STRUCTURE OF THE TRACTION DRIVE WITH THE HYDROGEN FUEL CELL

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ABSTRACT

The paper deals with the structure of the electric car traction drive supplied with the hydrogen fuel cell. The drive system consists of the induction machine, three-phase traction converter, ultracapacitor with the auxiliary converter, main step-up converter, and hydrogen fuel cell. The problems appearing as the result of the lower fuel cell power 2,2kW are discussed.

1. INTRODUCTION

At present, the mankind must very intensively deals with questions related to the oil substitution with alternative energy sources. One of possibilities is the substitution of the combustion machines with the electrical motors. However, this solution brings the main problem with the energy storage in the car because of the small energy capability of the electrical accumulators. It is possible to use the fuel cells to the change of the energy stored in hydrogen into electric energy.

The utilising of fuel cell technologies brings many of problems, mainly small power and low voltage levels of the fuel cells. Those are the basic reasons leading to the following solution of the electric traction drive.

2. DRIVE CONCEPTION

The traction electric drive consists of seven basic blocks. They are the hydrogen high-pressure iron can, hydrogen fuel cell, main step-up converter, lead acid accumulators, ultracapacitor with the auxiliary converter, traction converter, and induction machine. The block diagram is shown in Fig. 1.

The fuel cell can supply the average travelling power but it is not able to energize the higher power at the car acceleration. This is the reason why the accumulator is used, where is able to supply the traction converter with sufficient high current at the acceleration, and higher hill slope. However, the accumulator usage also brings the disadvantages, e.g. its disability to absorb the braking energy in the case of the fast braking. In the case of fast braking with the high current, the braking energy is changed into warm on the inner resistance in the time period of first seconds. The result of it is, that the dominant part of the braking energy is lost. The next disadvantage is the temperature stress in the accumulator during the fast acceleration and braking because of high peak current. This leads to the lifetime decreasing. This is the reason to use the ultracapacitor in the regime of the short-time energy accumulator. In the difference to the lead acid accumulators, the ultracapacitors can absorb the energy at high currents with the high efficiency. They have the positive influence to the car travelling reach, specially in the regime with the repeated braking. The next advantage is the ultracapacitor ability to work with high currents without the decreasing of the lifetime. Thanks to this feature the current strain of the accumulator decreases significantly, and it causes the increase of their lifetime. Unfortunately, the direct connection of the ultracapacitor to the accumulator is disadvantageous. The parallel connection does not permit the great voltage change in the ultracapacitor. The low voltage change does not allow the high energy storage. Because of it, the additional converter must be used, which allows the higher voltage change, and the better energy utilizing.

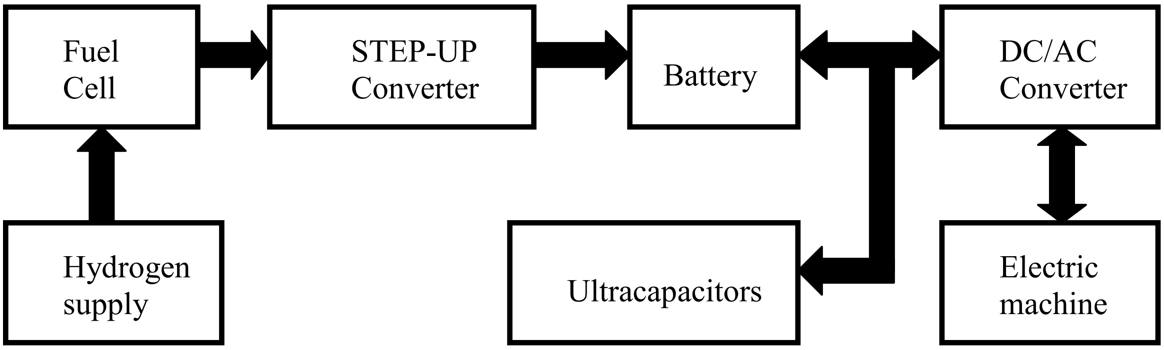

Figure 1: Block diagram of the drive.

2.1. ULTRACAPACITORS

The ultracapacitors are made as the electrochemical double-layer capacitors. The high energy concentration is caused by the usage of the highly porous carbon electrodes, whose active surface area is approximately 2000m^2/g. It is deals with the electrolyte capacitors. The charging and discharging is realised by the ions moving in the electrolyte. It is not deals with the chemical processes at which the electrochemical dissolving of the electrodes material appears. In the difference to the accumulators, the ultracapacitors have much higher lifetime, they do not need the service, and they are not sensitive to the charging and discharging. They would not be to the higher voltage as the nominal value is. In another case the lifetime decreases, and the destroying can appear at the overcharging over 2,7V. The ultracapacitors distinguish by the very small inner resistance. The charging and discharging currents would not increase the maximal datasheet values. The memory effect does not appear at the ultracapacitors. It is possible to discharge it to the zero voltage.

2.2. HYDROGEN FUEL CELL

The direct change of the chemical energy to the electric one appears in the fuel cells. From this point of view the fuel cells are similar to the accumulators. However, the great difference lies in the fact that the chemical substances must be supply from the outer environment. The electrodes do not wear down almost, their chemical structure does not change. From theoretical point of view, the fuel cell can work without time limitation.

