

1.

$$f := 50 \quad n1 := 3000 \quad P2 := 55000 \quad m := 3 \quad U1H := 220$$

$$p := 60 \cdot \frac{f}{n1} = 1$$

$$h := 0.225 \quad Da := 0.392 \quad Kd := 0.52$$

31. 4A225M2	55	380 (3,5)	3000
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$$D := Kd \cdot Da = 0.204 \quad (M)$$

$$\tau := \frac{\pi \cdot D}{2 \cdot p} = 0.32$$

$$ke := 0.98 \quad \eta := 0.90 \quad \cos \varphi := 0.91$$

$$P' := P2 \cdot \frac{ke}{\eta \cdot \cos \varphi} = 6.581 \cdot 10^4$$

$$A := 40000 \quad B\delta := 0.74$$

$$k\sigma61 := 0.95$$

$$kb := \frac{\pi}{2 \cdot \sqrt{2}} = 1.111$$

$$\Omega := \frac{2 \cdot \pi \cdot f}{p} = 314.159$$

$$l\delta := \frac{P'}{kb \cdot D^2 \cdot \Omega \cdot k\sigma61 \cdot A \cdot B\delta} = 0.161$$

$$\lambda := \frac{l\delta}{\tau} = 0.504$$

2.

$$t1max := 0.018 \quad t1min := 0.016$$

$$Z1min := \frac{\pi \cdot D}{t1max} = 35.577 \quad Z1max := \frac{\pi \cdot D}{t1min} = 40.024$$

$$Z1 := 36$$

$$q := \frac{Z1}{2 \cdot p \cdot m} = 6$$

$$t1 := \frac{\pi \cdot D}{2 \cdot p \cdot m \cdot q} = 0.018 \quad (M)$$

$$I_{1H} := \frac{P_2}{m \cdot U_{1H} \cdot \cos \varphi \cdot \eta} = 101.75$$

$$u' := \frac{\pi \cdot D \cdot A}{I_{1H} \cdot Z_1} = 6.993$$

$$u' := 7 \quad a := 2$$

$$u := a \cdot u' = 14$$

$$w_1 := \frac{u \cdot Z_1}{2 \cdot a \cdot m} = 42$$

$$A := \frac{2 \cdot I_{1H} \cdot w_1 \cdot m}{\pi \cdot D} = 4.004 \cdot 10^4$$

$$A := 40000$$

$$k_{об1} := 0.95$$

$$\Phi := \frac{k_e \cdot U_{1H}}{4 \cdot k_b \cdot w_1 \cdot k_{об1} \cdot f} = 0.024$$

$$B\delta := \frac{p \cdot \Phi}{D \cdot l\delta} = 0.739$$

$$B\delta := 0.74$$

$$AJ_1 := 185 \cdot 10^9$$

$$J_1 := \frac{AJ_1}{A} = 4.625 \cdot 10^6$$

предварительно

$$q_{эф} := \frac{I_{1H}}{a \cdot J_1} = 1.1 \cdot 10^{-5}$$

$$n_{эл} := 10$$

$$q_{эл} := \frac{q_{эф}}{n_{эл}} = 1.1 \cdot 10^{-6} \quad (M^2)$$

по таблице

$$q_{эл} := 1.094 \cdot 10^{-6} \quad d_{эл} := 1.18 \cdot 10^{-3} \quad du_3 := 1.26 \cdot 10^{-3}$$

$$q_{эф} := q_{эл} \cdot n_{эл} = 1.094 \cdot 10^{-5} \quad (M^2)$$

$$J_1 := \frac{I_{1H}}{a \cdot q_{эл} \cdot n_{эл}} = 4.65 \cdot 10^6$$

3.

$$kc := 0.97 \quad lcm1 := l\delta = 0.161 \quad Bz1 := 1.6 \quad Ba := 1.4$$

$$bz1 := \frac{B\delta \cdot t1 \cdot l\delta}{Bz1 \cdot lcm1 \cdot kc} = 0.008 \quad (м)$$

$$ha := \frac{\Phi}{2 \cdot Ba \cdot lcm1 \cdot kc} = 0.055 \quad (м)$$

$$b_{\text{шс}} := 4 \quad (мм)$$

$$h_{\text{шс}} := 1 \quad (мм)$$

$$hn := \frac{Da - D}{2} - ha = 0.039 \quad (м)$$

$$b1c := \frac{\pi \cdot (D + 2 \cdot hn)}{Z1} - bz1 = 0.016 \quad (м)$$

$$b2c := \frac{\pi \cdot (D \cdot 10^3 + 2 \cdot h_{\text{шс}} - b_{\text{шс}}) - Z1 \cdot b1c \cdot 10^3}{Z1 - \pi} = 10.005 \quad (мм)$$

$$h1c := hn \cdot 10^3 - \left(h_{\text{шс}} + \frac{b2c - b_{\text{шс}}}{2} \right) = 34.595 \quad (мм)$$

$$\Delta bn := 0.2 \quad \Delta hn := 0.2 \quad (мм)$$

$$b'1 := b1c \cdot 10^3 - \Delta bn = 15.843 \quad (мм)$$

$$b'2 := b2c - \Delta bn = 9.805 \quad (мм)$$

$$h'1 := h1c - \Delta hn = 34.395 \quad (мм)$$

$$bu3 := 0.4 \quad (мм)$$

$$Snp := 0 \quad Su3 := bu3 \cdot (2 \cdot hn \cdot 10^3 + b1c \cdot 10^3 + b2c) = 41.298 \quad (мм^2)$$

$$S'n := \frac{b'1 + b'2}{2} \cdot h'1 - Su3 - Snp = 399.796 \quad (мм^2)$$

$$k3 := \frac{(du3 \cdot 10^3)^2 \cdot u \cdot n_{\text{эл}}}{S'n} = 0.556$$

4.

