Verifica nominale dei becchi e del gambo del gancio

Inizializzazione dei dati

$$G_u := 55000\ kgf$$

$$v_{soll} := 5.5\ \frac{m}{min}$$

$$t_0 := 5\ s$$

$$a_{pm} := \frac{v_{soll}}{t_0} = 0.018\ \frac{m}{s^2}$$

$$a_{pmax} := 2 \cdot a_{pm} = 0.037\ \frac{m}{s^2}$$

$$s_p := 0.5 \cdot a_{pm} \cdot t_0^{\ 2} = 0.229\ m$$

$$v_{disc} := 1.1\ v_{soll} = 6.05\ \frac{m}{min}$$

$$a_m := \frac{v_{disc}}{t_0} = 0.02\ \frac{m}{s^2}$$

$$s := 0.5 \cdot a_m \cdot t_0^{\ 2} = 0.252\ m$$

$$a_{max} := 2 \cdot a_m = 0.04\ \frac{m}{s^2}$$

$$G_i := \frac{G_u}{9.81\ \frac{m}{s^2}} \cdot a_{max} = 226.13\ kgf$$

$$\left|\frac{G_i}{G_u}\right| \cdot 100 = 0.411$$

Quote riferite a tabella 4.2c - Fig 4.7d

$$d := 165\ mm$$
$$d_1 := 207\ mm$$

$$a := 145\ mm$$
$$b := 52\ mm$$
$$e := 166\ mm$$
$$m := 807\ mm$$
$$h := 321\ mm$$
$$r := 269\ mm$$
$$e_1 := 372\ mm$$

Verifica nominale dei becchi e del gambo del gancio

Dimensionamento sezione resistente trapezia

$$Q := \frac{G_u}{2} = \left(2.75 \cdot 10^4\right)\ kgf$$

$$I := \frac{m}{2} - r = 134.5\ mm$$

$$y_A := h - r = 52\ mm$$

$$x_A := \frac{e_1}{2} - I = 51.5\ mm$$

$$\gamma := \operatorname{atan}\left(\frac{I}{h - y_A}\right) = 26.565\ deg$$

$$\alpha := 0, \frac{\gamma}{6} .. \gamma$$

$$\beta(\alpha) := \gamma - \alpha$$

$$x_C(\alpha) := \left(h - y_A\right) \cdot \tan(\beta(\alpha))$$

$$y_C(\alpha) := 0$$

$$a_0(\alpha) := 1 + \tan(\beta(\alpha))^2$$

$$b_0(\alpha) := -2 \cdot y_A - 2 \cdot \tan(\beta(\alpha)) \cdot x_A$$

$$c_0(\alpha) := {x_A}^2 + {y_A}^2 - \frac{{d_1}^2}{4}$$

$$y_1(\alpha) := \frac{-b_0(\alpha) + \sqrt[2]{b_0(\alpha)^2 - 4 \cdot a_0(\alpha)\ c_0(\alpha)}}{2 \cdot a_0(\alpha)}$$

$$y_2(\alpha) := \frac{-b_0(\alpha) - \sqrt[2]{b_0(\alpha)^2 - 4 \cdot a_0(\alpha)\ c_0(\alpha)}}{2 \cdot a_0(\alpha)}$$

$$y_2(\alpha) = \begin{bmatrix} -28.098 \\ -29.675 \\ -31.26 \\ -32.858 \\ -34.475 \\ -36.114 \\ -37.778 \end{bmatrix} mm \qquad \alpha = \begin{bmatrix} 0 \\ 4.428 \\ 8.855 \\ 13.283 \\ 17.71 \\ 22.138 \\ 26.565 \end{bmatrix} deg$$

