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DEVELOPMENT AND ASSEMBLY OF A GO-KART SIZED FUEL CELL RESEARCH VEHICLE

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ABSTRACT – In continuation to the presentation on FISITA 2004 now the focus is on development, construction and build of a Go-Kart sized vehicle with a power train by fuel cell and electronic motors. Main features are an ABS-System, adjustable pedals, possibility of four wheel steering, to set up the toe-in and camber, direct rear wheel drive with two electronic motors without gearbox and differential. The vehicle is powered by means of power batteries and H2-Energy is stored in low pressure metallhydride storage cylinder.

TECHNICAL PAPER

The kart-project exists since several semesters at the University of applied sciences in Bingen, Germany. The main purpose of this project is the development of a research vehicle that has similar driving characteristics to an usual passenger car. Thus an independent wheel suspension was developed and a Bosch ABS System was installed.

Another intention was to show the vehicle at the schools to promote a technical study. The first of three planned karts was rolled-out successfully last winter. This Kart has the indication Kart 1 (Figure 1 and Figure 2) and has a common kart-sport gasoline-engine.



Figure 1: Kart 1, front view

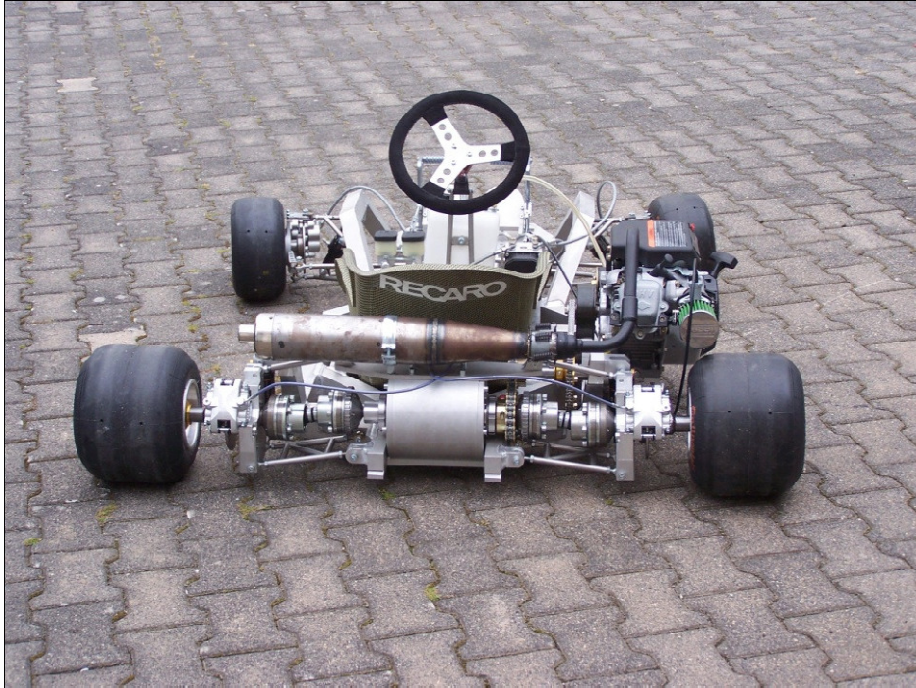


Figure 2: Kart 1, rear view

KART 2 WITH FUEL CELL AND ELECTRIC MOTORS

The second Kart, named Kart 2, has nearly the same frame and suspension like the Kart 1. The difference to Kart 1 is the power supply with two fuel cells which support two high power batteries which itself empower the two 3,5 kW electric motors. These motors drive the rear wheels directly without any gear needed. This Kart was still in its development process (most parts as CAD models, Figure 3) until the last winter. Thus we decided to improve several parts before they get manufactured in our garage. In the following, we want to shortly present some of our parts.