$$\delta := 1.2 \quad (мм)$$

$$Z2 := 32$$

$$\text{Внешний_диаметр} \quad D2 := D - 2 \cdot \delta \cdot 10^{-3} = 0.201 \quad (м)$$

$$L1 := l\delta = 0.161 \quad L2 := L1 = 0.161 \quad (м)$$

$$tz2 := \frac{\pi \cdot D2}{Z2} = 0.02 \quad (м)$$

$$k\vartheta := 0.23$$

$$Dj := k\vartheta \cdot Da = 0.09 \quad D\vartheta := Dj = 0.09 \quad (м)$$

$$vi := \frac{2 \cdot m \cdot w1 \cdot k_{об1}}{Z2} = 7.481$$

$$ki := 0.2 + 0.8 \cdot \cos\varphi = 0.928$$

$$I2 := ki \cdot I1H \cdot vi = 706.41$$

$$J2 := 3.3 \cdot 10^6$$

$$qc := \frac{I2}{J2} = 2.141 \cdot 10^{-4} \quad (м^2)$$

$$b_{\text{шп}} := 1.5 \quad h_{\text{шп}} := 0.7 \quad h'_{\text{шп}} := 0.3 \quad (мм)$$

$$Bz2 := 1.8$$

$$l_{cm2} := l\delta = 0.161$$

$$bz2 := \frac{B\delta \cdot tz2 \cdot l\delta}{Bz2 \cdot l_{cm2} \cdot kc} = 0.008 \quad (м)$$

$$b1p := \frac{\pi \cdot (D2 \cdot 10^3 + 2 \cdot h_{\text{шп}} - 2 \cdot h'_{\text{шп}}) - Z2 \cdot bz2 \cdot 10^3}{Z2 + \pi} = 10.447 \quad (мм)$$

$$b2p := \sqrt{\frac{b1p^2 \cdot \left(\frac{Z2}{\pi} + \frac{\pi}{2} \right) - qc \cdot 10^6 \cdot 4}{\frac{Z2}{\pi} - \frac{\pi}{2}}} = 7.04 \quad (мм)$$

$$h1p := (b1p - b2p) \cdot \frac{Z2}{2 \cdot \pi} = 17.354 \quad (мм)$$

Принимаем $b1p := 10 \quad b2p := 7 \quad h1p := 17.4 \quad (мм)$

$$h_{n2} := h'_{\text{шп}} + h_{\text{шп}} + \frac{b1p}{2} + h1p + \frac{b2p}{2} = 26.9 \quad (мм)$$

Принимаем $h_{n2} := 27 \quad (мм)$

$$q_c := \left(\frac{\pi}{8} \right) \cdot (b_1 p^2 + b_2 p^2) + 0.5 \cdot (b_1 p + b_2 p) \cdot h_1 p = 206.412 \text{ (мм}^2\text{)}$$

$$J_2 := \frac{I_2}{q_c \cdot 10^{-6}} = 3.422 \cdot 10^6$$

$$\Delta := 2 \cdot \sin \left(\frac{\pi \cdot p}{Z_2} \right) = 0.196$$

$$I_{кл} := \frac{I_2}{\Delta} = 3.604 \cdot 10^3$$

$$J_{кл} := 0.85 \cdot J_2 = 2.909 \cdot 10^6$$

$$q_{кл} := \frac{I_{кл}}{J_{кл}} = 0.001 \quad (\text{мм}^2)$$

$$b_{кл} := 1.25 \cdot h_{п2} = 33.75 \quad (\text{мм})$$

$$a_{кл} := \frac{q_{кл} \cdot 10^6}{b_{кл}} = 36.704 \quad (\text{мм})$$

$$q_{кл} := b_{кл} \cdot a_{кл} = 1.239 \cdot 10^3 \quad (\text{мм}^2)$$

$$D_{к.ср} := D_2 \cdot 10^3 - b_{кл} = 167.69 \quad (\text{мм}^3) \quad \text{мм}_2!!!!$$

5.

