



II WORKSHOP DE **ENERGIAS** OCEÂNICAS E FLUVIAIS

Modelagem CFD de um conversor de energia de onda

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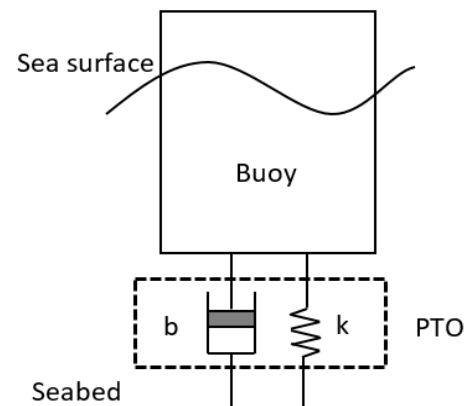
Resumo

1. Motivação
2. Dinâmica dos fluidos computacional
3. Modelamento não linear
4. Protótipo

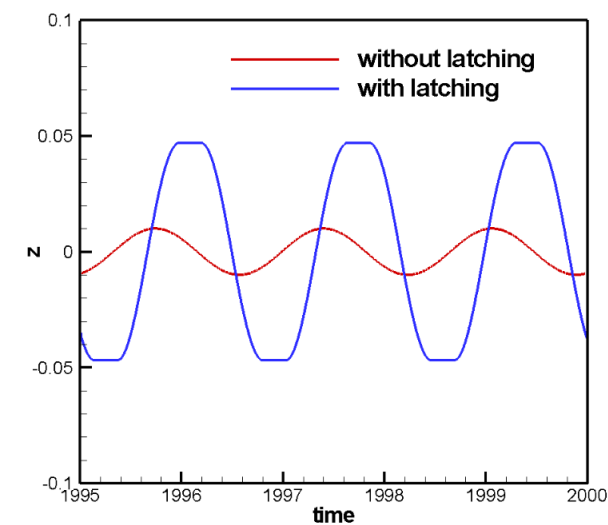
Motivação

Point absorber WEC

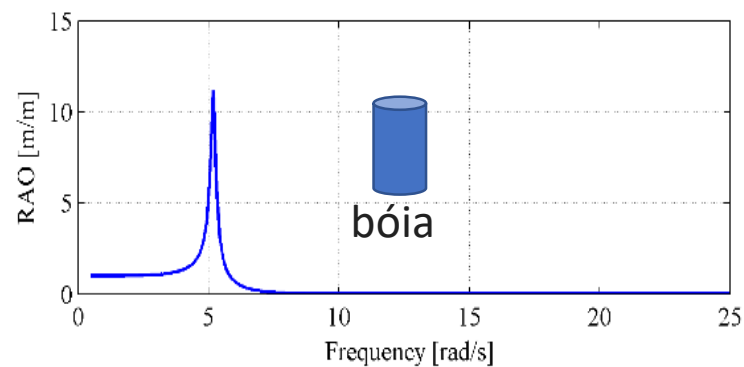
Período natural < Período da onda



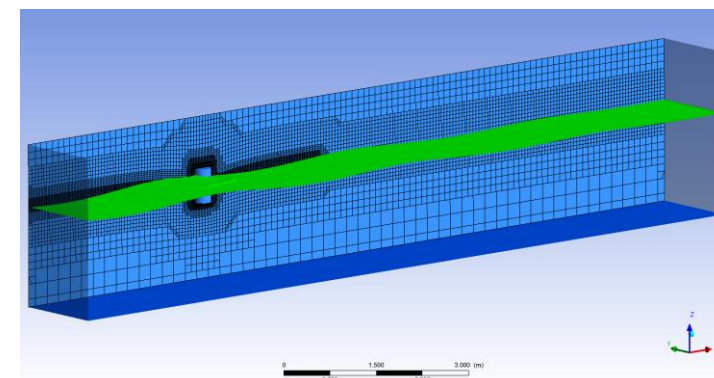
Sistema de controle
Latching



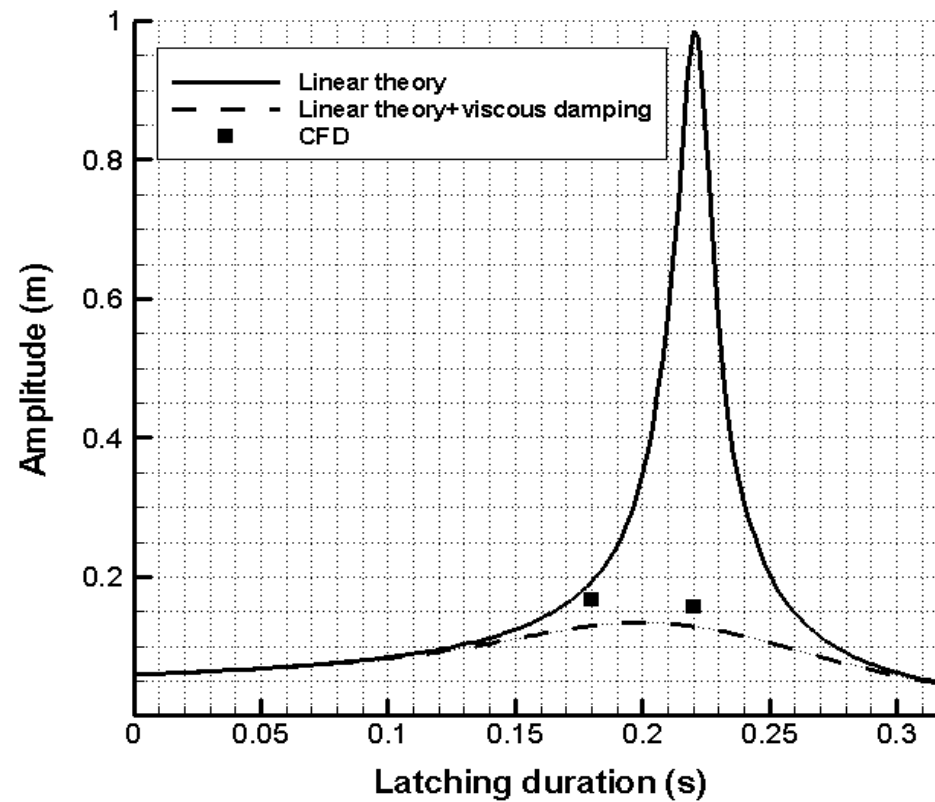
Teoria linear



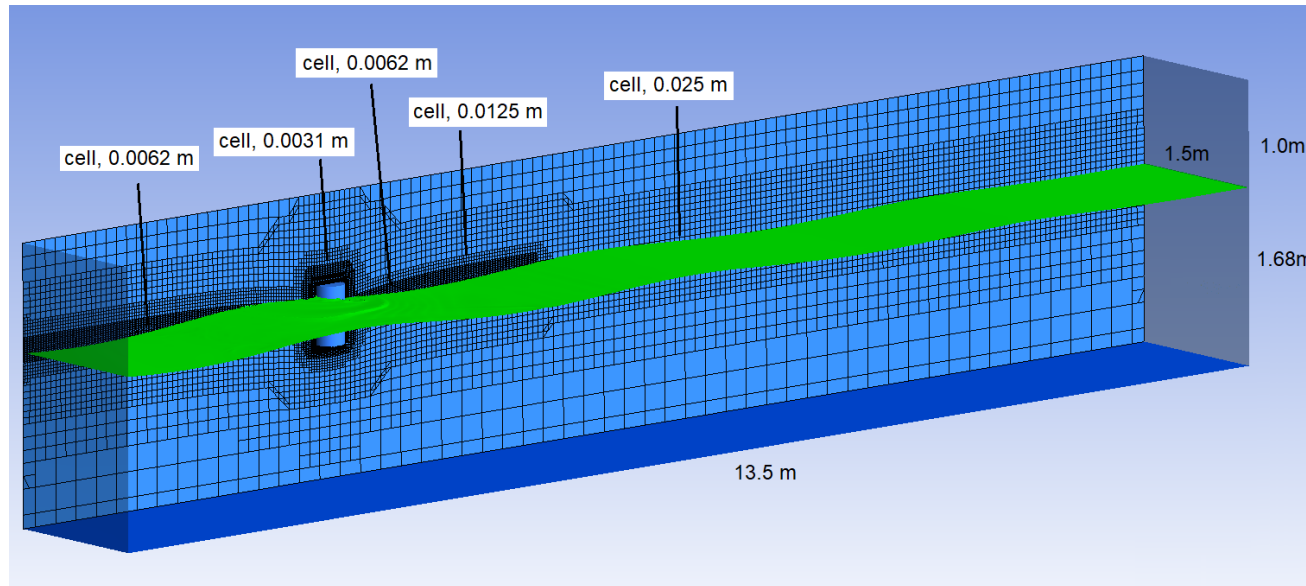
Dinâmica dos fluidos
