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Apêndice

Tabela A1 – Seis equações não lineares relativas ao deslocamento axial, u .

Começo da 1ª Equação

$$\begin{aligned} & \frac{3\pi^5 R C F_2^2}{16L^2} + \frac{5\pi^3 C v \alpha^2 B_1 B_3}{8R} - \frac{3\pi^3 C v \alpha B_1 F_2}{R} - \frac{12\pi^3 C v F_2^2}{R} + \frac{15\pi^3 C v F_1}{8} \\ & - \frac{3\pi^3 C v \alpha^2 B_1^2}{16R} - \frac{25\pi^3 C v \alpha^2 B_2^2}{32R} + \frac{6\pi^4 R C A_1}{L} + \frac{5\pi^3 C v \alpha F_2 B_3}{R} - \frac{5\pi^2 L R \rho h \omega^2 A_1}{4} \\ & - \frac{35\pi^3 C v \alpha^2 B_1 B_4}{128R} + \frac{63\pi^3 C v \alpha^2 B_3 B_4}{256R} - \frac{35\pi^3 C v \alpha F_2 B_4}{16R} = 0 \end{aligned}$$

Fim da 1ª Equação

Começo da 2ª Equação

$$\begin{aligned} & \frac{16\pi^2 L C A_2}{R} + \frac{\pi^4 R C A_2}{2L} - 2\pi^3 C B_1 - \frac{16\pi^2 L C v A_2}{R} + \frac{4\pi^2 L D \alpha^2 A_2}{R^3} + \frac{3\pi^5 R C F_2 F_1}{8L^2} \\ & - \frac{12\pi^3 C F_2 F_1}{R} + \frac{16\pi^3 D \alpha F_2}{R^2} + \frac{3\pi^3 D \alpha^2 B_1}{2R^2} - \frac{\pi^3 C v F_2}{2} - 2\pi^3 C v B_1 \\ & - \frac{35\pi^3 C v \alpha B_4 F_1}{64R} + \frac{3\pi^3 C v \alpha B_1 F_1}{2R} + \frac{5\pi^3 C v \alpha B_3 F_1}{8R} + \frac{21\pi^3 C v \alpha F_2 B_2}{8R} \\ & + \frac{9\pi^3 C v \alpha^2 B_1 B_2}{32R} - \frac{5\pi^3 C v \alpha^2 B_2 B_3}{64R} - \frac{4\pi^2 L D \alpha^2 v A_2}{R^3} + \frac{35\pi^3 C \alpha B_4 F_1}{64R} \\ & - \frac{\pi^2 R L \rho h \omega^2 A_2}{2} - \frac{5\pi^3 C \alpha B_3 F_1}{8R} - \frac{3\pi^3 C \alpha F_2 B_2}{8R} + \frac{12\pi^3 C v F_2 F_1}{R} - \frac{3\pi^3 C B_1 F_1}{2R} \\ & - \frac{3\pi^3 D \alpha^2 v B_1}{2R^2} - \frac{16\pi^3 D \alpha v F_2}{R^2} = 0 \end{aligned}$$

Fim da 2ª Equação

Começo da 3ª Equação

$$\begin{aligned}
 & -\frac{15\pi^2 LD\alpha^2 \nu A_3}{R^3} + \frac{3\pi^5 RCF_2^2}{32L^2} - \frac{35\pi^3 C\nu\alpha B_2 F_1}{4R} - \frac{35\pi^3 C\alpha F_2 B_4}{128R} - \frac{60\pi^2 LC\nu A_3}{R} \\
 & + \frac{3\pi^3 C\nu\alpha B_1 F_2}{4R} + \frac{9\pi^3 D\alpha^2 \nu B_2}{2R^2} - \frac{9\pi^3 D\alpha^2 B_2}{2R^2} + \frac{3\pi^3 C\nu\alpha^2 B_1^2}{32R} + \frac{5\pi^3 C\alpha F_2 B_3}{16R} \\
 & + 6\pi^3 CB_2 - \frac{5\pi^3 C\nu\alpha^2 B_1 B_3}{16R} + \frac{6\pi^3 CF_2^2}{R} + \frac{15\pi^2 LD\alpha^2 A_3}{R^3} + \frac{60\pi^2 LCA_3}{R} \\
 & + \frac{35\pi^3 C\alpha B_2 F_1}{4R} + \frac{35\pi^3 C\nu\alpha^2 B_1 B_4}{256R} - \frac{63\pi^3 C\nu\alpha^2 B_3 B_4}{512R} + \frac{3\pi^3 C\alpha B_1 F_2}{4R} \\
 & + \frac{3\pi^4 RCA_3}{L} - \frac{5\pi^2 RL\rho h\omega^2}{8} + 6\pi^3 C\nu B_2 + \frac{175\pi^3 C\alpha F_2 B_4}{128R} - \frac{45\pi^3 C\nu\alpha F_2 B_3}{16R} = 0
 \end{aligned}$$