$$Bz_1 := \frac{B\delta \cdot t_1 \cdot l\delta}{bz_1 \cdot lcm_1 \cdot kc} = 1.6$$

$$t_2 := tz_2 = 0.02$$

$$Bz_2 := \frac{B\delta \cdot t_2 \cdot l\delta}{bz_2 \cdot lcm_2 \cdot kc} = 1.8$$

$$Ba := \frac{\Phi}{2 \cdot ha \cdot lcm_1 \cdot kc} = 1.4$$

$$mk_2 := 0 \quad dk_2 := 0 \quad \text{Так_как_нет_аксиальных_каналов}$$

$$h'j := \frac{2+p}{3.2 \cdot p} \cdot \left(\frac{D_2 \cdot 10^3}{2} - h_{п2} \right) - \frac{2}{3} \cdot dk_2 \cdot mk_2 = 69.113 \quad (\text{мм})$$

$$Bj := \frac{\Phi}{2 \cdot h'j \cdot 10^{-3} \cdot lcm_2 \cdot kc} = 1.124$$

$$b_{ш1} := b_{шp} = 1.5 \quad (\text{мм})$$

$$\gamma := \frac{\left(\frac{buc}{\delta}\right)^2}{5 + \frac{buc}{\delta}} = 1.333$$

$$k\delta := \frac{t1 \cdot 10^3}{t1 \cdot 10^3 - \gamma \cdot \delta} = 1.099$$

$$F\delta := 1.59 \cdot 10^6 \cdot B\delta \cdot k\delta \cdot \delta \cdot 10^{-3} = 1.551 \cdot 10^3$$

$$Hz1 := 850 \quad Hz2 := 1520$$

$$hz1 := hn = 0.039 \quad (m)$$

$$hz2 := hn2 \cdot 10^{-3} - 0.1 \cdot b2p \cdot 10^{-3} = 0.026 \quad (m)$$

$$Fz1 := 2 \cdot hz1 \cdot Hz1 = 65.616$$

$$Fz2 := 2 \cdot hz2 \cdot Hz2 = 79.952$$

$$kz := 1 + \frac{Fz1 + Fz2}{F\delta} = 1.094$$

$$Ha := 400 \quad Hj := 1290$$

$$La := \frac{\pi \cdot (Da - ha)}{2 \cdot p} = 0.529 \quad (m)$$

$$hj := \left(\frac{D2 - Dj}{2} - hn2 \cdot 10^{-3} \right) = 0.029 \quad (m)$$

$$Lj := \frac{\pi \cdot (Dj + hj)}{2 \cdot p} = 0.187 \quad (m)$$

$$Fa := La \cdot Ha = 211.44$$

$$Fj := Lj \cdot Hj = 240.728$$

$$F\varrho := F\delta + Fz1 + Fz2 + Fa + Fj = 2.149 \cdot 10^3$$

$$k\mu := \frac{F\varrho}{F\delta} = 1.385$$

$$I\mu := \frac{p \cdot F\varrho}{0.9 \cdot m \cdot w1 \cdot k061} = 19.95$$

$$I''\mu := \frac{I\mu}{I1H} = 0.196$$

6.

$$\rho_{115} := \frac{10^{-6}}{41}$$

$$ln1 := l\delta = 0.161 \quad (м)$$

$$B := 0.01 \quad (м)$$

$$Kл := 1.2$$

$$hn1 := hn = 0.039 \quad (м)$$

$$\beta 1 := 1$$

$$b_{км} := \frac{\pi \cdot (D + hn1)}{2 \cdot p} \cdot \beta 1 = 0.381 \quad (м)$$

$$l_{л1} := Kл \cdot b_{км} + 2 \cdot B = 0.477 \quad (м)$$

$$l_{ср1} := 2 \cdot (ln1 + l_{л1}) = 1.277 \quad (м)$$

$$L1 := l_{ср1} \cdot w1 = 53.626 \quad (м)$$

$$r1 := \rho_{115} \cdot \frac{L1}{q_{эф} \cdot a} = 0.06$$

$$K_{выл} := 0.26$$

$$l_{выл} := K_{выл} \cdot b_{км} + B = 0.109 \quad (м)$$

$$r''1 := r1 \cdot \frac{I_{1H}}{U_{1H}} = 0.028$$

$$\rho_{115} := \frac{10^{-6}}{20.5} \quad \text{Примечание_таблицы_5.1}$$

$$l2 := l\delta = 0.161 \quad (м)$$

$$rc := \rho_{115} \cdot \frac{l2}{q_c \cdot 10^{-6}} = 3.815 \cdot 10^{-5}$$

$$h_{кл} := 1.2 \cdot hn2 = 32.4 \quad (мм)$$

$$D_{клср} := D2 - h_{кл} \cdot 10^{-3} = 0.169 \quad (м)$$

$$r_{кл} := \rho_{115} \cdot \frac{\pi \cdot D_{клср}}{Z2 \cdot q_{кл} \cdot 10^{-6}} = 6.535 \cdot 10^{-7}$$

$$r_2 := r_c + \frac{2 \cdot r_{\kappa\lambda}}{\Delta^2} = 7.216 \cdot 10^{-5}$$

$$r'_2 := r_2 \cdot \frac{4 \cdot m \cdot (w_1 \cdot k_{об1})^2}{Z_2} = 0.043$$

$$r''_2 := r'_2 \cdot \frac{I_{1H}}{U_{1H}} = 0.02$$

$$r'_2 := r_2 \cdot \frac{4 \cdot m \cdot (w_1 \cdot k_{об1})^2}{Z_2} = 0.043$$

$$\text{Относит.} \quad r''_2 := r'_2 \cdot \frac{I_{1H}}{U_{1H}} = 0.02$$

$$f_1 := f = 50 \quad l'\delta := l\delta = 0.161 \quad (\text{м})$$

$$h_3 := h_{1c} = 34.595 \quad (\text{мм}) \quad b_{1c} := 13 \quad (\text{мм}) \quad h_2 := 0$$

