Switched reluctance motor for electrical transport usage

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Abstract. The electric drive on basis of the Switched Reluctance Motor with the parallel accumulator of energy is offered for the wheels drive to the trolleybus. Main characteristic allow an engine successfully to complete with traction collector engines. They have higher reliability and less volume of active part. Recommendations are grounded in relation to designing taking into account the features of construction and on the basis of theory of electromagnetic transformation of energy. These recom–mendations are taken as a basis of project calculation.

Key words: switched reluctance motor, buffer of energy, trolleybus wheel's drive, relation equation, pseudo-U-similar construction.

Today, Ukraine was second in the world in number of trolleybus systems, which in 2013 were only over forty. Especially, important part of the transport network was trolleybus in big cities, although initially seen as suburban transport. Trolley tram in areas where difficult to lay the rails, particularly in the areas of cities with narrow streets are replaced later. The ability to reduce the congestion of urban road transport and improve the ecological status by expanding trolleybus networks con–tributed to the revival of interest in the trolley, both abroad and in Ukraine, where, according to some experts, in particular this was due to the acute shortage of buses, their low capacity and low capacity and relatively cheap electricity. However, there are some purely technical reasons.

Trolleybus mechanical part is more simply as a bus construction, because does not have oil system and air-cooling system, gear-box. Also, it is non-oil pressure. As a result, requiring the expenditure of much labour scheduled operations are increase, fall away necessity in technical liquid's using — motor oil, antifreeze. The combine trolleybus are more interesting, because it's are in addition equipped by system of autonomous accumulator motion (contacts electriobus). Last inves–tigation and internet-sources review said, that in wheels electric drive by present-day foreign trolleybus, a repla–cements traction direct current (DC) engine (TE) on frequency-controlled (FC) asynchronous motors (AM), in such - on synchronous motor [7] are perspective. That replacement allows to economy till 40% of electric energy.

The main advantages of AM before DC motor are simplicity design and small size. In the absence of brush-collector part, AM is free from such drawbacks as wear collector and brushes, arcing and burning in poor contact. However, asynchronous TE requires alternating current (three-phase) for their work, which is obtained in electronic DC converters by contact network, the cost of which can exceed the price of all other mechanical components in trolley. Then reliability, in some cases, may be insufficient due to the problems of electromagnetic incompatibility.

On the other hand, according to most experts, the most promising among the many types of engines in the modern controlled electric drives is brush-less motor (BLM) (fig. 1). BLM - is actually electromechanotronic system comprising an electromechanical converter (EC), which works as a actuator, rotor position sensor (RPS) and electronic switch (ES). In many cases, the ES is used for controlling the speed of rotation, which is carried out by a controlling system (CS), thanks to the fully controlled power elements.

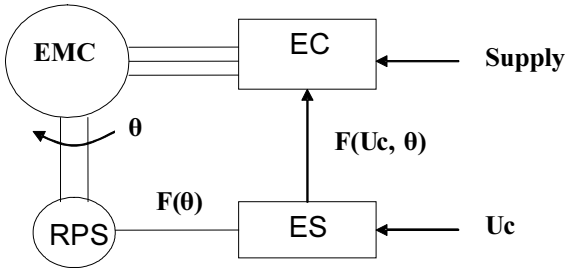

Fig. 1 Structural scheme of SRM

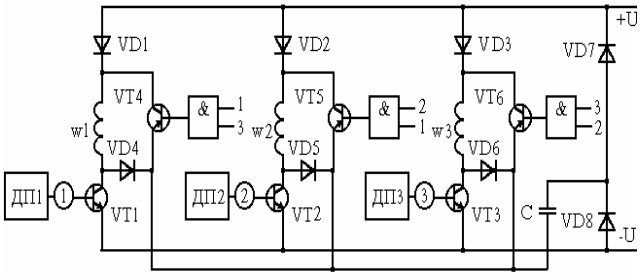

Fig. 2 Transistor commutate with capacity buffer of energy

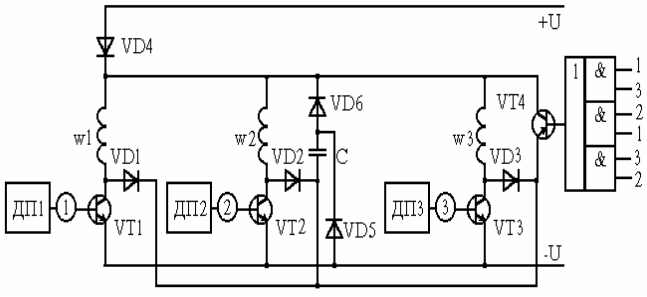

Fig. 3 Transistor commutater with capacity buffer of

It is well known that BLM have some design and technical-operational advantages, compared with DC TE. The most important are non-contacts and reliability. Operational speed and energy performances of BLM slightly changing during source voltage vibration and load changes, unlike AD. Natural mechanical characteristics of switched reluctance

motors (SRM) is almost the same as in DC TE, which enables the use SRM in vehicles electric drives, in particular, in the electric trolley wheels.

