OTBT

1. **Nonlinear Mathematical Model**

$$
\begin{aligned}
\dot{x}_1 &= -\frac{1}{c_0}x_1 + \frac{e^{-\tau s}}{c_0}u_1 \\
\dot{x}_2 &= \left(\frac{h_{fw} - d_{11}}{c_{11}}\right)(u_2 - u_4 - u_5) + \left(\frac{d_{11} - d_5}{c_{11}}\right) f_1(x_2 - g(x_2), h_5)u_3 + k_{11}\frac{x_1}{c_{11}} \\
\dot{x}_3 &= \left(\frac{h_{fw} - d_{12}}{c_{12}}\right)(u_2 - u_4 - u_5) + \left(\frac{d_{12} - d_5}{c_{12}}\right) f_1(x_2 - g(x_2), h_5)u_3 + k_{11}\frac{x_1}{c_{12}} \\
\dot{x}_4 &= \frac{D_3(h_4 - x_4)}{c_2} + k_{12}\frac{x_1}{c_2} \\
\dot{x}_5 &= \left(\frac{h_2 - d_{21}}{c_{31}}\right) D_2 + \left(\frac{d_{31} - x_6}{c_{31}}\right) f_2(x_5, x_6)u_3 + k_{13}\frac{x_1}{c_{31}} \\
\dot{x}_6 &= \left(\frac{h_2 - d_{22}}{c_{32}}\right) D_2 + \left(\frac{d_{32} - x_6}{c_{32}}\right) f_2(x_5, x_6)u_3 + k_{13}\frac{x_1}{c_{32}} \\
\dot{x}_7 &= -\frac{x_7}{c_4} + \frac{k_2(x_6 - h_{fw})f_2(x_5, x_6)u_3}{c_4} \\
y_1 &= x_5 \\
y_2 &= x_3 \\
y_3 &= x_7 \\
y_4 &= T_1(x_2, x_4) \\
y_5 &= T_2(x_5, x_6)
\end{aligned}
$$

where

$$
\begin{aligned}
h_5 &= lx_3 \\
p_5 &= x_2 - g_1(x_2) \\
p_3 &= x_2 - g_2(x_2) \\
D_5 &= f_1(p_5, h_5)u_3 \\
D_4 &= D_5 + u_4; \\
D_3 &= D_4 \\
D_2 &= D_3 + u_5; \\
h_2 &= \frac{D_3 h_3 + u_5 h_{sw2}}{D_2} \\
h_4 &= \frac{D_5 h_5 + u_4 h_{sw1}}{D_4}
\end{aligned}
$$

2. **Inputs, States & Outputs**

- *Inputs*

$$U = [u_1, u_2, u_3, u_4, u_5]^T = [u_B, D_{fw}, u_t, D_{sw1}, D_{sw2}]^T$$

- *States*

$$X = [x_1, x_2, x_3, x_4, x_5, x_6, x_7]^T = [r_B, p_m, h_m, h_3, p_{st}, h_{st}, N_e]^T$$

- *Outputs*

$$Y = [y_1, y_2, y_3, y_4, y_5]^T = [p_{st}, h_m, N_e, T_3, T_{st}]^T$$

3. **Parameters & Functions**

- *Static Parameters*

$$
\begin{aligned}
l &= -0.000016739 r_B^2 + 0.00294744 r_B + 0.973044 \\
k_{11} &= -0.10233 r_B^2 - 30.144 r_B + 16277 \\
k_{12} &= 0.07672 r_B^2 - 12.66 r_B + 2225.945 \\
k_{13} &= -0.2143 r_B^2 + 43.31 r_B - 338.57 \\
k_2 &= -1.5422 * 10^{-5} r_B^2 + 4.093 * 10^{-3} r_B + 0.33177
\end{aligned}
$$

- *Dynamic Parameters*

Parameter	Value
τ	12
c_0	152
c_{11}	110475
c_{12}	197128
c_2	89912
c_{31}	2667932
c_{32}	44805
c_4	10
d_{11}	103
d_{12}	2004
d_{21}	236
d_{22}	3001

- *Functions*

$$
\begin{aligned}
g_1(p_m) &= 0.01784 p_m^2 - 0.8 p_m + 10.0919 \\
g_2(p_m) &= -0.04112 p_m^2 + 1.867 p_m - 15.018 \\
f_1(p_{st}, h_{st}) &= \frac{91611 p_{st}}{0.76 h_{st} - 592.95} \\
f_2(p_5, h_5) &= \frac{889857 p_5}{6.29 h_5 + 2862.86} \\
h_{fw}(r_B) &= 471.67 r_B^{0.215} \\
h_{sw1}(r_B) &= 522.57 r_B^{0.193} \\
h_{sw2}(r_B) &= 522.57 r_B^{0.193} \\
T_1(p_5, h_5) &= \kappa_1 p_5^2 + \beta_1 p_5 + \gamma_1 \\
T_2(p_{st}, h_{st}) &= \kappa_2 p_{st}^2 + \beta_2 p_{st} + \gamma_2
\end{aligned}
$$

where

$$
\begin{aligned}
\kappa_1(h_5) &= -1.292 * 10^{-7} h_5^2 + 0.0009804 h_5 - 1.878 \\
\beta_1(h_5) &= 6.5093 * 10^{-6} h_5^2 - 0.0524 h_5 + 108.138 \\
\gamma_1(h_5) &= 1.8054 * 10^{-5} h_5^2 + 0.335 h_5 - 887.064 \\
\kappa_2(h_{st}) &= -1.15034 * 10^{-7} h_{st}^2 + 0.0008784 h_{st} - 1.6941 \\
\beta_2(h_{st}) &= 6.31422 * 10^{-6} h_{st}^2 - 0.0509 h_{st} + 105.32 \\
\gamma_2(h_{st}) &= 3.9667 * 10^{-6} h_{st}^2 + 0.4311 h_{st} - 1050.743
\end{aligned}
$$

4. **Steady States**

u_B [kgs^{-1}]	D_{fw} [kgs^{-1}]	u_t [%]	D_{sw1} [kgs^{-1}]	D_{sw2} [kgs^{-1}]
u_1	u_2	u_3	u_4	u_5
56.5	401.9	68.41	1.546	0.165

r_B [kgs^{-1}]	p_m [MPa]	h_m [kJkg^{-1}]	h_3 [kJkg^{-1}]	p_{st} [MPa]	h_{st} [kJkg^{-1}]	N_e [MW]
x_1	x_2	x_3	x_4	x_5	x_6	x_7
56.5	15.6	2834.7	3293.5	13.1	3486.5	496.5