$$h_1 := 0.5 \cdot (b_{1c} - b_{\omega c}) = 4.5 \quad (\text{мм})$$

$$k\beta := 1 \quad k'\beta := 1$$

$$\lambda_n := \frac{h_3}{3 \cdot b_{1c}} \cdot k\beta + \left(\frac{h_2}{b_{1c}} + \frac{3 \cdot h_1}{b_{1c} + 2 \cdot b_{\omega c}} + \frac{h_{\omega c}}{b_{\omega c}} \right) \cdot k'\beta = 1.78$$

$$l_l := l_{l1} = 0.477 \quad (\text{м}) \quad \beta := \beta_1 = 1$$

$$\lambda_{l1} := 0.34 \cdot \frac{q}{l'\delta} \cdot (l_l - 0.64 \cdot \beta \cdot \tau) = 3.438$$

$$\beta_{CK} := 0 \quad k'_{CK} := 1 \quad \text{для} \quad \frac{t_2}{t_1} = 1.112$$

$$\xi := 2 \cdot k'_{CK} \cdot k\beta - k_{об1}^2 \cdot \left(\frac{t_2}{t_1} \right)^2 \cdot (1 + \beta_{CK}^2) = 0.885$$

$$\lambda_{\partial 1} := \frac{t_1 \cdot 10^3}{12 \cdot \delta \cdot k\delta} \cdot \xi = 0.994$$

$$x_1 := 15.8 \cdot \frac{f_1}{100} \cdot \left(\frac{w_1}{100} \right)^2 \cdot \frac{l'\delta}{p \cdot q} \cdot (\lambda_n + \lambda_{l1} + \lambda_{\partial 1}) = 0.233 \quad (\text{Ом})$$

$$\text{относит.} \quad x_1'' := x_1 \cdot \frac{I_{1H}}{U_{1H}} = 0.108$$

$$h_1 := h_{n2} - 0.5 \cdot b_{1p} = 22 \quad (\text{мм})$$

$$k\partial := 1$$

$$\lambda n2 := \left(\frac{h1}{3 \cdot b1p} \cdot \left(1 - \frac{\pi \cdot b1p^2}{8 \cdot qc} \right)^2 + 0.66 - \frac{bwp}{2 \cdot b1p} \right) \cdot k\partial + \frac{hwp}{bwp} + 1.12 \cdot \frac{h'wp \cdot 10^{-3} \cdot 10^6}{I2} = 2.008$$

$$\lambda l2 := \frac{2.3 \cdot D\kappa \cdot cp \cdot 10^{-3}}{Z2 \cdot l' \delta \cdot \Delta^2} \cdot \log \left(\frac{4.7 \cdot D\kappa \cdot cp \cdot 10^{-3}}{a\kappa l \cdot 10^{-3} + 2 \cdot b\kappa l \cdot 10^{-3}} \right) = 1.707$$

$$\xi := 1$$

$$\lambda \partial 2 := \frac{t2 \cdot 10^3}{12 \cdot \delta \cdot k\delta} \cdot \xi = 1.25$$

$$x2 := 7.9 \cdot f1 \cdot l\delta \cdot (\lambda n2 + \lambda l2 + \lambda \partial 2) \cdot 10^{-6} = 3.166 \cdot 10^{-4} \quad (OM)$$

$$\Sigma \lambda 2 := \lambda n2 + \lambda l2 + \lambda \partial 2 = 4.965$$

$$x'2 := x2 \cdot \frac{4 \cdot m \cdot (w1 \cdot ko\delta 1)^2}{Z2} = 0.189 \quad (OM)$$

$$\text{Относит.} \quad x''2 := x'2 \cdot \frac{I1H}{U1H} = 0.087$$

7.

$$p1.5 := 2.55 \quad \beta := 1.5 \quad \gamma c := 7.8 \cdot 10^3$$

$$ha := 0.5 \cdot (Da - D) - hn1 = 0.055 \quad (M)$$

$$ma := \pi \cdot (Da - ha) \cdot ha \cdot lcm1 \cdot kc \cdot \gamma c = 71.637 \quad (\kappa 2)$$

$$bz1cp := bz1 = 0.008 \quad (M)$$

$$mz1 := hz1 \cdot bz1cp \cdot Z1 \cdot lcm1 \cdot kc \cdot \gamma c = 14.393 \quad (\kappa 2)$$

$$k\partial a := 1.6 \quad k\partial z := 1.8$$

$$P_{ст.осн} := p1.5 \cdot \left(\frac{f1}{50} \right)^\beta \cdot (k\partial a \cdot Ba^2 \cdot ma + k\partial z \cdot Bz1^2 \cdot mz1) = 741.992$$