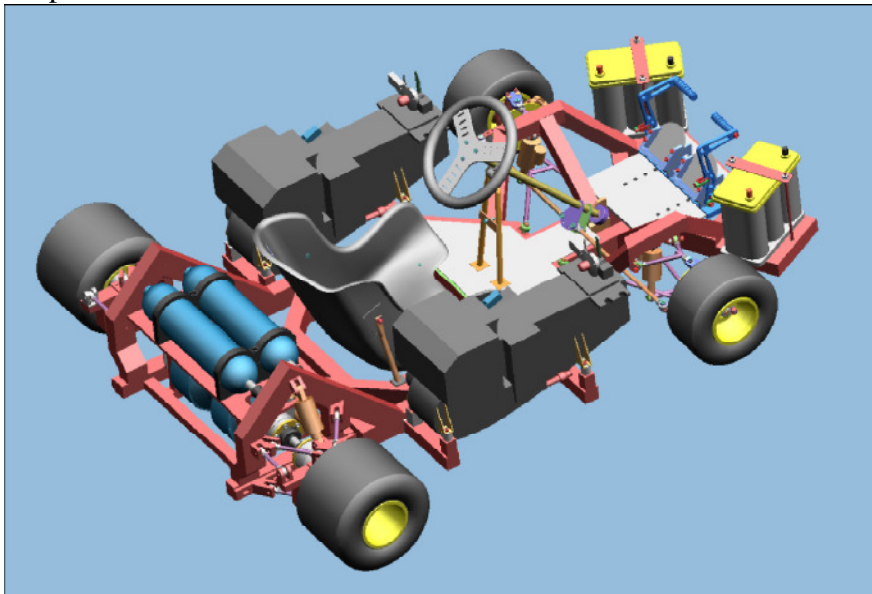


Figure 3: Kart 2 CAD Model

Electric Motor

We chose the Lynch electric motor model 119. We found several benefits, which helped us with our decision⁽¹⁾:

- High efficiency (about 93% maximum) gives longer running time and less frequent battery replacement
- if necessary less power can use lower voltage, giving even lower speeds which will allow the transmission to be cheaper and more efficient
- regenerative braking is possible, giving increased range and longer brake life or even the rear brakes can be dropped out because of the torque the motors create while running in regenerative modus

Weight	~ 11 kg
Power	maximum of 13,5 kW at 68V
Current	68 Volt maximum
Speed	3944 rpm at 68V

