

Table 1. Results of data simulation of mathematical model for empty carriage

Indicators	Sm=400[m]		units
	1st scheme	2 nd scheme	
Sb	90	= 90	%
Ev	0,63	> 0,59	kWh
Vmax	50,95	> 50,12	km/h
Vv	38,06	> 37,44	km/h
Ea	0,73	> 0,70	kWh
t	37,83	< 38,45	s
Erek	0,02	< 0,04	kWh

Here in the Table 1 Sb is a relative realized way before braking starts, Ev is the consumed energy by tramcar, Ea is the energy supplied from substation, Erek is the recuperation energy. As it can be seen when conditions of simulation are present (with constant Sb for both) energy consumption in the second case is little smaller but technical speed also is lower. Energy of recuperation in the second case is twice as big as for the first scheme but in average both variants are very similar in respect of indicators.

Similar indicators can be also obtained for full carriage (Table 2). As it can be seen there the indicator Ev for empty carriage is smaller to the indicator Ev for full carriage. Also comparing two solution variants – for full carriage, we can see that the indicators are very similarly for both variants.

Table 2. Results of data simulation of mathematical model for full carriage

Indicators	Sm=400[m]		Indicators
	1st scheme	2 nd scheme	
Sb	90	= 90	%
Ev	0,67	> 0,63	kWh
Vmax	50,95	> 50,01	km/h
Vv	37,91	> 37,32	km/h
Ea	0,78	> 0,74	kWh
t	37,98	< 38,56	s
Erek	0,02	< 0,04	kWh

For better evaluation of both variants it is needed to obtain equations for obtaining a qualitative relations between parameters and outputs.

Evaluation of results

Characteristics presented in Fig. 4–9 have been constructed for both variants from acquired data array.

From obtained array of data an equations for influence of parameters in normalized scale can be derived.

$$E_{rek} = 0.0827 + 0.0347 \cdot S_m^* - 0.0507 \cdot S_b^* + 0.0827 \cdot a^* - 0.0132 \cdot S_m^* \cdot S_b^* + 0.0348 \cdot S_m^* \cdot a^* - 0.0507 \cdot S_b^* \cdot a^* - 0.0132 \cdot S_m^* \cdot S_b^* \cdot a^*, \quad (1)$$

