USING THE LAGRANGE-MAXWELL EQUATIONS IN ANALYZING AN AUTONOMOUS INDUCTION GENERATOR

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In electrical engineering the use of Lagrange's equations together with Maxwell's equations finds the widest application. In particular, these equations can be used to analyze the operation of an autonomous asynchronous generator. First, it is necessary to determine the number of degrees of freedom. It is clear that in the electromechanical system of an autonomous induction generator there are at least two coordinates - one electrical and the other mechanical. It is easiest to consider electric current i or electric charge q as electrical, and the rotor speed ω as mechanical one. Second, it is necessary to consider what kinetic and potential energies can act in the electromechanical system under consideration. The energy of the magnetic field stored in the inductance L when the current i increases from zero to a certain value is identified with electrokinetic energy $W_m = \frac{1}{2}Li^2$, and the energy of a capacitor with a capacitance of C and a charge of q is identified with electropotential energy $W_e = \frac{1}{2}CU^2 = \frac{q^2}{2C}$. The interaction of the rotor protoflux ψdq with the stator winding must be added to the electrokinetic energy. The mechanical kinetic energy of the rotor of an induction generator with the moment of inertia J and angular speed of rotation ω will be equal to $W_k = \frac{J\omega^2}{2}$. The mechanical potential energy will be associated with the final elasticity C_{12} of the elements of the mechanic part of the system under consideration, namely, the connection of the generator shaft and the drive motor using a kinematic link, for example, a clutch. Thirdly, it is necessary to consider the dissipative function D, since during the operation of the induction generator there are losses associated with the flow of electric current through the stator windings with a resistance R, and friction of the shaft and rotor against the air, as well as friction in the bearings, which is characterized by the friction coefficient μ. We neglect magnetic losses. An important nuance is that inductance and protoflux are functions of the mechanical coordinate. We denote kinetic and potential energy as K, P, respectively. Thus, we obtain the equations:

$$K = \frac{1}{2}\left(J\omega^2 + L\left(\frac{dq}{dt}\right)^2\right) + \psi\frac{dq}{dt};$$

$$P = \frac{1}{2}\left(\mu\omega^2 + \frac{q^2}{C}\right);$$

$$D = \frac{1}{2}\mu\omega^2 + R\left(\frac{dq}{dt}\right)^2.$$