computacional



Motivação



Dinâmica dos fluidos computacional



Onda regular
 $T_w = 1.66 \text{ s}$, $H_w = 0.08 \text{ m}$

User defined Functions UDF/ Fluent

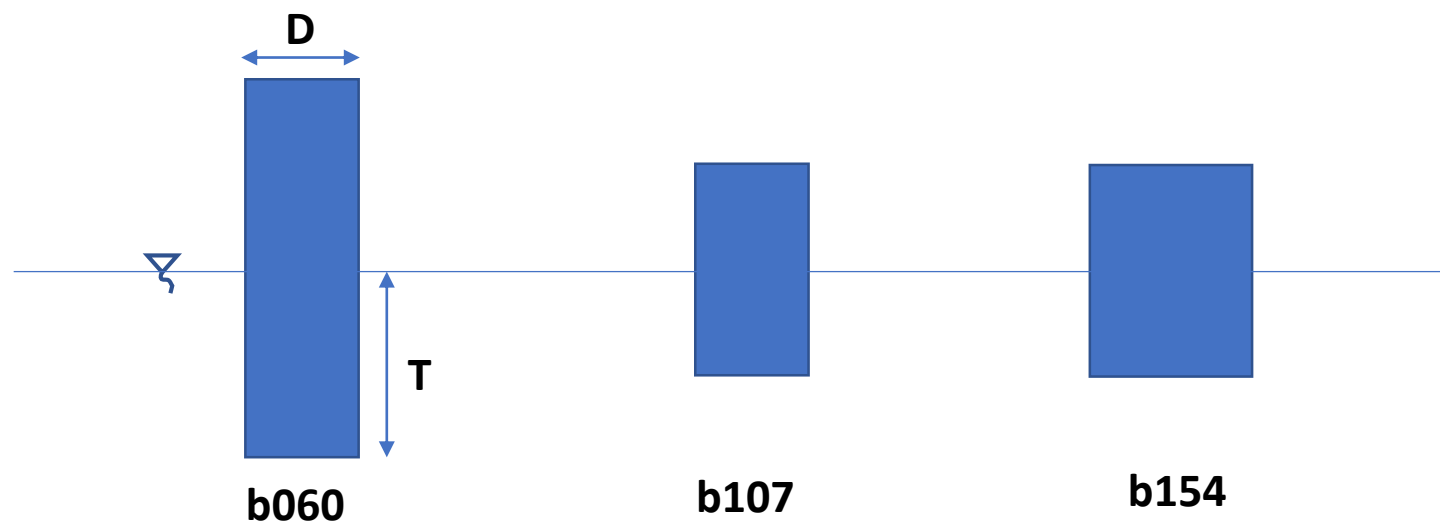
- Sistema de controle latching.

$$F_c = \frac{m(0 - v_o)}{\Delta t} - (F_H + F_W)$$

- Força do PTO (power take-off).

$$F_p = -b_{PTO}\dot{z}$$

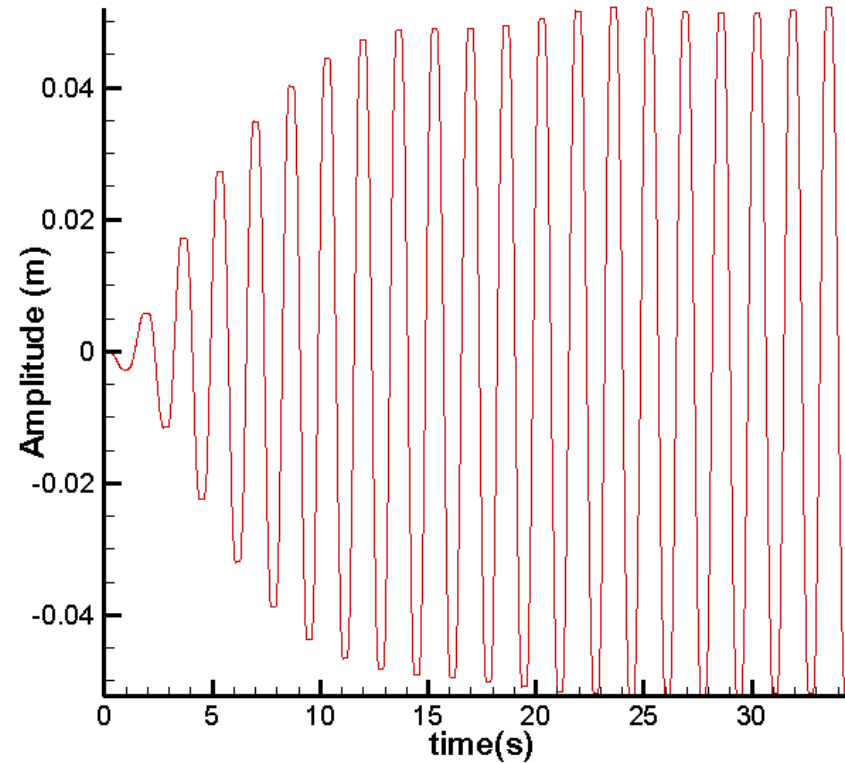
Dinâmica dos fluidos computacional



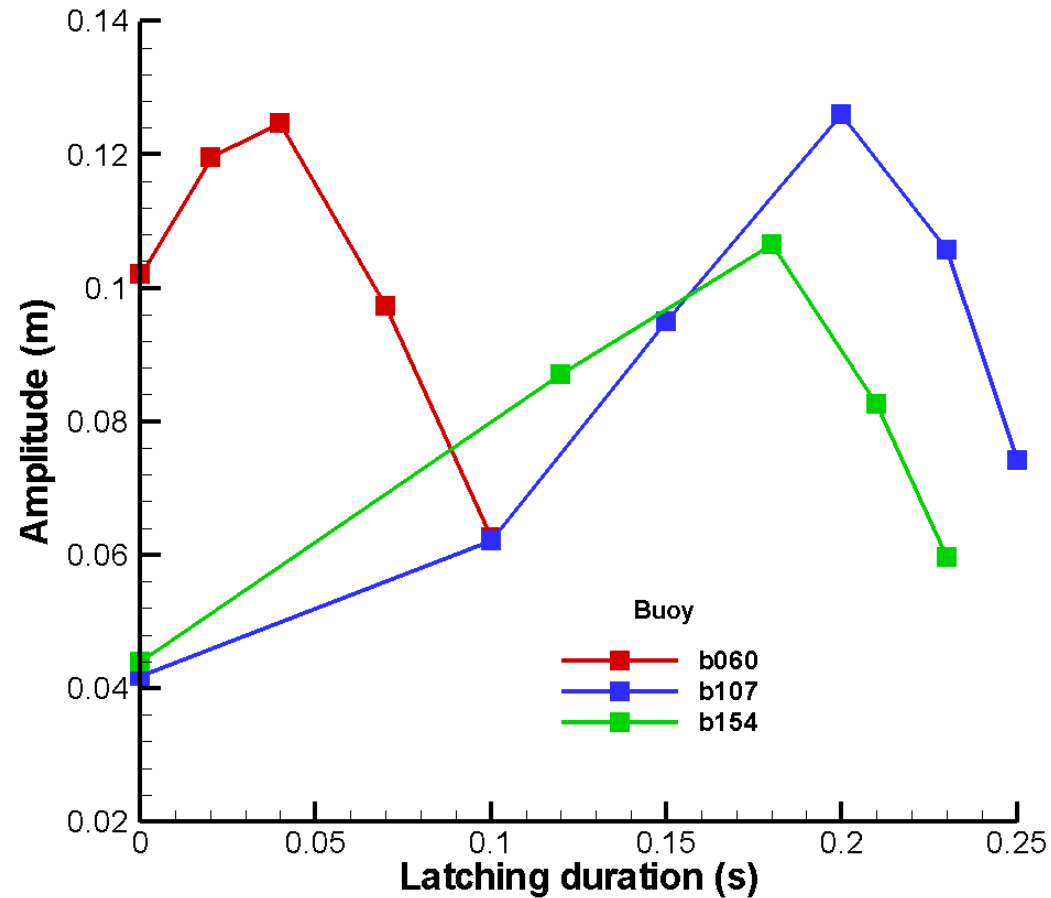
Bóia	Diâmetro, D (m)	Calado, T (m)	Massa (kg)	D/T	Período natural (s)
b060	0.3	0.5	35.28	0.60	1.52
b107	0.3	0.28	19.76	1.07	1.21
b154	0.43	0.28	40.59	1.54	1.25