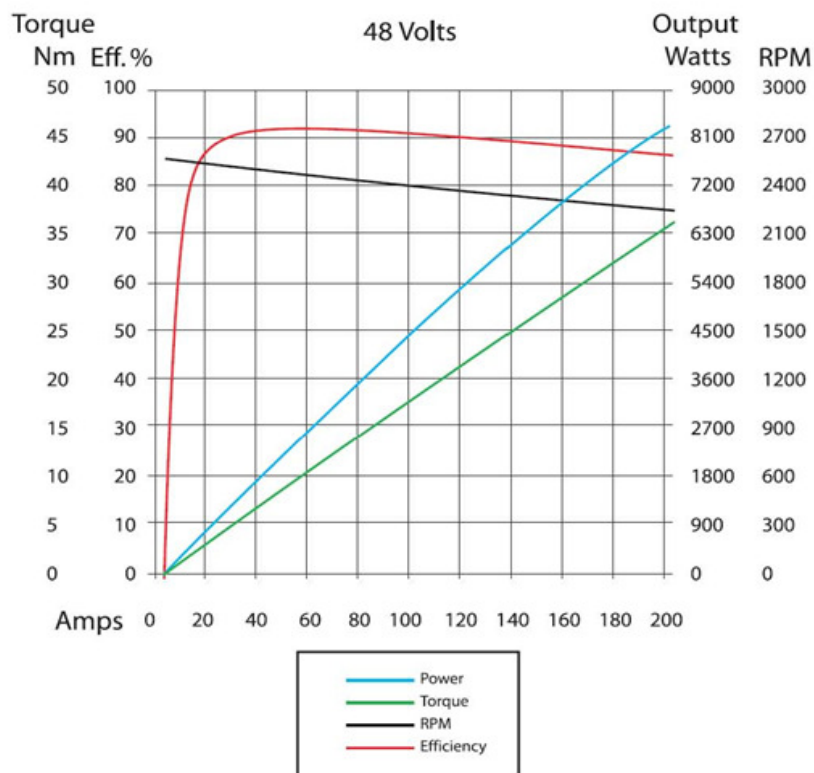


Figure 4: Characteristic Diagram

Recuperation brake

At Kart 2 we used a control which makes it possible to win back energy through braking. We have 3 different possibilities to recuperate:

1. direction-reversion-brake: released by reversing the direction-entrys at the Millipak control unit. (Vehicle heads forward allthough the direction of travelling is chosen backwards)
2. Foot brake: Activation by pressing the brake pedal. The potentiometer/commutator identifies the desired braking.
3. Neutral braking: Activated by releasing the gas pedal.

Work process (launching the Kart)

To power up and shut down the fuel cell some general parameter have to be set. At first the controller board has to be powered with a 48 V battery, than the Nexa module fades into the standby mode. Thereafter we have to make sure that sufficient fuel (hydrogen) is available. The fuel cell needs a 5 V startsignal for start up, which has to be applied to the controller board. Is the 5 V signal existent the Nexa modul starts a malfunction diagnosis before booting up. In case of failure the system isn't startet. Is the system operating and the 5 V signal is removed, the Nexa module shuts down. If the batteries which are loaded from the fuel cell are completely loaded the Nexa module stays in the off mode.

Fuel Cell

We decided to buy the fuel cell "Nexa" from Ballard (Figure 5), because it fits our purpose best. There are a few facts that helped us with this decision:

- one of the most sold fuel cells systems
- thus a proved and reliable system
- large accessories included in the package like
- compact format,necessary for our mobile use

Also see the table below⁽²⁾ for a data overview of this modell.

Nexa System Solution - 1.2 kW	
Rated voltage:	26 V
Rated current:	46 A
Rated output:	1200 W
Output voltage:	22...50 V
Hydrogen purity:	99,99 % H ₂ (vol)
Input pressure:	0,7... 17 bar
Hydrogen consumption:	max. 18,5 SL/min (at 0 °C / 32 °F, 1013 bar)

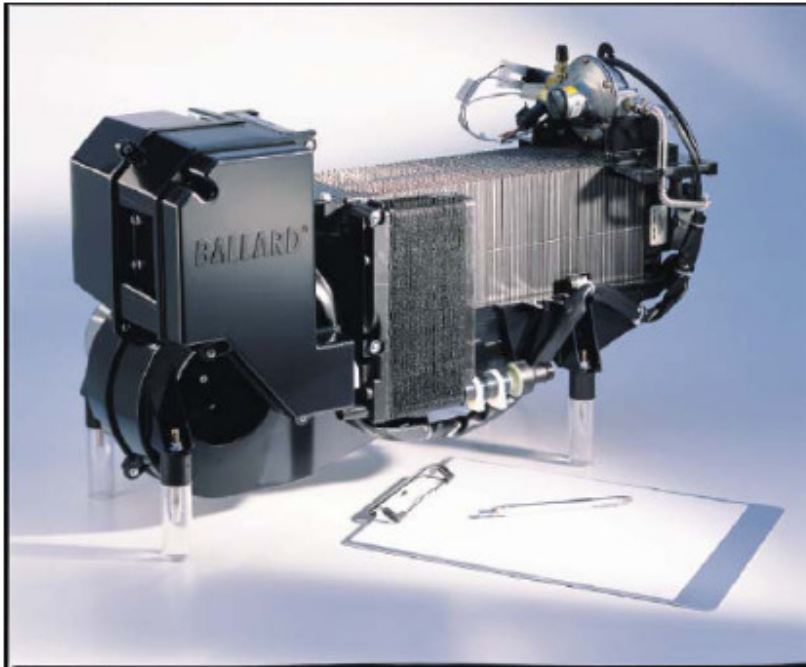


Figure 5: Fuel Cell “Nexa”

