Chapter 6

Vehicle Dynamics and Green Electronic Differential for eKart

Golebiowski Wlodzimierz, Kubiak Przemysław and
Szymon Madziara

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.72892

Abstract

Today, electric vehicles are becoming increasingly popular in our lives. In motorsport, however, they are not as widely used. Formula E, which was created to boost electric motorsport, is not enough to popularize it. Every driver who wants to advance to F1 (highest rank racing series) has to start from karting between the ages of 5 and 8. But, today, gokarts are only powered by combustion engines. In order to provide young drivers with the possibility of racing small green electric vehicles, the so-called eKarts, combustion engines have to be replaced with electric motors. eKarts should offer similar performance to combustion engine go-karts. Therefore, to determine the required power of the electric motors and the capacity of the batteries in eKarts for different age categories, the technical parameters of the different age categories of combustion engine racing go-karts were analyzed. In this chapter, the present Li-ion battery technology makes it possible to construct eKarts for children and junior categories. With the current technology, it is not possible to create an eKart for senior categories (15 and over) in line with the current regulations for go-karts. Chance such green electronics solution with torque vectoring will provide better efficiency of energy consumption and lover impact on natural environment in reduced emission of both noise and greenhouse gases.

Keywords: eKart, electric motorsport, Formula E, go-karts, green electronic differential

1. Introduction

The history of the electric car started at the beginning of the automobile era, that is, in the nineteenth century. At that time, electric vehicles competed with combustion and steam engine ones not only on the streets but also on racetracks. The world land speed record of 105.88 km/h was established by the Belgian Camille Jenats in 1899 with an electric vehicle and was unbeaten for another 3 years [1, 2]. The Paris-Bordeaux-Paris race was attended by the French electric constructor Charles Jeantud. His car offered great performance, but its 950-kg batteries had to be replaced 15 times during the race [3]. The problem with storing electricity was the reason why electric vehicles have disappeared from the streets and from motorsport for a long time.

Rising awareness of ecology and the search for new fields of experiments in motorsport have led to the development of hybrid technology, which was the first sign of a return to electricity. In the F1 racing series, fuel efficiency regulations have been intensified and the share of hybrid energy recovery systems has increased [5]. In 2006, regulations were announced, and in 2009, a kinetic energy recovery system was introduced in the F1 racing series. The system called kinetic energy recovery system (KERS) allowed the release of energy up to 400 kJ on one lap [6, 8] and no more than 60 kW. In long-distance races, the importance of the hybrid system has been confirmed during the most prestigious race. In the LeMans race on June 16–17, 2012, two Audi hybrid cars were classified in the first two places. This was the first long-distance race for hybrid vehicles; apart from the Audi LMP1 e-tron, Toyota also entered its TS030 hybrid vehicle [7].

Another step toward ecological motorsport was the creation of the electric Formula E series [4]. In Formula E, the race takes about 50 min, and the problem of storing a sufficient amount of energy has been resolved by the obligatory pit stop and car replacement. Formula E takes advantage of easy energy control and makes the sport more entertaining. In racing mode, maximum power is limited to 170 kW. However, the three drivers who win a fan online vote can receive an additional 100 kJ, increasing maximum power to 200 kW for couple of seconds [9].

Formula E has received credit from racing drivers. Former F1 driver and current Formula E driver, Nelson Piquet Jr., said that "if you care about the fame and flashes the F1 is the best racing series, but equally exciting for racing drivers is competing in Formula E. Formula E was created to boost electric motorsport, but still very few series are purely electric."

To get to F1, each driver has to start from karting between the ages of 5 and 8, but present-day go-karts are only powered by combustion engines. In order to introduce the possibility of racing small green electric racing vehicles for young drivers, the so-called eKarts, combustion engines have to be replaced with electric motors. It was assumed that for eKarts to gain a foothold, they should provide similar parameters to those of combustion engine go-karts. Therefore, to determine the required power of the electric motors and the capacity of the batteries in eKarts for different age categories, the technical parameters of the different age categories of combustion engine racing go-karts have been analyzed.

The Rotax Max Challenge series has been chosen for analysis due to the fact that it is one of the most popular karting series in the world and also in Poland. **Table 1** shows the main features of selected Rotax categories [19].

An analysis of the power used by go-karts was made on the basis of data from racing and official trainings on the following certified karting tracks:

- Speedworld in Bruck, Austria—length 1060, 1120, 1140 m (depending on configuration), 8–10 m wide, clockwise direction.
- Goethe Stadium in Kecskemet, Hungary—length 935 m, 7 m wide, anticlockwise.
- Pann Ring in Ostffyasszonyfa, Hungary—length 1071 m, 8 m wide counterclockwise direction.

- Autodromo Vysoke Myto in Vysoke Myto, Czech Republic—length 1142 m, 8 m clockwise directional width.
- Tor Radom, in Radom, Poland—length 820 m, 8–12 m in clockwise direction (possibly also in the opposite direction).
- Bydgoszcz in the city of Bydgoszcz, Poland—length 1017 m, 8–10 m wide counterclockwise direction
- 7 Laghi Kart—International Circuit in Castelletto di Branduzzo, Italy—length 1017 m, 8–10 m in clockwise direction (**Figure 1**—Picture of 7 Laghi Kart—International Circuit)

In each of the age categories, data from a dozen race laps were analyzed, and for each six races were selected, three fastest and three slowest lap times for three different racetracks. An Off Camber Data tool for Unipro devices was used for the analysis. **Figure 2** shows the Off Camber Data analysis panel.

	MicroMax	MiniMax	JuniorMax	SeniorMax	DD2
Driver age (years)	8–10	10–13	13–16	15+	15+
Min. mass of vehicle with driver (kg)	110	130	147	165	173
Chassis type, wheelbase (mm)	950	1050	1050	1050	1050
Power max. (kW/rpm)	6/7500	11/8500	17/8500	22/8500	25/8500
Torque (Nm/rpm)	9/6000	13/8000	19/8500	21/9000	22/10500
Mass of drive train (kg)	21.6	23.0	23.0	23.1	28.8
Mass of fuel (kg)	~4.0	~5.0	~6.0	~7.0	~7.0
Race distance (km)	14	16	18	20	20

Table 1. Main parameters of the Rotax series in Poland.

