Calcul des déformations des ressorts hélicoïdaux

Ressort cylindrique - Couple concentré dans l'axe du ressort

Flexion et torsion

Lame en acier de section rectangulaire, h dans le plan vertical, $h > e$

$h := 10 \cdot mm \quad e := 5 \cdot mm \quad S := h \cdot e \quad E := 2 \cdot 10^5 \cdot N \cdot mm^{-2} \quad G := \dfrac{E}{2.6} \quad \rho := 7.85 \cdot 10^3 \cdot kg \cdot m^{-3}$

Référence :E:\Résonateur (TA)\Tables\Modules J, I et W des barres élastiques.mcd(R)

$J_t := J_{t\_rect}(h, e) \qquad I_{22} := I_{f\_rect}(h, e) \qquad I_{33} := I_{f\_rect}(e, h)$

$W_t := W_{t\_rect}(h, e) \qquad W'_t := \dfrac{W_t}{\eta_{t\_rect}(h, e)} \qquad W_{f2} := W_{f\_rect}(h, e) \qquad W_{f3} := W_{f\_rect}(e, h)$

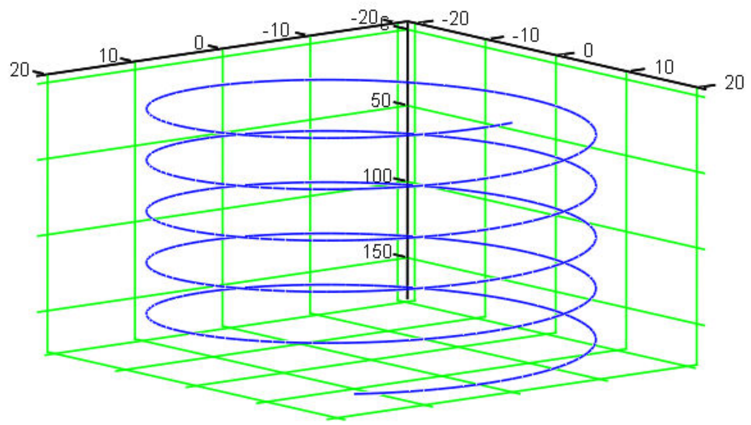
Caractéristiques du ressort $\quad D := 40 \cdot mm \quad R := 0.5 \cdot D \quad n_{sp} := 5.125 \quad \psi_{AB} := 2 \cdot \pi \cdot n_{sp}$

$\beta := 15 \cdot deg \quad p := 2 \cdot \pi \cdot R \cdot tan(\beta) \quad s(\alpha) := R \cdot \alpha \cdot cos(\beta)^{-1} \quad L := s(\psi_{AB}) \quad L = 66.675\, cm$

Forme du ressort

$x_0(\alpha) := R \cdot cos(\alpha) \qquad y_0(\alpha) := R \cdot sin(\alpha) \qquad z_0(\alpha) := R \cdot tan(\beta) \cdot \alpha$

$n := 100 \cdot n_{sp} + 1 \quad i := 0 .. n-1 \quad \alpha_{0_i} := \dfrac{\psi_{AB}}{n-1} \cdot i \quad x_i := x_0(\alpha_{0_i}) \quad y_i := y_0(\alpha_{0_i}) \quad z_i := z_0(\alpha_{0_i})$



$\left(\dfrac{x}{mm}, \dfrac{y}{mm}, \dfrac{z}{mm}\right)$

Forces extérieures selon l'axe du ressort du ressort $\qquad \psi_F := \psi_{AB} \qquad \chi_F := 0$

$P := 0 \cdot N \qquad r_F := z_0(\psi_F) \cdot cos(\chi_F)^{-1} \qquad \lambda_F := 0 \qquad \gamma_F := 0 \cdot deg$

$\mathbf{F} := P \cdot \left(cos(\lambda_F) \cdot sin(\gamma_F) \quad sin(\lambda_F) \cdot sin(\gamma_F) \quad cos(\gamma_F) \right)^T \qquad \mathbf{F}^T = (0 \quad 0 \quad 0)\, N$

$C := 20 \cdot N \cdot m \qquad r_C := z_0(\psi_F) \cdot cos(\chi_F)^{-1} \qquad \lambda_C := 0 \cdot deg \qquad \gamma_C := 0 \cdot deg$

$\mathbf{C} := C \cdot \left(cos(\lambda_C) \cdot sin(\gamma_C) \quad sin(\lambda_C) \cdot sin(\gamma_C) \quad cos(\gamma_C) \right)^T \qquad \mathbf{C}^T = (0 \quad 0 \quad 20)\, m N$

Référence :E:\Résonateur (TA)\Ressorts hélicoïdaux\Ressort hélicoïdal E_L - F&C.mcd(R)

