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DESIGN OF A SHORT-TIME ENERGY SAVING TANK FOR LIGHT WEIGHT ELECTRIC TRANSPORT VEHICLES

Запропоновано підхід до проектування резервуару для колеса електромобіля, який має коротку енергозбережну дію. Обґрунтовано, що новий продукт буде не лише енергозбережним, але й дасть змогу зекономити потужність під час гальмування та набирання швидкості. Для проектування обрано спеціалізовані бібліотеки ПЗ CATIA, оскільки вони є найвідповіднішими для розв'язку питань машинобудування.
Ключові слова: електромобіль, енергозбереження, колесо, резервуар, сенсор, CATIA.

The paper suggests the approach to the design of a short-time energy saving reservoir for light-weight electric transport vehicles. It is substantiated that the new product will be energy-saving and will ensure gains in traction and braking force. CATIA was chosen as the most proper environment for the design as its libraries are the most suitable for machine-building.
Key words: electromobile, power-saving, wheel, reservoir, dynamics, sensor, CATIA.

Introduction

Advanced trends of modern engineering call for the development of cheap and multifunctional electromobiles. The main purpose of these electromobiles is to abandon expensive and harmful fuel and to substitute it with electricity, which is less costly and harmless for the environment [1].

The main goal of the paper is to suggest the design and development of the electric drive wheel mechanism foe electromobiles with the engine braking force that can be used by pneumatic accumulator for its elimination.

A special tank for the electromobile (further TANK) has been suggested, which is in an additional component of its propulsion system and promotes energy-saving together with the increases of the elecromobile capacity. TANK seems to provide the solution of an urgent problem, as it helps to discover new ways of energy saving. The proposed design is somewhat innovative, because it reflects a new vision of wheel functioning in electric cars.

TANK components

The developed project concerns the special reservoir (the TANK) which is the component of the wheel and is directly connected with the electric drive [4]. The general shape of TANK is presented in Fig. 1.

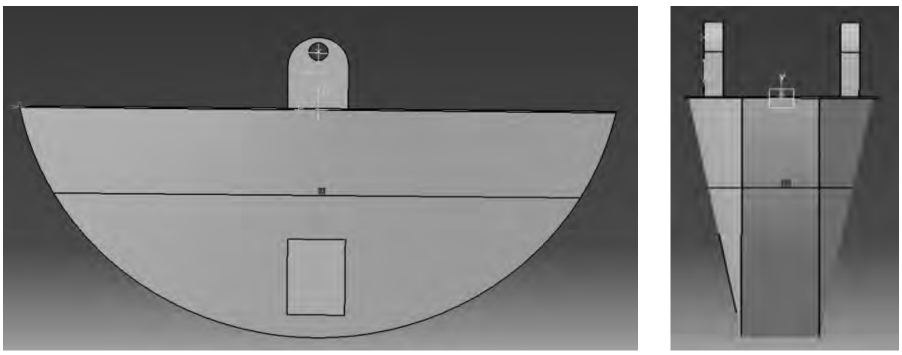


Fig. 1. The TANK's shape

TANK is attached to the wheel with fixing as shown in Fig. 2. The thickness of upper part is 2 mm.

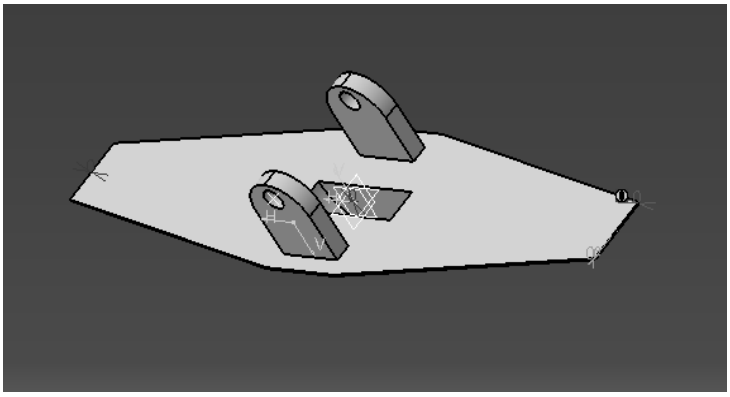


Fig. 2. The upper part of TANK with fixing

To provide the centre of mass to be better fixed different thickness of TANK walls should be used in the upper and lower parts of it (Fig. 3 and 4).