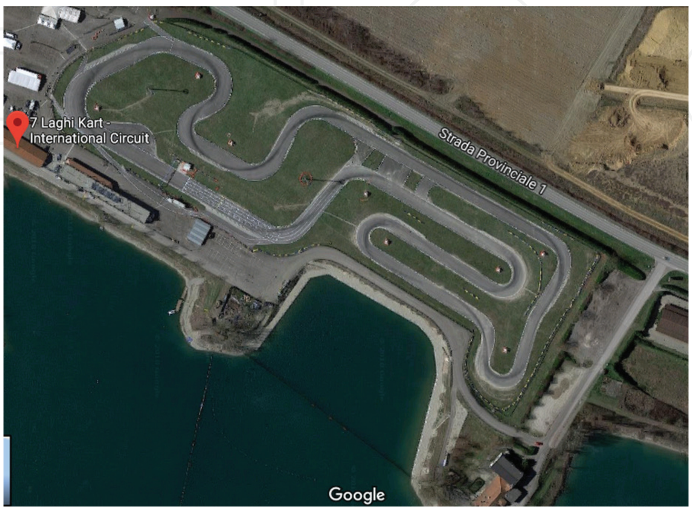

Figure 1. Picture of 7 Laghi Kart—International Circuit © Google Maps.

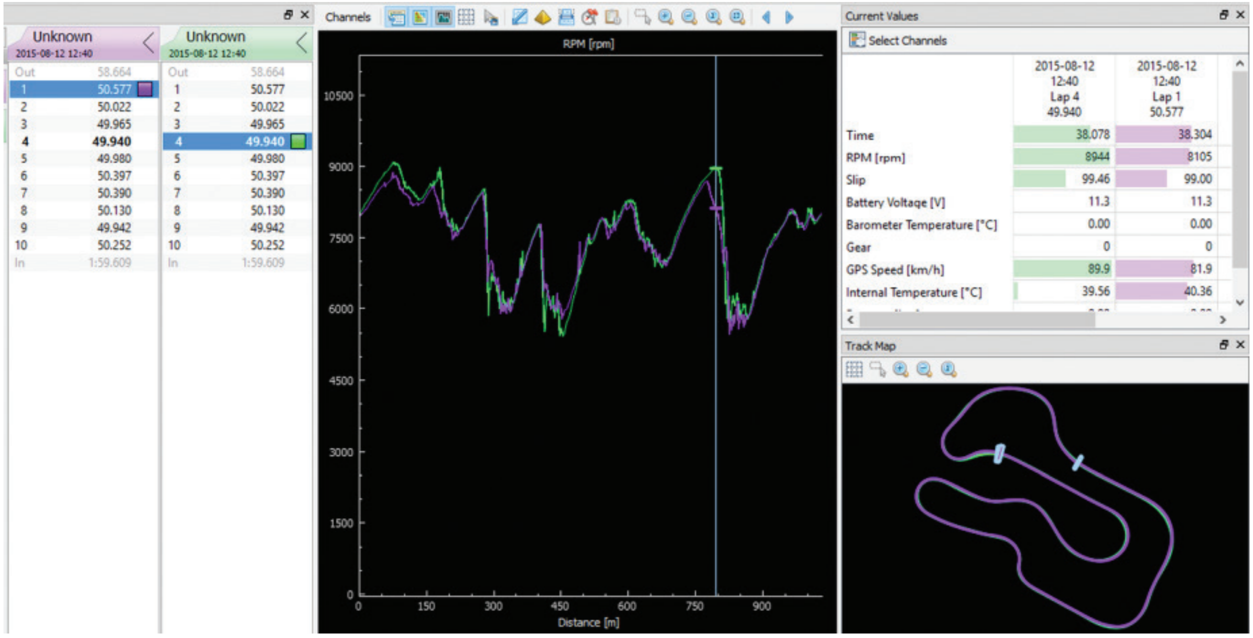

Figure 2. Analytical panel Off Camber Data application.

2. Model of go-kart energy usage

In order to determine energy requirements, the model assumes that the energy stored in batteries E_B must provide the possibility to finish a maximum duration race (based on the Rotax Max Challenge 2016 Cup) with the go-kart using maximum power, which was experimentally derived on different racetracks in Poland and Europe:

$$E_B = W_{Rmax} \times n \tag{1}$$

where E_B—energy stored in batteries (kWh), W_{Rmax}—work done by running go-kart during the race with maximum energy consumption (kWh), n—coefficient of securing sufficient level of energy (%).

In simplified terms, it was assumed that W_{Rmax} is the work done by the combustion engine of a go-kart of average power P_{Omax} throughout the maximum duration of the race t_{Rmax}.

$$W_{Rmax} = P_{Omax} \times t_{Rmax} \tag{2}$$

where t_{Rmax}—the maximum duration of the race based on an analysis of the Rotax Max Challenge 2016 Polish Championships (s), P_{Omax}—average power used by go-kart during a lap with the highest power usage (kW).

P_{Omax} was obtained by selecting the highest value from the calculated average power P_Os, for six different cases of go-kart racing in a given age category. We chose the shortest and longest run times on three racetracks with different characteristics.

The model assumes that the energy used on one lap P_O is equal to the sum of instantaneous power calculations in tenths of a second of the lap.

$$P_O = \frac{\sum_{i=0}^{N_O} P_{ch}}{N_O} \tag{3}$$

where P_O—average power value used during lap (kW), P_{ch}—instantaneous power (kW), N_O—number of measurements (measurement in 0.1-s intervals).

In the presented approach, it was assumed that P_{ch}—instantaneous power is calculated based on instantaneous engine rpm and the engine power/rpm specification curve presented in **Figure 4**. Due to the permanent coupling of the engine with the drive axle, in the course of the analysis, braking periods during the lap were identified and excluded from the calculation of average power. Based on observations and analysis, it was assumed that braking is a decrease in engine speed of at least 300 rpm with at least three measuring periods, that is, over 0.3 s and is associated with a significant decrease in vehicle speed, that is, at least 2 km in 0.1 s.

2.1. Analysis of race durations in the Rotax max challenge Poland championships in 2016

Following Eq. (2), it was necessary to analyze the duration of races t_{Rmax} to calculate the work performed by the power train. This analysis is based on the duration of go-kart races in the 12 rounds of the Rotax Max Challenge Poland Championships in 2016.

The analysis allowed us to determine maximum race times for the drivers who had completed full races in each of the age categories. **Figure 3** shows the time intervals in which the drivers finished the races of the given round of the Rotax Max Challenge Poland Championships in 2016. The data for wet races of the first round of the Rotax Max Challenge Poland Championships in 2016 are shown separately.

