National Conference with International Participation „Sliven 2014". 'Machinostroene i mashonoznanie', vol. 3, 2014, pp. 41–45. (in Bulgarian)
5. Dimitrov L. Experimental study of electric starting processes of traction motor. National Conference with International Participation „Sliven 2015". 'Machinostroene i mashonoznanie', vol. 3, 2015, pp. 39–42. ISSN 1312-8612. (in Bulgarian)
6. Evtimov I., R. Ivanov. Electric Vehicles. 'Angel Kanchev University of Ruse, 2011. ISBN 978-954-712-521-6. (in Bulgarian)
7. Ganov M. Electrical Equipment of Electric Vehicles, Technical University -Sofia, 1990. (in Bulgarian)
8. James Larminie John Lowry Electric Vehicle Technology Explained Copyright ⊿ 2003 John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, England ISBN 0-470-85163-5.
9. Kazakov Y.B., A. I. Tikhonov. Calculation of Traction Induction Motor Using Dynamic Model of the Field, Department of Electro Mechanics, Ivanovo State Power University named after V.I. Lenin, Ivanovo, Russian Federation, February 2010.
10. Larminie J. Electric Vehicle Technology Explained, Oxford Brookes University, Oxford, UK, 2003.
11. Liu Y., L. Xu. The Dual-Current-Loop Controlled Fed Induction Motor for EV/HEV Applications. IEEE Transactions on Energy Conversion, Vol. 27, №4, October, 1994.
12. Marc Brück ENGINEERING E-MOTORS. *ANSYS ADVANTAGE*, ISSUE 3/2017. Canonsburg, PA U.S.A.
13. Минков П. Електрическа тяга, София, 1992. (in Bulgarian)
14. Pauly Chris. Powering the New Generation of Electric Vehicle: Issues and Challenges, City Investment Research&Analysis, 2011. http://www.ceres.org/resources/reports/
15. Roderick V. N. Melnik, Ningning Song. Dynamics of Torque-Speed Profiles for Electric Vehicles and Nonlinear Models Based on Differential-Algebraic Equations, University of Southern Denmark, MCI, Faculty of Science and Engineering, Sonderborg, Denmark, 2002.
16. Tesla, N. Electric Autos, Special Correspondence. accessed 1 July 12. Manufacturers' Record, December 29, 1904 http://www.tfcbooks.com/tesla/.
17. Xu Y. Optimal Distributed Charging Rate Control of Plug-In Electric Vehicles for Demand Management. IEEE Transactions on Energy Conversion, Vol. 30, №3, November 2012.
18. www.capital.bg
19. www.caproni.bg
20. www.eldrive.eu
21. www.emic-bg.org/
22. https://evparts.alle.bg
23. http://koorteh.com/