Improve energy performance and reduce supply current ripple by switched reluctance motor with passive rotor allows one-period commutate with parallel capacity storage connec–tion [1] (Fig. 2).

For strong presumption of SMR with buffer of energy exploitation usage in trolley wheels drive are given such equations.

In equation of average electromagnetic moment of SRM [1]

$$M_{CEP} = Z_r \frac{I_c^2}{4} \mu_0 \frac{D \cdot l}{\delta} \alpha_s \frac{K_L}{K\mu} w_z (1 - \cos\gamma), \qquad (1)$$

are includes geometric sizes $(D, l, \delta, \alpha_s, z_r)$, windings geometry (w_z), and coefficients (K_L, K_μ). It allows to analyses value of moment by construction parameters and comprised SRM with any different electrical motors by its electromagnetic moment on 1 volume point. This comparison [5] shows that for the same diameter and length of SRM with CBE creates roughly the same electromagnetic torque as DC TE. And also in the sense of creating electromagnetic torque can compete with last, and the natural mechanical characteristics both engines are almost identical.

An important requirement for trolleys electric drive is an opportunity electrodynamics braking. Among the different methods of electric machines braking, most suited for SRM are method of one or more sections excitation and methods of reverse (anti-switching).

Design SRM for electric trolley's wheel drive conducted by using developed at the department of electrical machine and apparatus of computer-aided design system (CADS) of switched reluctance motors with energy storage [2]. To enable synthesis motors of higher power and voltage in CADS was previously amended accordingly.

Typical designing methods of traditional types of electrical machines based on the choice of electromagnetic loads values choice experience of witch for SRM with CBE are limited. These values require appropriate adjustments. The–refore, on the base of motor calculation for trolley's wheel electric drive are put the theory of electromechanical energy conversion in SRM with capacitive energy storage, as well as a comparative analysis of the moment and electromagnetic loads of SRM with CBE and DC TE.

The expressions for geometric size calculating of magnetic circuit of SRM with CBE with classic or pseudo-U-similar construction are given in [1]. However, due to defi–ciency of design experience in the field of SRM, we can't also use the practice adopted in the design of traditional types of electric machines by as machines designed according to similar or near design capacity and preset recommended values of the independent variables. Therefore, the choice of independent parameters due of this type motor's design carried out, based on the investigation results conducted at the department of "Elec–trical machines and apparatus." This takes into account that for the construction of pseudo-U-similar stator,

$$Z_r = Z_s \cdot \frac{2 \cdot m \pm 1}{2 \cdot m}; \quad Z_s = m \cdot q; \quad q = 4,6,8\ldots,$$

where m – number of section in SRM.

Equation for pseudo-U-similar stator's diameter calcu–lation is

$$D = 2 \cdot \sqrt[3]{\frac{2 \cdot M \cdot (\gamma^* + \theta^*_{\hat{A}})}{(2 \cdot m - 1) \cdot B_\delta \cdot A \cdot \pi \cdot \alpha_s \cdot K_L \cdot (1 - \cos\gamma) \cdot \lambda}}, \qquad (2)$$

where $B_\delta = \frac{I_c \cdot w_z}{K_\mu \cdot \delta} \cdot \mu_0$ - magnetic induction in air gap for state, when stator and rotor teeth match;

$$A = \frac{2 \cdot I_c \cdot w_z \cdot q}{\pi \cdot D} \cdot (\gamma^* + \theta^*_{\hat{A}}) \text{ - linear load;}$$

$\lambda = l / D$ - relative stator length;

$$\gamma^* = \frac{\gamma \cdot m}{2 \cdot \pi}; \; \theta^*_{\hat{A}} = t_o \cdot \frac{m \cdot z_r}{4 \cdot \pi} \cdot \omega.$$

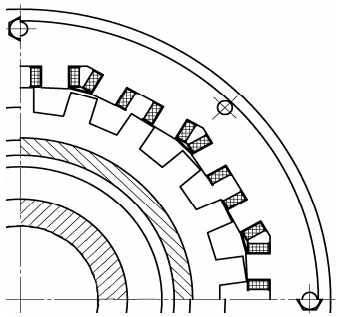

Fig. 3. Sectional part of switched reluctance motor

Optimality criteria selected variant served as mechanical characteristics and the maximal moment, which can motor develop. As a result of design, we have motor, cross section of which is shown on fig. 3, with the following data: supply vol–tage – 550 V; effective power – 36 kWt; rotation speed – 1600 rev / min; efficiency - 76.1%.