Torseur des forces de cohésion

$\alpha_M := 40 \cdot deg$ $\quad \mathbf{R_c}(\alpha_M)^T = (0 \;\; 0 \;\; 0)\, N$

$\mathbf{M_c}(\alpha_M)^T = (0 \;\; 0 \;\; 20)\, N \cdot m$

Sollicitations

Traction-compression $\quad N_c(\alpha_M) = 0\, N$

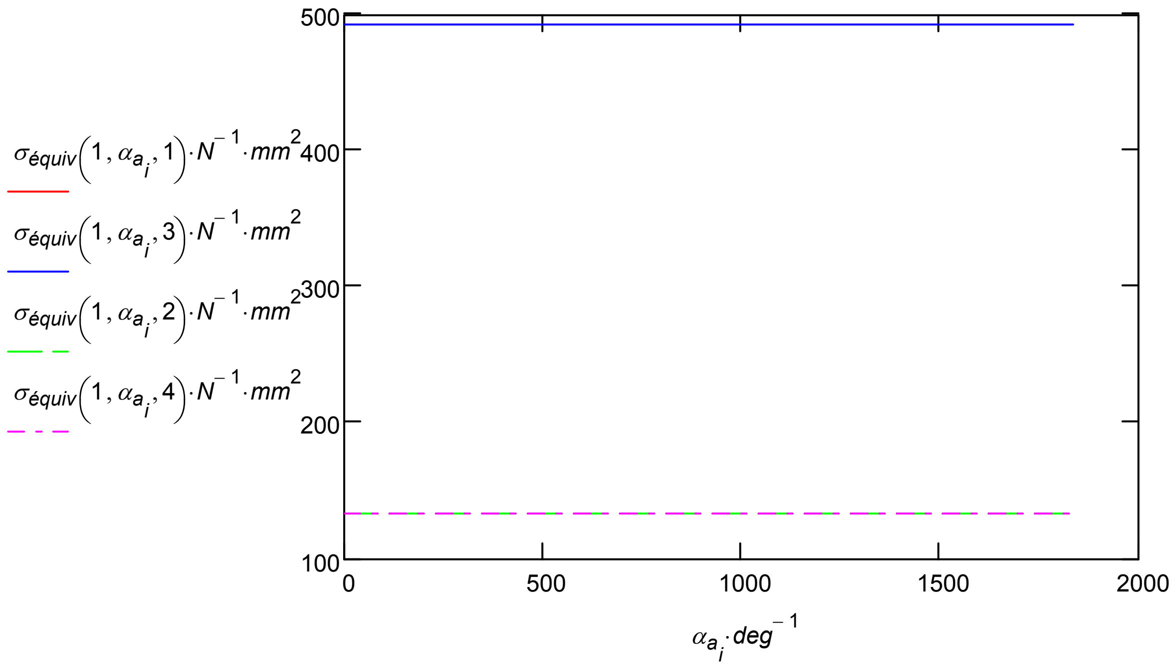
Efforts tranchants $\quad Q_2(\alpha_M) = 0\, N \qquad Q_3(\alpha_M) = 0\, N$

Moment de torsion $\quad M_t(\alpha_M) = 5.176\, N \cdot m$

Moments de flexion $\quad M_{f2}(\alpha_M) = 0\, N \cdot m \qquad M_{f3}(\alpha_M) = 19.319\, N \cdot m$

Contraintes

$n := 201 \qquad i := 1 .. n-1 \qquad \alpha_{a_i} := (i-1) \cdot \frac{\psi_{AB}}{n-1}$



Calcul des déplacements linéiques

Position du déplacement désiré $\qquad \alpha_M := \psi_{AB}$

Déplacement dans la direction de Ox $\quad \lambda := 0 \cdot deg \qquad \gamma := 90 \cdot deg \qquad |\mathbf{v}(\lambda, \gamma)| = 1$

$\delta_{tv}(\alpha_M, \lambda, \gamma) = -0.559\, mm \qquad \delta_{fv2}(\alpha_M, \lambda, \gamma) = 0\, mm \qquad \delta_{fv3}(\alpha_M, \lambda, \gamma) = -8.345\, mm$

$\delta_x(\alpha) := \delta_v(\alpha, \lambda, \gamma) \qquad \boxed{\delta_x(\alpha_M) = -8.904\, mm}$

Déplacement dans la direction de Oy $\quad \lambda := 90 \cdot deg \qquad \gamma := 90 \cdot deg \qquad |\mathbf{v}(\lambda, \gamma)| = 1$

$\delta_{tv}(\alpha_M, \lambda, \gamma) = 1.349\, mm \qquad \delta_{fv2}(\alpha_M, \lambda, \gamma) = 0\, mm \qquad \delta_{fv3}(\alpha_M, \lambda, \gamma) = 7.345\, mm$

$\delta_y(\alpha) := \delta_v(\alpha, \lambda, \gamma) \qquad \boxed{\delta_y(\alpha_M) = 8.694\, mm}$

