The 19th International Conference on
"Technical and Physical Problems of Engineering"
ICTPE-2023
31 October 2023
International Organization of IOTPE

SOME QUESTIONS ABOUT THE DESIGN OF ELEMENTS OF HYBRID ELECTRIC MACHINES

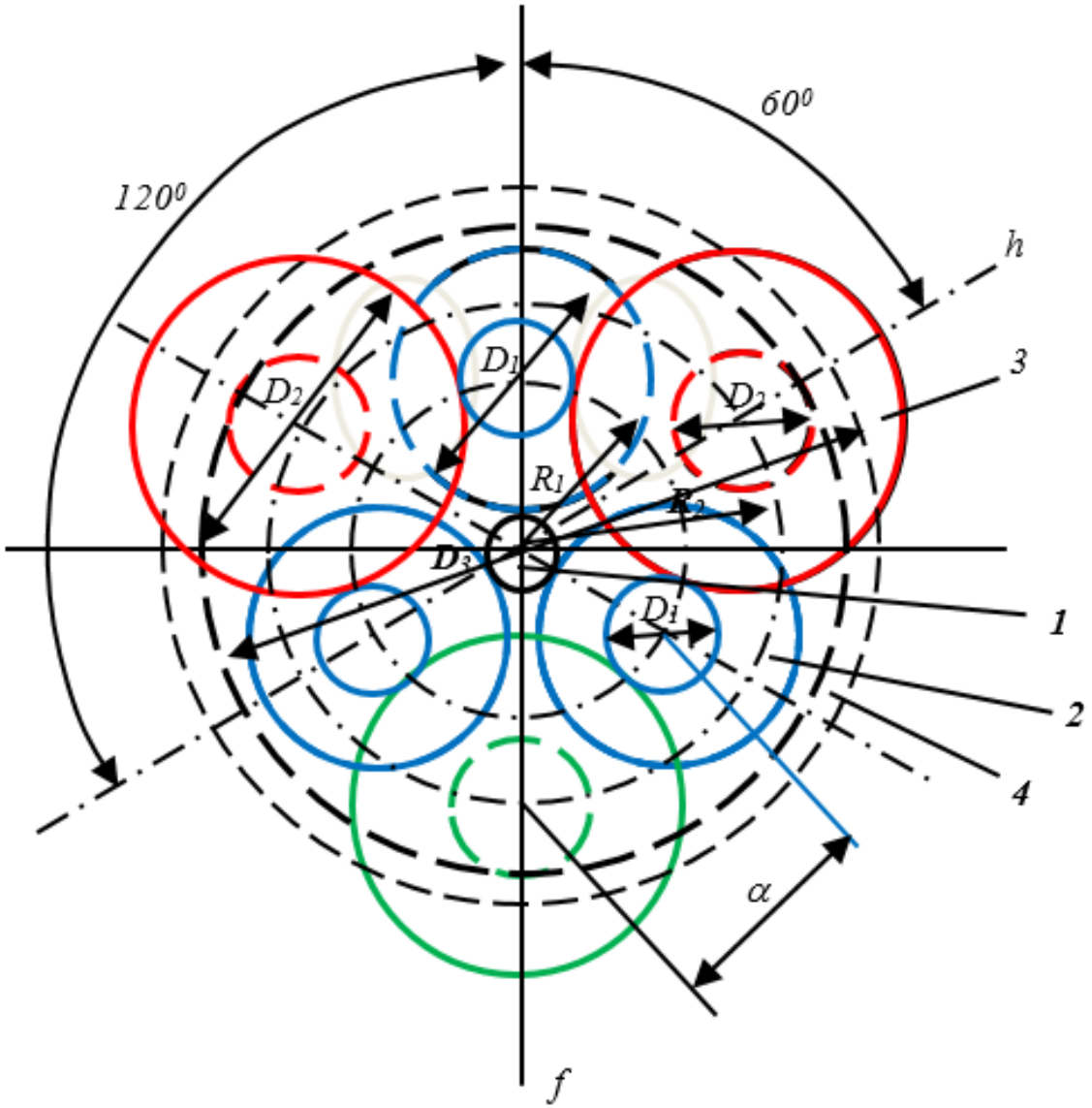
S.A. Khanahmedova, A.I. Mamedov

Azerbaijan State Oil and Industry University, Baku, Azerbaijan

Creation of a starter (motor) mode for a hybrid electric car:

- protection of gearbox and DC motor elements in start-up mode;
- performing a smooth transition to generator mode (without low mechanical shocks and overloads in the elements of the entire structure of the device);
- creation of a reliable mechanical connection between the shaft of a hybrid electric machine and the crankshaft with a sharp change in the rotational speed of the crankshaft of the internal combustion engine, taking into account the extreme permissible mechanical stresses of the parts;
- protection of the elements of the entire structure of the starter generator in the event of the command "Start" during the operation of the internal combustion engine;
- provision of generator mode over the entire range of rotation speed of the crankshaft of the internal combustion engine. Setting up the generator mode when the internal combustion engine stops.

The layout of the gears



$$R_2 + \frac{1}{2} D_{12} < \frac{1}{2} D_3$$

$$\frac{1}{2}\left(D_{11} + D_{12}\right) < a$$

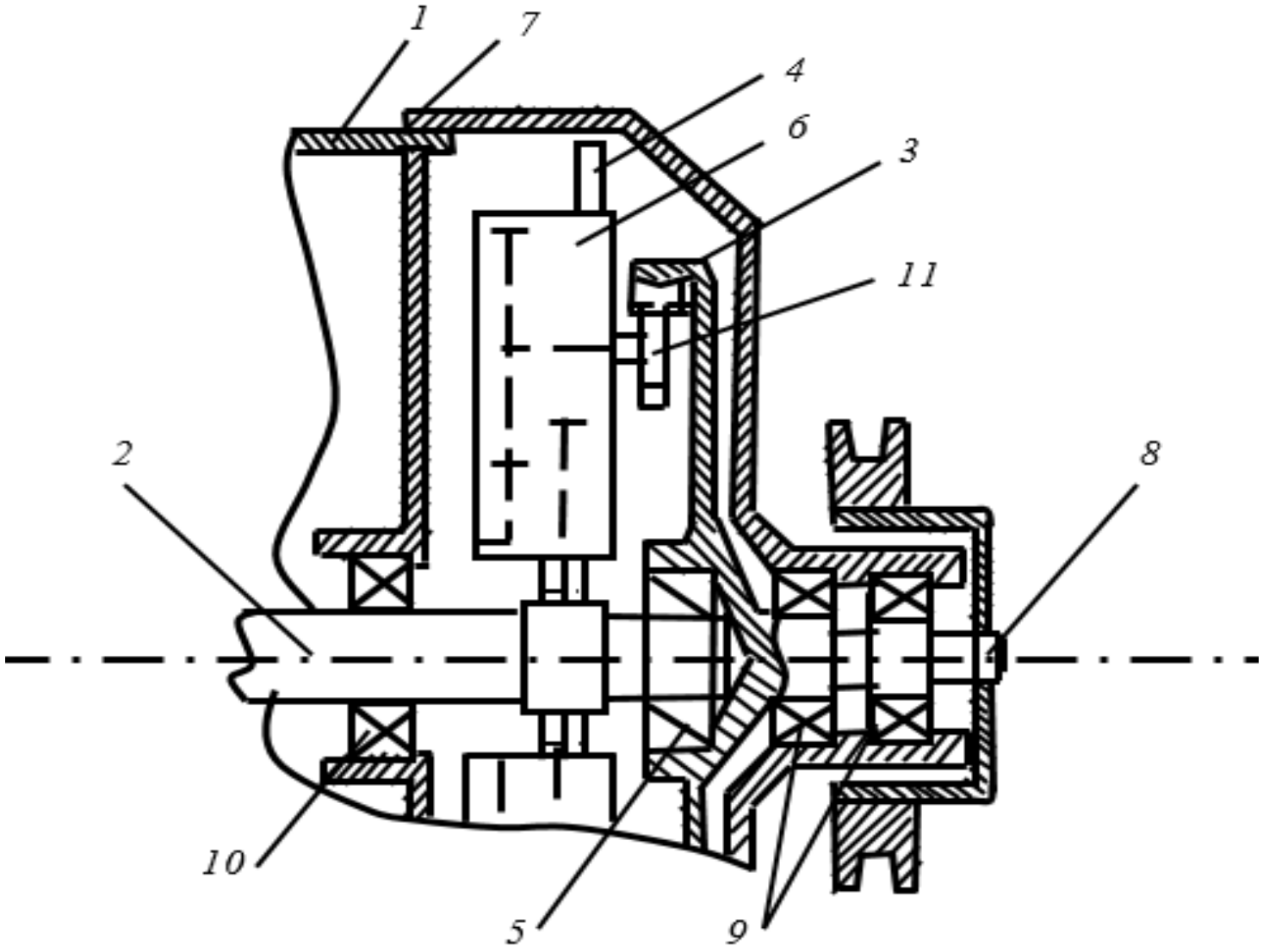
$$K_g = i_1 \cdot i_2 \cdot i_3$$

$$\omega_n = \omega_1 \frac{1}{K}$$

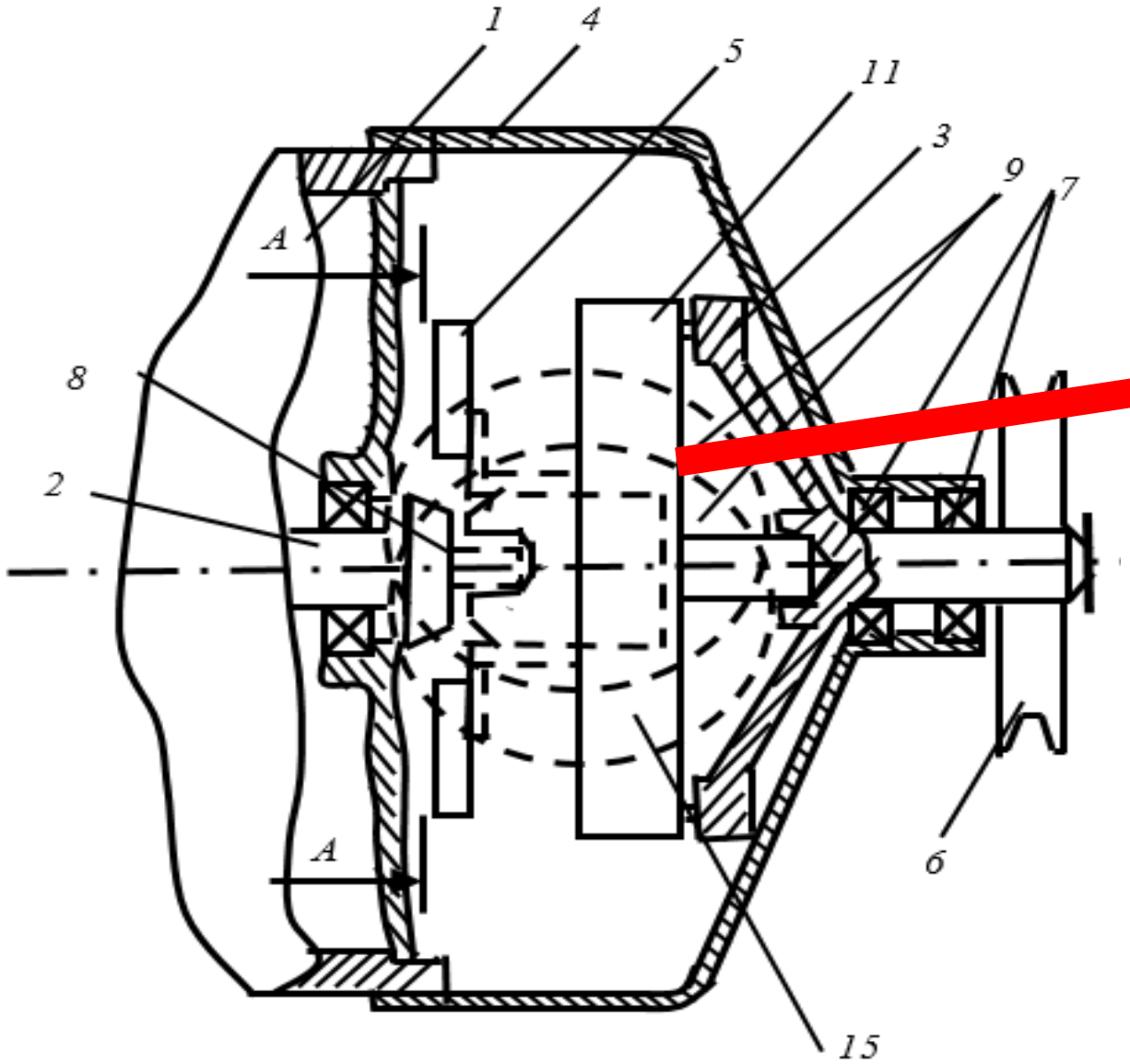
$$K = K_g K_b$$

$$K_g = i_{12} \cdot i_{23} \cdot i_{34}$$

• Design scheme of the drive device



The design diagram of the drive device for hybrid electrical drive



ANALYSIS OF THE ELECTRICAL CIRCUIT

$$\left.\begin{aligned} U &= C_E \Phi n + R_{a1} i_{a1} + L_a \frac{di_{a1}}{dt} \\ U &= C_E \Phi n + R_{a2} i_{a2} + L_a \frac{di_{a2}}{dt} \end{aligned}\right\} \Rightarrow U = C_E \Phi_n + R_a i_a + L_a \frac{di_a}{dt}$$

$$\left.\begin{aligned} C_M \Phi i_{a1} + T_1 &= 2\pi J \frac{dn}{dt} \\ C_M \Phi i_{a2} + T_2 &= 2\pi J \frac{dn}{dt} \end{aligned}\right\} \Rightarrow C_M \Phi i_a + T = 2\pi J \frac{dn}{dt}$$

$$i_a(t) = I_a \left[1 - exp(-\frac{t}{T_a}) \right]$$

$$i_a = U / R_a$$

$$i_a(t) = I_a + \left(I_{an} - I_a\right)\frac{exp\,P_1 t - exp\,P_2 t}{\sqrt{\Delta}};$$