Fim da 3ª Equação

Começo da 4ª Equação

$$\begin{aligned}
 & \frac{15\pi^5 RCF_2 F_1}{32L^2} + \frac{15\pi^3 CF_2 F_1}{R} + \frac{10\pi^2 LCA_4}{R} + \frac{5\pi^2 LD\alpha^2 A_4}{2R^3} - \frac{10\pi^2 LC\nu A_4}{R} \\
 & - \frac{15\pi^3 C\nu B_3}{4} - \frac{5\pi^2 LD\alpha^2 \nu A_4}{2R^3} + \frac{45\pi^3 D\alpha^2 B_3}{16R^2} - \frac{63\pi^3 C\alpha B_4 F_1}{64R} + \frac{5\pi^3 C\alpha F_2 B_2}{16R} \\
 & - \frac{15\pi^3 C\nu F_2 F_1}{R} - \frac{45\pi^3 D\alpha^2 \nu B_3}{16R^2} - \frac{9\pi^2 LR\rho h\omega^2 A_4}{16} - \frac{35\pi^3 C\nu\alpha F_2 B_2}{16R} \\
 & - \frac{15\pi^3 C\nu\alpha B_1 F_1}{8R} + \frac{15\pi^3 C\alpha B_1 F_1}{8R} - \frac{15\pi^3 C\nu\alpha^2 B_1 B_2}{64R} + \frac{63\pi^3 C\nu\alpha B_4 F_1}{64R} \\
 & - \frac{15\pi^3 CB_3}{4} + \frac{45\pi^4 RCA_4}{16L} + \frac{105\pi^3 C\nu\alpha^2 B_2 B_3}{256R} - \frac{189\pi^3 C\nu\alpha^2 B_2 B_4}{1024R} = 0
 \end{aligned}$$

Fim da 4ª Equação

Começo da 5ª Equação

$$\begin{aligned}
 & -\frac{315\pi^3 C\nu B_4}{64} - \frac{63\pi^2 LD\alpha^2 \nu A_5}{32R^3} - \frac{63\pi^2 LC\nu A_5}{8R} + \frac{945\pi^3 D\alpha^2 B_4}{256R^2} - \frac{35\pi^3 C\alpha B_1 F_1}{64R} \\
 & + \frac{35\pi^3 C\nu F_2 F_1}{8R} - \frac{945\pi^3 D\alpha^2 \nu B_4}{256R^2} + \frac{35\pi^3 C\nu\alpha B_1 F_1}{64R} + \frac{63\pi^2 C\nu A_5}{8R} \\
 & - \frac{315\pi^3 C\nu\alpha^2 B_2 B_3}{1024R} - \frac{63\pi^3 C\nu\alpha B_3 F_1}{64R} - \frac{175\pi^3 RC F_2 F_1}{256L^2} - \frac{35\pi^3 C F_2 F_1}{8R} \\
 & - \frac{315\pi^3 C B_4}{64} + \frac{63\pi^3 C\alpha B_3 F_1}{64R} + \frac{63\pi^2 LD\alpha^2 A_5}{32R^3} + \frac{1575\pi^4 R C A_5}{256L} \\
 & + \frac{1155\pi^3 C\nu\alpha^2 B_2 B_4}{2048R} - \frac{175\pi^2 RL\rho h\omega^2 A_5}{256} = 0
 \end{aligned}$$

Fim da 5ª Equação

Começo da 6ª Equação

$$\begin{aligned}
 & -\frac{693\pi^3 c\nu\alpha^2 B_1 B_4}{1024R} + \frac{1287\pi^3 C\nu\alpha^2 B_3 B_4}{2048R} - \frac{4725\pi^2 RL\rho h\omega^2 A_6}{2048} \\
 & - \frac{693\pi^3 C\nu\alpha^2 B_3^2}{2048R} + \frac{2079\pi^4 R C A_6}{64L} + \frac{945\pi^5 R C F_1^2}{256L^2} - \frac{693\pi^3 C\nu\alpha F_2 B_4}{128R} = 0
 \end{aligned}$$

Fim da 6ª Equação

Tabela A2 – Quatro equações não lineares relativas ao deslocamento circunferencial, v .