Déplacement dans la direction de Oz $\lambda := 0 \cdot deg$ $\gamma := 0 \cdot deg$ $|\mathbf{v}(\lambda, \gamma)| = 1$

$\delta_{tv}(\alpha_M, \lambda, \gamma) = 2.962\,mm$ $\delta_{fv2}(\alpha_M, \lambda, \gamma) = 0\,mm$ $\delta_{fv3}(\alpha_M, \lambda, \gamma) = -3.13\,mm$

$\delta_z(\alpha) := \delta_v(\alpha, \lambda, \gamma)$ $\boxed{\delta_z(\alpha_M) = -0.169\,mm}$

Calcul des déplacements angulaires

Déplacement angulaire autour de Ox $\lambda_c := 0 \cdot deg$ $\gamma_c := 90 \cdot deg$ $|\mathbf{cv}(\lambda, \gamma)| = 1$

$\theta_{tcv}(\alpha_M, \lambda_c, \gamma_c) = -0.079\,deg$ $\theta_{fcv2}(\alpha_M, \lambda_c, \gamma_c) = 0\,deg$ $\theta_{fcv3}(\alpha_M, \lambda_c, \gamma_c) = 0.083\,deg$

$\theta_x(\alpha) := \theta_{cv}(\alpha, \lambda_c, \gamma_c)$ $\boxed{\theta_x(\alpha_M) = 4.491 \times 10^{-3}\,deg}$

Déplacement angulaire autour de Oy $\lambda_c := 90 \cdot deg$ $\gamma_c := 90 \cdot deg$ $|\mathbf{cv}(\lambda, \gamma)| = 1$

$\theta_{tcv}(\alpha_M, \lambda_c, \gamma_c) = 0.19\,deg$ $\theta_{fcv2}(\alpha_M, \lambda_c, \gamma_c) = 0\,deg$ $\theta_{fcv3}(\alpha_M, \lambda_c, \gamma_c) = -0.201\,deg$

$\theta_y(\alpha) := \theta_{cv}(\alpha, \lambda_c, \gamma_c)$ $\boxed{\theta_y(\alpha_M) = -0.011\,deg}$

Déplacement angulaire autour de Oz $\lambda_c := 0 \cdot deg$ $\gamma_c := 0 \cdot deg$ $|\mathbf{cv}(\lambda, \gamma)| = 1$

$\theta_{tcv}(\alpha_M, \lambda_c, \gamma_c) = 2.324\,deg$ $\theta_{fcv2}(\alpha_M, \lambda_c, \gamma_c) = 0\,deg$ $\theta_{fcv3}(\alpha_M, \lambda_c, \gamma_c) = 34.217\,deg$

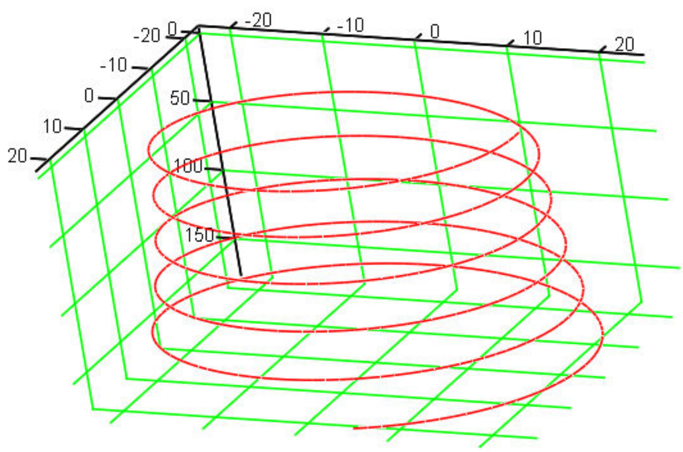
$\theta_z(\alpha) := \theta_{cv}(\alpha, \lambda_c, \gamma_c)$ $\boxed{\theta_z(\alpha_M) = 36.541\,deg}$

Graphe de la déformation

$x_d(\alpha) := x_0(\alpha) + \delta_x(\alpha)$ $y_d(\alpha) := y_0(\alpha) + \delta_y(\alpha)$ $z_d(\alpha) := z_0(\alpha) + \delta_z(\alpha)$

$x'_d(\alpha) := \dfrac{d}{d\alpha} x_d(\alpha)$ $y'_d(\alpha) := \dfrac{d}{d\alpha} y_d(\alpha)$ $z'_d(\alpha) := \dfrac{d}{d\alpha} z_d(\alpha)$

$X := \overrightarrow{x_d(\alpha_0)}$ $Y := \overrightarrow{y_d(\alpha_0)}$ $Z := \overrightarrow{z_d(\alpha_0)}$



$$\left(\frac{X}{mm}, \frac{Y}{mm}, \frac{Z}{mm}\right)$$