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Andrzej BAIER, Adam PĘKAŁA*, Łukasz SZWALA
Institute of Engineering Processes Automation and Integrated Manufacturing Systems,
Faculty of Mechanical Engineering, Silesian University of Technology, Gliwice, Poland
*adam.pekala@protonmail.com

STUDIES ON THE IMPACT OF WHEELS' TILT ANGLE ON MOTION RESISTANCE OF ELECTRIC RACE VEHICLE

Abstract: The article is describing project about tilting wheels of Greenpower team's bolide, which would cause in the reducing face surface. Changes in face surface depending on wheels' tilt angle were and chosen components of a chassis that were modified thanks to the NX 10 software were presented.

1. Introduction

Electric cars that take part in the Greenpower races are running on the electrical motor powered by electrical energy collected in two batteries (12V, 240Ah each). Each car has the same DC Motor with an output of 240W and similar amount of energy collected in batteries [1]. The aim of the races is to drive as much circuits as possible during specified amount of time. Specific form of a competition demands focusing on reducing the energy consumption [4].

In this particular case of Silesian Greenpower car, aerodynamic drag represents 70 per cent of the all frictions that are the consequences of car motion. Reduction of the drag helps to achieve the best results during the race. Aerodynamic drag can be described by the equation (1):

$$R = \frac{1}{2}\rho C A v^2, \tag{1}$$

where: R-aerodynamic drag, ρ- density of the medium, C- coefficient depending on the shape of the object, A-sectional area of the body, ν- speed of the body relative to the medium.

Based on the formula (1) one of the elements responsible for an air resistance is the size of vehicle's face surface. Body is the main part that increases the resistance in the car. To enable some changes in a body, outline modifications of the chassis are necessary. It was decided, in the first place, that wheels will stay as they are- under the body outline and the wheelbase will not be changed. It was also decided that the wheels will be negative tilted, because this redesign would result in reducing the size of face surface.

2. Effects of camberangle on the size of face surface

Firstly, the effects of wheels' tilt angle on the size of face surface of a car were specified (Fig.1.).

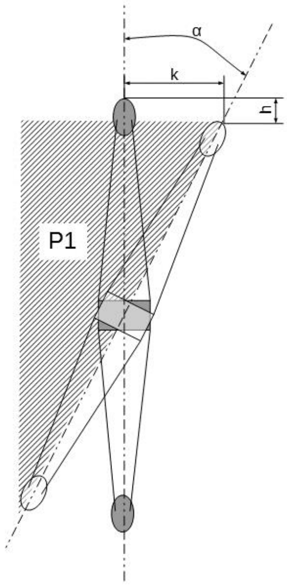

Fig.1. P1 - Crosshatched area, α - wheel's tilt angle

P1 value was doubled and related to the output size of the face surface which was 0,276m^2. Relative value of changes in the size depending on a wheels' tilt angle was received and it should be treated as maximum. Various options of tilt angle were presented in Tab.1.

Tab.1. Gained size of the surface depending on the wheel's tilt angle

α	h[mm]	k[mm]	change in the size of face surface
1 ^{0}	0,1	3,6	2,2%
2 ^{0}	0,3	7,3	4,4%
3 ^{0}	0,6	10,9	6,6%
4 ^{0}	1,0	14,5	8,8%
5 ^{0}	1,6	18,2	10,9%
6 ^{0}	2,3	21,8	13,1%
7 ^{0}	3,1	25,4	15,2%
8 ^{0}	4,1	29,0	17,4%
9 ^{0}	5,2	32,6	19,5%
10 ^{0}	6,4	36,2	21,5%

Calculation of the parameter k shows how much the center of the wheels should be pushed closer to the axis of the car to keep the track of the vehicle.

3. Modeling the wheels' tilt angle

In the next place, the virtual model of the car was mapped out using the NX software. It helped to virtually control the camber angle and width of a track of the vehicle. Parts of the car that should be modified to effectuated changes planed by the team were defined and the limitations caused by the twist of the front axis were investigated. If it comes to the front axis it was decided to keep the original steering and it's fastening to the chassis.

In the next step of the studies, some possible modifications were laid down. One variant for the front (Fig.2a) and back (Fig.2b) part of the chassis were chosen. This decision was based on the couple of aspects, such as: modification simplicity, easiness of the wheels fixing to the chassis and construction toughness. During the selection of the wheel camber the aim was to gain the maximum angle while minimizing the changes needed to be put in the frame structure. Minimum profitable and sensible value of the angle was 2 degrees, corresponding to the reduction of the face by a maximum of 4.4%. Track of the vehicle was increased to 529mm compared to the 505mm on the beginning of the process and 4-stepwise wheels' tilt angle was chosen.