$$ko2 := 1.5$$

$$\frac{buc}{\delta} = 3.333 \quad \beta o2 := 0.24$$

$$Bo2 := \beta o2 \cdot k\delta \cdot B\delta = 0.195 \quad (Tл)$$

$$pнов2 := 0.5 \cdot ko2 \cdot \left(\frac{Z1 \cdot n1}{10000} \right)^{1.5} \cdot (Bo2 \cdot t1 \cdot 10^3)^2 = 320.791 \quad (Bm)$$

$$t2 := 0.012 \quad (M)$$

$$Pнов2 := pнов2 \cdot (t2 - bwp \cdot 10^{-3}) \cdot Z2 \cdot lcm2 = 17.399 \quad (Bm)$$

$$Bz2cp := Bz2 = 1.8 \quad (Tл)$$

$$Bnyл2 := \frac{\gamma \cdot \delta \cdot 10^{-3}}{2 \cdot t2} \cdot Bz2cp = 0.12 \quad (Tл)$$

$$bz2cp := bz2 = 0.008 \quad (м) \quad hz2 := hn2 = 27 \quad (мм)$$

$$kc2 := kc \cdot 7800 = 7.566 \cdot 10^3$$

$$mz2 := Z2 \cdot hz2 \cdot 10^{-3} \cdot bz2cp \cdot lcm2 \cdot kc2 = 8.844 \quad (кг)$$

$$Pnyл2 := 0.11 \cdot \left(\frac{Z1 \cdot n1}{1000} \cdot Bnyл2 \right)^2 \cdot mz2 = 163.407 \quad (Bм)$$

$$Pcm.дoб := Pпov2 + Pnyл2 = 180.806 \quad (Bм)$$

$$Pcm := Pcm.ocн + Pcm.дoб = 922.798 \quad (Bм)$$

$$Kt := 1$$

$$Pмex := Kt \cdot \left(\frac{n1}{10} \right)^2 \cdot Da^4 = 2.125 \cdot 10^3 \quad (Bм)$$

$$Pдoб.н := 0.005 \cdot \frac{P2}{\eta} = 305.556 \quad (Bм)$$

$$Pэ1xx := 3 \cdot I\mu^2 \cdot r1 = 71.375 \quad (Bм)$$

$$Ixxa := \frac{Pcm + Pмex + Pэ1xx}{m \cdot U1н} = 4.726 \quad (A)$$

$$Ixx := \sqrt{Ixxa^2 + I\mu^2} = 20.502 \quad (A)$$

$$\cos\varphi_{xx} := \frac{Ixxa}{Ixx} = 0.231$$

8.

$$r12 := \frac{Pcm.ocн}{m \cdot I\mu^2} = 0.621 \quad (Oм)$$

$$x12 := \frac{U1н}{I\mu} - x1 = 10.795 \quad (Oм)$$

$$c1 := 1 + \frac{x1}{x12} = 1.022 \quad \text{Так_как_}\gamma' < 1^\circ$$

$$\gamma' := \operatorname{atan}\left(\frac{r1 \cdot x12 - r12 \cdot x1}{r12 \cdot (r1 + r12) + x12 \cdot (x1 + x12)}\right) = 0.004$$

$$I0a := \frac{P_{cm.оч} + 3 \cdot I\mu^2 \cdot r1}{3 \cdot U1H} = 1.232 \quad (A)$$

$$a' := c1^2 = 1.044$$

$$b' := 0$$

$$a := c1 \cdot r1 = 0.061 \quad (Ом)$$

$$b := c1 \cdot (x1 + c1 \cdot x'2) = 0.435 \quad (Ом)$$

$$P_{cm} + P_{mex} = 3.048 \cdot 10^3 \quad (Вт)$$

$$sH := r''2 = 0.02$$

РАСЧЁТЫ_ДЛЯ_ТАБЛИЦЫ_1

$$P_H := 55 \quad (кВт) \qquad 2 \cdot p = 2 \qquad U1H = 220 \quad (В)$$

$$I0a = 1.232 \quad (A) \qquad I0p := I\mu = 19.95 \quad (A)$$

$$P_{cm} + P_{mex} = 3.048 \cdot 10^3 \quad (Вт) \qquad r1 = 0.06 \quad (Ом)$$

$$r'2 = 0.043 \quad (Ом) \qquad c1 = 1.022$$

$$a' = 1.044 \qquad a = 0.061 \quad (Ом)$$

$$b' = 0 \quad (Ом) \qquad b = 0.435 \quad (Ом)$$

Принимаем $s := sH$

$$a' \cdot \frac{r'2}{s} = 2.256 \quad (Ом)$$

$$b' \cdot \frac{r'2}{s} = 0 \quad (Ом)$$

$$R := a + a' \cdot \frac{r'2}{s} = 2.318 \quad (Ом)$$

$$X := b + b' \cdot \frac{r'2}{s} = 0.435 \quad (Ом)$$

$$Z := \sqrt{R^2 + X^2} = 2.358 \quad (OM)$$

$$I''_2 := \frac{U_{1H}}{Z} = 93.298 \quad (A)$$

$$\cos \varphi'_2 := \frac{R}{Z} = 0.983$$

$$\sin \varphi'_2 := \frac{X}{Z} = 0.185$$

$$I_{1a} := I_{0a} + I''_2 \cdot \cos \varphi'_2 = 92.927 \quad (A)$$

$$I_{1p} := I_{0p} + I''_2 \cdot \sin \varphi'_2 = 37.169 \quad (A)$$

$$I_1 := \sqrt{I_{1a}^2 + I_{1p}^2} = 100.085 \quad (A)$$

$$I'_2 := c_1 \cdot I''_2 = 95.311 \quad (A)$$

$$P_1 := 3 \cdot U_{1H} \cdot I_{1a} \cdot 10^{-3} = 61.332 \quad (\kappa Bm)$$

$$P_{\exists 1} := 3 \cdot I_1^2 \cdot r_1 \cdot 10^{-3} = 1.796 \quad (\kappa Bm)$$

