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FEATURES OF THE USE RECUPERATION BRAKING ON ELECTRIC ROLLING STOCK OF DC RAILWAYS

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Recuperation braking in railway transport is the process of converting the kinetic energy of train movement into electrical energy by traction electric motors operating in generator mode. The generated electrical energy is transmitted to the contact network, unlike rheostat braking, in which the generated electrical energy is extinguished on the braking resistors, that is, it is converted into heat and dissipated by the cooling system [1, 2].

Recuperation braking is used to slow down electric rolling stock in cases where it is going down a relatively gentle slope and the use of an air brake is irrational. That is, recuperation braking is used to maintain a set speed when the electric rolling stock moves downhill. This type of braking provides significant energy savings, as the generated electrical energy is transferred to the catenary network and can be used by other electric rolling stock on this section of the catenary network [3, 4].

One of the disadvantages of DC substations is that they cannot return recovery energy from the DC network to the AC network unless the substation has recuperation inverters. Recuperation electric brakes can only work when the braking electric rolling stock is simultaneously accelerated by another electric rolling stock. Since the protection control of the on-board converter depends on the voltage of the catenary network on the pantograph, the functioning of the recuperation braking under such conditions cannot be guaranteed. When the recuperation braking force is insufficient, mechanical pneumatic braking is additionally used to compensate for the braking force. The energy absorbed by the mechanical brake is lost due to heating and wear of the brake disk, which requires periodic maintenance of the rolling stock. The concept of pure electric braking creates a strategy for making the most efficient use of recuperation electric braking [5, 6].

In railway traction, there are two challenges to making full use of recuperation electric braking:

– determining the speed of movement at slow speeds is difficult, therefore electrical braking is replaced by mechanical braking at very low speed;

– sufficient braking force cannot be generated at high speed range according to field weakening.

In Fig. 1 shows the proposed concept of electric braking on an electrified DC railway. To eliminate the first drawback, speed determination using a digital observer with double sampling is proposed in order to stabilize the control of traction force at low speeds. The best use of electric brakes is to start with less braking force and stop with maximum effort at low speed.

To solve the second drawback, as well as for a better exchange of electrical energy with other electric rolling stock, it is necessary to change the driving mode: it is necessary to constantly apply only a small braking force at high speeds. This driving mode is called a "constant power braking scheme". However, the braking mode is complicated with manual control by the train driver. Therefore, it is advisable to use automatic electric rolling stock stop control or automatic drive mode, which is well suited for such a braking mode.