Verifica nominale dei becchi e del gambo del gancio

$$y_B(\alpha) := |y_2(\alpha)|$$

$$x_B(\alpha) := |y_2(\alpha) \cdot \tan(\beta(\alpha))|$$

$$x_B(\alpha) = \begin{bmatrix} 14.049 \\ 12.072 \\ 9.982 \\ 7.757 \\ 5.371 \\ 2.796 \\ 0 \end{bmatrix} mm \quad y_B(\alpha) = \begin{bmatrix} 28.098 \\ 29.675 \\ 31.26 \\ 32.858 \\ 34.475 \\ 36.114 \\ 37.778 \end{bmatrix} mm \quad \alpha = \begin{bmatrix} 0 \\ 4.428 \\ 8.855 \\ 13.283 \\ 17.71 \\ 22.138 \\ 26.565 \end{bmatrix} deg$$

$$I_C(\alpha) := \sqrt[2]{\left(x_C(\alpha) - x_B(\alpha)\right)^2 + \left(h - y_C(\alpha) - y_A - y_B(\alpha)\right)^2}$$

$$I_C(\alpha) = \begin{bmatrix} 269.337 \\ 258.372 \\ 249.568 \\ 242.633 \\ 237.354 \\ 233.583 \\ 231.222 \end{bmatrix} mm$$

$$BO(\alpha) := \frac{I_C(\alpha)}{3} \cdot \frac{a + 2\ b}{a + b}$$

$$AB(\alpha) := \sqrt[2]{x_B(\alpha)^2 + y_B(\alpha)^2}$$

$$AO(\alpha) := BO(\alpha) + AB(\alpha)$$

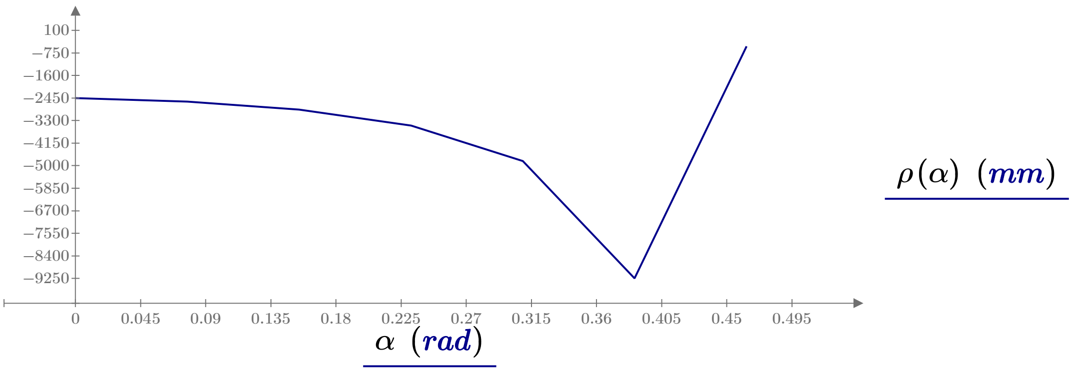
$$x_O(\alpha) := -AO(\alpha) \cdot \sin(\beta(\alpha))$$

$$y_O(\alpha) := -AO(\alpha) \cdot \cos(\beta(\alpha))$$

Calcolo curvatura baricentrica

$$\rho(\alpha) := \frac{\left(AO(\alpha)^2 + \left(\frac{d}{d\alpha} AO(\alpha)\right)^2\right)^{1.5}}{\left(AO(\alpha)\right)^2 + 2 \cdot \left(\frac{d}{d\alpha} AO(\alpha)\right)^2 - AO(\alpha) \cdot \frac{d^2}{d\alpha^2} AO(\alpha)}$$

Verifica nominale dei becchi e del gambo del gancio



Calcolo dell'anomalia della curvatura rispetto ad una retta orizzontale

$$\Theta(\alpha) := \operatorname{atan}\left(\frac{\frac{d}{d\alpha} y_O(\alpha)}{\frac{d}{d\alpha} x_O(\alpha)}\right)$$

$$\delta(\alpha) := \Theta(\alpha) + \frac{\pi}{2}$$

$$\alpha_{neg\rho} := 0.448\ rad$$

$$\alpha_{pos\rho} := 0.464\ rad$$

$$\alpha := 0, \frac{\alpha_{neg\rho}}{10} .. \alpha_{neg\rho}$$

Verifica nominale dei becchi e del gambo del gancio

$$I_r := h - \frac{d_1}{2} = 217.5\ mm$$

$$\psi := \operatorname{atan}\left(\frac{e_1}{2 \cdot h}\right) = 30.09\ °$$

$$NR := \frac{I_r}{3} \cdot \frac{(a + 2\ b)}{a + b} = 91.637\ mm$$

$$MR := I_r - NR = 125.863\ mm$$

$$b_x := \left(NR + \frac{d_1}{2}\right) \sin(\psi) + \left(NR + \frac{d_1}{2}\right) \frac{\sqrt[2]{2}}{2} = 235.816\ mm$$