$$P_{\exists 2} := 3 \cdot I'_2{}^2 \cdot r'_2 \cdot 10^{-3} = 1.174 \quad (\kappa Bm)$$

$$P_{\partial o6} := P_{\partial o6.H} \cdot 10^{-3} \cdot \left(\frac{I_1}{I_{1H}} \right)^2 = 0.296 \quad (\kappa Bm)$$

$$\Sigma P := (P_{cm} + P_{Mex}) \cdot 10^{-3} + P_{\exists 1} + P_{\exists 2} + P_{\partial o6} \cdot 10^{-3} = 6.019$$

$$P_2 := P_1 - \Sigma P = 55.313 \quad (\kappa Bm)$$

$$\eta := 1 - \frac{\Sigma P}{P_1} = 0.902$$

$$\cos \varphi := \frac{I_{1a}}{I_1} = 0.928$$

$$\nu_{pac4} := 115$$

$$hc := h\nu_2 - (h\nu_p - h'\nu_p) = 26.6 \quad (mM)$$

$$s := 1$$

$$\xi := 63.61 \cdot hc \cdot 10^{-3} \cdot \sqrt{s} = 1.692$$

$$\varphi := 0.55$$

$$\varphi' := 0.85$$

$$\varphi_{089} := 0.89 \cdot \xi^4 = 7.295$$

$$hr := \frac{hc \cdot 10^{-3}}{1 + \varphi} = 0.017 \quad (M)$$

$$b1p = 10$$

$$b2p = 7$$

$$h1p = 17.4$$

$$k\partial := \varphi' = 0.85$$

$$\frac{b1p}{2} = 5 \quad (MM) \quad \frac{b1p}{2} + h1p = 22.4 \quad (MM)$$

$$3.8 < 17 < 19$$

$$br := b1p - \frac{b1p - b2p}{h1p} \cdot \left(hr \cdot 10^3 - \frac{b1p}{2} \right) = 7.903 \quad (MM)$$

$$qr := \frac{\pi \cdot b1p^2}{8} + \frac{b1p + br}{2} \cdot \left(hr \cdot 10^3 - \frac{b1p}{2} \right) = 148.133 \quad (MM^2)$$

$$kr := \frac{qc}{qr} = 1.393$$

$$qc = 206.412$$

$$rc = 3.815 \cdot 10^{-5}$$

$$KR := 1 + \frac{rc}{r2} \cdot (kr - 1) = 1.208$$

$$r2 = 7.216 \cdot 10^{-5}$$

$$r'2 = 0.043$$

$$r'2\xi := KR \cdot r'2 = 0.052 \quad (OM)$$

$$\lambda n2\xi := \left(\frac{h1}{3 \cdot b1p} \cdot \left(1 - \frac{\pi \cdot b1p^2}{8 \cdot qc} \right)^2 + 0.66 - \frac{bwp}{2 \cdot b1p} \right) \cdot k\partial + \frac{bwp}{hwp} + 1.12 \cdot \frac{h'wp \cdot 10^3}{6.5 \cdot I2} = 3.122$$

$$Kx := \frac{\lambda n2\xi + \lambda n2 + \lambda \partial 2}{\lambda n2 + \lambda n2 + \lambda \partial 2} = 1.224$$

$$x'2 = 0.189$$

$$x'2\xi := x'2 \cdot Kx = 0.231 \quad (OM)$$

$$I'2 := \frac{U1H}{\sqrt{\left(r1 + \frac{r'2\xi}{s} \right)^2 + (x1 + x'2\xi)^2}} = 460.64 \quad (A)$$

$$kHac := 1.35$$

$$I1 := I'2 = 460.64 \quad (A)$$

$$a := 2$$

$$ky := 1$$

$$Fn.cp := 0.7 \cdot \frac{kHac \cdot I1 \cdot u}{a} \cdot \left(k'\beta + ky \cdot ko61 \cdot \frac{Z1}{Z2} \right) = 6.304 \cdot 10^3$$

$$Cn := 0.64 + 2.5 \cdot \sqrt{\frac{\delta \cdot 10^{-3}}{t1 + t2}} = 1.142$$

$$B\phi\delta := \frac{Fn.cp}{1.6 \cdot \delta \cdot 10^{-3} \cdot Cn} \cdot 10^{-6} = 2.876 \quad (Tл)$$

$$\kappa\delta := 0.75$$

$$c1 := (t1 \cdot 10^3 - b\omega c) \cdot (1 - \kappa\delta) = 3.447 \quad (мм)$$