Começo da 1ª Equação

$$\begin{aligned}
 & \frac{54\pi^2 LC\alpha F_2^3}{R^3} + \frac{27\pi^2 LC\alpha^4 B_1^3}{256R^3} + \frac{3\pi^4 CF_2 F_1}{2L} + \frac{3\pi^4 C\alpha F_2^3}{32RL} + \frac{3\pi^3 D\alpha^2 A_2}{2R^2} - 2\pi^3 CvA_2 \\
 & + \frac{32\pi^2 LD\alpha^2 B_1}{R^3} + \frac{256\pi^2 LD\alpha F_2}{R^3} - \frac{\pi^4 RCvB_1}{4L} + \frac{6\pi^4 D\alpha F_2}{RL} + \frac{9\pi^4 D\alpha^2 B_1}{16RL} - 2\pi^3 CA_2 \\
 & + \frac{\pi^4 RCB_1}{4L} + \frac{4\pi^2 LCF_2}{R} + \frac{32\pi^2 LCB_1}{R} - \frac{35\pi^4 Cv\alpha B_4 F_1}{128L} - \frac{9\pi^4 Cv\alpha B_2 F_2}{64L} + \frac{3\pi^3 C\alpha^2 vA_3 B_1}{16R} \\
 & + \frac{5\pi^4 Cv\alpha B_3 F_1}{8L} + \frac{25\pi^4 C\alpha^2 F_1 F_2 B_2}{128RL} - \frac{15\pi^3 C\alpha vA_4 F_1}{8R} + \frac{3\pi^3 C\alpha vA_3 F_2}{4R} \\
 & - \frac{35\pi^3 C\alpha^2 vA_1 B_4}{128R} - \frac{3\pi^3 C\alpha vA_1 F_2}{R} - \frac{3\pi^3 C\alpha^2 vA_1 B_1}{8R} + \frac{35\pi^3 C\alpha vA_5 F_1}{64R} + \frac{9\pi^3 C\alpha^2 vA_2 B_2}{32R} \\
 & + \frac{5\pi^3 C\alpha^2 vA_1 B_3}{8R} - \frac{693\pi^3 C\alpha^2 vA_6 B_4}{1024R} - \frac{567\pi^2 LC\alpha^4 B_1 B_3 B_4}{4096R^3} - \frac{45\pi^2 LC\alpha^3 B_1 B_3 F_2}{32R^3} \\
 & - \frac{567\pi^2 LC\alpha^3 B_3 B_4 F_2}{512R^3} - \frac{5\pi^3 C\alpha^2 vA_3 B_3}{16R} + \frac{35\pi^3 C\alpha^2 vA_3 B_4}{256R} - \frac{15\pi^3 C\alpha^2 vA_4 B_2}{64R} \\
 & + \frac{3\pi^3 C\alpha vA_2 F_1}{2R} - \frac{3\pi^4 Cv\alpha B_1 F_1}{8L} + \frac{189\pi^2 LC\alpha^4 B_2^2 B_4}{4096R^3} + \frac{3\pi^3 C\alpha A_3 F_2}{4R} - \frac{35\pi^3 C\alpha A_5 F_1}{64R} \\
 & + \frac{315\pi^2 LC\alpha^4 B_1 B_3^2}{2048R^3} + \frac{75\pi^2 LC\alpha^3 B_2^2 F_2}{16R^3} + \frac{75\pi^2 LC\alpha^4 B_1 B_2^2}{128R^3} - \frac{45\pi^2 LC\alpha^2 F_2^2 B_3}{8R^3} \\
 & - \frac{525\pi^2 LC\alpha^4 B_2^2 B_3}{2048R^3} - \frac{45\pi^2 LC\alpha^4 B_1^2 B_3}{512R^3} + \frac{2079\pi^2 LC\alpha^4 B_1 B_4^2}{16384R^3} + \frac{2079\pi^2 LC\alpha^3 B_4^2 F_2}{2048R^3} \\
 & + \frac{2079\pi^2 LC\alpha^4 B_3^2 B_4}{32768R^3} + \frac{315\pi^2 LC\alpha^3 B_3^2 F_2}{256R^3} + \frac{81\pi^2 LC\alpha^3 F_2 B_1^2}{32R^3} + \frac{81\pi^2 LC\alpha^2 F_2^2 B_1}{4R^3} \\
 & - \frac{2\pi^4 D\alpha vF_2}{RL} - \frac{9\pi^4 D\alpha^2 vB_1}{16RL} + \frac{9\pi^4 C\alpha B_2 F_2}{64L} + \frac{3\pi^4 C\alpha B_1 F_1}{8L} + \frac{5\pi^4 C\alpha^2 F_2^2 B_3}{512RL} \\
 & + \frac{25\pi^2 LC\alpha^2 F_1 B_3}{128R^2} - \frac{35\pi^2 LC\alpha^2 F_1 B_4}{1024R^2} - \frac{63\pi^4 C\alpha^2 F_1^2 B_4}{256RL} + \frac{35\pi^4 C\alpha B_4 F_1}{128L} - \frac{5\pi^4 C\alpha B_3 F_1}{8L} \\
 & + \frac{15\pi^3 C\alpha A_4 F_1}{8L} - \frac{9\pi^4 CvF_2 F_1}{2L} - \frac{15\pi^2 LC\alpha F_1 F_2}{4R^2} + \frac{35\pi^4 C\alpha F_1^2 F_2}{8RL} + \frac{18\pi^2 LC\alpha F_2 B_2}{R^2} \\
 & - \frac{9\pi^2 LC\alpha^2 F_2 B_2}{32R^2} - \frac{15\pi^2 LC\alpha^2 F_1 B_1}{32R^2} + \frac{3\pi^4 C\alpha^2 F_2^2 B_1}{256RL} + \frac{35\pi^4 C\alpha^2 F_1^2 B_1}{64RL} - \frac{3\pi^3 D\alpha^2 vA_2}{2R^2} \\
 & - \frac{\pi^2 RL\rho h\omega^2 B_1}{2} - \frac{3\pi^3 C\alpha A_2 F_1}{2R}
 \end{aligned}$$