Jin et al. (2018) ←

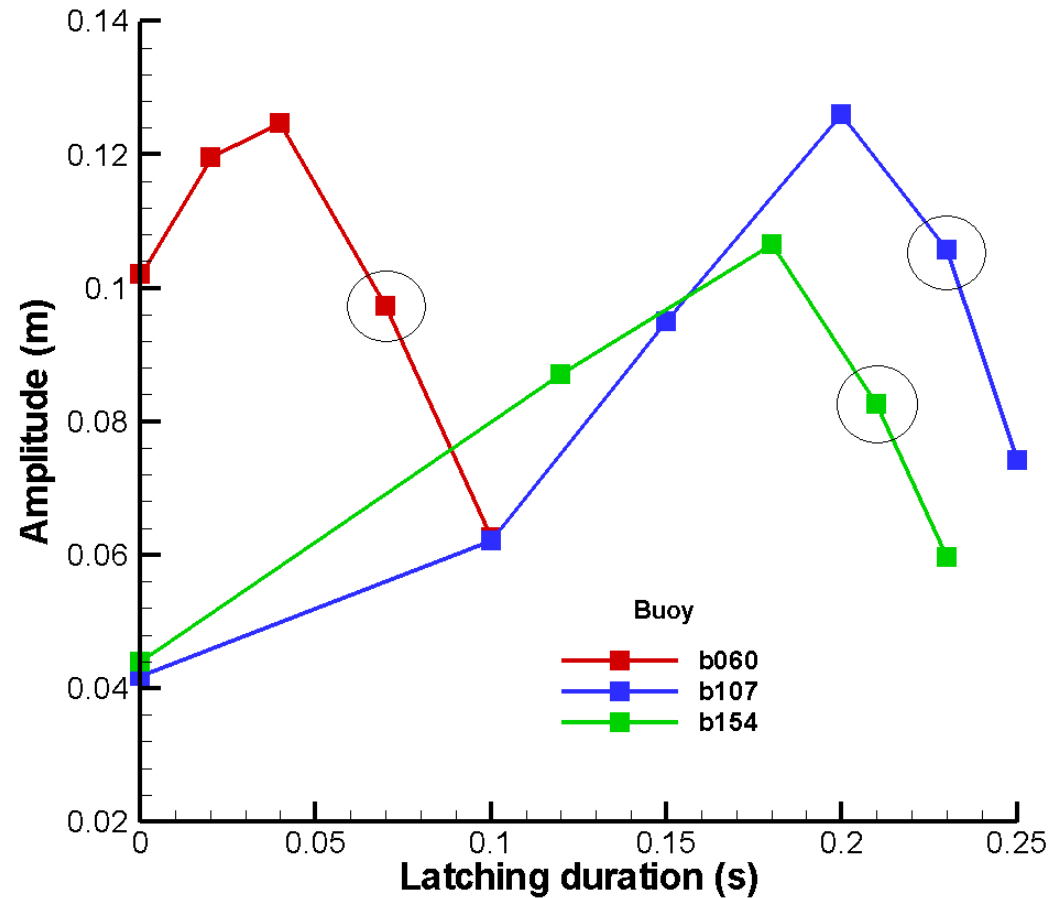
Resultados CFD



Resultados CFD

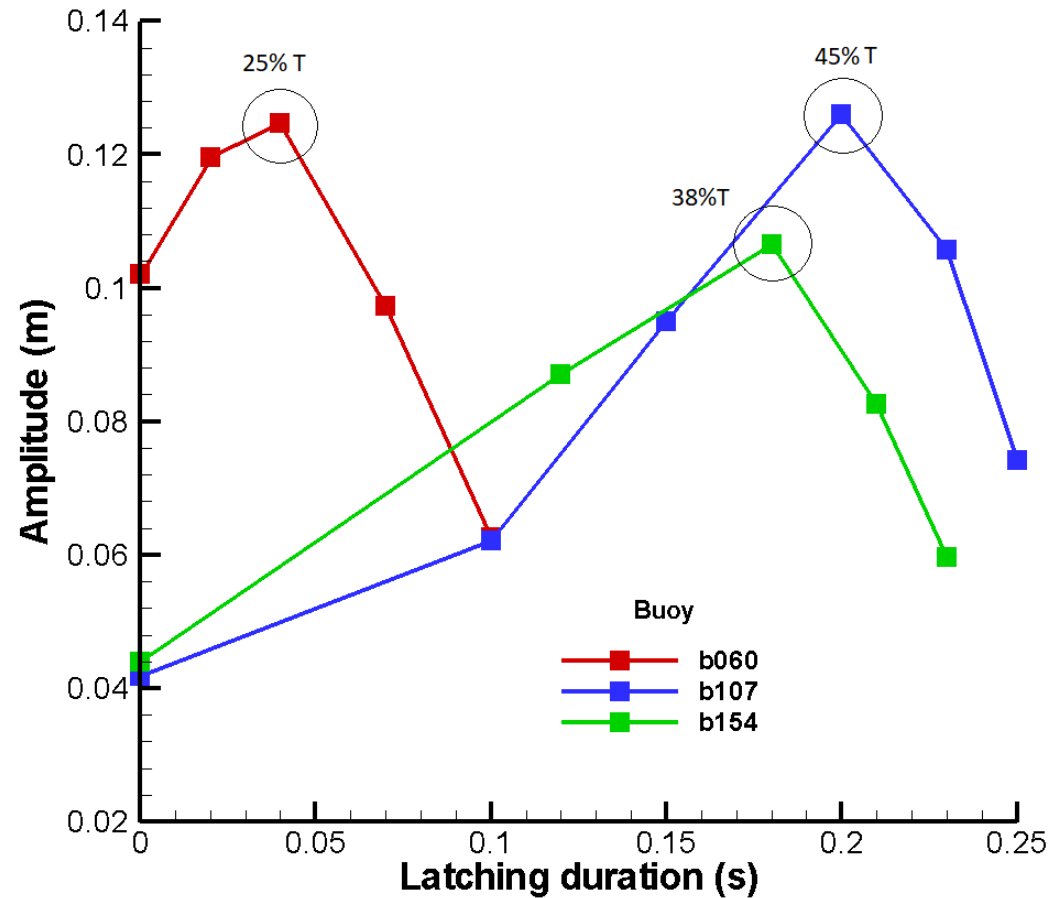


Resultados CFD

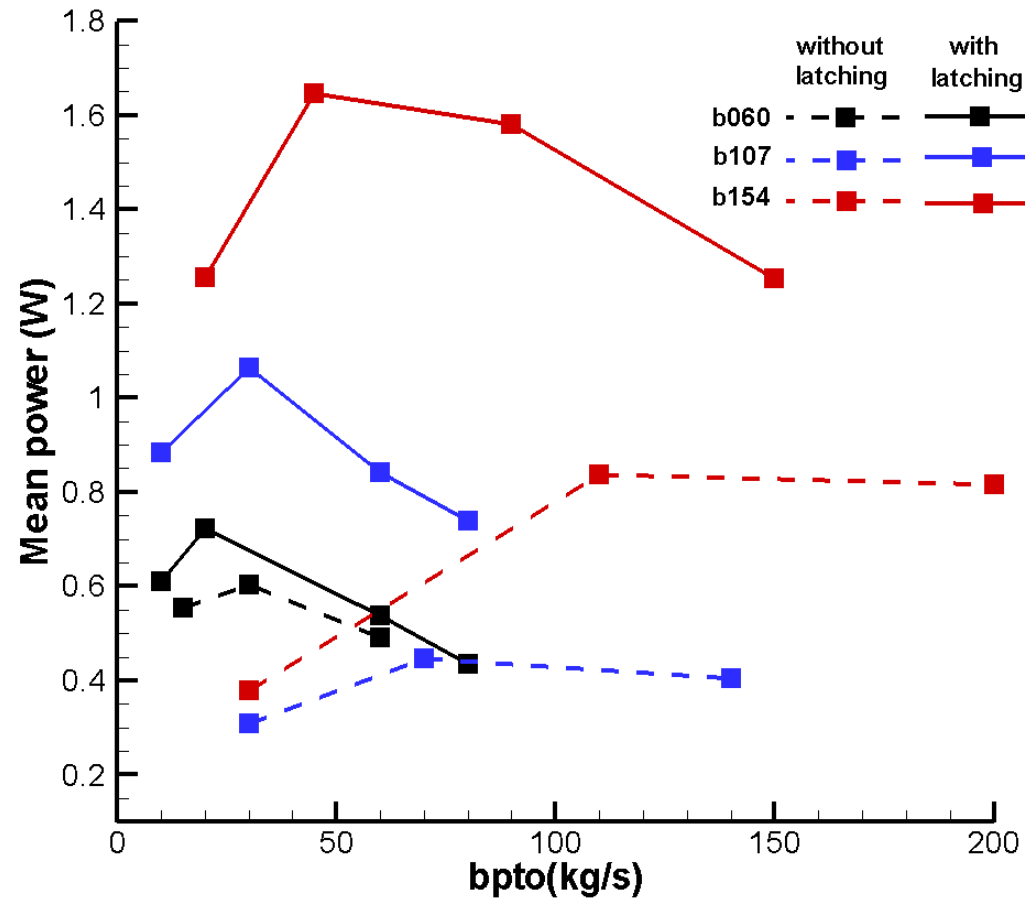


$$T_L = \frac{T_w - T_n}{2}$$

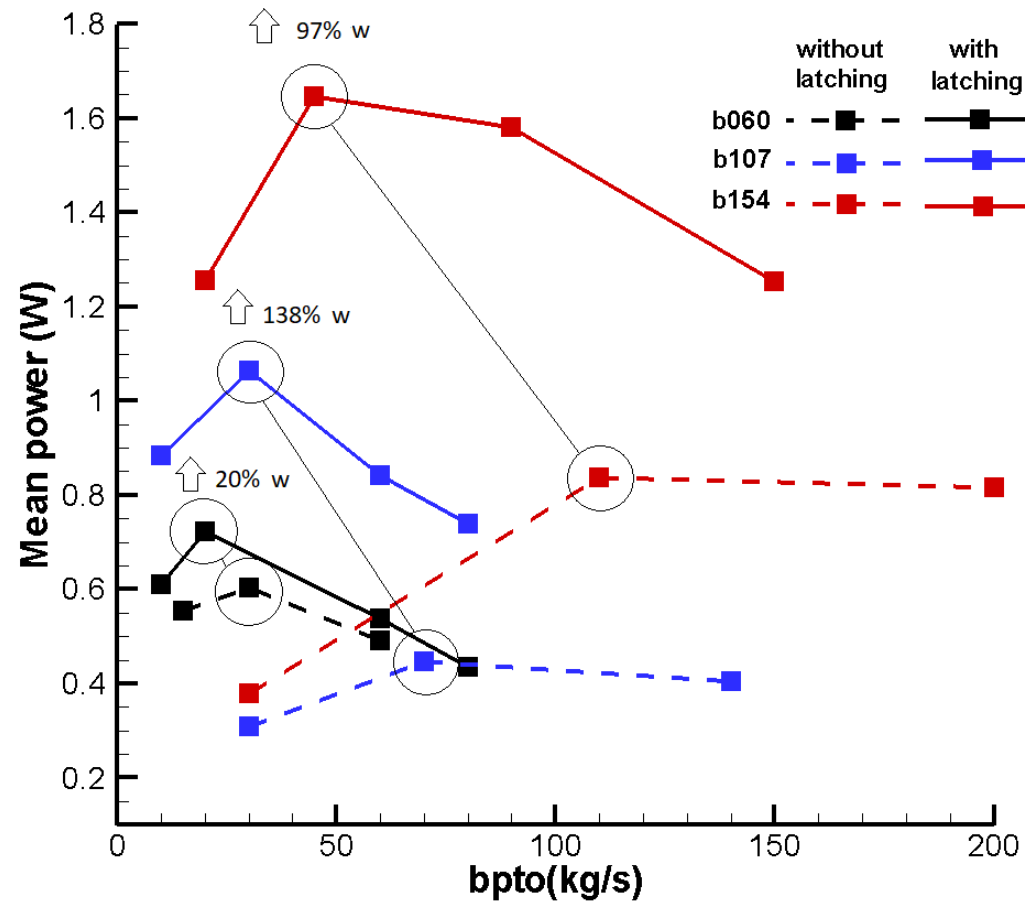
Resultados CFD



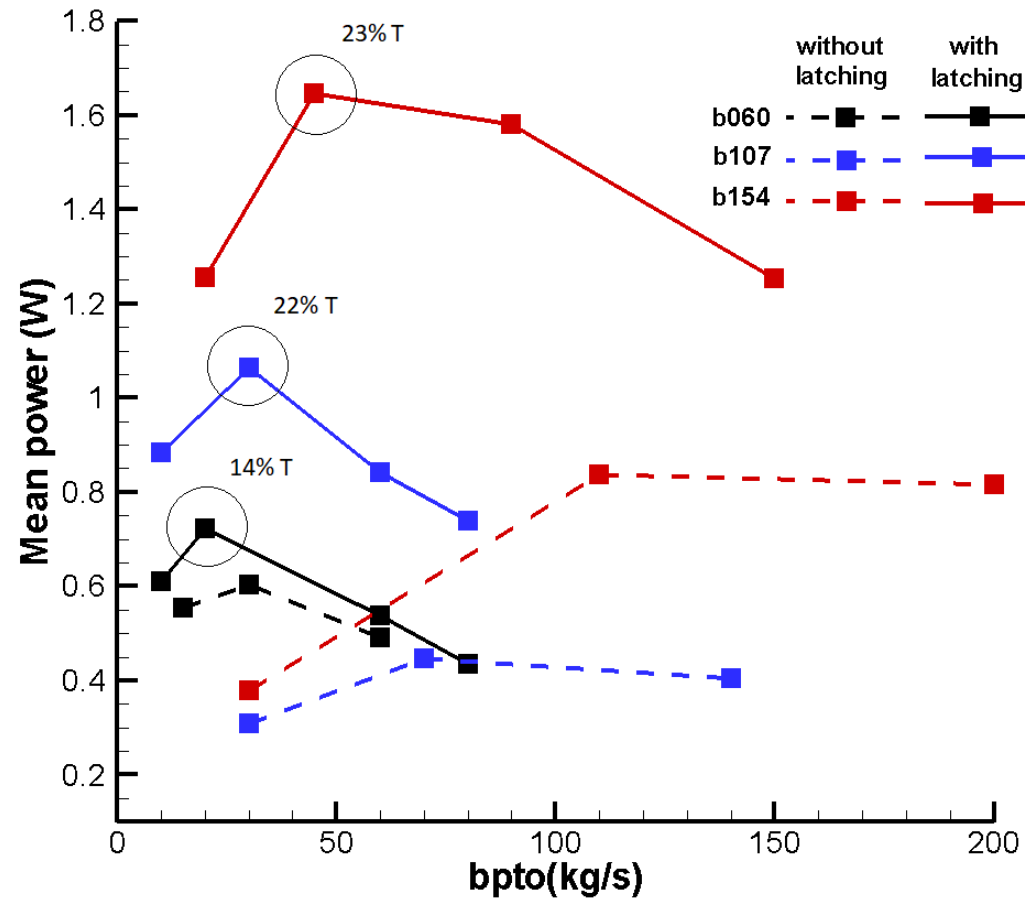
Resultados CFD



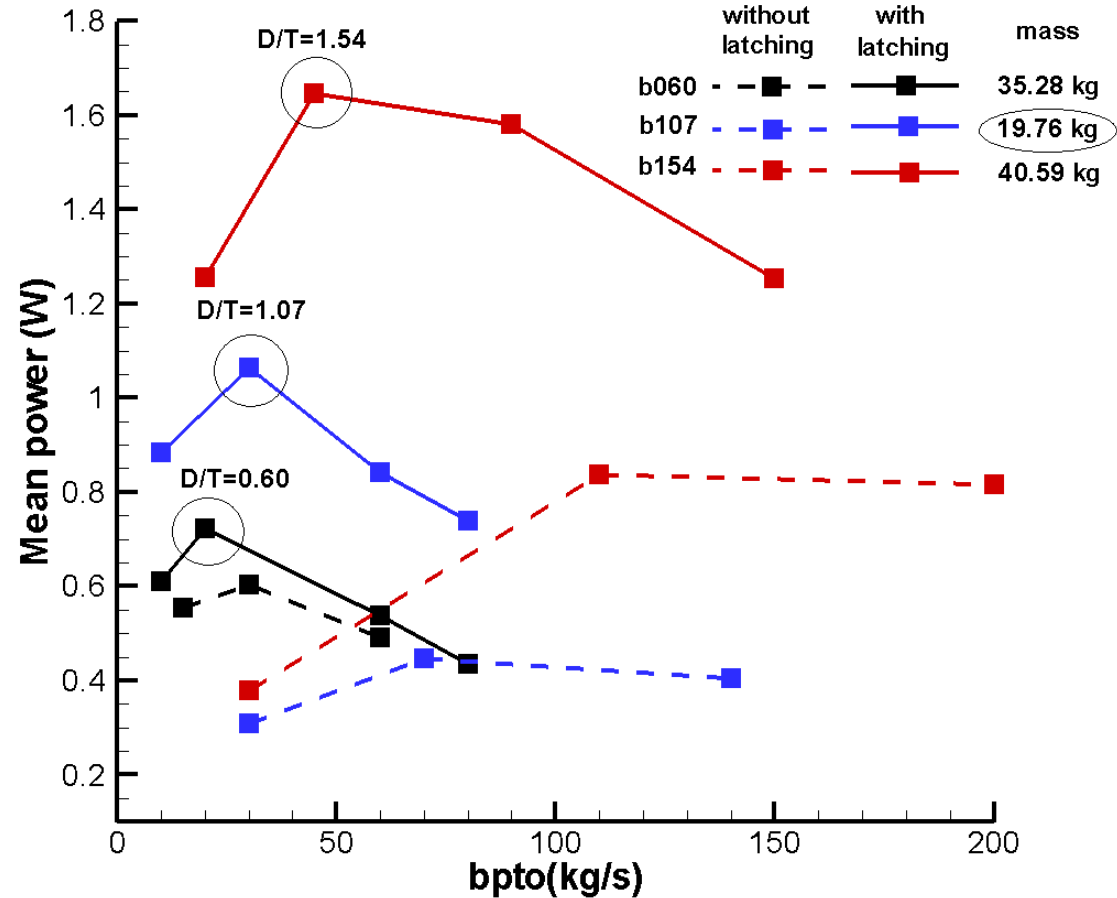
Resultados CFD