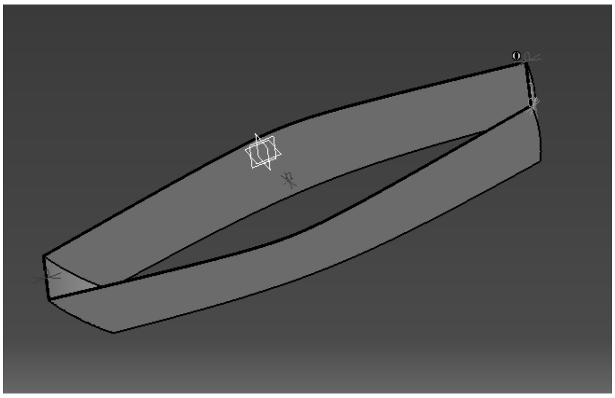


Fig. 3. Upper part (2 mm)

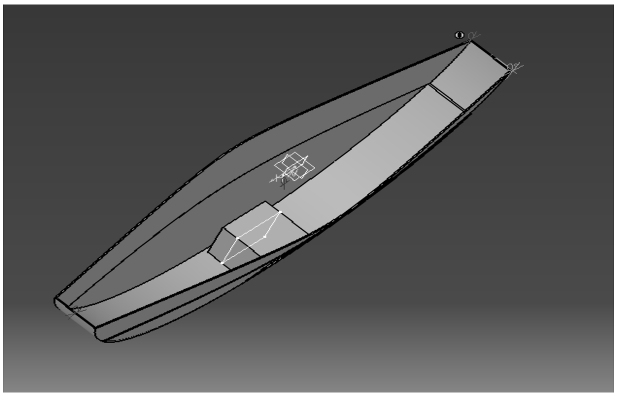


Fig 4. Lower part (5 mm)

Calculations of TANK limitations

Within TANK the values of pressure can be different (Fig. 5).

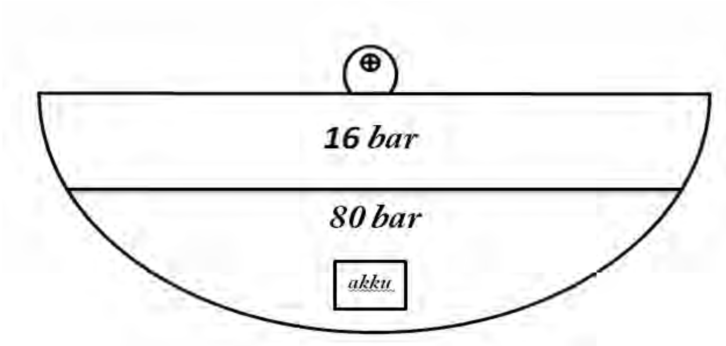


Fig. 5. TANK maximum internal pressures

TANK internal pressures are calculated as follows:

$$16\,bar \triangleq 1{,}6\cdot 10^6\,\frac{N}{m^2}, \qquad 80\,bar \triangleq 8\cdot 10^6\,\frac{N}{m^2}$$

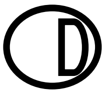
$$11{,}4l \triangleq 0{,}0114m^3, \qquad 9l \triangleq 0{,}09m^3$$

$$E_{16\max} = 1{,}6\cdot 10^6\cdot 0{,}0114 = 18{,}24\ kJ, \qquad E_{80\max} = 8\cdot 10^6\cdot 0{,}09 = 72\ kJ,$$

$$E_{\max} = 18{,}24 + 72 = 90{,}24\ kJ.$$

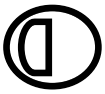
There are some limitations which include:

- **Low pressure range**



Typical E_{16} 16 bar ↕ =15 bar
1 bar

- **High pressure range**



Typical E_{80} 80 bar ↕ =64 bar
16 bar

To calculate the $P_{\max}$ useful power content

$$E_{ges} = V_1 P_1 + V_1 P_1 \tag{1}$$

$$E_{ges} = 0,0114 m^3 \cdot (1,5 \cdot 10^6) \frac{N}{m^2} + 0,009 m^3 \cdot (6,4 \cdot 10^6) \frac{N}{m^2} = 74,7\ kJ$$

$$E_{ges} = 74700\ Nm$$

$$E_{ges} \approx 267857,14 \frac{W}{s}.$$

That means, we can get a maximum speed up/speed down during some interval:

$$E = Pt \tag{2}$$

$$t = \frac{E_{ges}}{P}$$

$$t_{\max}(P) = \frac{74700}{740} = 101 s.$$

Despite the indicated limitations the gains provided by TANK operation allow to conclude that this reservoir makes the car more controllable.