Fim da 1ª Equação

Começo da 8ª Equação

$$\begin{aligned}
 & -\frac{9\pi^3 D\alpha^2 A_3}{2R^2} + 6\pi^3 C\nu A_3 - \frac{9\pi^2 LC\alpha F_2^2}{4R^2} + \frac{288\pi^2 LD\alpha^2 B_2}{R^3} + \frac{27\pi^4 D\alpha^2 B_2}{16RL} \\
 & -\frac{3\pi^4 RC\nu B_2}{4L} + \frac{3675\pi^2 LC\alpha^4 B_2^3}{4096R^3} + \frac{5\pi^4 C\alpha^2 F_2^2 B_2}{128RL} - \frac{3\pi^3 C\alpha A_2 F_2}{8R} \\
 & + \frac{105\pi^3 C\alpha^2 \nu A_4 B_3}{256R} + \frac{1155\pi^3 C\alpha^2 \nu A_5 B_4}{2048R} + \frac{35\pi^4 C\alpha^2 F_1 F_2 B_3}{1024RL} \\
 & -\frac{693\pi^2 LC\alpha^4 B_2 B_3 B_4}{2048R^3} - \frac{5\pi^3 C\alpha^2 \nu A_2 B_3}{64R} - \frac{9\pi^4 C\nu\alpha B_1 F_2}{64L} - \frac{35\pi^3 C\alpha\nu A_4 F_2}{16R} \\
 & + \frac{25\pi^4 C\alpha^2 F_1 F_2 B_1}{128RL} - \frac{189\pi^4 C\alpha^2 F_1 F_2 B_4}{2048RL} + \frac{75\pi^2 LC\alpha^3 B_1 B_2 F_2}{8R^3} - \frac{15\pi^3 C\alpha^2 \nu A_4 B_1}{65R} \\
 & -\frac{189\pi^2 LC\alpha^4 B_1 B_3 B_4}{2048R^3} - \frac{189\pi^3 C\alpha^2 \nu A_4 B_4}{1024R} + \frac{5\pi^4 C\nu\alpha B_3 F_2}{128L} - \frac{25\pi^4 C\nu\alpha B_2 F_1}{16L} \\
 & -\frac{315\pi^3 C\alpha^2 A_5 B_3}{1024R} - \frac{525\pi^2 LC\alpha^4 B_1 B_2 B_3}{1024R^3} + \frac{9\pi^3 C\alpha^2 \nu A_2 B_1}{32R} - \frac{35\pi^3 C\alpha\nu A_3 F_1}{4R} \\
 & + \frac{21\pi^3 C\alpha\nu A_2 F_2}{8R} + \frac{189\pi^2 LC\alpha^3 B_2 B_4 F_2}{256R^3} - \frac{525\pi^2 LC\alpha^3 B_2 B_3 F_2}{128R^3} \\
 & -\frac{25\pi^3 C\alpha^2 \nu A_1 B_2}{16R} - \frac{3\pi^4 C\nu F_2^2}{2L} + \frac{3\pi^4 C F_2^2}{4L} + \frac{3\pi^4 RC B_2}{4L} - \frac{288\pi^2 LC B_2}{R} \\
 & + \frac{144\pi^2 LC F_2^2}{R^2} + 6\pi^3 C A_3 - \frac{3\pi^2 RL\rho h\omega^2 B_2}{2} + \frac{35\pi^3 C\alpha A_3 F_1}{4R} - \frac{5\pi^4 C\alpha B_3 F_2}{128L} \\
 & -\frac{27\pi^4 D\alpha^2 \nu B_2}{16RL} + \frac{5\pi^3 C\alpha A_4 F_2}{16R} + \frac{3861\pi^2 LC\alpha^4 B_2 B_4^2}{16384R^3} + \frac{5\pi^2 LC\alpha^2 F_2 B_3}{64R^2} \\
 & + \frac{567\pi^2 LC\alpha^4 B_2 B_3^2}{2048R^3} - \frac{9\pi^2 LC\alpha^2 F_2 B_1}{32R^2} + \frac{25\pi^4 C\alpha B_2 F_1}{16L} - \frac{175\pi^2 LC\alpha^2 F_1 B_2}{128R^2} \\
 & -\frac{5\pi^2 LC\alpha B_3 F_2}{R^2} + \frac{9\pi^3 D\alpha^2 \nu A_3}{2R^2} + \frac{9\pi^4 C\alpha B_1 F_2}{64L} + \frac{75\pi^2 LC\alpha^4 B_1^2 B_2}{128R^3} \\
 & + \frac{25\pi^4 C\alpha F_1 F_2^2}{16RL} + \frac{75\pi^2 LC\alpha^2 F_2^2 B_2}{2R^3} + \frac{18\pi^2 LC\alpha B_1 F_2}{R^2} + \frac{735\pi^4 C\alpha^2 F_1^2 B_2}{512RL}
 \end{aligned}$$