$$h' := 0.5 \cdot (b1p - b2p) = 1.5$$

$$\Delta\lambda n1_{\text{нас}} := \frac{h\omega c + 0.58 \cdot h'}{b\omega c} \cdot \frac{c1}{c1 + b\omega c} = 0.216$$

$$\lambda n1 := \lambda n = 1.78$$

$$\lambda n1_{\text{нас}} := \lambda n1 - \Delta\lambda n1_{\text{нас}} = 1.564$$

$$\lambda\partial1_{\text{нас}} := \lambda\partial1 \cdot \kappa\delta = 0.746$$

$$\Sigma\lambda1_{\text{нас}} := \lambda n1_{\text{нас}} + \lambda\partial1_{\text{нас}} + \lambda l1 = 5.748$$

$$\Sigma\lambda1 := \lambda n1 + \lambda\partial1 + \lambda l1 = 6.213$$

$$x1_{\text{нас}} := x1 \cdot \frac{\Sigma\lambda1_{\text{нас}}}{\Sigma\lambda1} = 0.215$$

$$c2 := (t2 \cdot 10^3 - b\omega p) \cdot (1 - \kappa\delta) = 2.625 \quad (мм)$$

$$\Delta\lambda n2_{\text{нас}} := \frac{h\omega p}{b\omega p} \cdot \frac{c2}{c2 + b\omega p} = 0.297$$

$$\lambda n2_{\text{нас}} := \lambda n2\xi - \Delta\lambda n2_{\text{нас}} = 2.825$$

$$\lambda\partial2_{\text{нас}} := \lambda\partial2 \cdot \kappa\delta = 0.937$$

$$\lambda2\xi_{\text{нас}} := \lambda n2_{\text{нас}} = 2.825$$

$$\Sigma\lambda2\xi_{\text{нас}} := \lambda2\xi_{\text{нас}} + \lambda\partial2_{\text{нас}} + \lambda l2 = 5.47$$

$$x'2\xi_{\text{нас}} := x'2 \cdot \frac{\Sigma\lambda2\xi_{\text{нас}}}{\Sigma\lambda2} = 0.208 \quad (Ом)$$

$$x12n := x12 \cdot \frac{F\varphi}{F\delta} = 14.954$$

$$c1n_{\text{нас}} := 1 + \frac{x1_{\text{нас}}}{x12n} = 1.014$$

$$a_n := r_1 + c_{1n} n_{\text{нас}} \cdot \frac{r'^2 \xi}{s} = 0.113$$

$$b_n := c_{1n} n_{\text{нас}} \cdot x'^2 \xi_{\text{нас}} + x_{1\text{нас}} = 0.427$$

$$I'^2_n := \frac{U_{1H}}{\sqrt{a_n^2 + b_n^2}} = 498.539 \quad (\text{A})$$

$$I_1 := I'^2_n \cdot \frac{\sqrt{a_n^2 + (b_n + x_{12n})^2}}{c_{1n} n_{\text{нас}} \cdot x_{12n}} = 505.494 \quad (\text{A})$$

Относительные значения

$$I_{1n} := I_1 = 505.494 \quad I'^2_n := I'^2 = 498.539$$

$$I''_n := \frac{I_{1n}}{I_{1H}} = 4.968$$

$$s = 1 \quad s_H := r''^2 = 0.02$$

$$I'^2_n := 16.385 \quad (\text{A}) \quad \text{по_таблице_1_при_} s_H \text{ (вместо } s \text{)}$$

$$M''_n := \left(\frac{I'^2_n}{I'^2_H} \right)^2 \cdot KR \cdot \frac{s_H}{s} = 22.281$$

9.

$$K := 0.19$$

$$P_{\Sigma 1} := 175 \quad (\text{Вт}) \quad \text{по_таблице_1_при_} s_H$$

$$\alpha_1 := 140$$

$$l_{cp1} = 1.277$$

$$k_p := 1.07 \quad \text{для_изоляции_класса_} F$$

$$l_1 := l\delta = 0.161 \quad (\text{м}) \quad P_{\text{ст.осн}} = 741.992$$

$$P'_{\Sigma.n1} := k_p \cdot P_{\Sigma 1} \cdot \frac{2 \cdot l_1}{l_{cp1}} = 47.346 \quad (\text{Вт}) \quad D = 0.204$$

$$\Delta \zeta_{\text{нов1}} := K \cdot \frac{P'_{\Sigma.n1} + P_{\text{ст.осн}}}{\pi \cdot D \cdot l_1 \cdot \alpha_1} = 10.363 \quad (^\circ\text{C}) \quad l_1 = 0.161$$

$$\Pi n_1 := 2 \cdot h_n + b_{1c} \cdot 10^{-3} + b_{2c} \cdot 10^{-3} = 0.1 \quad (\text{м})$$

$$\lambda_{\text{экв}} := 0.16 \quad \text{для_изоляции_класса_} F \quad \lambda'_{\text{экв}} := 1.1$$

