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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 H_2-Energy is stored in low pressure metallhydride storage cylinder.

TECHNICAL PAPER

The kart-project exists since several semesters at the University of applied siences 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 succesfully 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

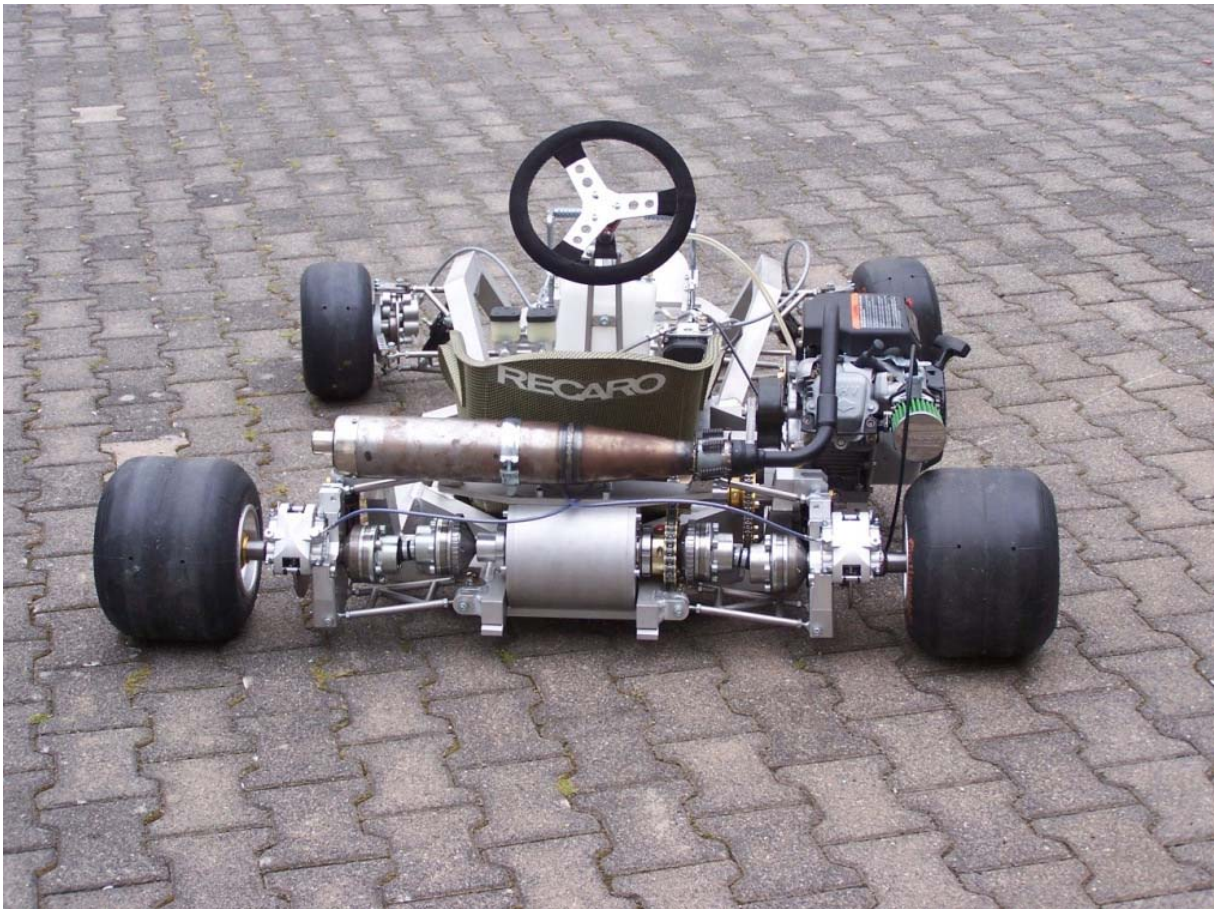

Figure 2: Kart 1, rear view

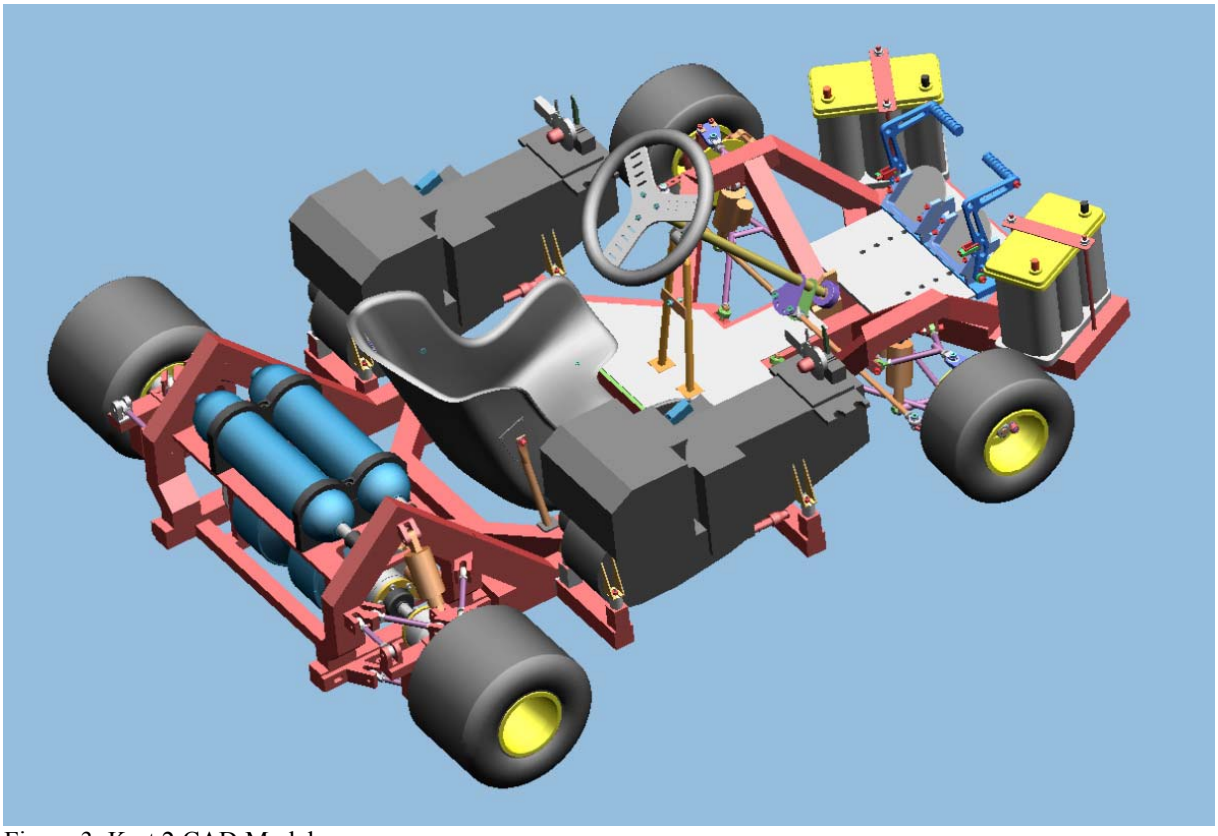
Figure 3: Kart 2 CAD Model

CONCEPT FOR THE FRONT SUSPENSION

A part of our team, which worked on the front axle, decided to review the construction and try to improve several parts. But unfortunately we didn't have enough time to completely replace the old suspension of the existing Karts 1 and 2. Thus we decided to use the new construction for the upcoming Kart3.
The concept for the front suspension of Kart 3 provides a double wishbone axle. The upper wishbone is linked to the frame and the steering knuckle via ball joints. To provide an adjustment of the caster, the length of the rear wishbone bar is made variable through a threaded bush. A threaded bush is also been used between the wishbone and the upper swivel joint to make the camber variable.