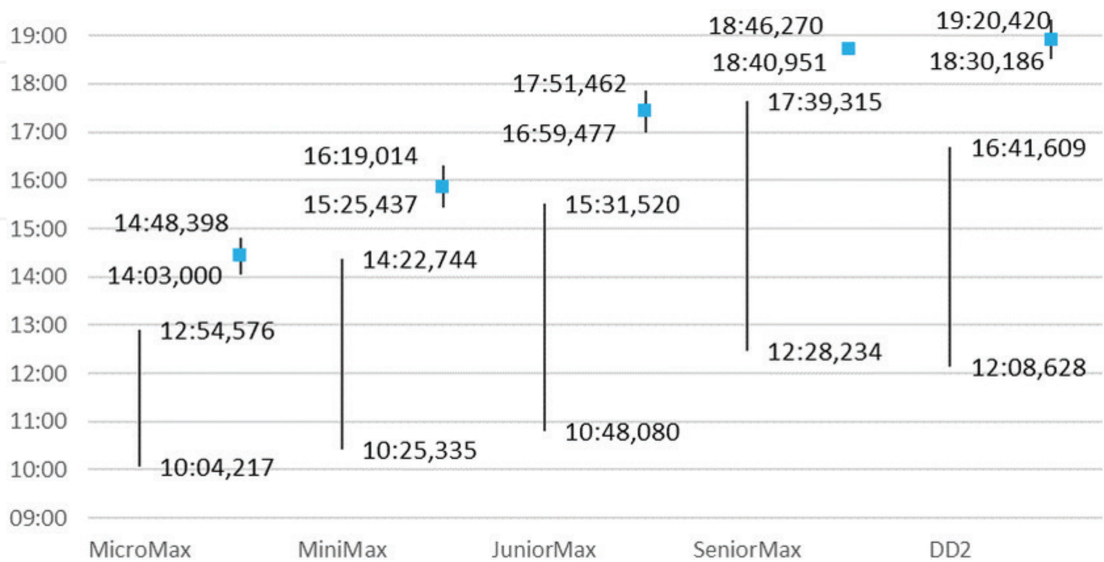

Figure 3. Race durations in Rotax Max Challenge Poland Championships 2016 for given categories.

2.2. Go-kart used power analysis based on Rotax max challenge series

The MicroMax Rotax Max Challenge category according to **Table 1** is a category for children aged 8–10. In this category of go-karts, maximum engine power is 6 kW with engine power/rpm curve shown in **Figure 4**.

The chassis of this category is the so-called "small frame" with a wheelbase of 950 mm, with brakes only on the rear axle. Maximum race distance for this category is 14 km, which translates to a maximum race time of 12 min and 54.576 s.

The data for the analysis were collected during official races and trainings on the following tracks:

- Speedworld
- Go-kart Stadion
- Pannónia Ring

Two lap times from the session on August 12, 2015, on Speedworld track with the configuration of 1120 m shown in **Figure 5** were selected:

i. 49,940 (s)—the fastest one

ii. 50,577 (s)—the slowest one

The power usage diagram for lap (i) and (ii) is shown in **Figure 6**.

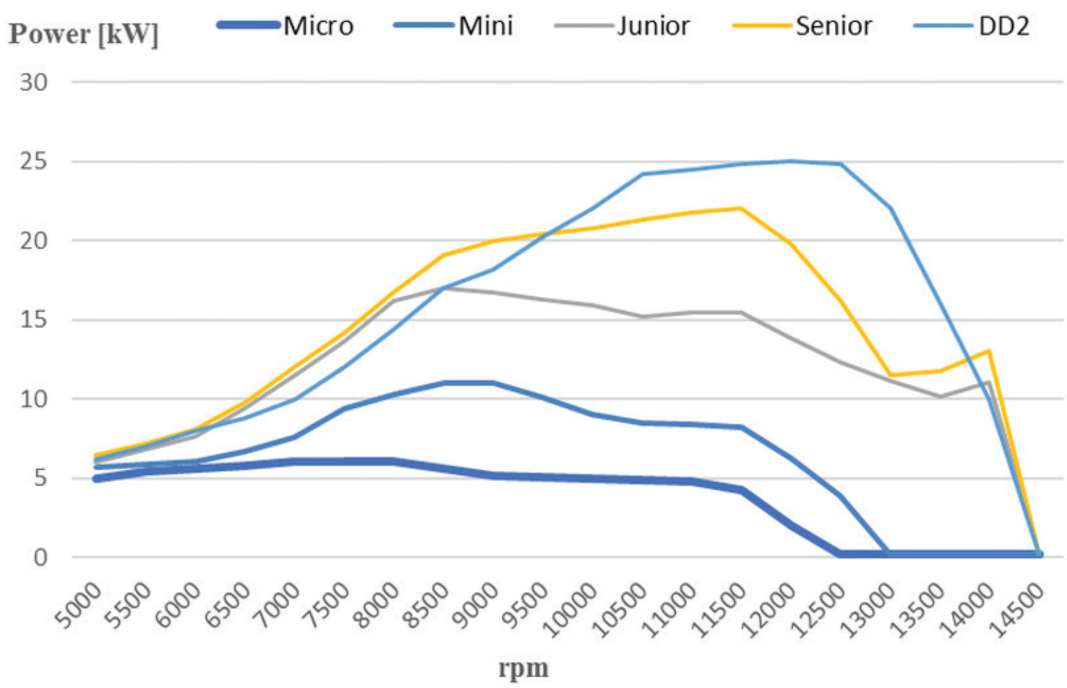

Figure 4. Rotax engine power/rpm curve for different categories [10].

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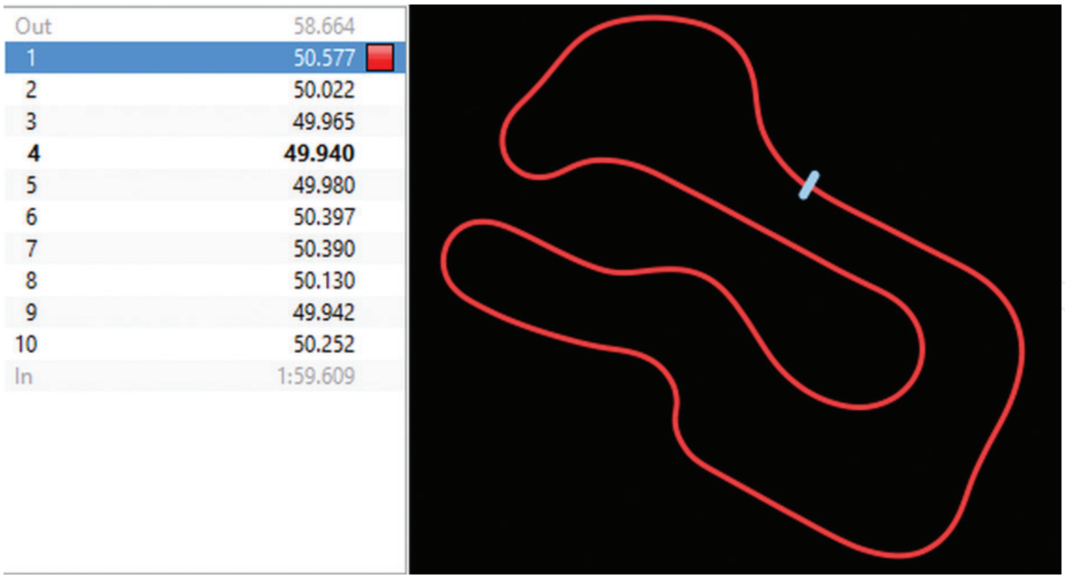

Figure 5. Race data from MicroMax category during Speedworld session on August 12, 2015, and track configuration Off Camber Data tool.