$$b_y := \left(NR + \frac{d_1}{2}\right) \cos(\psi) - \left(NR + \frac{d_1}{2}\right) \frac{\sqrt[2]{2}}{2} = 30.858\ mm$$

$$M_q := Q \cdot b_x + Q \cdot b_y = \left(7.334 \cdot 10^6\right)\ kgf \cdot mm$$

$$A := \frac{(a + b)\ I_r}{2} = \left(2.142 \cdot 10^4\right)\ mm^2$$

$$\rho := NR + \frac{d_1}{2} = 195.137\ mm$$

$$\chi := -\frac{1}{A} \int_{-MR}^{NR} \frac{\eta}{\rho + \eta} \left(b + \frac{a - b}{I_r}\ (MR + \eta)\right) \mathrm{d}\eta = 0.137$$

$$\sigma_N := \frac{1}{A}\ \frac{Q}{\frac{\sqrt{2}}{2}}\ \sin\left(\psi + \frac{\pi}{4}\right) - \frac{M_q}{A \cdot \rho} - \frac{M_q}{\chi \cdot A \cdot \rho} \cdot \frac{-NR}{\rho - NR} = 11.364\ \frac{kgf}{mm^2}$$

$$\sigma_M := \frac{1}{A}\ \frac{Q}{\frac{\sqrt{2}}{2}}\ \sin\left(\psi + \frac{\pi}{4}\right) - \frac{M_q}{A \cdot \rho} - \frac{M_q}{\chi \cdot A \cdot \rho} \cdot \frac{MR}{\rho + MR} = -5.033\ \frac{kgf}{mm^2}$$

Verifica nominale dei becchi e del gambo del gancio

$$\tau_{ND} := \frac{3}{2} \frac{\frac{\frac{Q}{\sqrt{2}}}{2} \cos\left(\psi + \frac{\pi}{4}\right)}{b \cdot \left(\sqrt{\left(\frac{e_1}{2}\right)^2 + h^2} - \frac{d_1}{2}\right)} = 1.079 \ \frac{kgf}{mm^2}$$

$$\tau_{Ir} := \frac{3}{2} \frac{\frac{\frac{Q}{\sqrt{2}}}{2} \cos\left(\psi + \frac{\pi}{4}\right)}{b \cdot I_r} = 1.327 \ \frac{kgf}{mm^2}$$

Verifica nominale dei becchi e del gambo del gancio

Considero un nuovo solido fittizio più cautelativo

$$a_0 := 1 + \tan\left(\frac{-\pi}{4}\right)^2$$

$$q := y_A - \tan\left(\frac{-\pi}{4}\right) x_A$$

$$b_0 := 2 \tan\left(\frac{-\pi}{4}\right) q$$

$$c_0 := q^2 - h^2$$

$$x_1 := \frac{-b_0 + \sqrt[2]{b_0^{\ 2} - 4\ a_0 \cdot c_0}}{2\ a_0} = 272.753\ mm$$

$$x_2 := \frac{-b_0 - \sqrt[2]{b_0^{\ 2} - 4\ a_0 \cdot c_0}}{2\ a_0} = -169.253\ mm$$

$$x_S := x_1$$

$$y_S := \tan\left(\frac{-\pi}{4}\right) \cdot x_1 + q = -169.253\ mm$$

$$h_s := \sqrt[2]{\left(x_S - x_A\right)^2 + \left(y_S - y_A\right)^2} = 312.899\ mm$$

$$NU := h_s - \frac{d_1}{2} = 209.399\ mm$$

$$NV := \frac{NU}{3}\ \frac{a + 2\ b}{a + b} = 88.224\ mm$$

$$UV := NU - NV = 121.175\ mm$$

$$b_x := \left(NV + \frac{d_1}{2}\right) \sin(\psi) + \left(NV + \frac{d_1}{2}\right) \frac{\sqrt{2}}{2} = 231.691\ mm$$

$$b_y := \left(NV + \frac{d_1}{2}\right) \cos(\psi) - \left(NV + \frac{d_1}{2}\right) \frac{\sqrt{2}}{2} = 30.318\ mm$$

$$M_q := Q \cdot b_x + Q \cdot b_y = \left(7.205 \cdot 10^6\right)\ kgf \cdot mm$$