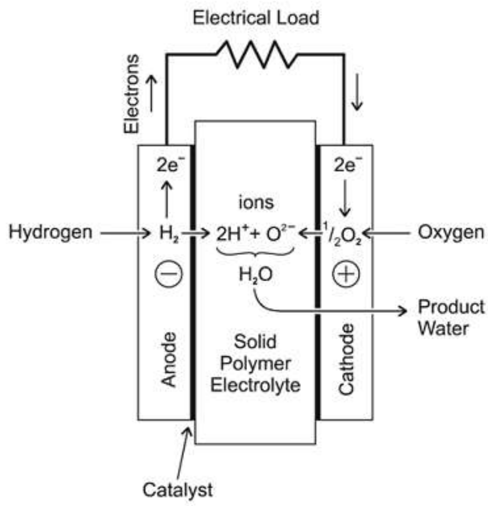

Figure 2: Fuel cell principle.

The fuel cell principle is similar. The fuel is lead to the negative electrode. As the fuel can serve hydrogen H_2, carbon oxide CO, hydrazine N_2H_4, methanol CH_3OH or same metals as sodium Na, magnesium Mg, zinc Zn, and cadmium Cd. The fuel oxidizes, its atoms get one or more electrons rid from the valency sphere (at contributing of the catalyst often). The free electrons can move to the positive electrode by the outer circuit. The oxidize agent is lead to the positive electrode (oxygen O_2, chlorine Cl_2, mercury oxide HgO, manganese oxide MnO_2). The reduction runs here (atoms of the oxidize agent receives the free electrons) at the simultaneous reaction with the positive ions, which penetrates through the electrolyte. The chemical reaction will be stop when the current is interrupt. It is possible to name this chemical reaction as the cold combustion. The fuel in form of the gas (often hydrogen) is lead to the one side of the cell, and oxidation agent (often oxygen, in practice the air) to the another one. The special foil is placed between both electrodes. This foil is saturated by electrolyte in the form of the acid or alkaline solution. The electrolyte must be the electric insulator insuring that electrons can be changed via the outer current circuit only. The voltage difference approximately 1,2V appears between both electrodes. Because of to get the demanded voltage level, the individual cells are connected in the series. The bipolar surfaces are placed between neighbouring cells. They are electrical conductive, they lead the current, and create the gas seal between cells.

In the described car drive will be used two pieces of the NEXA fuel cells, shown in Fig.3. The Nexa system provides up to 1200 watts of unregulated DC power at a nominal output voltage of 26VDC. With the use of an external fuel supply, operation is continuous, limited only by the amount of fuel storage. Using hydrogen fuel, the Nexa module is extremely quiet and produces zero harmful emission. The Nexa product specification is shown in Table 1.

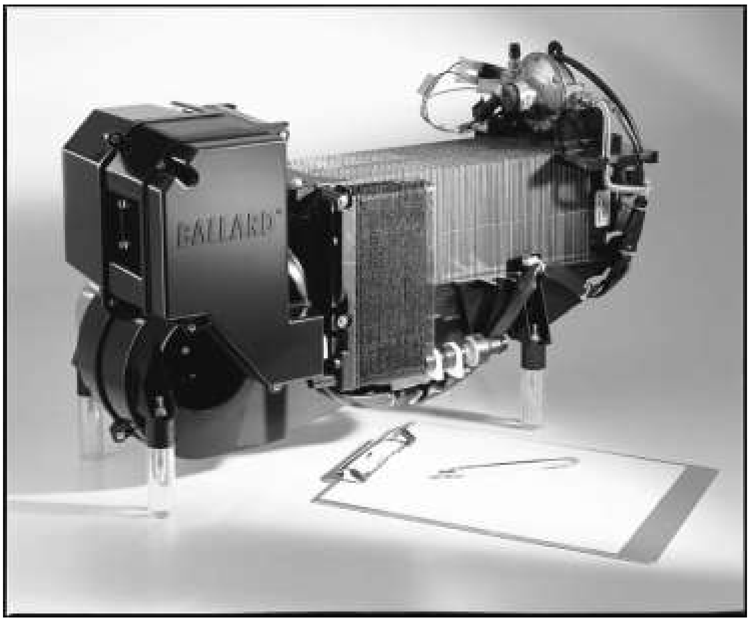

Figure 3: The Nexa Power Module.

OUTPUTS	REQUIREMENT	DEFINITION	QUANTITY
Power	Rated Power	Capacity at Standard Conditions	1200W
	Voltage	Operating voltage range Voltage at Rated Power	22V to 50V 26V
	Start-up Time	Minimum time to achieve Rated Power from a cold Start condition	2 minutes
Emission	Noise	Maximum noise emission at 1m	72dBA
	Water	Maximum quantity of liquid water produced at Rated Power	870 mL/hr
Lifetime	Operating Life	Minimum number of operating hours	1500 hours
	Cyclic Life	Minimum number of start-up & shout-down cycles	500
	Shelf Life	Minimum storage (non-operation)	2 years

Table 1: Nexa specifications.

3. CONCLUSION

It seems that the described drive conception is very expensive thing at present. It is possible to suppose that the prices of the fuel cells will be decreased in the future. Under advantageous market conditions, this conception could partially solve some problems in the personal and load transportation from ecology point of view.

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