Based on **Figure 6**, the average levels of power used for laps were calculated:

i. 5.58 (kW)

ii. 5.64 (kW)

The maximum power was determined for both laps at the same level, that is, 6 kW.

Further laps were selected from the following sessions on the following tracks:

- Gokart Stadion session on June 21, 2015, data from two laps:

iii. 41,232 (s)—the fastest lap

iv. 41,760 (s)—the slowest lap

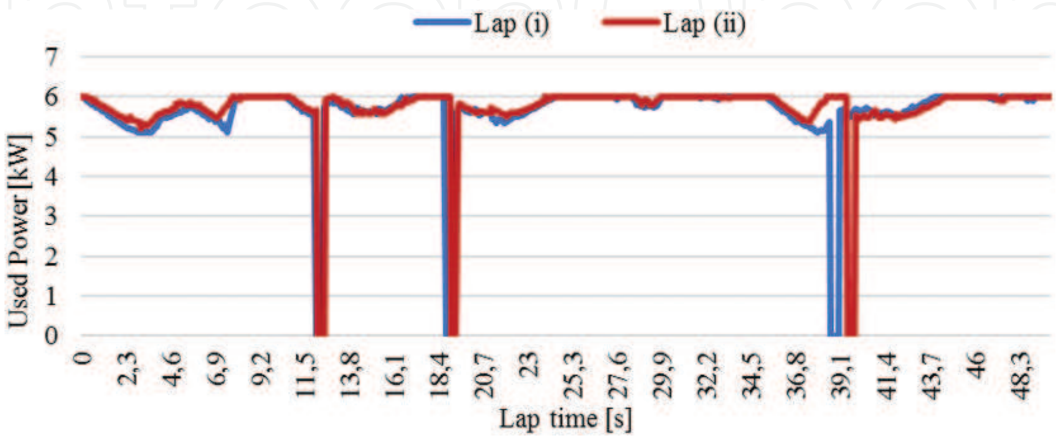

Figure 6. The power usage diagram for lap (i) and (ii) on Speedworld track, session on August 12, 2015.

- Pannónia Ring session on September 20, 2015, data from two laps:

v. 50,626 (s)—the fastest lap

vi. 52,015 (s)—the slowest lap

The average power value used during laps and the maximum power achieved in the MicroMax category were summarized in **Table 2**.

Maximum power of electric motors for MicroMax category was defined on the level of P_{max} = 6 kW. Average power value used during the lap with the highest power requirements P_{Omax} = 5.83 kW.

Knowing that the maximum race time is t_{Rmax} = 12: 54,576, the work done by the MicroMax go-kart drive systems according to Eq. (2) W_{Rmax}:

$$W_{Rmax} = P_{Omax} \times t_{Wmax} = 9.29 \times 0.239651 = 2.23 \text{ kWh}$$

Similar analyses and calculations were conducted for each Rotax Max Challenge category, and the results are presented in condensed form.

Knowing the value of average power used during a lap for each of the categories P_{Omax} and knowing maximum race time t_{Rmax} based on **Figure 3**, and Section 2.1. Analysis of race durations in the Rotax Max Challenge Poland Championships in 2016, we calculated the work done by a running go-kart during the race with maximum energy consumption W_{Rmax}. The results are presented in **Table 4**.

2.3. eKart: initial definition of main parameters

Based on the analysis of go-kart power usage presented in Section 2.2, the average power calculated based on Eq. (3) is assumed to be the minimum power that an eKart should generate. Maximum power for each category of eKarts is the maximum power achieved in a given age category for safety reasons. The engine power ranges for each eKart age category are shown in **Figure 7**.

Knowing the work done by a running go-kart during the race with maximum energy consumption for every Rotax Max Challenge category in **Table 4**, we can assume to conserve the same energy for each of the age categories of eKarts.

However, in order to calculate the practical value of energy stored in batteries in accordance with Eq. (1), it is assumed that n should be 120%.

	Lap (i)	Lap (ii)	Lap (iii)	Lap (iv)	Lap (v)	Lap (vi)
Average power used (kW)	5.58	5.64	5.81	5.83	5.64	5.78
Maximum power (kW)	6	6	6	6	6	6

Table 2. Average power used and maximum power of MicroMax category in six different laps of three sessions.

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	Lap (i)	Lap (ii)	Lap (iii)	Lap (iv)	Lap (v)	Lap (vi)
MiniMax						
Session	Speedworld August 14, 2015		Motodrom Vysoke Myto July 12, 2015		Pannónia Ring May 28, 2016	
Lap time (s)	46,520	47,224	49,315	50,165	49,252	50,027
Fastest/slowest lap	Fastest	Slowest	Fastest	Slowest	Fastest	Slowest
Average power used (kW)	9.15	9.12	8.91	8.95	9.29	9.21
Maximum power (kW)	11	11	11	11	11	11
JuniorMax						
Session	Pannónia Ring May 29, 2016		Tor Radom May 22, 2016		Tor Bydgoszcz May 1, 2016	
Lap time (s)	47,152	48,356	32,480	33.34	46,331	46,821
Fastest/slowest lap	Fastest	Slowest	Fastest	Slowest	Fastest	Slowest
Average power used (kW)	13.70	13.41	13.64	14.00	13.45	13.75
Maximum power (kW)	17	17	17	17	16.99	17
SeniorMax						
Session	Speedworld May 21, 2015		Pannónia Ring September 19, 2015		—	
Lap time (s)	44,086	45,597	45,786	46,532	—	—
Fastest/slowest lap	Fastest	Slowest	Fastest	Slowest	—	—
Average power used (kW)	17.63	18.44	17.22	16.71	—	—
Maximum power (kW)	22	21.99	22	21.99	—	—
DD2						
Session	Speedworld August 29, 2015		7 Laghi Kart May 16, 2016		Pannónia Ring May 29, 2016	
Lap time (s)	56,173	57,048	49,568	51,918	45,455	46,527
Fastest/slowest lap	Fastest	Slowest	Fastest	Slowest	Fastest	Slowest
Average power used (kW)	19.05	18.80	20.16	19.59	20.79	20.16
Maximum power (kW)	24.99	25	25	25	24.99	25

Table 3. Summarized sessions and laps information with average power used and maximum power on the lap for rest of Rotax max challenge categories, that is, MiniMax, JuniorMax, SeniorMax and DD2 [17].