Approach for simulating the energy management (Kart2 and 3)

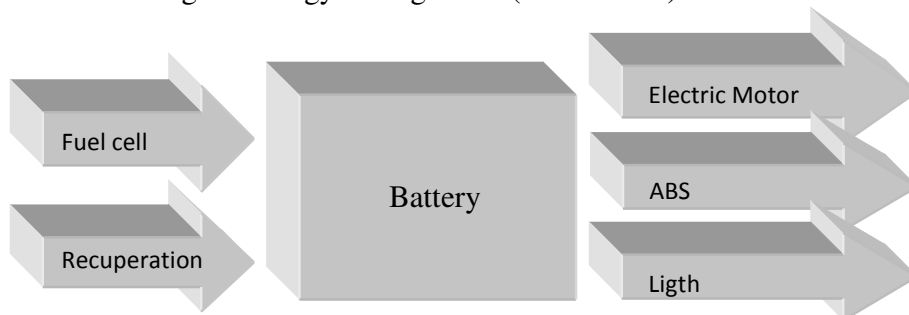


Figure 6: energy management

Fuell cell energy E_{Br}

It's the energy which is created from the fuel cell and delivered to the battery. The fuel cell delivers the electric current irregular and with voltage swing. This complicates the simulation and the application.

The fuel cell is subject to some kind of wear that occurs with increasing life-time respectively the number of starts and stops.

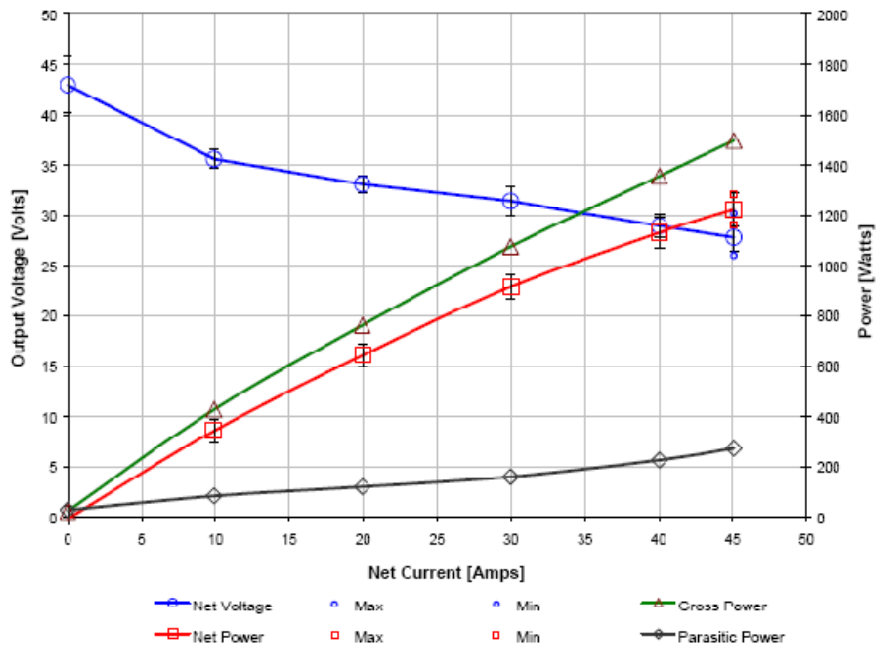


Figure 7: General trait

Net Voltage	$U_{Br} = -0,3004 * I_{Ent} + 40,338$
Gross Power	$P_{BrGes} = 32,301 * I_{Ent} + 88,636$
Net Power	$P_{BrAus} = 27,372 * I_{Ent} + 61,898$
Parasitic Power	$P_{BrVer} = 4,929 * I_{Ent} + 26,738$

