ECOLOGICAL CITY CAR. CONCEPTS, DESIGN AND REALIZATION

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Abstract

The paper deals with concepts, design and realization of a small ecological city car. A small, electric car is anticipated to be a solution to city traffic problems. The future users of a city electric car have been defined. City car should be characterized by the following features: low cost of purchase and maintenance, high functionality, possibilities of movement in zero emission zone, large space and easy access to luggage compartment, simplicity of parking manoeuvres, possibilities of customizing a car body features.

These features made this car a perfect means of transport for the elder and disabled. Three versions of a city car with different drive lines are considered. The same car body for each version is proposed. The car chassis is also the same in each version. The version 1 of city car is made. It is an L6e class car. This prototype allows carrying out some research on a new electric motor, new kind of batteries and working out the control units for cooperation between the electric motor and generator.

In the paper the basic performances of the car are presented and its main part the structure is shown. Features of the next version of small ecological city car are described as well as their advantages.

Keywords: *city transport, green cars, hybrid drive line, electric car, car body design*

1. Introduction

In the 20th century vehicles with internal combustion engines contributed to the improvement of life comfort and quality but at the same time they contributed also to the increase of noise, road and street congestion and became the main cause of air pollution particularly in urban complexes. It is expected that the solution of these problems may be achieved by changes in transportation system, wider use of city transport, carpooling and introducing alternative means of transport such as small electric city cars. An electric city car is noiseless and its emission of harmful products is very low. Taking into account the results of research realized in Civitas Caravel program it can be stated that average occupancy is 1.5 person for a vehicle for commuting. Driving in a city is of a specific character and it is characterized by short distances covered, low velocity and numerous braking and start manoeuvres. The results of city traffic research indicate that daily distance in city complexes is smaller than 60 km and average velocity, for example in Paris, is about 17km/h. Moreover in a city the complex problem of the number of parking places has come out. It is possible to deal with this problem by proper approach to city car construction, especially by restricting its length. However, it is very important to realize that a proposed city car should ensure the driver and passenger with high drive comfort so as to make people want to drive this kind of car. A city car should be characterized by big inner space, good manoeuvrability, easy handling and service and excellent visibility. It is important to remember that this car should also be a means of transport for the elderly and disabled. This car can be a friendly solution to their mobility loss not only in the city centre but also in suburbs. An ecological city car can be used as an educational model for young people that is much safer then a typical scooter.

2. Concepts of a city car

The study of city car construction should define the future users. The expected future users are as follows:

2.1. Institutions

- municipal police,
- mail service,
- telecoms service.
- power industry service,
- rent-a-car.

2.2. Private firms

- courier services,
- catering services,
- guard services.

2.3. Individual client

- car for shopping,
- alternative means of transportation,
- car for the disabled ,
- neighbourhood car,
- educational car,
- fun car.

To fulfil the requirements of the users indicated above the city car should be characterized by the following features:

- Low cost of purchase and exploitation,
- High functionality,
- Possibilities of movement in zero emission zone,
- Large space and easy access to luggage compartment,
- Simplicity of parking manoeuvres,
- Possibilities of customizing a car body features.

The features mentioned above determine the car construction. This car should be ZEV (Zero Emission Vehicle) or PZEV (Partially Zero Emission Vehicle) class. If internal combustion engine is used the emission of harmful substance should fulfil the requirements of SULEV (Super Ultra Low Emission Vehicle) car class. Low cost of production and purchase determine also of the car construction solutions. However it can be still possible to customize a car version so as to meet a client's requirements in that case not necessarily maintaining low production cost. A city car cannot be too long, but in order to ensure high drive comfort as a car of trade segment "C" it should be relatively high and wide. The inner space is a function of wheel base which also cannot be too big as it influence car manoeuvrability. It is easy to obtain a big value of wheel turn angle when the rear axle is a driven axle. Utility options of a vehicle are, first of all, volume of luggage compartment with easy an access and possibilities of simple changes of inner car configuration. Using this car for disabled people requires special preparation so there should be possibilities for optional devices to be used. Taking into consideration the requirements of city traffic and expected car users it seems that the best solution is a city car of class from L1e to L7e. For determining a city car dimensions and weight it is possible to use the technical characteristics of the microcars that are produced nowadays. Attention should be paid to different engines used in these cars that are key factors determining cars class and category. For example Effedi car, showed in fig 1. has 4 versions as a hybrid car, L7e car, L6e car, and electric car also of L6e class. The significant

dimensions of this car are its length, width and height. The length of this two person car is 2,64m and the height is 1,67m. The maximum velocity of Effedi as an L7e class car is 80km/h. Ligier Be Up (Fig. 2) is another example of a microcar. It rather belongs to Fun Car category. Its main dimensions are very similar to Effedi car presented earlier and its length, height, width are successively 2.68m,1.56m,1.41m. Ligier is available as L6e and L7e class car on the car market.