	8–10	10–13	13–16	15+	15+ gears
P_{Omax} (kW)	5.83	9.29	14.00	18.44	20.79
t_{Rmax} (mins:s)	12:54,576	14:22,744	15:31,520	17:39,315	16:41,609
t_{Rmax} (h)	0.21516	0.23965	0.25876	0.2942	0.2783
W_{Rmax} (kWh)	1.25	2.23	3.62	5.42	5.79

Table 4. Work done by running go-kart during the race with maximum energy consumption for every Rotax Max Challenge category.

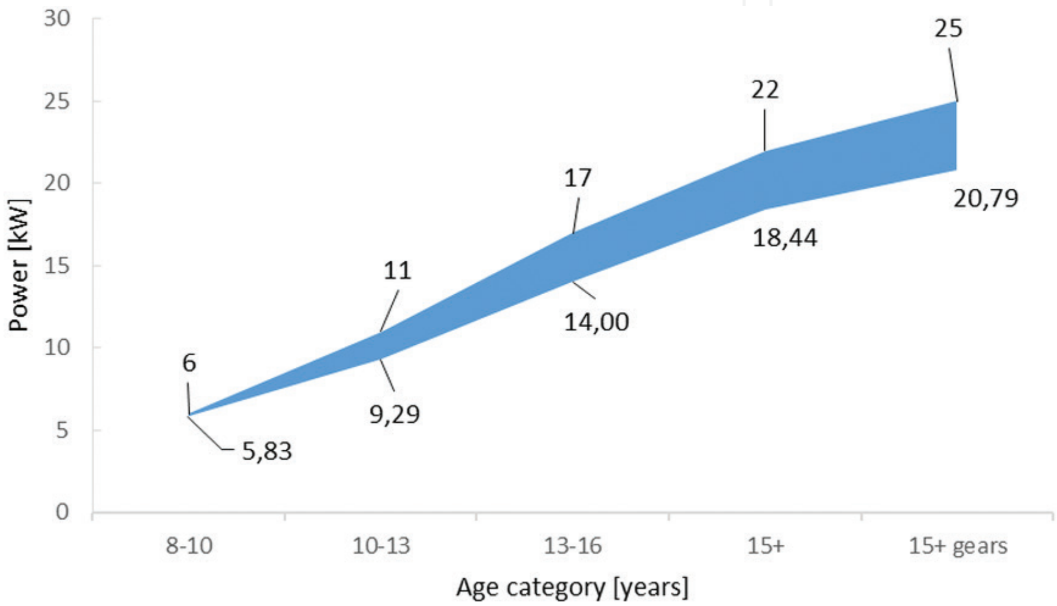

Figure 7. Power range of eKart drive system for different age categories.

$$E_A = W_{Rmax} \times 120\% \tag{4}$$

This assumption was stated because of the necessity to provide energy for additional formation laps and potentially higher consumption during rain races. On average, a rain race is longer than a race in normal conditions by 18% (**Figure 3**).

It was assumed that eKarts will be equipped with Li-ion batteries due to their best energy-to-weight ratio [11]. Degradation of Li-ion depends on the conditions, but it is up to 10% less capacity already at 300 charging-discharging cycles and 20% at about 1000 cycles [12, 13]. Therefore, it was proposed that the batteries should have 20% larger capacity than the expected E_A energy needed for an eKart race. Such a solution in addition will provide optimum, fast loading and braking capability from the first lap. The above can be described as:

$$Q_B = 120\,\% \times E_A \tag{5}$$

where Q_B—battery capacity (kWh).

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	MicroMax	MiniMax	JuniorMax	SeniorMax	DD2
Average power used by eKart on lap, P_{Omax} (kW)	5.83	9.29	14.00	18.44	20.79
Expected race time, t_{Rmax} (min:s)	12:54,576	14:22,744	15:31,520	17:39,315	16:41,609
Expected race time, t_{Rmax} (h)	0.21516	0.23965	0.25876	0.2942	0.2783
Work expected to be done during the race, W_{Rmax} (kWh)	1.25	2.23	3.62	5.42	5.79
Energy stored in batteries, E_B (kWh)	1.50	2.68	4.34	6.50	6.95
Capacity of batteries, Q_B (kWh)	1.75	3.12	5.07	7.59	8.11

Table 5. Capacity of batteries for different age categories of eKarts.