Fim da 8ª Equação

Começo da 9ª Equação

$$\begin{aligned}
 & -\frac{567\pi^2 LC\alpha^3 B_1 B_4 F_2}{512R^3} - \frac{63\pi^3 C\alpha^2 \nu A_3 B_4}{512R} + \frac{2079\pi^2 LC\alpha^3 B_3 B_4 F_2}{2048R^3} \\
 & -\frac{5\pi^3 C\alpha^2 \nu A_3 B_1}{16R} + \frac{105\pi^3 C\alpha^2 \nu A_4 B_2}{256R} - \frac{45\pi^3 C\alpha \nu A_3 F_2}{16R} - \frac{15\pi^3 C\nu A_4}{4} \\
 & + \frac{63\pi^3 C\alpha^2 \nu A_1 B_4}{256R} - \frac{693\pi^3 C\alpha^2 \nu A_6 B_3}{1024R} + \frac{5\pi^4 C\nu A_1 F_1}{8L} + \frac{5\pi^3 C\alpha \nu A_2 F_1}{8R} \\
 & + \frac{5\pi^3 C\alpha^2 \nu A_1 B_1}{8R} + \frac{5\pi^3 C\alpha \nu A_1 F_2}{R} - \frac{105\pi^2 LC\alpha^2 F_1 B_3}{512R^2} + \frac{57915\pi^2 LC\alpha^4 B_3 B_4^2}{524288R^3} \\
 & -\frac{45\pi^2 LC\alpha^3 F_2 B_1^2}{64R^3} + \frac{25\pi^2 LC\alpha^2 F_1 B_1}{128R^2} + \frac{5\pi^3 C\alpha A_3 F_2}{16R} + \frac{35\pi^4 C\alpha^2 F_2^2 B_3}{2048RL} \\
 & + \frac{315\pi^2 LC\alpha^4 B_1^2 B_3}{2048R^3} - \frac{5\pi^2 LC\alpha F_2 B_2}{R^2} - \frac{5\pi^4 C\alpha B_2 F_2}{128L} + \frac{63\pi^4 C\alpha^2 F_2^2 B_4}{8192RL} \\
 & -\frac{45\pi^2 LC\alpha^2 F_2^2 B_1}{8R^3} - \frac{405\pi^4 D\alpha^2 \nu B_3}{128RL} - \frac{45\pi^3 D\alpha^2 \nu A_4}{16R^2} - \frac{525\pi^2 LC\alpha^4 B_1 B_2^2}{2048R^3} \\
 & + \frac{693\pi^2 LC\alpha^4 B_2^2 B_4}{4096R^3} - \frac{567\pi^2 LC\alpha^4 B_2^2 B_3}{2048R^3} - \frac{525\pi^2 LC\alpha^3 B_2^2 F_2}{256R^3} \\
 & -\frac{9\pi^2 RL\rho h\omega^2 B_3}{16} - \frac{567\pi^2 LC\alpha^4 B_1^2 B_4}{8192R^3} - \frac{567\pi^2 LC\alpha^2 F_2^2 B_4}{128R^3} + \frac{5\pi^2 LC\alpha^2 F_2 B_2}{64R^2} \\
 & + \frac{315\pi^2 LC\alpha^2 F_2^2 B_3}{32R^3} + \frac{63\pi^2 LC\alpha^2 F_1 B_4}{512R^2} - \frac{693\pi^4 C\alpha^2 F_1^2 B_4}{8192RL} + \frac{25\pi^2 LC\alpha F_1 F_2}{16R^2} \\
 & + \frac{5\pi^4 C\alpha^2 F_2^2 B_1}{512RL} + \frac{189\pi^4 C\alpha^2 F_1^2 B_3}{1024RL} - \frac{63\pi^4 C\alpha B_4 F_1}{256L} + \frac{63\pi^3 C\alpha A_5 F_1}{64R} \\
 & -\frac{5\pi^4 C\alpha B_1 F_1}{8L} + \frac{35\pi^4 C\nu F_2 F_1}{8L} - \frac{5\pi^3 C\alpha A_2 F_1}{8R} - \frac{15\pi^3 CA_4}{4} + \frac{20\pi^2 LC B_3}{R} \\
 & + \frac{45\pi^4 RCB_3}{32L} - \frac{15\pi^2 LC\alpha^4 B_1^3}{512R^3} + \frac{5\pi^4 C\alpha F_2^3}{64RL} + \frac{2079\pi^2 LC\alpha^4 A_4}{32768R^3} + \frac{45\pi^3 D\alpha^2 A_4}{16R^2} \\
 & + \frac{405\pi^4 D\alpha^2 B_3}{128RL} - \frac{45\pi^4 RC\nu B_3}{32L} - \frac{15\pi^2 LC\alpha F_2^3}{R^3} + \frac{20\pi^2 LD\alpha^2 B_3}{R^3} - \frac{45\pi^4 CF_2 F_1}{8L} \\
 & + \frac{315\pi^2 LC\alpha^3 B_1 B_3 F_2}{128R^3} - \frac{5\pi^3 C\alpha^2 \nu A_2 B_2}{64R} + \frac{2079\pi^2 LC\alpha^4 B_1 B_3 B_4}{16384R^3} \\
 & + \frac{35\pi^4 C\alpha^2 F_1 F_2 B_2}{1024RL} - \frac{315\pi^3 C\alpha^2 \nu A_5 B_2}{1024R} + \frac{5\pi^4 C\nu A_2 F_2}{128L} + \frac{1287\pi^3 C\alpha^2 \nu A_6 B_4}{2048R} \\
 & + \frac{63\pi^4 C\nu A_4 F_1}{256L} - \frac{63\pi^3 C\alpha \nu A_5 F_1}{64R}
 \end{aligned}$$

