# SECTION 4

# LATES ACHIEVEMENTS IN ENGINEERING, ECOLOGY AND ARCHITECTURE

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## TRANSIENT PROCESSES IN THE TROLLEYBUS STEERING SYSTEM

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One of the main requirements for steering systems of vehicles is the impact on the stability of the driven wheels. Such requirements correspond to the systems of a steering, in which an electric power steering as an amplifier is used [1].

As a power drive of the electric power steering, it is proposed to use of an engine with a rolling rotor. This solution is due to the high output torque of this type of engine, as well as a possibility of positioning the output shaft of the engine with a given accuracy.

The kinematic scheme of the trolleybus steering system is presented in Fig. 1.

To research the transient's processes of the trolleybus steering system with an electric power booster, based on the engine with a rolling rotor, a mathematical model is developed, the functional scheme of which is shown in Fig. 2.

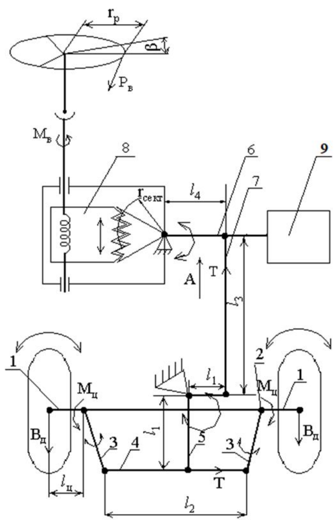

Figure 1 – Kinematic scheme of the steering system
1 – pin; 2 – beam of the front axle; 3 – levers; 4 – transverse draft; 5 – double-shoulder lever; 6 – steering arm; 7 – longitudinal draft; 8 – steering gear; 9 - electric amplifier

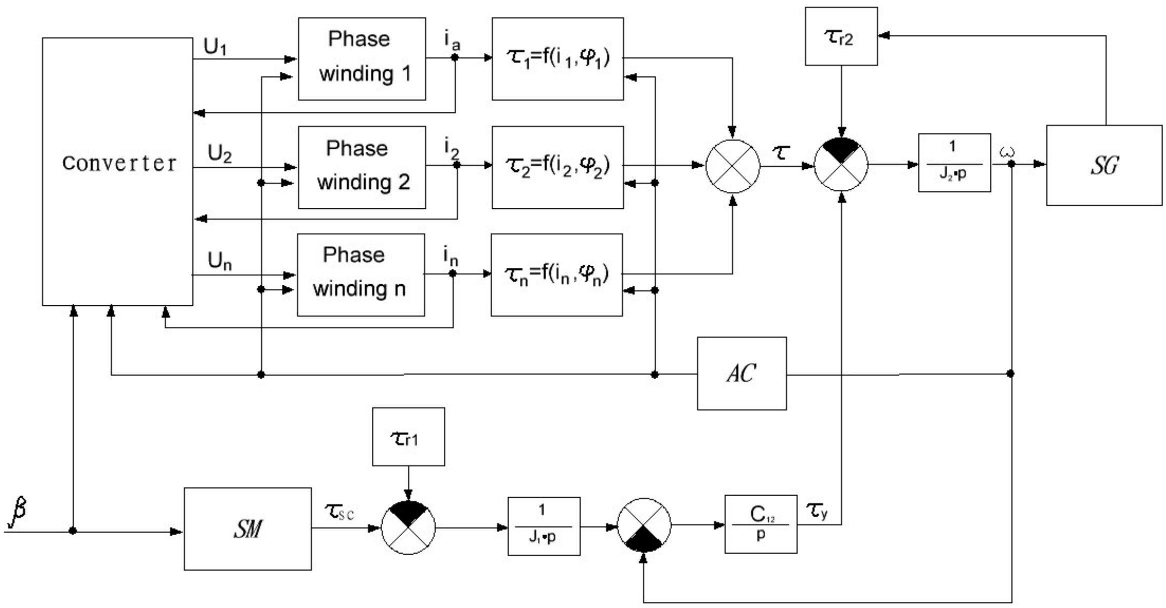


Figure 2 – Functional scheme of the steering system

The mechanical part of the steering system can be considered as two-mass one [2]. This scheme is described by a system of equations:

$$\begin{cases} J_1 \dfrac{d\omega_1}{dt} = \tau_{sc} - \tau_y - \tau_{r1} \\ J_2 \dfrac{d\omega_2}{dt} = \tau + \tau_y - \tau_{r2} \\ \tau_y = C_{12} \int (\omega_1 - \omega_2) dt \end{cases} , \qquad (1)$$

where: $\tau_y$ – torque of elasticity; $\tau_{r1}$ – torque of resistance of the steering mechanism; $\tau_{sc}$ – torque of impact of the driver; $\tau$ – torque of electric motor; $\tau_{r2}$ – torque of resistance of the steering gear; $C_{12}$ – set rigidity factor; $\omega_1, \omega_2$ – angular velocities corresponding to the shaft of the steering mechanism and the shaft of the engine of steering gear.

The electric motor with a rolling rotor is described by the following system of differential equations [3]:

$$\begin{cases} u(t) = R \cdot i + \dfrac{\partial \Psi(i,\varphi)}{\partial i} \cdot \dfrac{di}{dt} + \dfrac{\partial \Psi(i,\varphi)}{\partial \varphi} \cdot \dfrac{d\varphi}{dt} \\ \tau = \dfrac{\partial W_m^{*}(\varphi, i)}{\partial \varphi} \end{cases} , \qquad (2)$$

where: $u$ – phase voltage of the engine; $R$ – active phase resistance; $i$ – phase current; $\varphi$ – angle of rotation of the rotor; $\Psi$ – flux linkage; $\tau$ – electromagnetic torque; $W_m^{*}$ – co-energy.

The obtained mathematical model allows to evaluate the reaction of the trolleybus steering system to the control effect created by the driver of the vehicle, as well as the speed of the steering drive.

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## FULLY AUTOMATED SHOTCRETE ROBOT FOR ROCK SUPPORT

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### 1 Shotcrete application on site

Shotcrete is used worldwide as temporary or final lining in tunnels or in building pits. The application of shotcrete is strenuous and, because of this, tiring if it is done manually by a nozzle operator. This holds especially for the use of wet shotcrete. The capacity that may be handled is less than 5 to 8 m3/h when spraying manually and normally up to 20 m3/h by using manipulators (30 m3/h were already applied).

Shotcrete application as the first step of rock support often has to be done in a zone of danger (rock fall). With use of the robot, the safety of the worker can be improved. The handling of the robot is easier and less strenuous than steering a manipulator. A basic difference between common manipulators and the new robot is that the user steers the movements of the nozzle directly. He or she does not have to take care of the different boom joints. In the manual and semi-automated mode, the nozzle operator judges the surface himself or herself to get the required application. In the fully automated mode, total control is by the robot.