The lower wishbone is formed with two separate bars, which are linked to the frame with two ball joints. Towards the steering knuckle the wishbone bars are linked with two ball joints to a plate, which is screwed to the underside of the steering knuckle. This assembly is called a split wishbone, which is comparable to the wishbones used by Mercedes Benz in the E- and S-Class. This setup makes a reduction of the kingpin offset towards negative possible. With this configuration one pivot at the steering knuckle is set further to the middle of the car, to create a different angle of the two wishbone bars and consequently make a steering out of the zero position possible.
The steering knuckle is a solid part with a bore for the wheel bearing. In the opposite way than normally found in a car, the wheel and its wheel hub is mounted on a shaft, which is guided by the wheel bearing whose outer ring is fixed in the steering knuckle. A nut at the outer end of the shaft secures the wheel hub axially and a key on the shaft transfers the braking torque to the wheel hub. The brake disc is flanged to the shaft on the inner side of the steering knuckle.
Further the steering knuckle provides two threaded bores at its rear to mount the steering arm with screws. This arm has a bore at its end to fix the steering tie rod at. To adjust the wheel toe angle the length of the steering tie rods is made variable by threads at the ends.
At the front of the steering knuckle there are also two screws to mount the linkage plate for the brake caliper. This plate has another two holes to mount the caliper at.
The spring/damper unit is fixed to the middle of the auxiliary plate for the lower wishbone and to the frame via lugs.

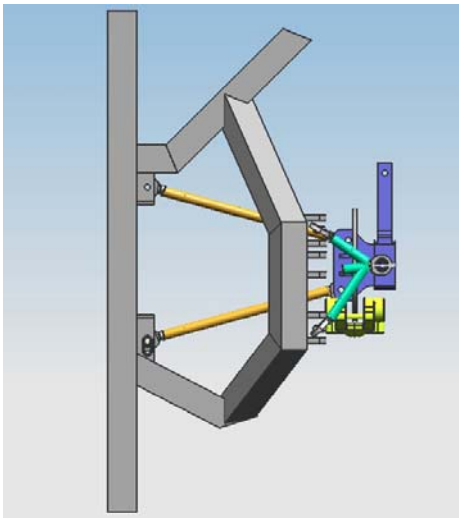

Figure 4: View from above. The form of the split wishbones is visible.

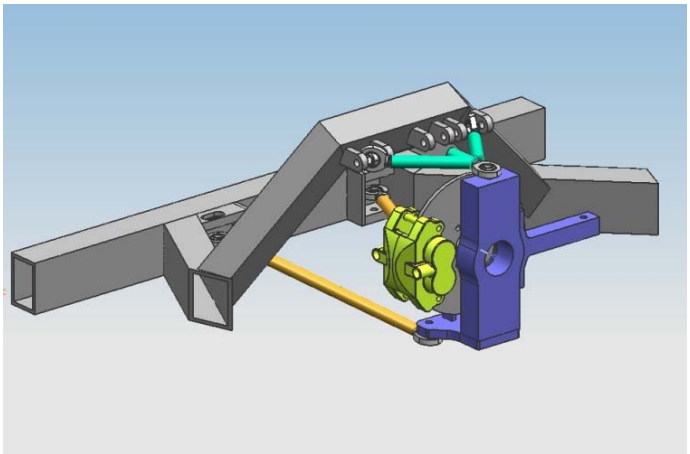

Figure 5: An assembly of the suspension. Some parts are left out for better overview.

REAR AXLE

The design of the wheel carriers and the damper alignment was changed several times during the whole development process. At the beginning the dampers were supposed to be placed above the differential. But we realized, that this wouldn't have any benefit. Then we decided to completely redesign the rear wheel carrier last winter, because we also had to adapt the design of Kart 1 to the two electric motors. They have different dimensions than the differential. We made several changes in relation to the former design:
- damper and axle are now in line, thus no unnecessary torque is created while damper compresses (Figure 7)
- horizontal wishbone to construct the roll center on the ground (Figure 8)
- new lower wishbones, all wishbones will only be pulled or pushed now, not also distorted (old construction can be seen in Figure 6)
- we can now absorb the appearing torque wile braking because of the two top wishbones