Fig. 1. Effedi Maranello [9]

Fig. 2. Ligier Beup [4]

The values of maximum engine power and maximum car velocity are defined by a car class. But as it was mentioned earlier in this kind of cars different kinds of engines are very often used. These cars dimensions cause them to be the best means of transportation in urban complexes. As an urban complex is usually an area of zero emission an electric car should be the best solution. Microcar MC1, showed in Fig. 3, is an example of this solution.

In a Canadian car market Microcar MC1 is an electric car called ZENN (Zero Emission No Noise). Its dimensions are close to "A" trade segment car. The length, width and height are successively 3.130m, 1.468m,1.455m. The maximum velocity of this electric car is 40km/h and its range with conventional batteries is about 80km.Its successor in Europe is MGo car produced in France (Fig. 4). The application of lithium-ion battery increases car range to 150km. The battery mass is about 170kg.

Fig. 3. Microcar MC 1 ZENN [5]

Fig. 4. Microcar MGo [6]

Microcars world comprises numerous producers so review presented above gives only introductory view related to main dimensions, applied engines, maximum velocities and ranges of these cars. Tubular space frame is very popular as a chassis of these cars. The Mc Pherson strut suspension is usually the front suspension, and longitudinal arm is a rear suspension. The internal combustion engine works with CVT gearbox usually with rubber belt in these cars.

3. Car design

Taking into consideration the technical description of cars presented earlier the assumption data for a small ecological city car are elaborated. Three versions of this car with different drive

lines were considered. The cost of car production and its price depend on a drive line applied. The car body is the same in each version. That is a reason why the shape of car body has to be adjusted for each drive line that is considered. The same problem appears with construction of chassis. The car body concept together with frame shape is presented in Figure 5. In this project the car wheels act as a bumper that is why they are the most advanced element of car body. Luggage compartment consists of two parts behind the seats and under them.

3.1. Version 1

Category of car- ZEV (Zero Emission Vehicle)
L6e - Class of car

The proposed car will be a four wheel electric car with driven rear axle. The single electric motor of 4KW power in accordance with car class will be used. ACIM (Alternating Induction Motor) motor or PMAC (Permanent Magnet Alternating Current), PMDC (Permanent Magnet Direct Current) motors can be used. In accordance with car class the car mass could not exceed 350kg. The range of this car depends on the batteries which will be used. For example the typical six TROJAN lead acid batteries with capacity each 185 Ah ensure car range about 50 to 60 km. The mass of one battery is about 28kg. Applying the lithium-ion battery (LiFePO4 Thunder Sky or LiFeMgPO4 Valence) makes decreasing the mass of batteries 2.5 times possible but in that case the cost may increase 3 times. With the use of the lithium –ion batteries it is possible to increase significantly the car range. It is possible to apply the ultracapacitors (Boostcaps Maxwell) to energy recovery during braking. Approximately, in an ECE 15 cycle about 20% of energy delivered can be recovered.

Fig . 5. Car body concept [3]