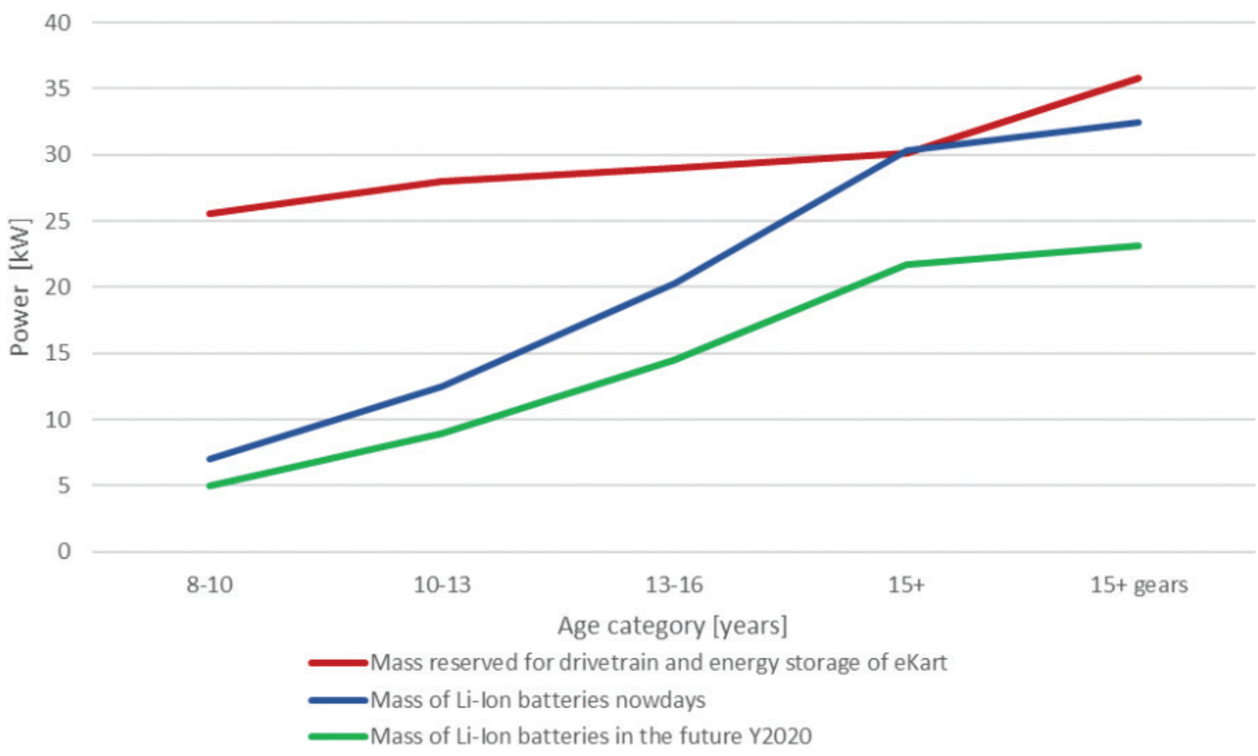

Figure 8. Maximum weight of drive train unit of eKart with batteries compared to potential mass of the batteries in Li-ion technology nowadays and in 3-year time for given age categories.

Therefore, we can rewrite **Table 4** for the eKart categories as following in **Table 5**.

An additional guideline for the selection of detailed electrical system parameters was the current weight of the go-kart in each age category. It was assumed that the weight of the eKart drive train system and the batteries should not exceed the weight of the current kart drive train system and weight of the fuel for the race shown in **Table 1**.

Based on battery capacity Q_B (6), we analyzed the options for designing eKarts for each category, within the limits of the maximum mass of the drivetrain system and the battery. We took into consideration the energy density of today's most efficient Li-ion battery technology (250 Wh/kg) and the technology expected in 3 years time (350 Wh/kg). The analysis is shown in **Figure 8**.

3. The concept of electric go-kart

For working out creation of the concept, it was assumed that the eKart design should be a simple four-wheeled vehicle with rear-wheel drive, using advantages of an electric drive. The key advantages of the electric drive are the compact size, power-to-weight ratio, high torque of the drive, and the ability to provide almost identical output parameters (speed, power, and torque) [18].

The ability to provide identical driving parameters like ICE go-kart has also become the basis for vehicle chassis design. It was assumed that for the simplicity of the eKart, a tubular flat frame without suspension element will form the chassis.

In the eKarta project, it was decided to use the compact dimensions of the electric motor. It was assumed that each wheel of the rear axle would be driven by a separate engine. This solution will allow to vary the speed of the inner wheel and the outer rear axle while cornering. This will help to achieve better stability with a similar balance of eKart versus the ICE go-kart [15].

The use of an electronic differential is an advantage of the electric motor to provide the same or better driving performance. In the case when the ICE go-kart is moving in a turn with rigidly join left and right wheel by rear axle, forces a large understeer as the inner wheel moves at a higher speed than that vehicle trajectory and the outer wheel moves at a lower speed than the trajectory. Thanks to the torque vectoring correction of independent rear axle motors, eKart handling will be neutral. Disconnection of rear axle wheels and powering them by separate motors make possible to adjust its settings so that, depending on the track, the effect can be configured under or above the steering.

According to the assumptions, the following solution was proposed.

eKart chassis is ICE go-kart chassis with two modifications shown in **Figure 9**.

The first modification marked 1 in **Figure 9** is the additional rear axle support to the left side of the chassis. Support is symmetrical longitudinally to the existing double supports on the right side, in a way that the rear axle can be divided into two components.

The second modification marked 2 in **Figure 9** is the division of the rear axle into two independent elements. Because the rear axle in ICE go-karts connects its fulcrum points (shown in **Figure 10**, marked 2), it is also the structural component of the rear frame of the vehicle. In the ICE go-karts, the rear axle has different stiffness parameters so allow to adjust the rear traction of the vehicle. The traction of the rear axle of the eKart will be adjusted by strut bar between the inner axle support points (not present ICE go-karts) and the spacer between the outer support points (solution in go-karts marked 2 in **Figure 10**).

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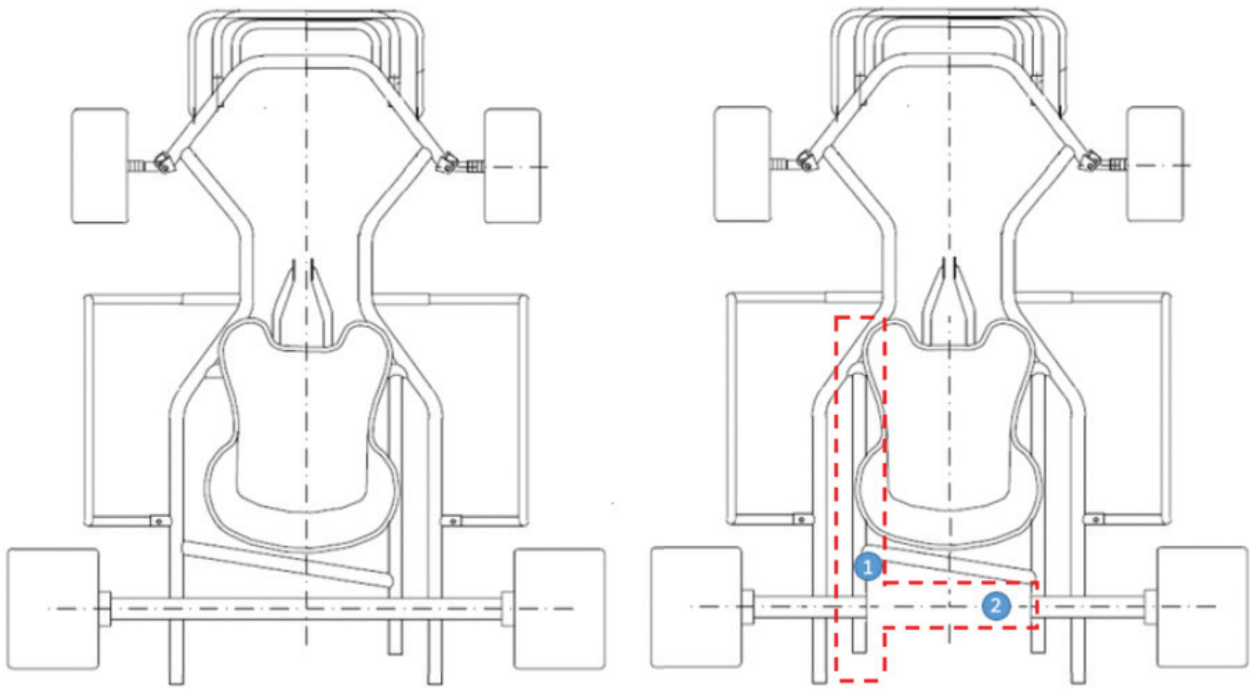

Figure 9. Sketch of modification of the ICE go-kart chassis for the eKart construction.