$$\delta_{rek} = 1.7881E-18, \quad (2)$$

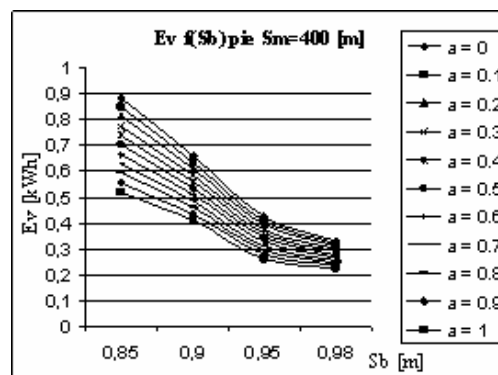


Fig. 4. Ev=f(Sb) for the first scheme, Sm=400 m and empty carriage

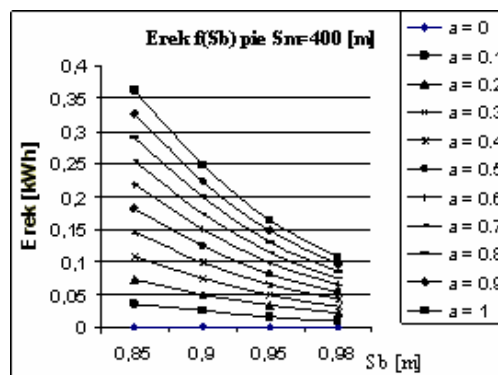


Fig. 5. Erek=f(Sb) for the first scheme, Sm=400 m and empty carriage

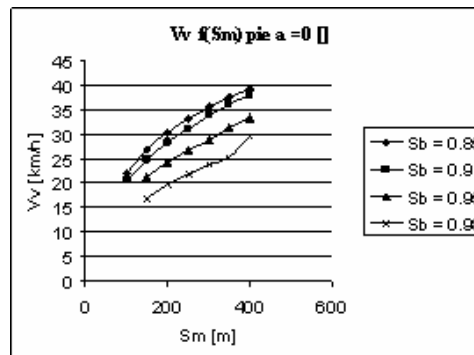


Fig. 6. Vv=f(Sm) for the first scheme and empty carriage

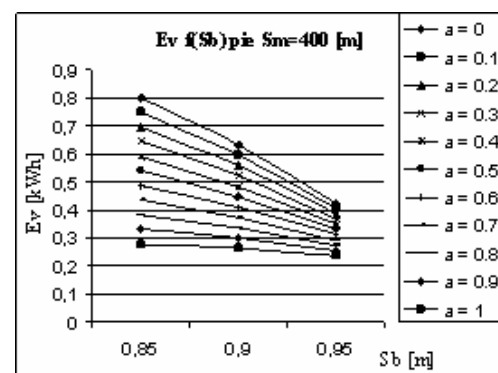


Fig. 7. Ev=f(Sb) for the second scheme, Sm=400 m and empty carriage

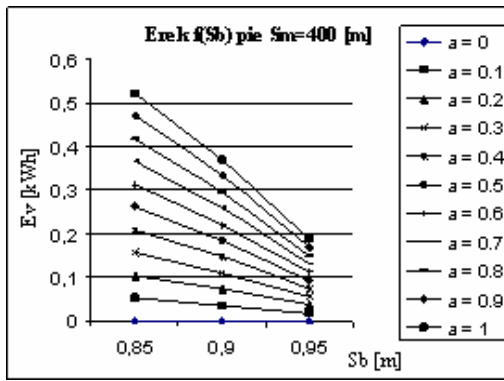


Fig. 8. Erek=f(Sb) for the second scheme, Sm=400 m and empty carriage

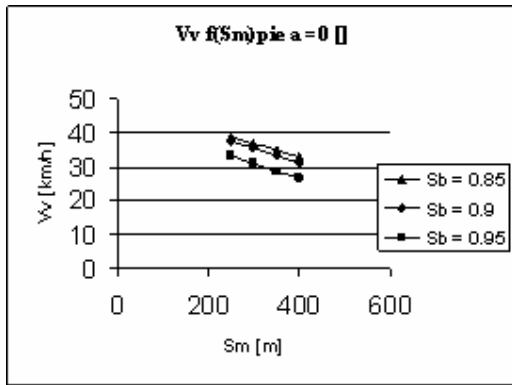


Fig. 9. Vv=f(Sm) for the second scheme and empty carriage

$$V_V = 28,1559 - 4,8829 \cdot S_b^* + 6,3569 \cdot S_m^*, \quad (3)$$

$$E_{rek} = 0.0642 + 0.0285 \cdot S_m^* - 0.0473 \cdot S_b^* + 0.0642 \cdot a^* - 0.0175 \cdot S_m^* \cdot S_b^* + 0.0285 \cdot S_m^* \cdot a^* - 0.0473 \cdot S_b^* \cdot a^* - 0.0175 \cdot S_m^* \cdot S_b^* \cdot a^*, \quad (4)$$