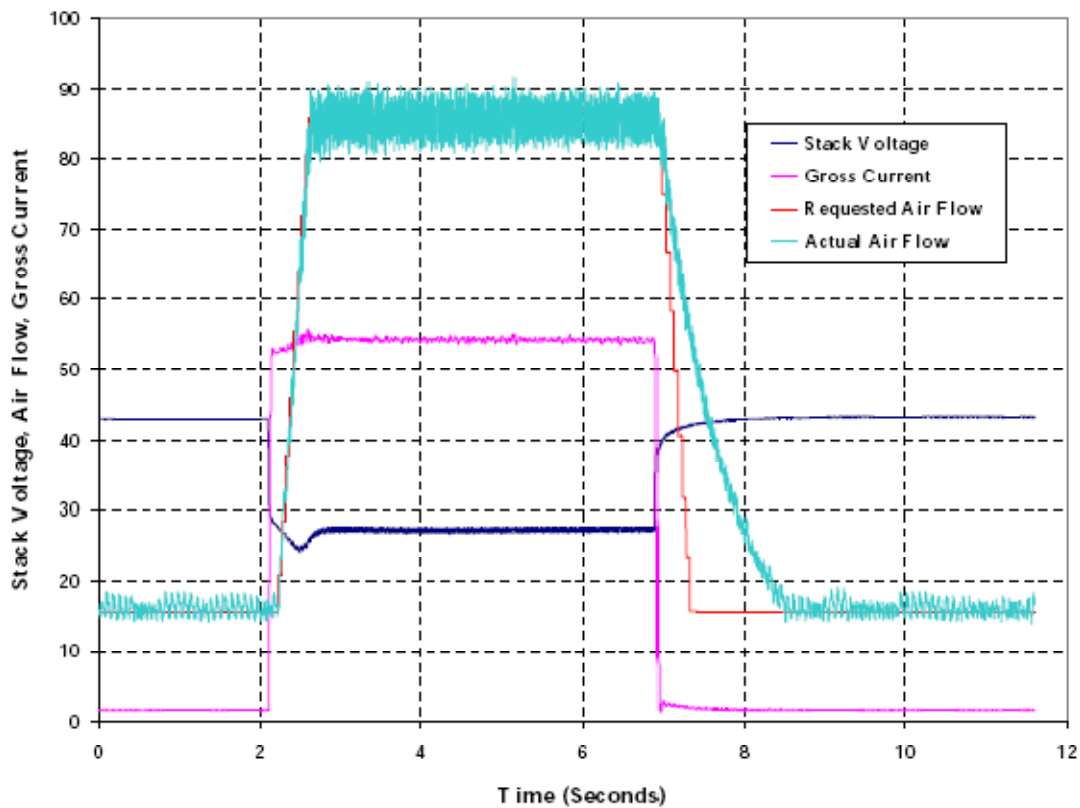


Figure 8: Transient Response Characteristics

The existent airstream is sufficient for a low current flow. Increases the current to 54 A a deficit can occur. The effective air flow needs approx. 0,5 s until the required air flow of 85 l/min is reached. The output voltage collapses and stabilises at approx. 26 V within 0,5s. A similar occurrence can be monitored in the inverted direction.

Hydrogen tank

To power the fuel cells hydrogen tanks are required. At this project we selected a 1000NI-tank from Udomi. The tanks are placed at the rear-axle-construction because of the easy way of connection. Additional we have more designed space left. At usage of these tanks we have to consider that strict security regulations are given that have to be abided by!

OUTLOOK

At the moment the Kart 2 is in the buildup phase and should be finished within this summer. With the experiences made with the first two Karts, we want to build a third Kart with fuel cell power supply like Kart 2. Then some new features like steer-by-wire, four wheel steering or a fully adjustable front axle are intended. We also think about to install further sensors for an Electronic Stability Program.

REFERENCES

(1) Information from <http://www.agnimotors.com>

(2) Information from

http://www.heliocentris.com/en/rd_solutions/nexa_system_solution.html