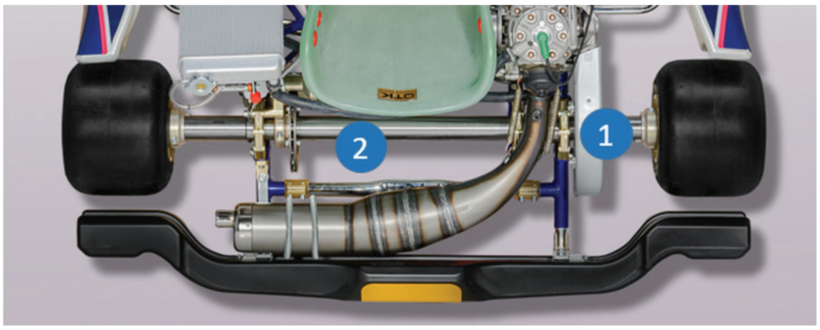

Figure 10. Rear suspension elements of Kosmic MERCURY MY15 [16].

Since in the ICE go-kart support of the rear axle on the right-hand side are at the same time structural parts of the engine mounting, modification marked 1 in **Figure 9** will allow the installation of separate motors for both wheels of the rear axles. At the design stage, it will be determined whether the motors are located ahead of or behind the rear axle of the vehicle; as illustrated in **Figure 11**, both variants are possible.

eKart will be equipped with electric motors of different power depending on the age category. There can be also different kinds of motor cooling, air cooled and liquid cooled, depending on its power.

Potential position of batteries is also shown in **Figure 11**. It was indicated to ensure the best balance of eKarts. The position of the batteries must at the same time ensure maximum protection due to poisoning or burns in case of damage. The position of the batteries has been proposed in places least exposed to other eKarts and track elements (barriers) during the

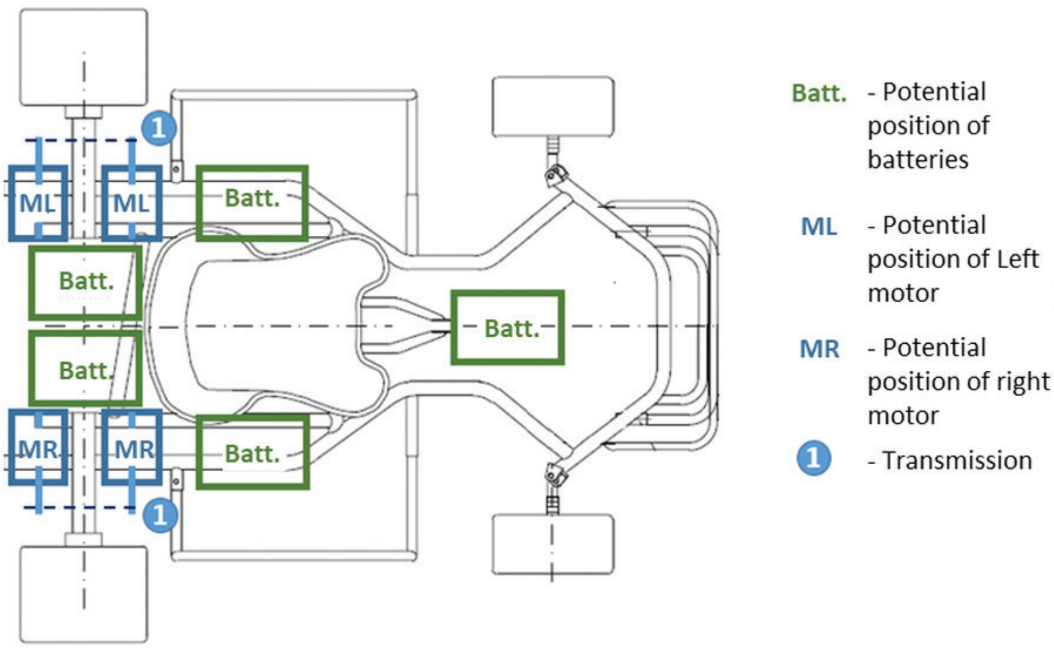

Figure 11. Potential position of the main components of eKart.

crash. The proposed battery position at the rear of the vehicle is located between the rear axles and is protected by a rear bumper, and lateral side seats are secured with side chassis, aerodynamic elements, and a bumper. The front battery compartment is located at the fuel tank of ICE go-kart. The advantage of rear or side mounts is the distance to the motor, while the advantage of the front position is a better eKart static balance.

4. Construction of eKart

For proving the concept of eKart, prototype of eKart was designed and built according to the concept [13]. After design phase where different technologies and component were analyzed, eKart was built with following parameters:

- Power transmission — Synchronous toothed belt
- Maximum power of electric motors — 2×5 kW
- Maximum torque of electric motors — 2×14 Nm
- Protection class — IP54
- Operating voltage — 39–58 V
- Battery capacity — 108 Ah
- Vehicle mass — 97.3 kg
- Dimensions — 1870 × 1340 mm

Figure 12. Assembly of eKart.

- Wheelbase 1050 mm
- Battery mass 23.2 kg

The construction of the eKart was realized in cooperation with car enthusiast student club from Faculty of Mechanical Engineering of the Technical University of Lodz. In **Figure 12**, assembly of eKart is presented.

5. Tests of eKart

The purpose of the test was to verify the concept and the design assumptions in experimental research. Test run was conducted on the Tor Łódź circuit in Stryków, Poland 596 m short track, 8–12 m wide, clockwise direction (**Figure 13**).

Test runs were carried out on November 19, 2016, air temperature 11°C and atmospheric pressure ~ 992 hPa. The surface at the start of the tests was wet, while the test surface was mostly wet.