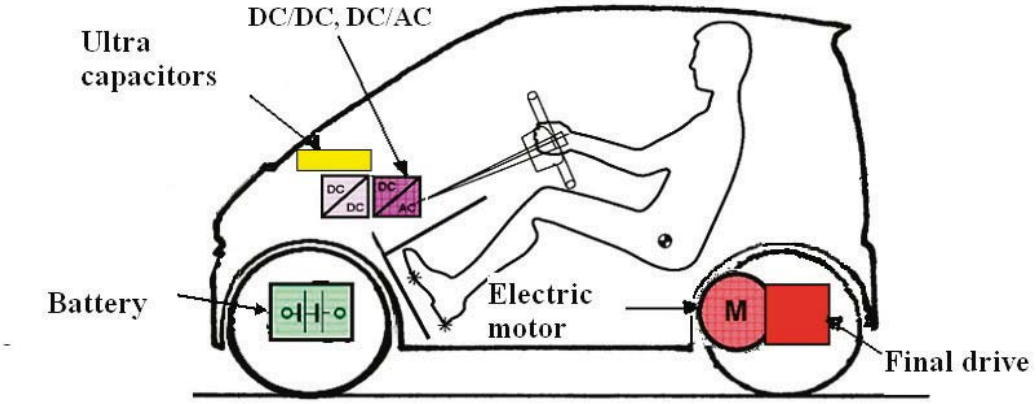

Fig. 6. Small electric car version 1

3.2. Version 2 (Fig. 7)

Category of car- PZEV (Partially Zero Emission Vehicle)
L6e - Class of car

The proposed car will still be a four wheel electric car with a driven rear axle. Introducing the small internal combustion engine that serves as a backup generator or power assist will change this car to ReCharge hybrid type. The generator allows decreasing the number of batteries that consequently decreases the mass and cost of a car. The mass of generator, for example Honda silent, is very similar to the mass of one lead acid battery. The category of car will change, it is not ZEV car category, however the number of batteries should ensure the sufficient car range for urban complexes. This generator may be used as life belt in case of the batteries discharge, then a car changes into series hybrid and its performance will be lower. It is also possible to charge the batteries during car stop. The other car parts such as electric motor, rear axle, suspension remain the same.

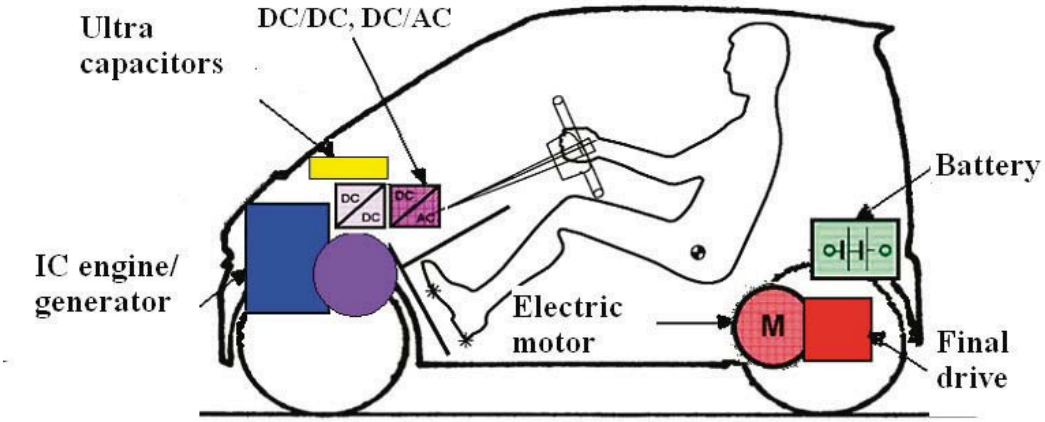

Fig. 7. Small electric car version 2

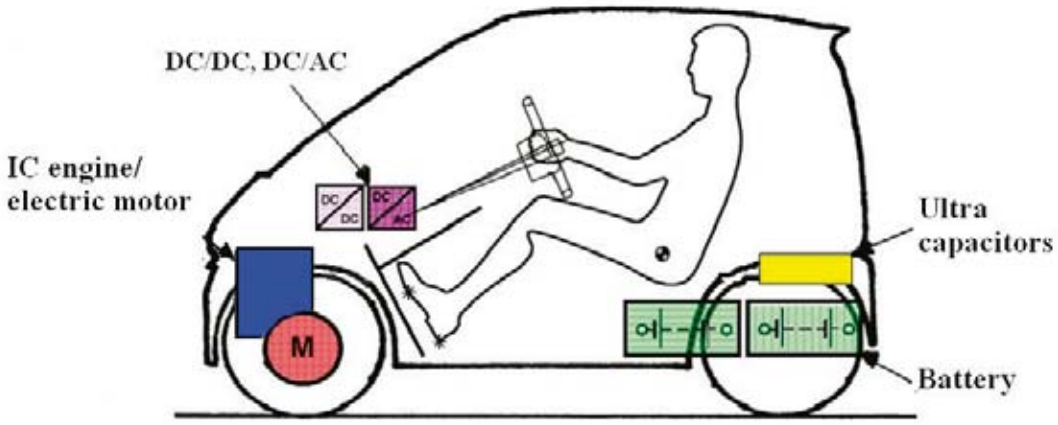

Fig. 8. Small electric car version3

3.3. Version 3 (Fig. 8)

Category of car- hybrid car
L6e or L7e - Class of car

The proposed car will be a hybrid car. In front of a car the internal combustion engine can be fitted together with CVT gearbox (Lombardini CTMove)[8] (Fig. 9).

