**Problem**

Design an asynchronous motor that has three-phase star-connected stator and rotor windings.

The power of the motor is 11 kW, stator voltage 660 V, frequency 50 Hz and synchronous speed 1500 rpm. The efficiency is assumed to be 0.92 and power factor 0.85. The rotor voltage is 260 V.

The outer diameter of the stator is 235 mm, inner diameter 145 mm, length $l_s$ = 195 mm, number of stator slots $Q_s$ = 36. Figure a) shows the shape of the stator slot. The number of phases is $m_s$ = 3, the number of pole pairs is $p$ = 2. The stator winding is a single-layer winding.

The outer diameter of the rotor is 144.0 mm, inner diameter 53 mm, length $l_r$ = 195 mm, number of stator slots $Q_r$ = 24. Figure b) shows the shape of the rotor slot. The number of phases is $m_r$ = 3, the number of pole pairs is $p$ = 2. The rotor winding is also a single-layer winding.
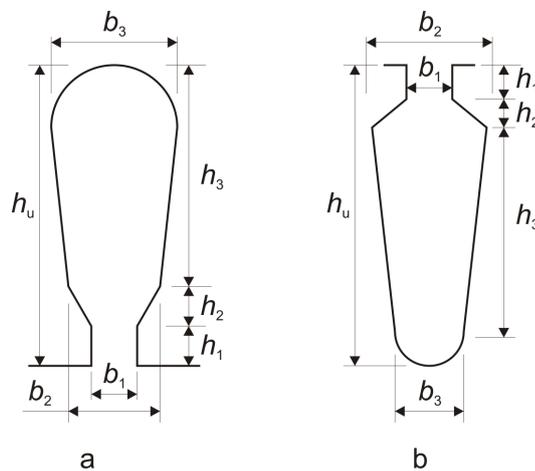


a) Define all the dimensions of the stator and rotor slots.
   **Dimensioning the stator slot:**
   Heights: total height $h_{u,s}$ = 20.0 mm, slot opening $h_{1,s}$ = 1.3 mm, wedge $h_{2,s}$ = 1.5 mm.
   The bottom of the slot is a half circle, width of the tooth is constant, average width of the slot is equal to the width of the tooth.
   **Dimensioning the rotor slot:**
   Heights: total height $h_{u,r}$ = 23.5 mm, slot opening $h_{1,r}$ = 1.5 mm, wedge $h_{2,r}$ = 3.0 mm.
   The bottom of the slot is a half circle, width of the tooth is constant, average width of the slot is equal to the width of the tooth.

b) Define the reluctances of the main magnetic circuit

c) Draw the winding schema of the stator and rotor windings and calculate the winding factor for the fundamental harmonic.

d) Define the numbers of turns and current densities in both the stator and rotor windings.

   Assumption: The peak value of the fundamental air-gap flux density is 0.80 T. The leakage flux is neglected. The filling factor of the iron core is 0.95 and the filling factor of copper in the stator and rotor slots is 0.58.