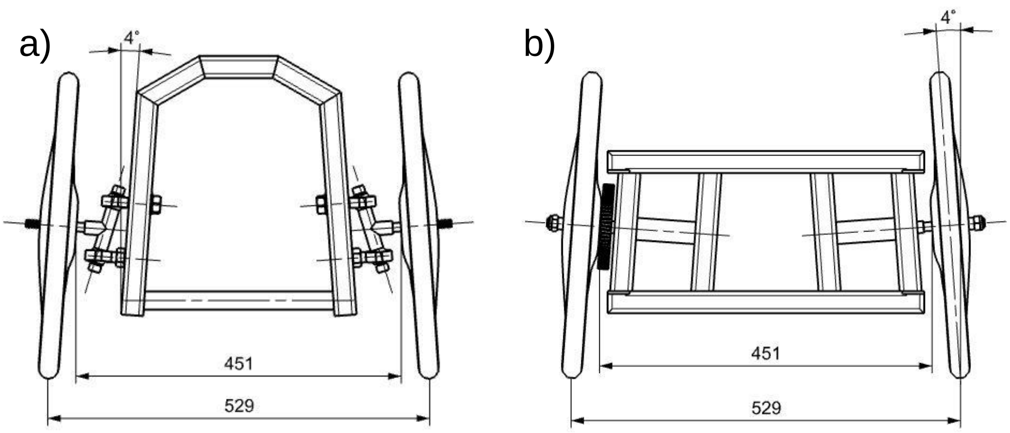

Fig 2. Chosen variants: a)front, b)back part of the chassis

Virtual chassis model was modified and two conceptions of it were taken into account. One concept involves theory that in order of boosting stability of the car during driving on high speed, caster angle should be increased. Verification of the results was necessary because of the precalculations that can be riddled with plenty of errors. Changes in body outline were approximated with help of B-splines and new size of body outline was calculated (Fig. 3.).

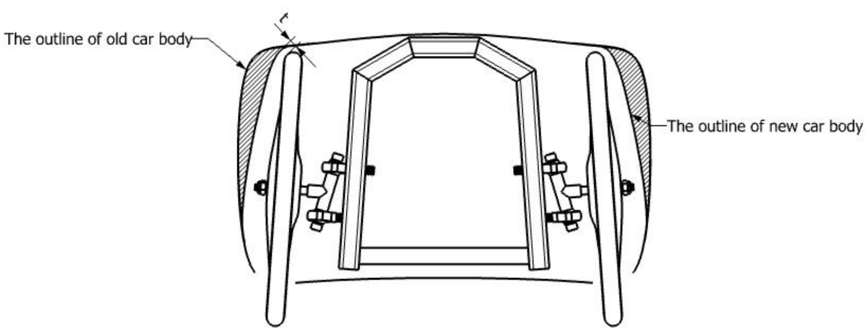

Fig.3. Difference in size of present and proposed body outline.

It was calculated that size of crosshatched area is 0,00921m^2. In relations to the total face area it would cut the size over 3,3%.

4. Conclusions

Suggested modifications consisting of negative wheels' camber over 4^o will contribute to cutting the face area by over 3,3%.

There is possibility that chassis modifications based on changing its parts to new one would give worse results compared to the planned and in that case building up brand new chassis with some parts changed into the ones that were modified may be better (Fig.2).

Camber of wheels might have influence on other resistance factors and stability of the car motion. During the race, deformations of the body and wheels take place and it can cause rubbing of those parts. Small gap between them (Fig.3) is the reason of this phenomenon. On the other hand, dilatation of them causes enlargement of the car's face area.

References

1. Baier A., Baier M., Sobek M., Grabowski Ł., Dusik D., Papaj P.: Computer aided process of designing the mechatronic Silesian Greenpower electric car, The Second International Conference on Modern Manufacturing Technologies in Industrial Engineering. ModTech 2014, ModTech Publishing House.
2. Baier M., Dusik D.: Belt Vibrations Measurement and Relative Efficiency of the Powertrain Study on the Engine Test Stand for Silesian Greenpower Vehicle, Selected Engineering Problems, Institute of Engineering Processes Automation and Integrated Manufacturing Systems, Gliwice, marzec 2015, ISSN 2299-954X
3. Baier M., Franiasz J., Mierzwa P., Wylenzek D.: Engine Test Stand of Electrical Race Car, ModTech 2015, Wydawnictwo ModTech Publishing House, Iasi, czerwiec 2015, ISSN 2286-4369
4. Baier A., Baier M., Sobek M., Grabowski Ł., Dusik D., Papaj P.: Computer Aided Process of Designing the Mechatronic Silesian Greenpower Electric Car, Advanced Materials Research Vol. 1036 (2014) pp 674-679, Trans Tech Publications, Switzerland
5. Grabowski Ł., Labus M., Sobek M.: Projektowanie i wytwarzanie kompozytowego nadwozia elektrycznego bolidu wyścigowego, Projektowanie i Konstrukcje, Wydawnictwo ITER, Warszawa, listopad 2013, ISSN: 1899-699X
6. Baier M., Dziewior M., Franiasz J., Zuk M.: Thermal Analysis of a DC Motor Cooling System Availing an Engine Test Stand of Electrical Race Car, Applied Mechanics and Materials Vols. 809-810 (2015) pp 1145-1150, Trans Tech Publications, Switzerland