Fim da 9ª Equação

Começo da 10ª Equação

$$\begin{aligned}
& \frac{1155\pi^3 C\alpha^2 \nu A_5 B_2}{2048R} + \frac{63\pi^3 C\alpha^2 \nu A_1 B_3}{256R} + \frac{2079\pi^2 LC\alpha^3 B_1 B_4 F_2}{1024R^3} \\
& - \frac{63\pi^2 C\alpha^2 \nu A_3 B_3}{512R} + \frac{63\pi^3 C\alpha \nu A_4 F_1}{64R} - \frac{35\pi^4 C\nu \alpha B_1 F_1}{128L} - \frac{189\pi^4 C\alpha^2 F_1 F_2 B_2}{2048LR} \\
& + \frac{63\pi^4 C\nu \alpha B_3 F_1}{256L} - \frac{567\pi^2 LC\alpha^3 B_1 B_3 F_2}{512R^3} + \frac{1575\pi^4 RC B_4}{512L} + \frac{63\pi^2 LC B_4}{4R} \\
& - \frac{315\pi^3 C A_5}{64} - \frac{63\pi^3 C\alpha^2 F_1^2 B_1}{256LR} - \frac{63\pi^4 C\alpha F_1^2 F_2}{32LR} - \frac{105\pi^4 C\nu F_2 F_1}{64L} \\
& + \frac{35\pi^4 C\alpha B_1 F_1}{128L} - \frac{14175\pi^4 D\alpha^2 \nu B_4}{2048LR} + \frac{2079\pi^2 LC\alpha^4 B_1 B_3^2}{32768R^3} + \frac{63\pi^2 LC\alpha^2 F_1 B_3}{512R^2} \\
& + \frac{189\pi^2 LC\alpha^3 B_2^2 F_2}{512R^3} - \frac{693\pi^4 C\alpha^2 F_1^2 B_3}{8192LR} - \frac{2079\pi^2 LC\alpha^3 B_3^2 F_2}{4096R^3} \\
& - \frac{567\pi^2 LC\alpha^2 F_2^2 B_3}{128R^3} + \frac{189\pi^2 LC\alpha^4 B_1 B_2^2}{4096R^3} + \frac{63\pi^4 C\alpha^2 F_2^2 B_3}{8192R} + \frac{175\pi^3 C\alpha \nu A_3 F_2}{128R} \\
& - \frac{35\pi^3 C\alpha \nu A_2 F_1}{64R} - \frac{35\pi^3 C\alpha^2 \nu A_1 B_1}{128R} - \frac{35\pi^3 C\alpha \nu A_1 F_2}{16R} - \frac{189\pi^3 C\alpha^2 \nu A_4 B_2}{1024R} \\
& + \frac{35\pi^3 C\alpha^2 \nu A_3 B_1}{256R} + \frac{1287\pi^3 C\alpha^2 \nu A_6 B_3}{2048R} - \frac{693\pi^3 C\alpha^2 \nu A_6 B_1}{1024R} - \frac{693\pi^3 C\alpha \nu A_6 F_2}{128R} \\
& - \frac{945\pi^3 D\alpha^2 \nu A_5}{256R^2} - \frac{63\pi^3 C\alpha A_4 F_1}{64R} - \frac{63\pi^4 C\alpha B_3 F_1}{256L} + \frac{231\pi^4 C\alpha^2 F_2^2 B_4}{16384LR} \\
& - \frac{693\pi^2 LC\alpha^2 F_1 B_4}{4096R^2} - \frac{35\pi^2 LC\alpha^2 F_1 B_1}{1024R^2} + \frac{2145\pi^4 C\alpha^2 F_1^2 B_4}{8192LR} - \frac{567\pi^2 LC\alpha^4 B_1^2 B_3}{8192R^3} \\
& - \frac{2079\pi^2 LC\alpha^4 B_1^2 B_4}{16384R^3} - \frac{35\pi^2 LC\alpha F_1 F_2}{128R^2} + \frac{63\pi^2 LD\alpha^2 B_4}{4R^3} + \frac{175\pi^4 C F_2 F_1}{64L} \\
& - \frac{1575\pi^4 RC \nu B_4}{512L} + \frac{14175\pi^4 D\alpha^2 B_4}{2048LR} + \frac{945\pi^3 D\alpha^2 A_5}{256R^2} \\
& - \frac{315\pi^3 C \nu A_5}{64} - \frac{415701\pi^2 LC\alpha^4 B_4^3}{8388608R^3}
\end{aligned}$$

Fim da 10ª Equação

Tabela A3 – Duas equações não lineares relativas ao deslocamento radial, w .