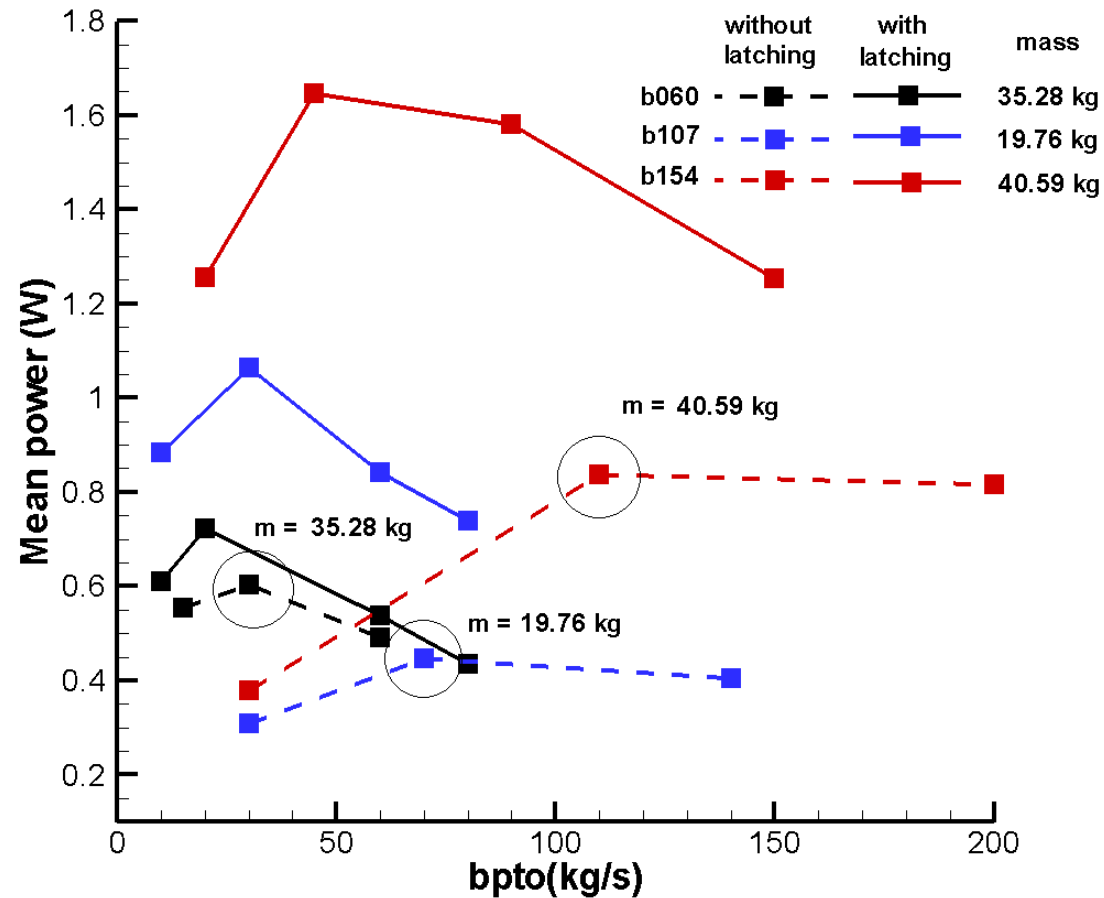
Resultados CFD



Resultados CFD

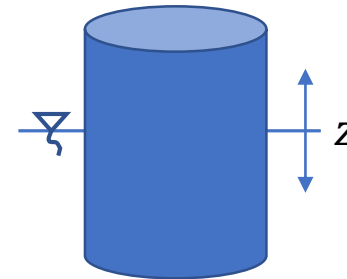


Resultados CFD



Modelamento não linear

$$m\ddot{z} = F_e + F_b + F_r + F_p + F_c + F_v$$



Força de excitação

$$F_e = F_{33}\sin(\omega t)$$

Força de Restauração

$$F_b = -c_{33}z$$

Força de radiação

$$F_r = -a_{\infty}\ddot{z} - \int_0^t K_r(t - \tau)\dot{z}(\tau) d\tau$$