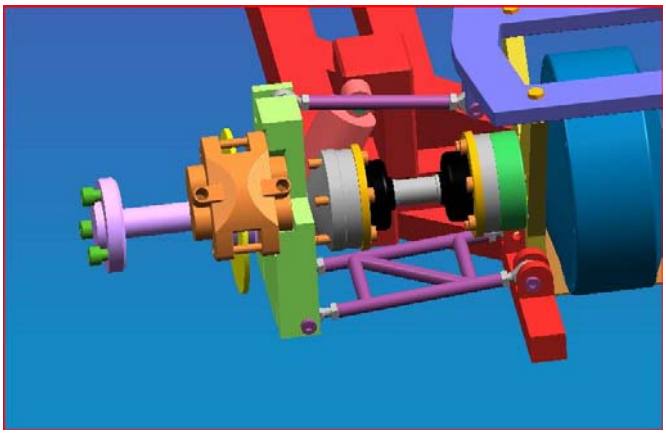
Figure 6: Kart 2, old rear suspension

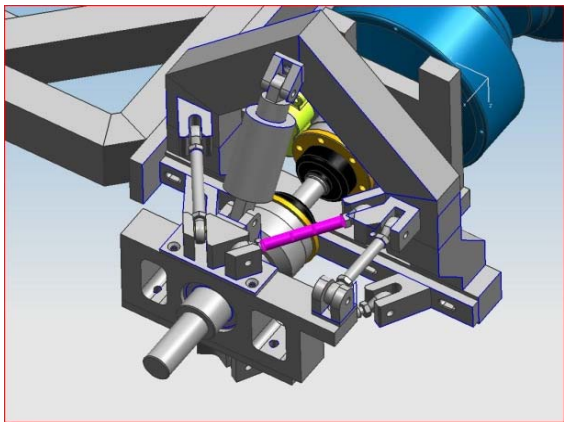
Figure 7: Kart 2, new rear suspension

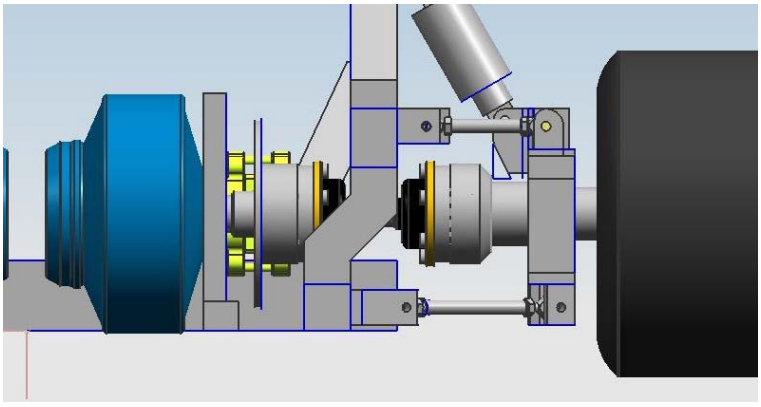
Figure 8: Kart 2, rear suspension, back view

With this new construction we have also the possibility to change the driving behavior with little effort. It is possible to adjust the
- wheel camber
- toe-in
- steering axis inclination
- backlash

BRAKING SYSTEM

The braking system was basical overstraint from Kart 1 and persists of disc brake with floating back gauge at the front and rear axle.

The ABS-system consists of a 3-channel-system originated from a Smart Roadster.

To commission the system fitting increment- and brake-discs (Figure 9) had to be constructed, produced and positioned. After that the ABS-system was given to a BOSCH test bed for calibration to our specific conditions. Additionally the braking system was expanded to the possibility of regulating the brake force distribution during the ride. On request the ABS also can be shut down.