Começo da 11ª Equação

$$\begin{aligned}
 & \frac{24\pi^6 R D F_1}{L^3} + \frac{105\pi^2 L C F_1}{64R} - \frac{315\pi^4 C \nu F_1^2}{64L} - \frac{27\pi^4 C \nu F_2^2}{64L} - \frac{15\pi^2 L C F_2^2}{R^2} \\
 & - \frac{45\pi^4 C F_2 B_3}{8L} + \frac{3C\pi^4 F_2 B_1}{2L} + \frac{3465C\pi^6 R F_1^3}{512L^3} + \frac{25C\pi^4 \alpha B_2^2}{32L} - \frac{35C\pi^3 F_2 A_5}{8R} \\
 & + \frac{15\pi^3 C F_2 A_4}{R} - \frac{12\pi^3 C F_2 A_2}{R} + \frac{3\pi^4 C \alpha B_1^2}{16L} + \frac{63\pi^2 L C \alpha^2 B_3 B_4}{512R^2} \\
 & - \frac{35\pi^2 R L \rho h \omega^2 F_1}{16} - \frac{35C\pi^3 \alpha A_5 B_1}{64R} - \frac{25C\pi^4 \nu \alpha B_2^2}{32L} + \frac{35C\pi^3 \alpha A_3 B_2}{4R} \\
 & + \frac{35C\pi^4 \nu F_2 B_3}{8L} - \frac{3C\pi^4 \nu \alpha B_1^2}{16L} - \frac{105\pi^4 \nu C F_2 B_4}{64L} - \frac{9\pi^4 C \nu F_2 B_1}{2L} - \frac{63\pi^4 C \alpha B_3 B_4}{256L} \\
 & - \frac{5C\pi^4 \alpha B_1 B_3}{8L} + \frac{35C\pi^4 \alpha B_1 B_4}{128L} + \frac{189C\pi^4 \alpha^2 B_3^2 F_1}{1024LR} - \frac{63C\pi^4 F_2 F_1 B_4}{16LR} \\
 & + \frac{35C\pi^4 \alpha^2 B_1^2 F_1}{8L} + \frac{35\pi^4 C F_2 F_1 B_1}{128L} + \frac{25\pi^4 C F_2^2 B_2}{1024LR} - \frac{175\pi^5 C R F_2 A_5}{16LR} \\
 & + \frac{64LR}{45C\pi^6 R F_2^2 F_1} + \frac{4LR}{35C\pi^4 F_2^2 F_1} + \frac{16LR}{945C\pi^5 R F_1 A_6} - \frac{256L^2}{15C\pi^5 R F_2 A_4} \\
 & + \frac{64L^3}{3C\pi^5 R F_2 A_2} + \frac{12C\pi^3 \nu F_2 A_2}{LR} - \frac{63\pi^3 C \alpha A_4 B_4}{128L^2} - \frac{15\pi^3 C \nu F_2 A_4}{32L^2} + \frac{35\pi^3 C \nu F_2 A_5}{8R} \\
 & + \frac{8L^2}{35C\pi^3 \alpha A_2 B_4} - \frac{R}{5C\pi^3 \alpha A_2 B_3} - \frac{64R}{3C\pi^3 \alpha A_2 B_1} + \frac{R}{15C\pi^3 \alpha A_4 B_1} + \frac{8R}{63C\pi^3 \alpha A_5 B_3} \\
 & + \frac{64R}{5C\pi^4 \nu \alpha B_1 B_3} + \frac{8R}{63\pi^3 C \nu \alpha A_4 B_4} - \frac{2R}{15\pi^3 C \nu \alpha A_4 B_1} - \frac{8R}{35C\pi^3 \alpha A_2 B_4} \\
 & + \frac{8L}{3C\pi^3 \nu \alpha A_2 B_1} + \frac{64R}{5C\pi^3 \nu \alpha A_2 B_3} - \frac{8R}{63C\pi^3 \nu \alpha A_5 B_3} - \frac{64R}{35C\pi^4 \nu \alpha B_1 B_4} \\
 & + \frac{2R}{35\pi^3 C \nu \alpha A_5 B_1} - \frac{8R}{35\pi^3 C \nu \alpha A_3 B_2} - \frac{64R}{735C\pi^4 \alpha^2 B_2^2 F_1} - \frac{128L}{2145C\pi^4 \alpha^2 B_4^2 F_1} \\
 & + \frac{64R}{25C\pi^2 L \alpha^2 B_1 B_3} - \frac{4R}{15C\pi^2 L \alpha F_2 B_1} - \frac{512R}{35C\pi^2 L \alpha F_2 B_4} + \frac{8192LR}{35\pi^2 L C \alpha^2 B_1 B_4} \\
 & + \frac{128R^2}{25\pi^2 L C \alpha F_2 B_3} + \frac{4R^2}{175C\pi^4 F_2 B_4} - \frac{128R^2}{693C\pi^2 \alpha^2 B_4^2} - \frac{1024R^2}{15CL\pi^2 \alpha^2 B_2^2} \\
 & - \frac{16R^2}{105C\pi^2 L \alpha^2 B_3^2} - \frac{64L}{175C\pi^2 L \alpha^2 B_2^2} + \frac{8192R^2}{35C\pi^4 \alpha^2 B_2 B_3 F_2} + \frac{64R^2}{25\pi^4 C \alpha^2 B_1 F_2 B_2} \\
 & - \frac{1024R^2}{189\pi^4 C \alpha^2 B_2 B_4 F_2} - \frac{256R^2}{693C\pi^4 \alpha^2 B_3 B_4 F_2} - \frac{1024LR}{63C\pi^4 \alpha^2 B_1 F_1 B_4} + \frac{128LR}{63C\pi^4 \nu \alpha B_3 B_4} \\
 & + \frac{2048LR}{15C\pi^3 \nu A_1} - \frac{3\pi^2 R L P_H}{2} - \frac{4096LR}{3\pi^2 R L p} \\
 & + \frac{15C\pi^3 \nu A_1}{8} - \frac{3\pi^2 R L P_H}{2} - \frac{3\pi^2 R L p}{2}
 \end{aligned}$$