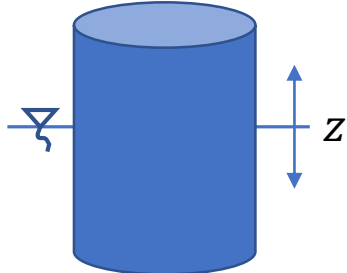
Força do PTO

$$F_p = -b_{PTO}\dot{z}$$

Força do sistema de controle latching

$$F_c = \frac{m(v_f - v_o)}{\Delta t} - (F_b + F_r + F_e + F_v + F_p)$$

Modelamento não linear

$$m\ddot{z} = F_e + F_b + F_r + F_p + F_c + F_v$$


Força viscosa

NM1

$$F_v = -\frac{1}{2}\rho C_d A (u - \dot{z}) |u - \dot{z}|$$

Morison

NM2

$$F_v = -\frac{1}{2}\rho \beta A (u - \dot{z}) |u - \dot{z}|^\alpha$$

Modelo proposto

Critério de ajuste

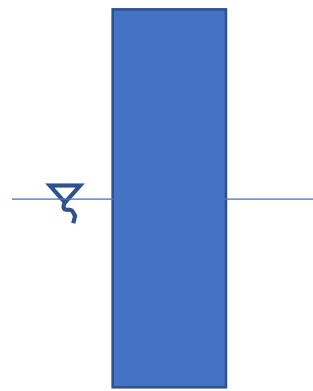
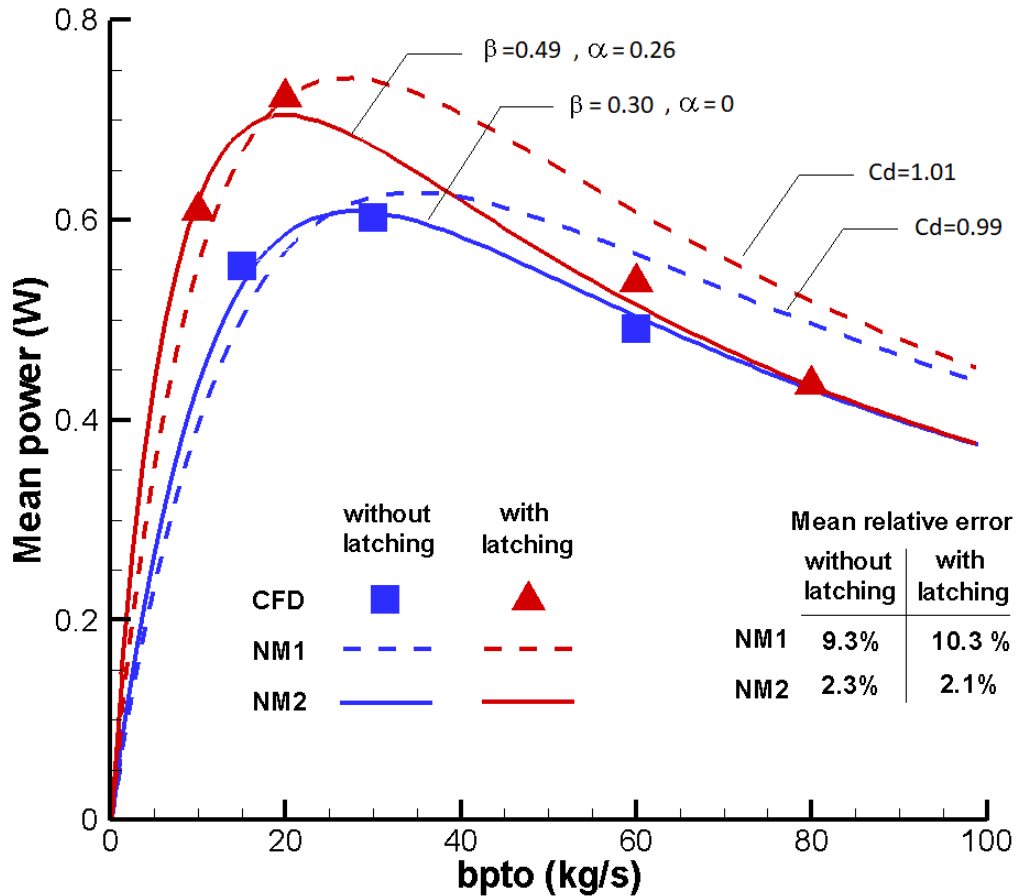
NM1

$$R(Cd) = \min \sum (P_m(t_i, Cd) - P_{CFD}(t_i))^2$$

NM2

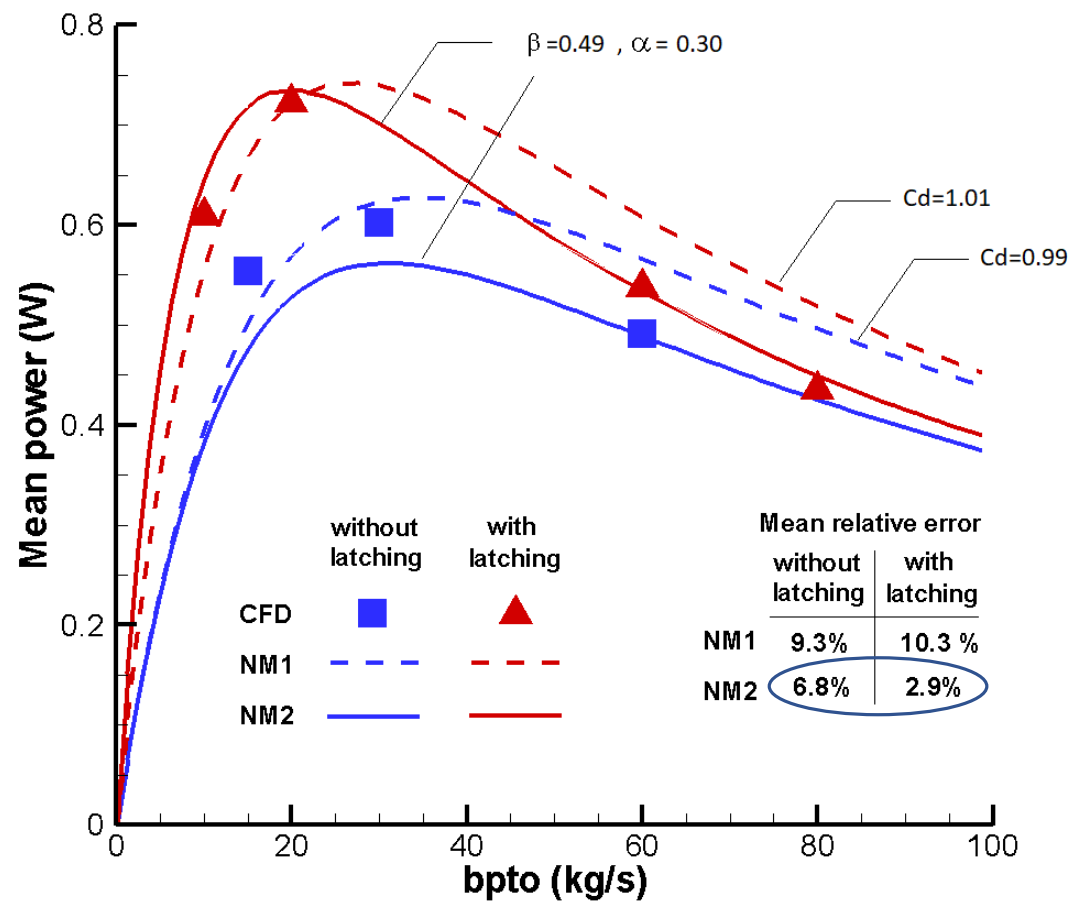
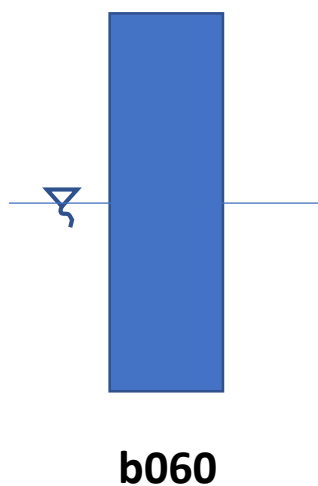
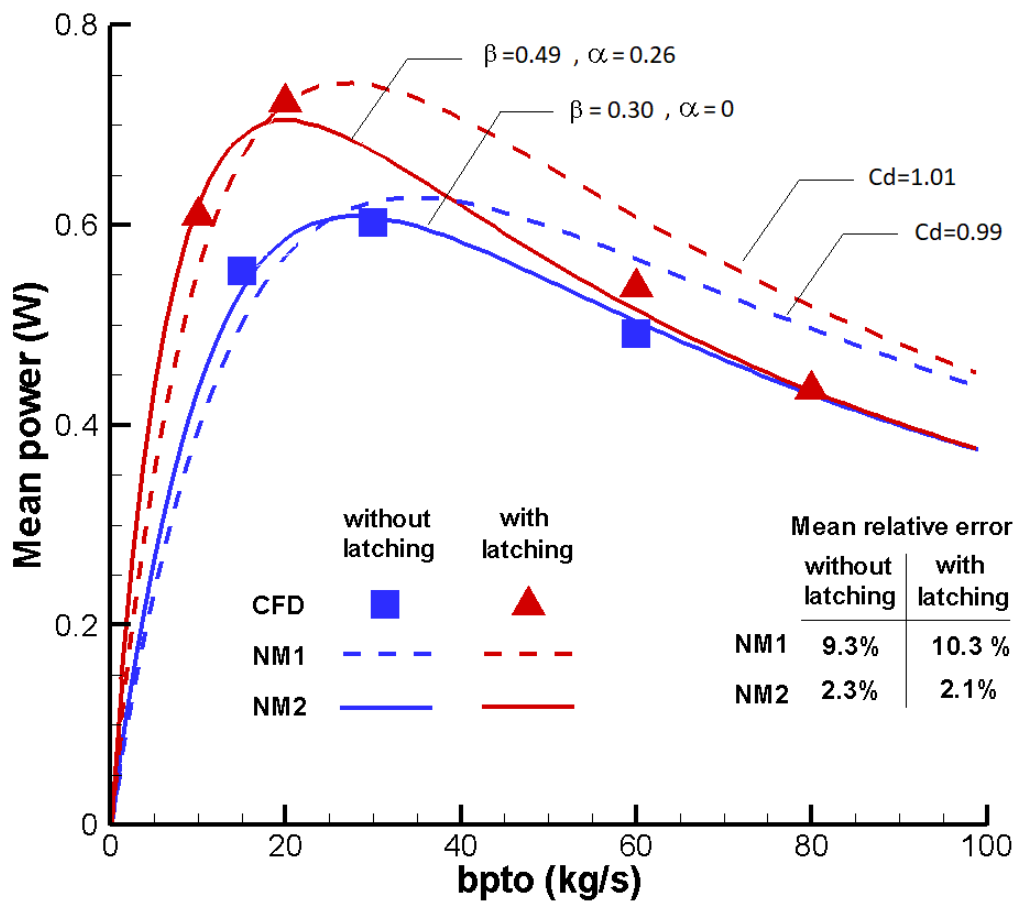
$$R(Cd) = \min \sum (P_m(t_i, \alpha, \beta) - P_{CFD}(t_i))^2$$