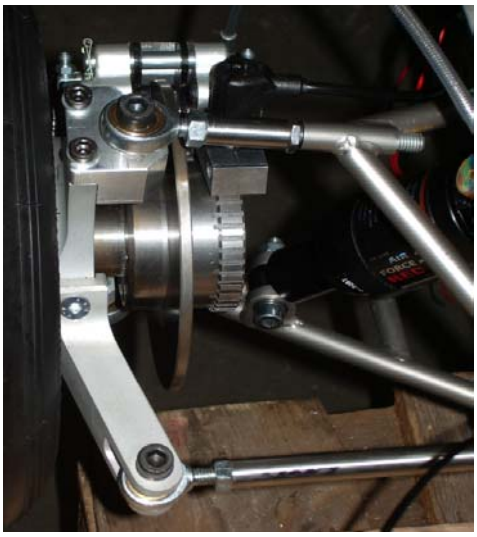

Figure 9: Kart 1, increment- and brake discs

PEDALS

The pedals are adjustable in the longitudinal direction to make it possible, that drivers with different length can reach the acceleration and brake pedals (Figure 10). This feature is important because of the main purpose of these Karts, to let teenager drive it.

Figure 10: Adjustable pedals

SIMULATION

Kinematics

Before we could simulate the kart in our new simulation software from IPG, we had to input the whole geometry of both, the front (e.g. Figure 11 (1)) and the rear axle. Thus, we measured the necessary data at the already built Kart 1 and used the CAD model of the Kart 2, either. Then we could export the whole data to use it in the simulation software "CarMaker".

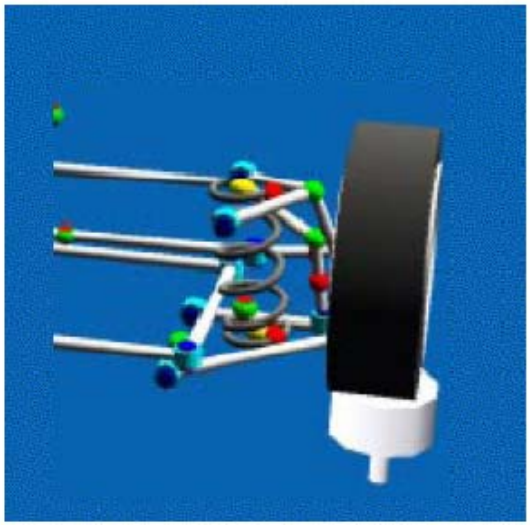

Figure 11: IPG Kinematics

CarMaker

With this software we can simulate different usual driving maneuver like braking on different friction coefficients or a slalom course (Figure 12). The results from these simulations could be used to improve the existing and upcoming Karts. For example we can find out, which forces in the wishbones act and see if our construction has the right dimensioning.

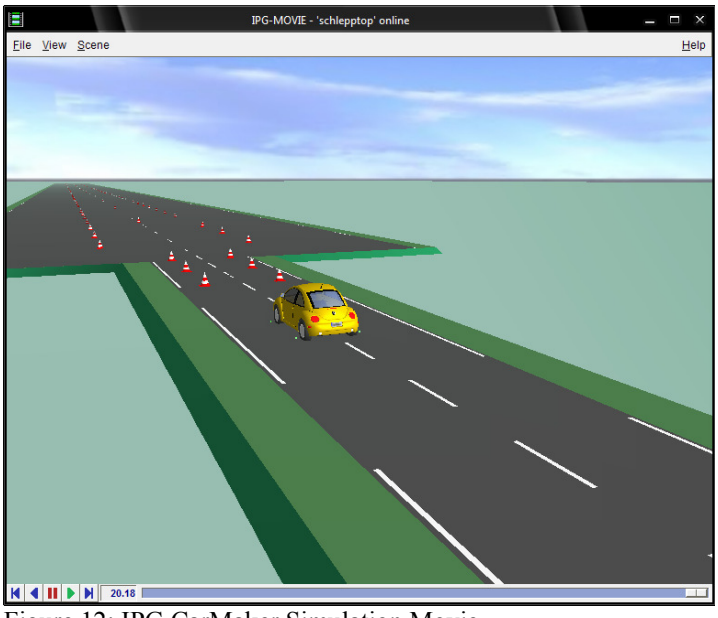

Figure 12: IPG CarMaker Simulation Movie

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) Picture from IPG-Kinematics Version 3.4 User Manual, IPG Automotive GmbH, Cover page, © 1993-2006