$$A := \frac{(a + b) \cdot NU}{2} = \left(2.063 \cdot 10^4\right)\ mm^2$$

$$\rho := NV + \frac{d_1}{2} = 191.724\ mm$$

Verifica nominale dei becchi e del gambo del gancio

$$\chi := -\frac{1}{A} \int_{-UV}^{NV} \frac{\eta}{\rho+\eta} \left(b + \frac{a-b}{NU} \, (UV+\eta)\right) \mathrm{d}\eta = 0.129$$

$$\sigma_N := \frac{1}{A} \frac{Q}{\frac{\sqrt{2}}{2}} \sin\left(\psi + \frac{\pi}{4}\right) - \frac{M_q}{A \cdot \rho} - \frac{M_q}{\chi \cdot A \cdot \rho} \cdot \frac{-NV}{\rho - NV} = 12.016 \; \frac{kgf}{mm^2}$$

$$\sigma_U := \frac{1}{A} \frac{Q}{\frac{\sqrt{2}}{2}} \sin\left(\psi + \frac{\pi}{4}\right) - \frac{M_q}{A \cdot \rho} - \frac{M_q}{\chi \cdot A \cdot \rho} \cdot \frac{UV}{\rho + UV} = -5.459 \; \frac{kgf}{mm^2}$$

Carico applicato verticalmente, passante per O' con il nuovo solido fittizio per la verifica del gambo

$$\rho := \frac{d_1}{2} + \frac{d}{2} = 186 \; mm$$

$$b_X := \rho \cdot \left(1 + \frac{\sqrt{2}}{2}\right) = 317.522 \; mm$$

$$b_Y := \rho \cdot \frac{\sqrt{2}}{2} = 131.522 \; mm$$

$$M_q := Q \cdot b_X - Q \cdot b_Y = \left(5.115 \cdot 10^6\right) \; kgf \cdot mm$$

$$A := \pi \cdot \frac{d^2}{4} = \left(2.138 \cdot 10^4\right) \; mm^2$$

$$\chi := \frac{1}{4} \cdot \left(\frac{d}{2\,\rho}\right)^2 + \frac{1}{8} \left(\frac{d}{2\,\rho}\right)^4 + \frac{5}{6+4} \cdot \left(\frac{d}{2\,\rho}\right)^6 = 0.058$$

$$\sigma_K := \frac{Q}{A} - \frac{M_q}{A \cdot \rho} + \frac{M_q}{\chi \cdot A \cdot \rho} \cdot \frac{d}{2 \cdot \rho - d} = 17.727 \; \frac{kgf}{mm^2}$$

$$\sigma_W := \frac{Q}{A} - \frac{M_q}{A \cdot \rho} - \frac{M_q}{\chi \cdot A \cdot \rho} \cdot \frac{d}{2 \cdot \rho + d} = -6.833 \; \frac{kgf}{mm^2}$$

Verifica nominale dei becchi e del gambo del gancio

Verifica del gambo del gancio

$$M_q := \rho \cdot Q = \left(5.115 \cdot 10^3\right)\ m \cdot kgf$$

$$P := 16\ mm$$
$$m := 125\ mm$$

$$i := \frac{0.8\ m}{P} = 6.25$$

$$G_g := 1800\ kgf$$

$$G_i := \frac{G_u + G_g}{9.81\ \frac{m}{s^2}}\ a_{max} = 233.53\ kgf$$

$$\left|\frac{G_i}{G_u}\right| \cdot 100 = 0.425$$

$$d_3 := 122.4\ mm$$

$$\sigma := \frac{G_u + G_g + G_i}{\frac{\pi \cdot \left(1.2 \cdot d_3\right)^2}{4}} = 3.366\ \frac{kgf}{mm^2}$$

$$\tau := 1.5 \cdot \frac{G_u + G_i + G_g}{\pi \cdot d_3 \cdot P \cdot i} = 2.225\ \frac{kgf}{mm^2}$$

Verifica a schiacciamento dei filetti

$$d := 140\ mm$$

$$\sigma := \frac{G_u + G_g + G_i}{i \cdot \frac{\pi \cdot \left(d^2 - {d_3}^2\right)}{4}} = 2.516\ \frac{kgf}{mm^2}$$