При	$Z1 = 36$	$l1 = 0.161$
$\frac{d\lambda}{du} = 0.937$	$\Pi n1 = 0.1$	
$buз. n1 := buз = 0.4$		
$\Delta\zeta_{уз. n1} := \frac{P'_{\lambda. n1}}{Z1 \cdot \Pi n1 \cdot l1} \cdot \left(\frac{buз. n1 \cdot 10^{-3}}{\lambda_{\lambda\kappa\theta}} + \frac{(b1c + b2c) \cdot 10^{-3}}{16 \cdot \lambda'_{\lambda\kappa\theta}} \right) = 0.31$		$(^{\circ}C)$
$P'_{\lambda. l1} := kp \cdot P_{\lambda 1} \cdot 2 \cdot \frac{l_{l1}}{l_{cp1}} = 139.904$	(Bm)	$\lambda_{\lambda\kappa\theta} = 0.16$
$P_{\lambda 1} = 175$	$l_{l1} = 0.477$	$b1c = 13$
$\Pi l1 := \Pi n1 = 0.1$	$(м)$	$l_{cp1} = 1.277$
	$h_{n1} = 0.039$	$b2c = 10.005$
		$\lambda'_{\lambda\kappa\theta} = 1.1$
$buз. l1 := 0$	$l_{\text{выл}} = 0.109$	$\alpha 1 = 140$
$\Delta\zeta_{уз. l1} := \frac{P'_{\lambda. l1}}{2 \cdot Z1 \cdot \Pi l1 \cdot l_{l1}} \cdot \left(\frac{buз. l1}{\lambda_{\lambda\kappa\theta}} + \frac{h_{n1}}{12 \cdot \lambda'_{\lambda\kappa\theta}} \right) = 0.119$		$(^{\circ}C)$
$\Delta\zeta_{нов1} = 10.363$	$\Delta\zeta_{нов. l1} := \frac{K \cdot P'_{\lambda. n1}}{2 \cdot \pi \cdot D \cdot l_{\text{выл}} \cdot \alpha 1} = 0.46$	$(^{\circ}C)$
$\Delta\zeta_{уз. n1} = 0.31$		$P'_{\lambda. n1} = 47.346$
$l_{cp1} = 1.277$		$K = 0.19$
$l1 = 0.161$		$D = 0.204$
$\Delta\zeta_{нов. l1} = 0.46$	$\Delta\zeta'1 := \frac{(\Delta\zeta_{нов1} + \Delta\zeta_{уз. n1}) \cdot 2 \cdot l1}{l_{cp1}} + \frac{(\Delta\zeta_{нов. l1} + \Delta\zeta_{уз. l1}) \cdot 2 \cdot l_{l1}}{l_{cp1}} = 3.131$	
$\Delta\zeta_{уз. l1} = 0.119$		
$l_{l1} = 0.477$	$P_{\lambda 2} := 88$	(Bm)
	$\Sigma P := 420$	(Bm)
	$no_таблице_1_при_сн$	
	$\Sigma P' := \Sigma P + (kp - 1) \cdot (P_{\lambda 1} + P_{\lambda 2}) = 438.41$	(Bm)
	$\Sigma P'_{\theta} := \Sigma P' - (1 - K) \cdot (P'_{\lambda. n1} + P_{\text{ст.осн}}) - 0.9 \cdot P_{\text{мех}} = -2.114 \cdot 10^3$	(Bm)
	$P'_{\lambda. n1} = 47.346$	
$\Pi p := 0.17$	$(м)$	$K = 0.19$
		$P_{\text{ст.осн}} = 741.992$
		$P_{\text{мех}} = 2.125 \cdot 10^3$
$Skop := (\pi \cdot Da + 8 \cdot \Pi p) \cdot (l1 + 2 \cdot l_{\text{выл}}) = 0.983$		$(м^2)$
$\alpha \theta := 19$	$Da = 0.392$	$\Pi p = 0.17$
		$\Sigma P = 420$
$\Delta\zeta_{\theta} := \frac{\Sigma P'_{\theta}}{Skop \cdot \alpha \theta} = -113.126$		$(^{\circ}C)$
	$l_{\text{выл}} = 0.109$	$kp = 1.07$
		$P_{\lambda 1} = 175$
$\Delta\zeta'1 := \Delta\zeta'1 + \Delta\zeta_{\theta} = -109.995$		$(^{\circ}C)$
	$\Delta\zeta'1 = 3.131$	
$km := m \cdot \sqrt{\frac{n1}{100} \cdot Da} = 10.288$		$\Sigma P'_{\theta} = -2.114 \cdot 10^3$
$Q_{\theta} := \frac{km \cdot \Sigma P'_{\theta}}{1100 \cdot \Delta\zeta_{\theta}} = 0.175$	$\left(\frac{M^3}{c} \right)$	$n1 = 3 \cdot 10^3$
		$Da = 0.392$
$Q'_{\theta} := 0.6 \cdot Da^3 \cdot \frac{n1}{100} = 1.084$	$\left(\frac{M^3}{c} \right)$	

$$Q'_{\text{в}} > Q_{\text{в}}$$

вывод

$$Ca := \frac{l\delta \cdot D^2 \cdot w1}{P'} = 4.28 \cdot 10^{-6}$$

$$P' = 6.581 \cdot 10^4$$

$$D = 0.204$$

$$w1 = 42$$

$$l\delta = 0.161$$