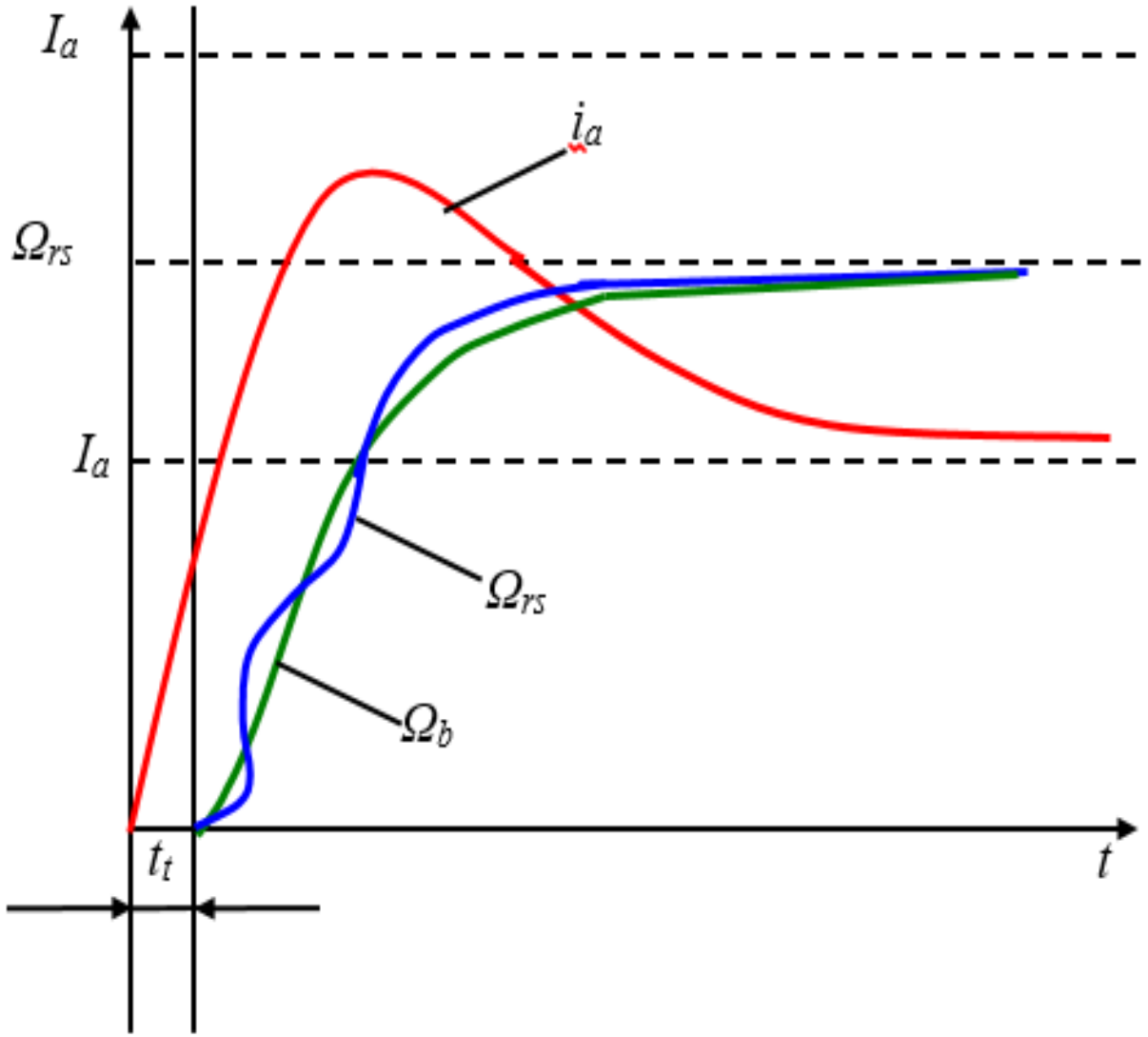
$$\Omega(t) = \Omega_C\left(1 + T_a\frac{P_2\,exp\,P_1 t - P_1\,exp\,P_2 t}{\sqrt{\Delta}}\right).$$

$$t_p = J\int_0^{\Omega 0}\frac{d\Omega}{M_{En}} = \frac{d\Omega_0}{M_{En}} = M_{EM}$$

$$T_{EM} = \frac{J\Omega_0}{M_E}$$

$$M_d = J\frac{d\Omega_0}{dt}$$

Changes in current (i_a) and speed (Ω_c) depending on the start-up time



Switching a hybrid electric machine to a steady-state mode is a special action considering the influence of two freely acting electromotive forces (generator and battery) combined into one system, i.e. into the electrical network of the on-board power supply.

CONCLUSION

- ✓ the transition to the generator mode after the starter is carried out without any outside interference;
- ✓ the transition to generator mode is performed without any mechanical overload, the transfer is performed with a soft mechanical connection;
- ✓ according to the specifics of the generator mode in case of sudden transients, the mechanical disconnected and the connection between the drive and driven shafts is carried out automatically depending on the speed of rotation;
- ✓ if the "Start" command is given during normal operation of the internal combustion engine, there are no mechanical overloads or an emergency situation between the crankshaft of the internal combustion engine and the starter generator;
- ✓ when the internal combustion engine is not working, the drive device is set to generator mode; any mechanical starting process can be performed using methods provided for modern designs.