$$\delta_{rek} = 3.5E-18, \quad (5)$$

$$V_V = 25,8146 - 4,0286 \cdot S_b^* + 6,7335 \cdot S_m^*, \quad (6)$$

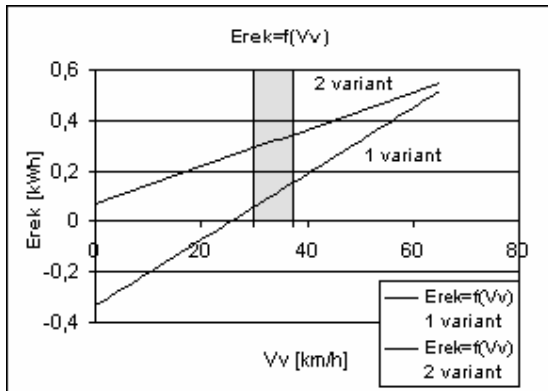


Fig. 10. Characteristics obtained from normalized equations for empty carriage

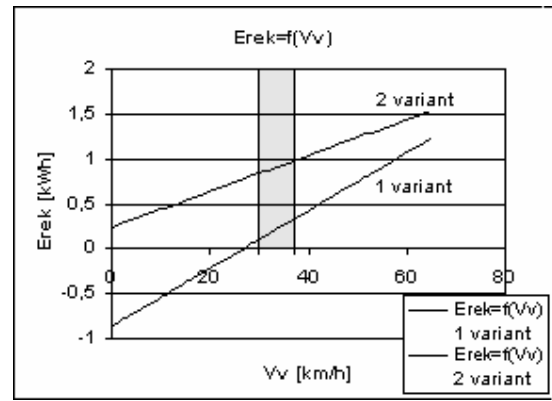


Fig. 11. Characteristics obtained from normalized equations for full carriage

Characteristics showed in Fig. 11 are obtained by using equations with normalized parameters for full carriage, where we can see, that the value of Erek is higher using the first solution variant, than using the second variant by approximately two times or 100% – very similar characteristics are obtained for empty carriage also, shown in Fig. 10.

Conclusions

1. If calculations are made in relative values, then Erek what is returned to network in second variant is 100% higher than in first variant.
2. If calculations are made in absolute values.– then difference among those two solutions variants is 0.02 kWh – not much.
3. These both variants of solutions are very similar to each other notwithstanding according the calculations with relative values not using equations with normalized parameters – there can be seen very big difference among them.

Note:

This work has been partly supported by European Social Fund within the National Programme "Support with the carrying out doctoral study program's and post-doctoral researchers" project "Support for the development of doctoral studies at Riga Technical University".

References

1. Rankis I., Vitols A. Analysis of power consumption for tramcar with pulse mode speed regulation // Proceeding: Topical problems of education in the field of electrical and power engineering. – Kuressaare, 2006. – 31 p.
2. Holec ridderkerk buklet "Refurbish-ment modules Technical specification". – ABB Industrie AG 1-1997. – 11 p.
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I. Rankis, L. Ribickis, A. Vitols. Comparison of Two Solutions of Regeneration Circuits for Tramcars // Electronics and Electrical Engineering. - Kaunas: Technologija, 2006. – No. 5(69). – P. 53–56.

In the following paper are presented comparison of two solution variants for tramcars T3. There are presented results obtained from computer simulations and two principal schemes of both solutions. Also there are presented results obtained from data array and analysis of them, too. 6 characteristics of simulation of these two schemes are showed, too. Then equations with normalized parameters are presented, what is very important for clear understanding and working principles of both schemes from absolute point of view. Then there are presented characteristics that are obtained from equations with normalized parameters. Il. 11, bibl. 3 (in English; summaries in English, Russian and Lithuanian).

И. Ранкис, Л. Рибикис, А. Витолс. Сравнение решения двух схем регенерации энергии для трамваев // Электроника и электротехника. – Каунас: Технология, 2006. – № 5(69). – С. 53–56.

Представлены два решения для трамвая Т3. Также показаны результаты, полученные от компьютерной симуляции и две принципиальные схемы двух вариантов решения. Представлены результаты, полученные из массива данных и их анализ. Показано 6 характеристик компьютерной симуляции этих двух схем. Даны уравнения с нормализованными параметрами, что очень важно для понятия сущности работы этих схем в абсолютном масштабе. И наконец показаны характеристики полученные используя уравнения с нормализованными параметрами. Ил. 11, библи. 3 (на английском языке; рефераты на английском, русском и литовском яз.).

I. Rankis, L. Ribickis, A. Vitols. Dviejų energijos regeneracijos tramvajuose schemų variantų palyginimas // Elektronika ir elektrotechnika.- Kaunas: Technologija, 2006. – Nr. 5(69). – P. 53–56.

Pateikiamos dviejų tramvajų T3 energijos regeneracijos variantų principinės schemas ir kompiuterinės imitacijos rezultatai, gauti iš duomenų masyvo, bei jų analizė. Parodytos 6 charakteristikos, gautos jau minėtų dviejų schemų kompiuterinės imitacijos metu. Pateikiamos lygtys su normuotais parametrais, nes tai svarbu norint suvokti šių schemų veikimą absoliučiu požiūriu. Taip pat pateikiamos charakteristikos, gautos panaudojus lygybes su normuotais parametrais. Il. 11, bibl. 3 (anglų kalba, santraukos anglų, rusų ir lietuvių k.).

DOI: 10.5755/j02.eie.10677