Resultados modelamento não linear

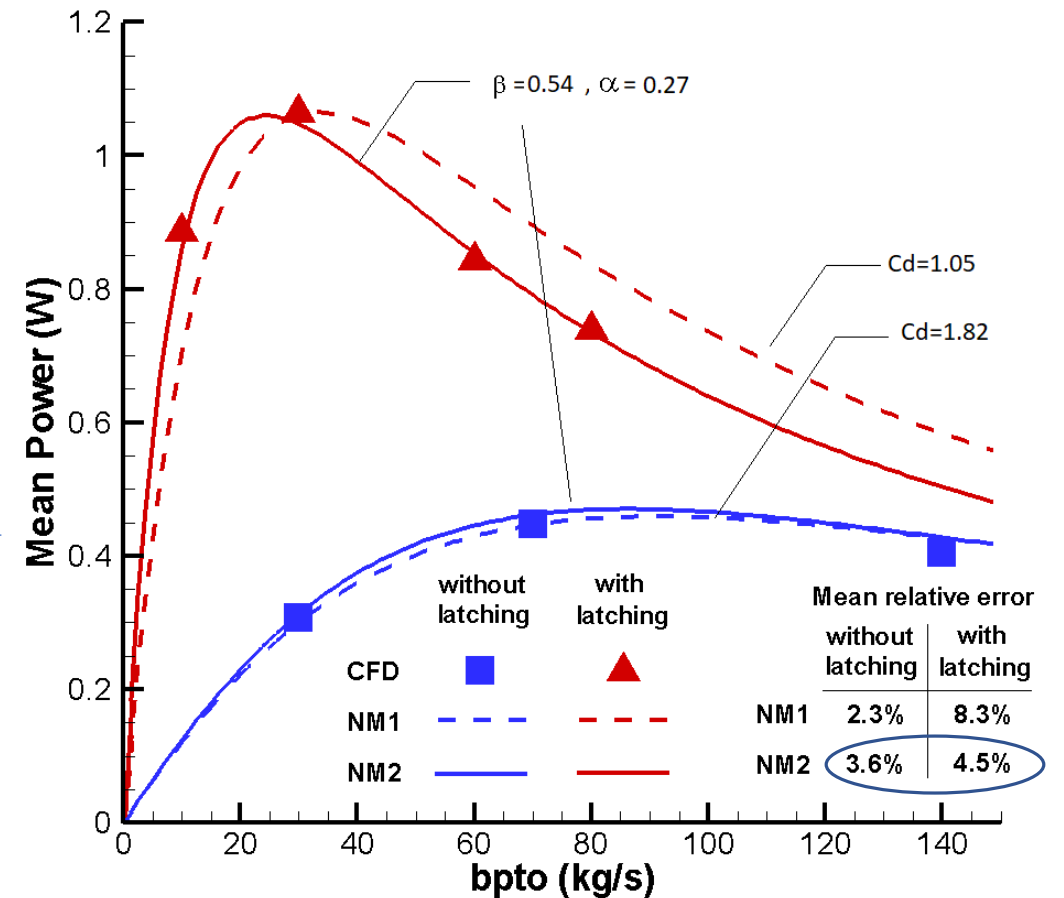
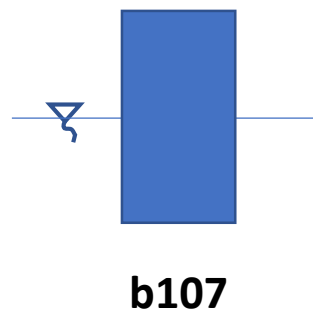
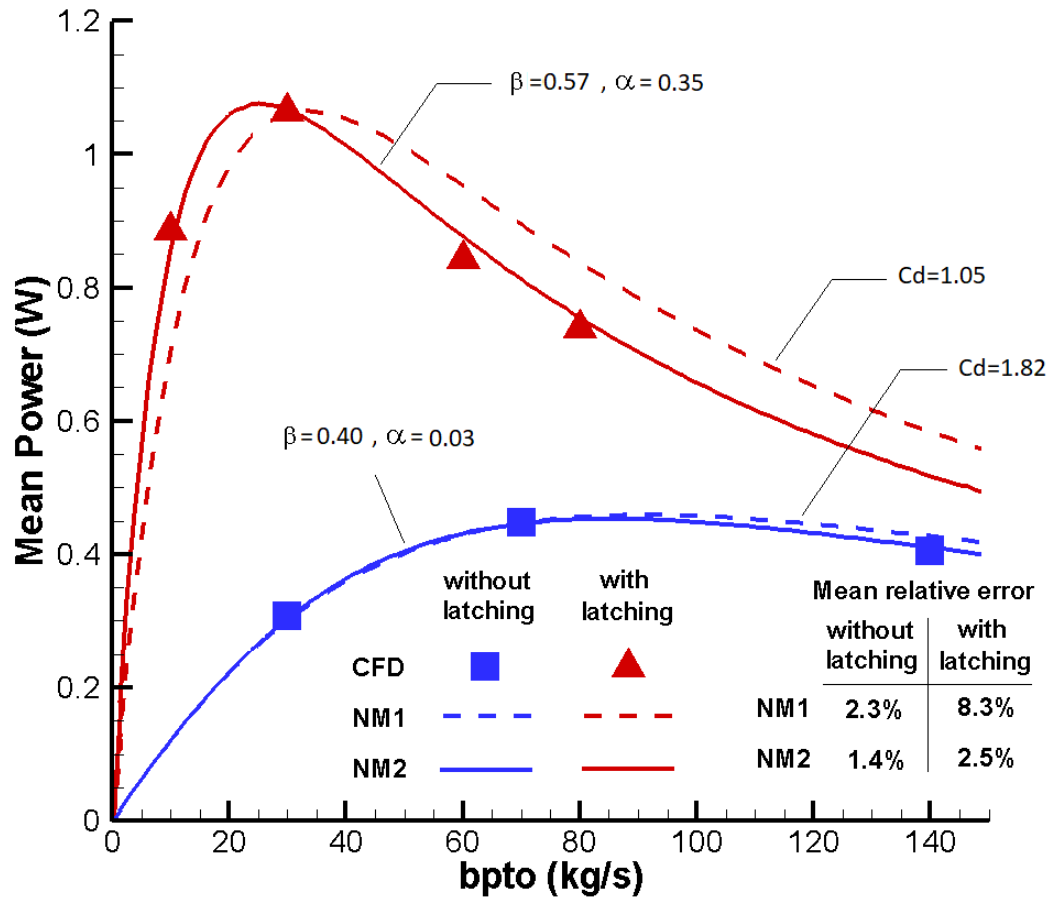