Fim da 11ª Equação

Começo da 12ª Equação

$$\begin{aligned}
 & - \frac{525\pi^2 LC\alpha^3 B_2^2 B_3}{256R^3} - \frac{45\pi^2 LC\alpha^3 B_1^2 B_3}{64R^3} - \frac{\pi^2 LR\rho h\omega^2 F_2}{2} + \frac{35\pi^4 C\alpha F_1^2 B_1}{8LR} \\
 & - \frac{45\pi^2 LC\alpha^2 F_2 B_1 B_3}{4R^3} - \frac{567\pi^2 LC\alpha^2 B_1 B_3 B_4}{512R^3} - \frac{567\pi^2 LC F_2 B_3 B_4}{64R^3} + \frac{5\pi^3 C\nu\alpha A_1 B_3}{R} \\
 & + \frac{25\pi^4 C\alpha^2 B_1 B_2 F_1}{128LR} - \frac{693\pi^3 C\nu\alpha A_6 B_4}{128R} - \frac{9\pi^4 C\nu\alpha B_1 B_2}{64L} - \frac{189\pi^4 C\alpha^2 B_2 B_4 F_1}{2048LR} \\
 & - \frac{3\pi^3 C\alpha A_1 B_1}{R} + \frac{5\pi^4 C\nu\alpha B_2 B_3}{128L} + \frac{5\pi^4 C\alpha^2 B_1 B_3 F_2}{256LR} - \frac{35\pi^3 C\nu\alpha A_1 B_4}{16R} + \frac{175\pi^3 C\nu\alpha A_3 B_4}{128R} \\
 & + \frac{3\pi^3 C\nu\alpha A_3 B_1}{35\pi^3 C\nu\alpha A_4 B_2} + \frac{21\pi^3 C\nu\alpha A_2 B_2}{45\pi^3 C\nu\alpha A_3 B_3} \\
 & + \frac{4R}{25\pi^4 C\alpha F_1 F_2 B_2} + \frac{16R}{63\pi^4 C\alpha^2 B_3 B_4 F_2} + \frac{8R}{35\pi^4 C\alpha^2 B_2 B_3 F_1} + \frac{16R}{75\pi^2 LC\alpha^3 B_1 B_2^2} \\
 & + \frac{16LR}{81\pi^2 LC\alpha^2 F_2 B_1^2} + \frac{4096LR}{162\pi^2 LC\alpha F_2^2 B_1} + \frac{1024LR}{189\pi^2 LC\alpha^3 B_2^2 B_4} + \frac{16R^3}{315\pi^2 LC\alpha^2 F_2 B_3^2} \\
 & + \frac{4R^3}{2079\pi^2 LC\alpha^3 B_3^2 B_4} + \frac{R^3}{35\pi^3 C\nu F_1 A_5} + \frac{512R^3}{9\pi^4 C\alpha B_1 B_2} - \frac{9\pi^4 C\nu F_1 B_1}{63\pi^4 C\alpha F_1^2 B_4} \\
 & + \frac{4096R^3}{75\pi^2 LC\alpha^2 F_2 B_2^2} - \frac{8R}{24\pi^3 C\nu F_2 A_1} + \frac{64L}{2079\pi^2 LC\alpha^3 B_1 B_4^2} + \frac{2L}{35\pi^4 C\alpha^2 B_3^2 F_2} \\
 & + \frac{2R^3}{25\pi^2 LC\alpha F_1 B_3} - \frac{R}{5\pi^2 LC\alpha B_2 B_3} - \frac{4R^2}{15\pi^2 LC\alpha F_1 B_1} - \frac{2R^2}{9\pi^2 LC\alpha F_2 B_2} - \frac{128R^2}{35\pi^2 LC\alpha F_1 B_4} \\
 & + \frac{16R^2}{3\pi^4 C\alpha F_2^2 B_1} + \frac{R^2}{5\pi^2 LC\alpha^2 B_2 B_3} - \frac{4R^2}{16\pi^3 D\nu\alpha A_2} + \frac{2R^2}{5\pi^4 C\alpha^2 B_2^2 F_2} - \frac{128R^2}{105\pi^4 C\nu F_1 B_4} \\
 & + \frac{32LR}{5\pi^4 C\alpha F_2^2 B_3} - \frac{64R^2}{3\pi^3 C\alpha A_2 B_2} + \frac{R^2}{12\pi^3 C\nu F_1 A_2} - \frac{128LR}{5\pi^4 C\alpha B_2 B_3} + \frac{64L}{5\pi^3 C\alpha A_3 B_3} \\
 & + \frac{64LR}{2\pi^4 D\nu\alpha B_1} - \frac{8R}{3\pi^4 C\nu F_2 B_2} - \frac{R}{35\pi^3 C\alpha A_3 B_4} - \frac{128L}{15\pi^3 C\nu F_1 A_4} + \frac{16R}{25\pi^4 C F_2 B_2 F_1} \\
 & + \frac{LR}{231\pi^4 C\alpha^2 B_4^2 F_2} + \frac{L}{3\pi^4 C\alpha^2 B_1^2 F_2} + \frac{128R}{315\pi^2 LC\alpha^3 B_3^2 B_1} - \frac{R}{30\pi^2 LC F_2 F_1} + \frac{16LR}{16384LR} \\
 & + \frac{288\pi^2 LC F_2 B_2}{45\pi^6 RCF_1^2 F_2} + \frac{256LR}{6\pi^4 D\alpha B_1} + \frac{256\pi^2 LD\alpha B_1}{256R^3} - \frac{R^2}{12\pi^3 CF_2 A_3} \\
 & + \frac{R^2}{15\pi^3 CF_1 A_4} - \frac{64L^3}{45\pi^4 CF_1 B_3} - \frac{LR}{35\pi^3 CF_1 A_5} + \frac{R^3}{5\pi^4 CF_2^2 B_3} + \frac{R}{3\pi^3 RCF_1 A_2} \\
 & + \frac{R}{3\pi^4 CF_2^2 B_1} + \frac{8L}{15\pi^5 RCF_1 A_4} + \frac{8R}{3\pi^4 CF_1 B_1} + \frac{32LR}{3\pi^4 CF_2 B_2} + \frac{8L^2}{12\pi^3 CF_1 A_2} \\
 & - \frac{16LR}{175\pi^5 RCF_1 A_5} + \frac{32L^2}{3\pi^5 RCF_2 A_3} + \frac{2L}{3\pi^5 RCF_2 A_1} + \frac{2L}{35\pi^4 CF_2 F_1^2} + \frac{R}{175\pi^4 CF_1 B_4} \\
 & + \frac{256L^2}{16\pi^3 D\alpha A_2} - \frac{16L^2}{\pi^3 C\nu A_2} + \frac{8L^2}{27\pi^2 LC\alpha^3 B_1^3} + \frac{LR}{4\pi^2 LC B_1} + \frac{LR}{\pi^2 LC F_2} + \frac{64L}{3\pi^4 CF_2^3} \\
 & + \frac{R^2}{27\pi^6 RCF_2^3} + \frac{2}{2048\pi^2 LDF_2} + \frac{32R^3}{432\pi^2 LC F_2^2} + \frac{R}{\pi^6 RDF_2} + \frac{2R}{64\pi^4 DF_2} \\
 & + \frac{27\pi^6 RCF_2^3}{256L^3} + \frac{2048\pi^2 LDF_2}{R^3} + \frac{432\pi^2 LC F_2^2}{R^3} + \frac{\pi^6 RDF_2}{2L^3} + \frac{64\pi^4 DF_2}{LR}
 \end{aligned}$$

Fim da 12ª Equação