Motor was investigated using developed at the depart–ment EMA in Lviv Polytechnic computer-aided research sub–systems of SRM with CBE [3], the input data for such is file with output data, calculated using the CADS. There have been some variations of work simulation in starting and queasy-steady state modes by different loads.

The mechanical characteristics of one SRM with buffer of energy are given on fig. 4. In electric trolleybus drive pro–vided four SRM with the total capacity of 144 kWt, to replace DC TE type KR4389 with power 132 kWt, rotation speed - 1500 rev / min.

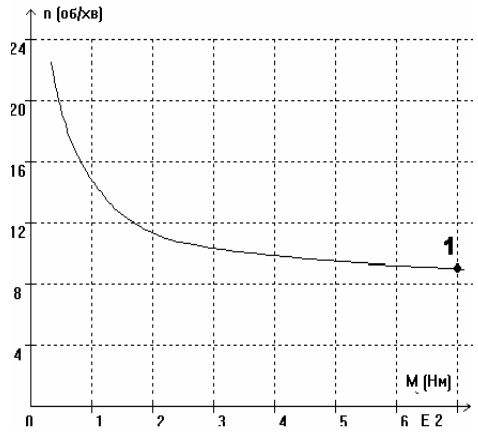

Fig. 4. Mechanical characteristic of SRM in trolleybus electric drive

The calculations results by known techniques which used for to dynamic characteristics calculation of DC TE and which based on a given mechanical characteristics of drive motor shown, that the electric drive, based on designed SRM provides on a horizontal section trolley's speed till up 90 km / h (85 km / h for trolley with DC TE type KR4389). The power developed by SRM per weight unit, is about 7 kWt / hour, and the angle at which the trolley can move up without acceleration with speed of 25 km / hour is 11.2°. It is meet to modern foreign and domestic trolleybus.

Conclusions.

A switched reluctance motor with capacity storage for the trolley wheel's drive, characteristics of which allow it to compete with collector traction motors, for improved reliability and lower the volume of the active part. The electric drive based on the developed SRM provides high dynamic performance in comparison with trolley electric substation at the DC TE.

Structurally switched reluctance motor with CBE is similar and reliably as FD AD. The natural mechanical characteristic of the SRM does not require additional formation and electronic components for both drives are almost identical, so SRM with CBE can be recommended for application in electric trolley wheels.

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До питання про природу кінетичних властивостей провідних кристалів та їх діагностика

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Abstract. .In this article the method of the analyses of the experimental data of crystal's kinetic properties is described to find out their nature.

Key words: crystal's kinetic properties.

Вступ

Концентрація носіїв зарядів n, електропровідність кристалів σ, коефіцієнт ефекта Холла R, коефіцієнт ефекта Зеебека α, коефіцієнт ефекта Нернста–Еттінгсгаузена N, дрейфова рухливість U_D носіїв зарядів в кристалі, та холлівська рухливість U_H – це дуже важливі властивості напівпровідникових кристалів, бо практично часто ці властвості безпосередньо визначають практичне значення напівпровідникового кристала у виробництві низки приладів твердотілої електроніки. Крім того ці властивості часто використовуються в аналізах експериментальних даних різних кінетичних властивостей кристалів з метою вияснення їх природи.Це дуже важлива задача, бо вона пов'язана з проблемою прогнозування напівпровідникових кристалів із заданими властивостями в процесах їх технологічного синтезу.

Елементи теорії

В кінетичній теорії кристалів [1–5], яка ґрунтується на методах статистичних ансамблів із змінною кількістю частинок і користуючись великим канонічним розподілом Гіббса для нерівноважних ансамблів, показано, що для ізотропних кристалів, в умовах слабкого магнітного поля, або його відсутності, їх кінетичні властивості $\sigma, R, \alpha, U_H, U_D$ та концентрація носіїв зарядів n в кристалах описуються такими загальними формулами:

$$n(\mu^{\bullet}, T) = J(0, 0, \mu^{\bullet}, T) \qquad (1)$$