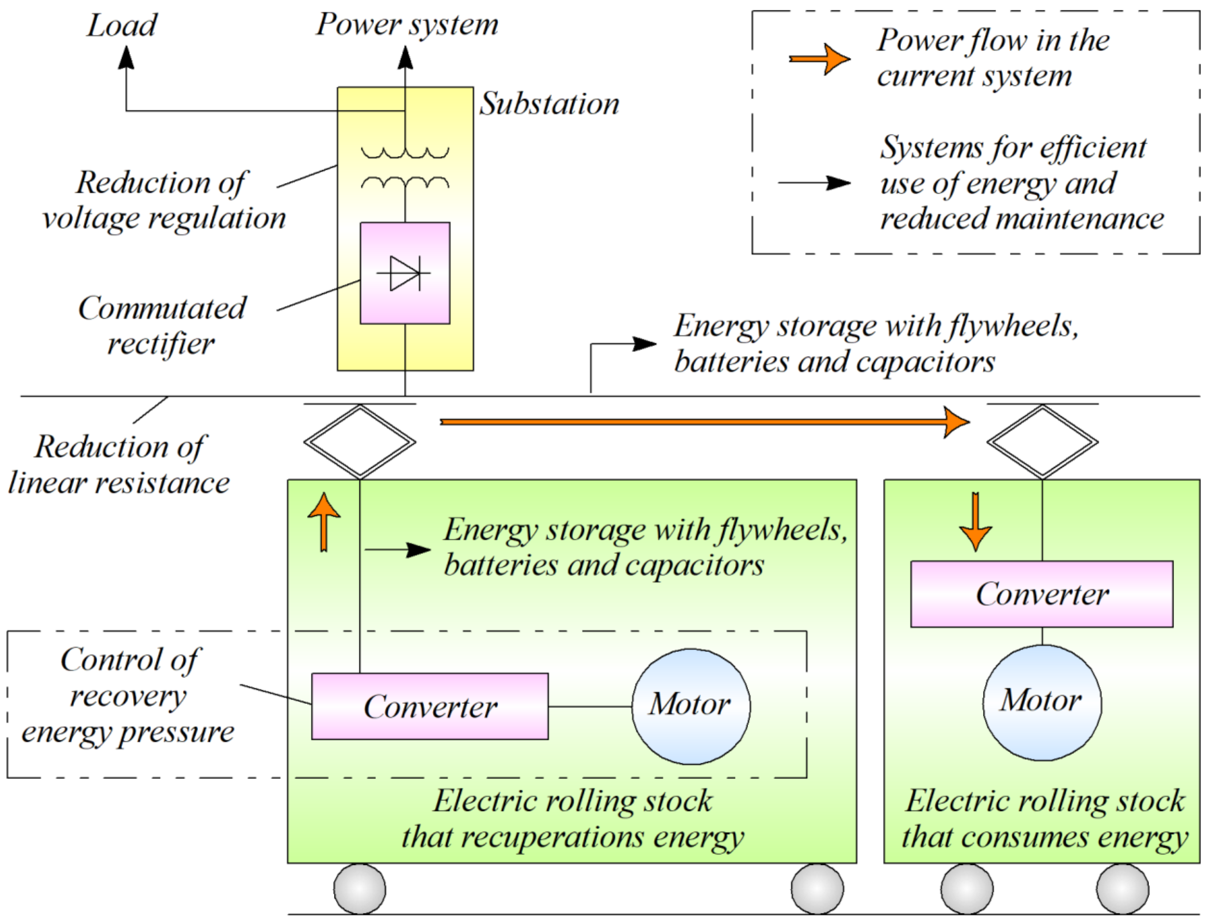

Fig. 1. Energy flow during recuperation braking

Control of the protection of the on-board converter from low voltage, as well as the introduction of the continuous recuperation mode on the on-board inverters ensure an effective increase of the recuperation energy in the contact network during the electrification of DC railways. And the introduction of DC recuperation substations is one way to guarantee recuperation braking.

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НАПРЯМКИ РОЗВИТКУ ВИСОКОШВИДКІСНОГО РУХУ

DIRECTIONS OF THE DEVELOPMENT OF HIGH-SPEED MOVEMENT

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Натепер у світі розробляються концепції, та виготовляються дослідні зразки тягового рухомого складу для експлуатації на шляхах високої швидкості. Світові виробники зорієнтовані на підвищення швидкості електрорухомого складу при одночасному зменшенні шкідливих викидів в атмосферу.

Нині можна розглянути наступні види тягового рухомого складу:

- CRH-380A (швидкісний поїзд Китаю) максимальна швидкість 380 км/год
- ICE (Німеччина) максимальна швидкість 330 км/год
- Сінкансен (Японія) максимальна швидкість 320 км/год
- TGV (Франція) максимальна швидкість 320 км/год
- Alta Velocidad Española (Іспанія) максимальна швидкість 300 км/год
- Українська залізнична швидкісна компанія (УЗШК) максимальна швидкість 200 км/год.

Найбільш перспективним напрямком розвитку тягового рухомого складу є розвиток тягового рухомого складу на альтернативних джерелах енергії. В якості альтернативних джерел ряд світових виробників пропонують наступні концепції:

- Alstom Coradia iLint (Німеччина): Цей поїзд був представлений компанією Alstom у Німеччині та став першим у світі комерційним поїздом на водневих паливних елементах. Він почав експлуатуватися у Нижньосаксонському регіоні Німеччини.