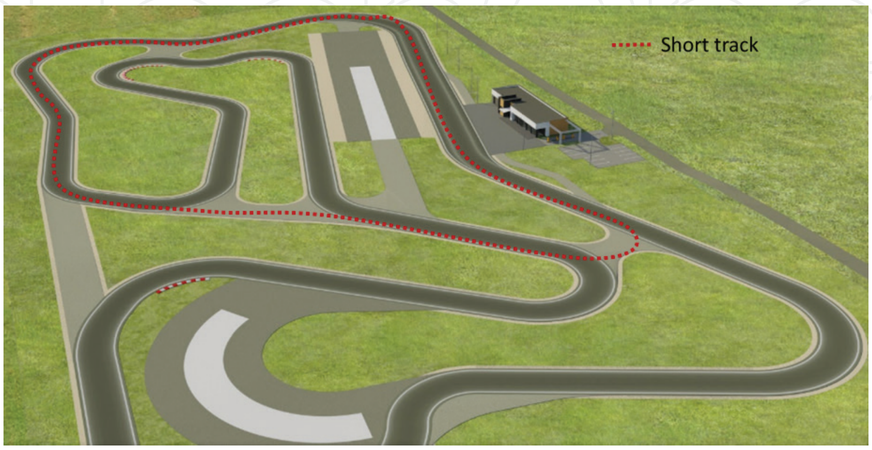

Figure 13. Short track of Tor Łódź © circuit.

The analysis was based on data from RaceCapture Pro2 as shown in **Figure 14.**

The maximum speed on the test section was 52.64 mph, that is, 84.75 km/h (**Figure 9**). The maximum measured acceleration measured on a straight run was 13,787 s from 0 to 100 km/h. Acceleration was extrapolated from an increase in speed from 40.41 km/h to 84.75 km/h in 6.12 s, on a straight line allowing maximum acceleration. In **Figure 15** the extrapolated acceleration of the eKarts with comparison to three categories of the Rotax Max Challenge Series.

Comparing the maximum speed and acceleration of the eKart with ICE go-kart of the Rotax Max Challenge categories shown in **Table 6**; not considering the movement resistance and air resistance, it can be assumed that, by increasing the gear ratio by 22% in eKart, eKart would have similar parameters to the MiniMax category of the Rotax Max Challenge series.

Figure 14. Data from eKart road tests on Tor Łódź © circuit.

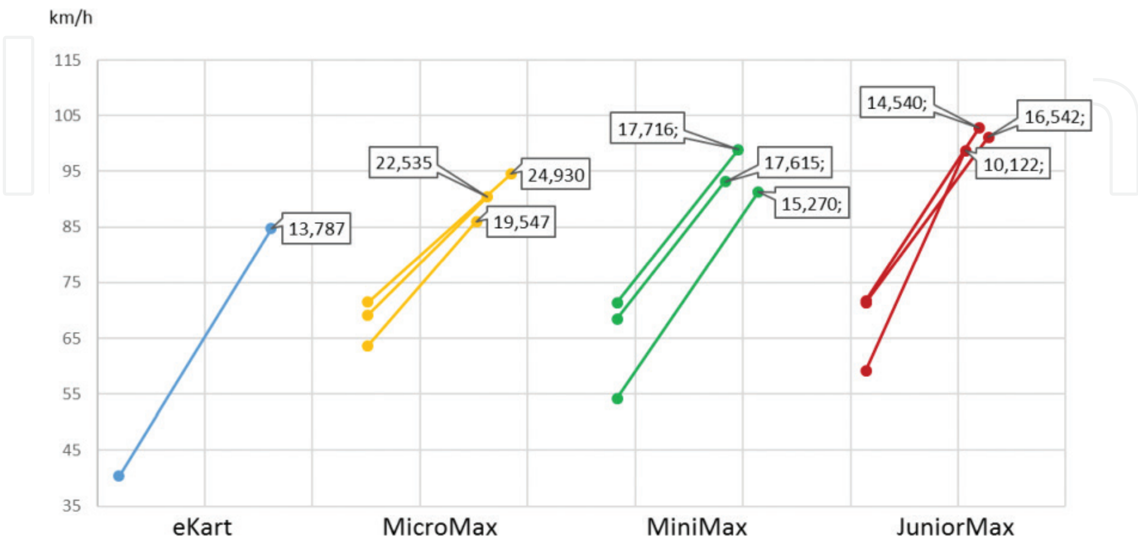

Figure 15. Comparison of extrapolated accelerations of eKart and the category Rotax Max.

http://dx.doi.org/10.5772/intechopen.72892

	Acceleration (0–100 km/h)	Max velocity (km/h)	Acceleration diff. eKarta (%)	Max velocity diff. eKarta (%)
eKart	13.79	84.75	—	—
MicroMax	22.34	91.23	162	108
MiniMax	16.87	103.07	122	122
JuniorMax	13.74	110.67	100	131

Table 6. Comparison of speed and acceleration of eKart with ICE go-karts of Rotax Max Challenge categories.

Figure 16. eKart noise intensity measurement.

During the tests, eKart sound loudness was measured. At a distance of 5 m from the track axis, the Benetech GM1356 was used, with the range of 30–130 dB and tolerance of ± 1.5 dB. In three tests, the noise level was measured at 80.3 dB; measurement is shown in **Figure 16**.

The measured value of the eKart noise is about six times lower than the noise level generated by the comparable class of ICE go-kart from Rotax Max Challenge series which is 90 dB [14].

6. Conclusions

With existing Li-ion battery technology, it is possible to construct eKarts for children and junior categories. With the current technology, it is not possible to create eKarts for senior categories in line with the current regulations for go-karts as the mass of the battery exceeds the weight of the entire drive train system of the go-kart. In order to provide a solution for senior categories, it would be necessary to change the regulations, for example, race time and vehicle weight, or wait for emerging battery technology to provide an energy density of at least 350 Wh/kg, which should take place within 3 years.

In this chapter, author proves that current technology is enabled to create eKart which is competitive and more efficient to ICE go-kart MiniMax category from Rotax Max Challenge series.

eKart also has better functional parameters; for example, noise generated by eKart is about six times lower than that for ICE go-kart MiniMax category from Rotax Max Challenge series. Due to electronic differential, which can actively manage torque and power on each of the rear wheels, called torque vectoring, eKart with 10 kW has parameters comparable with 12 kW ICE go-kart. That means that positive influence on natural environment is not only caused by applied electric motor but also due to algorithm in so-called green electronic differential. Due to electronic differential, which can actively manage torque and power on each of the rear wheels, called torque vectoring, eKart with 10 kW has parameters comparable with 12 kW ICE go-kart. That means that positive influence on natural environment is not only caused by applied electric motor but also due to algorithm in so-called green electronic differential.

Author details

Golebiowski Wlodzimierz*, Kubiak Przemysław and Szymon Madziara

*Address all correspondence to: golebiowskiw@wp.pl

Department of Vehicles and Fundamentals of Machine Design, Faculty of Mechanical Engineering, Technical University of Lodz, Poland

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