Data processing and TANK effectiveness calculation

- Mass of the TANK was obtained from CATIA project

$$m = 13,05\ [\text{kg}] \tag{3}$$

- To calculate the T we apply the formula:

$$T_{\max} = mw = mhg \tag{4}$$

$$T_{\max} = 0,291 \cdot 13,5 \cdot 9,81 = 37,2\ [\text{Nm}].$$

- All the physical forces which influence the wheel are shown in Fig. 6.

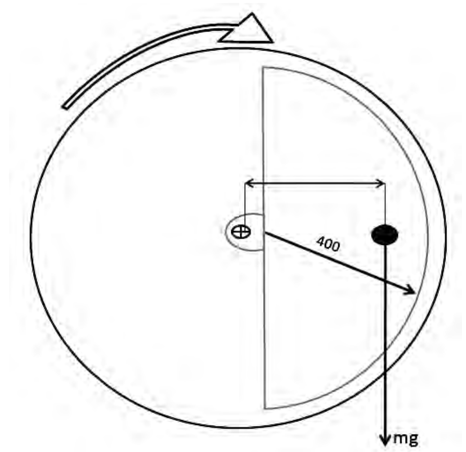


Fig. 6. Forces acting on the wheel

- To calculate the P with different meanings we apply the formula:

$$P = T \cdot 2\Pi \cdot \frac{v}{u}. \quad (5)$$

The results of calculations containing our data are shown in the table below.

$P = T \cdot 2\Pi \cdot \frac{v}{u}.$	T_{max} [Nm]	2Π	V [m/s]	U	P [W]	[PS]
P_{max}	37	6,28	10	3,14	740	1,01
	37	6,28	9	3,14	666	0,91
	37	6,28	8	3,14	592	0,81
	37	6,28	7	3,14	518	0,70
	37	6,28	6	3,14	444	0,60
	37	6,28	5	3,14	370	0,50
	37	6,28	4	3,14	296	0,40
	37	6,28	3	3,14	222	0,30
	37	6,28	2	3,14	148	0,20
P_{min}	37	6,28	1	3,14	74	0,10

$$U = \pi_x d_w = 3{,}14 \cdot 1m = 3{,}14\ [\text{m}] \quad (6)$$

$$n = \frac{v}{u} \quad (7)$$

$$n_{10\frac{m}{s}} = \frac{10}{3{,}14} = 3{,}18$$

$$w = 2\pi n \quad (8)$$

$$w_{10\frac{m}{s}} = 2\pi \cdot 3{,}18 = 20 s^{-1}$$

- to calculate the $P_{\max(1\,\text{whell})}$

$$P = Tw = T_{\max} w_{10\frac{m}{s}} \quad (9)$$

$$P_{1\,\text{whell}} = 37\ Nm \cdot 20\,s = 740\ [\text{W}], \qquad P_{1\,\text{whell}} = 740\ W \cdot 1{,}36 \approx 1\,[\text{PS}].$$

At the result, we have 2 horse powers gain.

Having chosen pneumatic forces as the basis for TANK movement inside the wheel, we have calculated its power and its coefficient of efficiency which amounts to 20 %. After all the calculations have been done, the maximum power reserve has been determined. It amounts to 2 horse powers.

Conclusion

Thus, the paper presents the newest development for electric wheel that allows to save 20 % of fuel due to gains in traction and braking power. Knowledge of modern integrated system provided an opportunity to use CAD programme CATIA (Computer Aided Three Dimensional Interactive Application) of the French company Dassault Syst?mes to build proper design of the TANK (a special reservoir inside the wheel of the electromobile) which provides better functional operation. The paper presents the organization and structure of the software, informational, methodical and organizational support of research in general. In the process of developing the design of the TANK for electric vehicle using CAD (CATIA v5 r19), the following tasks were solved: 1) the strength and weight of the model was determined; 2) sketching of details was made; 3) power savings were calculated.

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