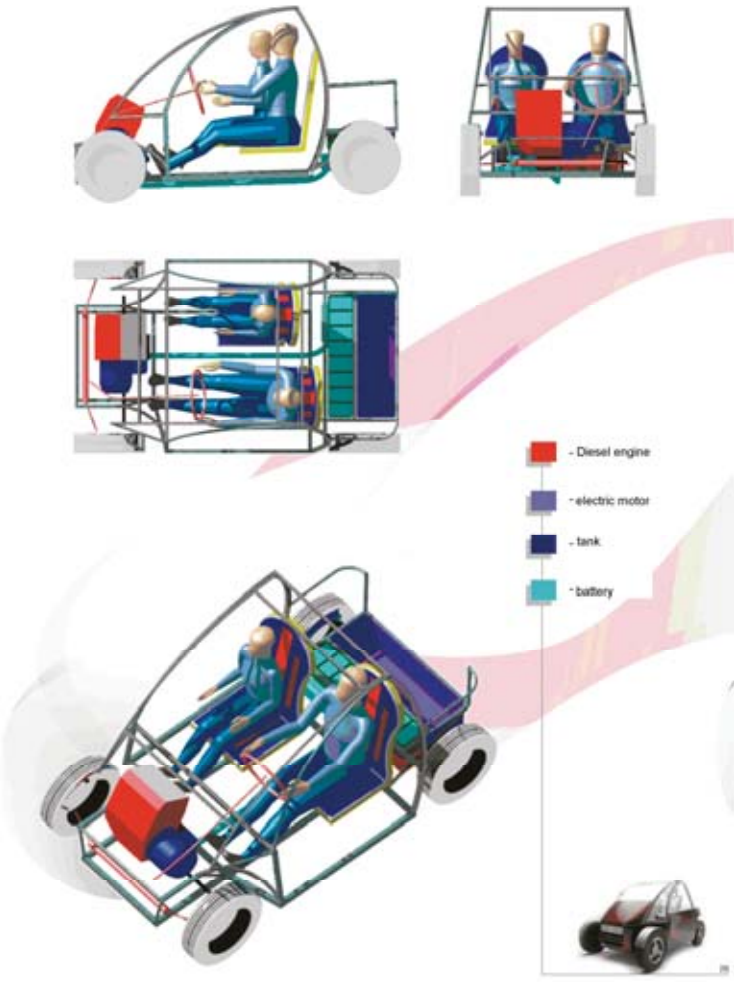

Fig. 9. Main parts of a city car version 3 [3]

The electric motor can be integrated with internal combustion engine (Lombardini ECOMOVE)[8] or it can drive the rear axle. The drive line with integrated electric motor is similar to construction solution presented by Honda (Integrated Assist Motor). In urban complex and for manoeuvring the electric motor will be use, and for long distances the internal combustion engine substitutes the electric motor and during car acceleration both motors can be used. Depending on motors power and maximum velocities a car can belong to L6e or L7e class. It is important that it is possible to drive L6e class car without driving permission. There is a possibility of working out the hybrid drive line with no changes in chassis as the designed vehicle may have both front and rear axles driven.

4. Realization

The first main assumption is that a car body is not an integral structure. Outer and inner panels are not to carry any forces caused by car motion. These panels are made of thermoplastic materials and fitted to the space frame. In this way it is possible to create any shape of a car body according to client wishes. Moreover, it is easy, to make new body version such as cabrio or fun car (Fig. 10).

Fig. 10. Space frame [1]

Space frame is made of standard steel and aluminum profiles joined by welding. It is important to use the materials which can be recycled. For calculating the stresses in space frame ANSYS program was used. The car has independent suspension of all wheels.(Fig. 11).

Fig. 11a. Front suspension[1]

Fig. 11b. Rear suspension[1]

The front suspension is of unequal wishbone type with modified Seicento swivel axle. The front disc brake from Seicento is also used. Front wheels can be driven because the modified swivel axle from seicento is used. The rear suspension is a longitudinal arm. Flexible coupling and drum brake from Fiat 126 is used for rear axle. The steering system is Seicento rack and pinion steering system.

The main car dimensions are:

- length – 2.550m,
- width – 1.550m,
- height – 1.500m,
- wheel base – 1.950m,
- mass without batteries – 280 kg.

Car dimensions and weight are similar to dimensions and weight of other cars mentioned earlier. Its inner space is big and similar to inner space in "B" trade category cars.

The car is made in version 1 with DC motor driving rear axle. Rear axle is adopted from golf car Melex but it is modified because of the use of the independent rear suspension. Six lead –acid Trojan batteries are used to ensure the car range about 50 km. The maximum velocity is 38km/h (Fig.12 a, b).

Fig. 12a. Front view of city car

Fig. 12b. Side view of city car

This is the study of a small electric car. It will be possible to carry out research on new electric motor, new drive line, new kind of batteries and work out the control units for cooperation between the electric motor and generator.

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