b060

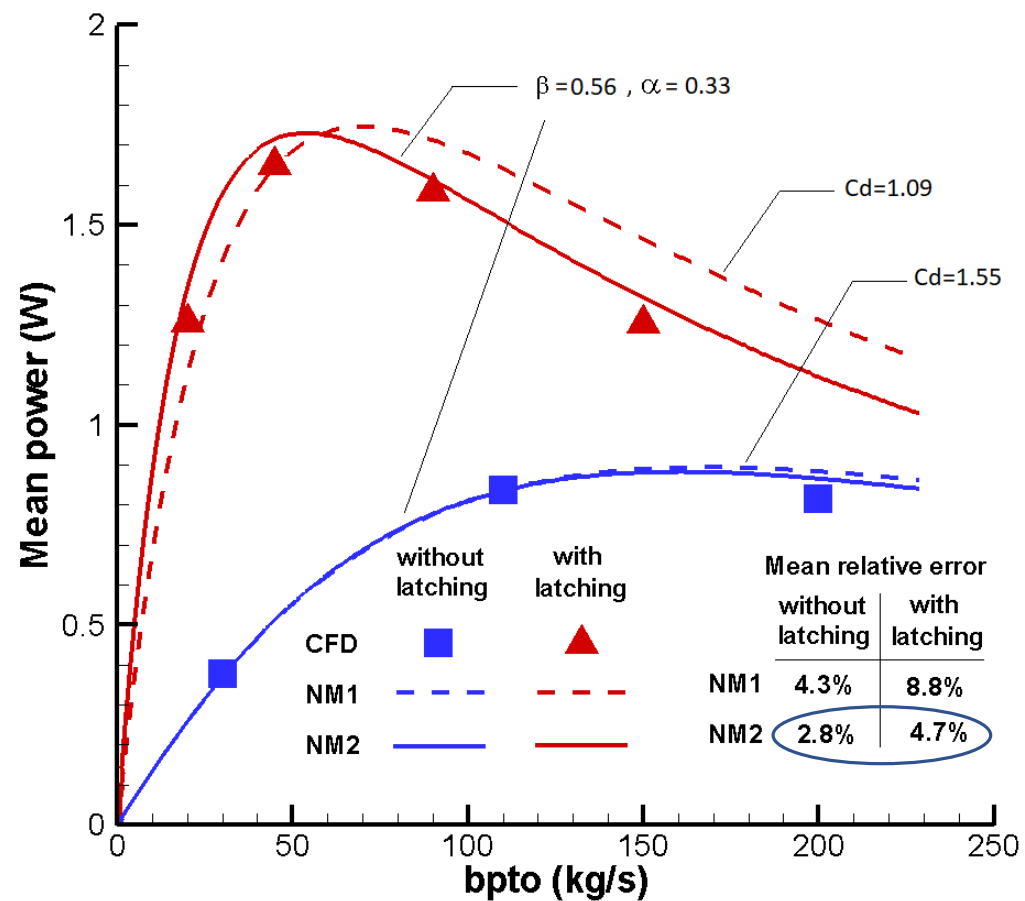
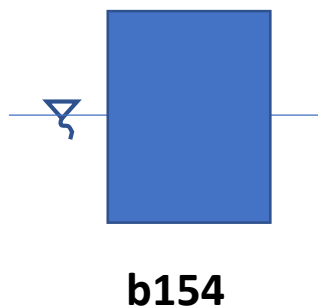
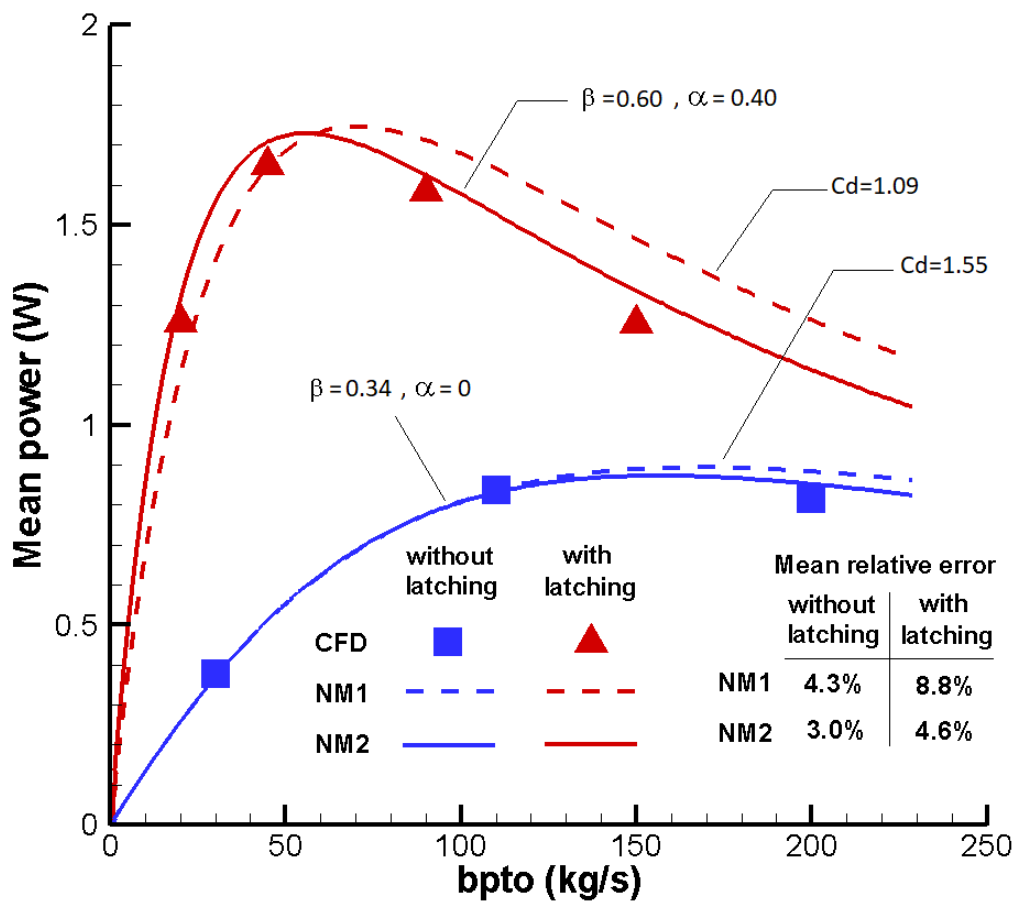
Resultados modelamento não linear



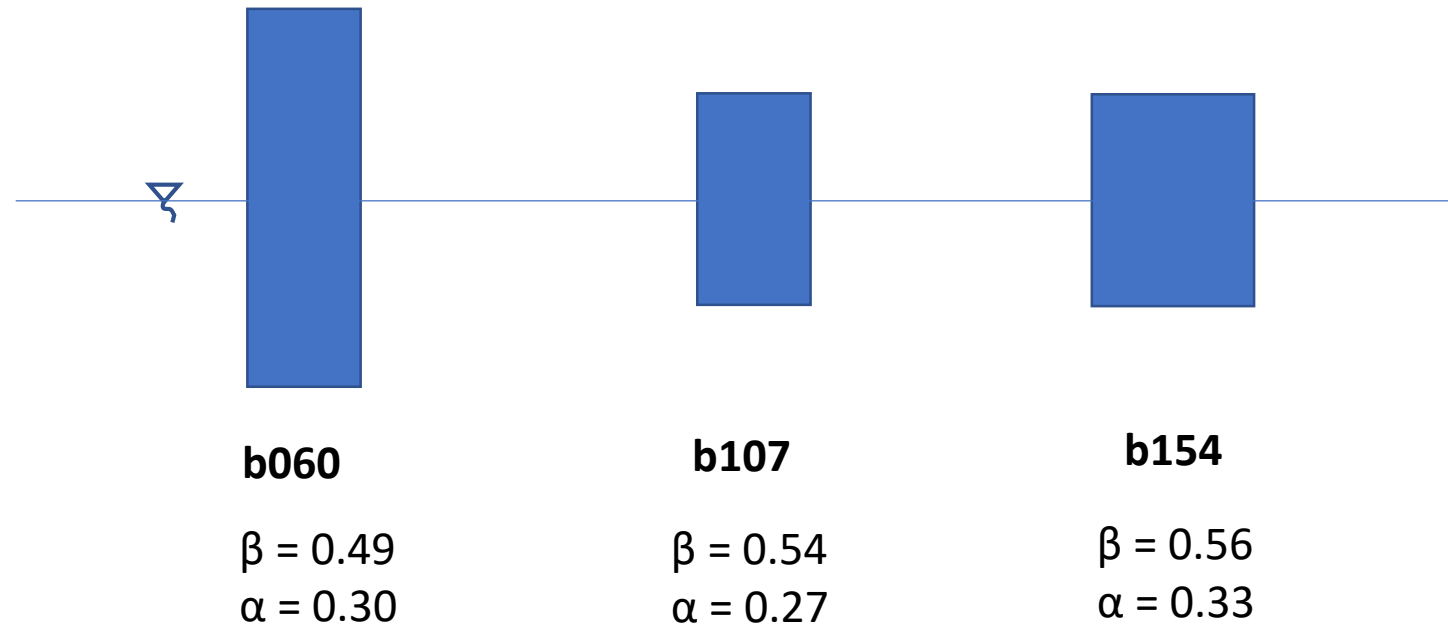
Resultados modelamento não linear



Resultados modelamento não linear



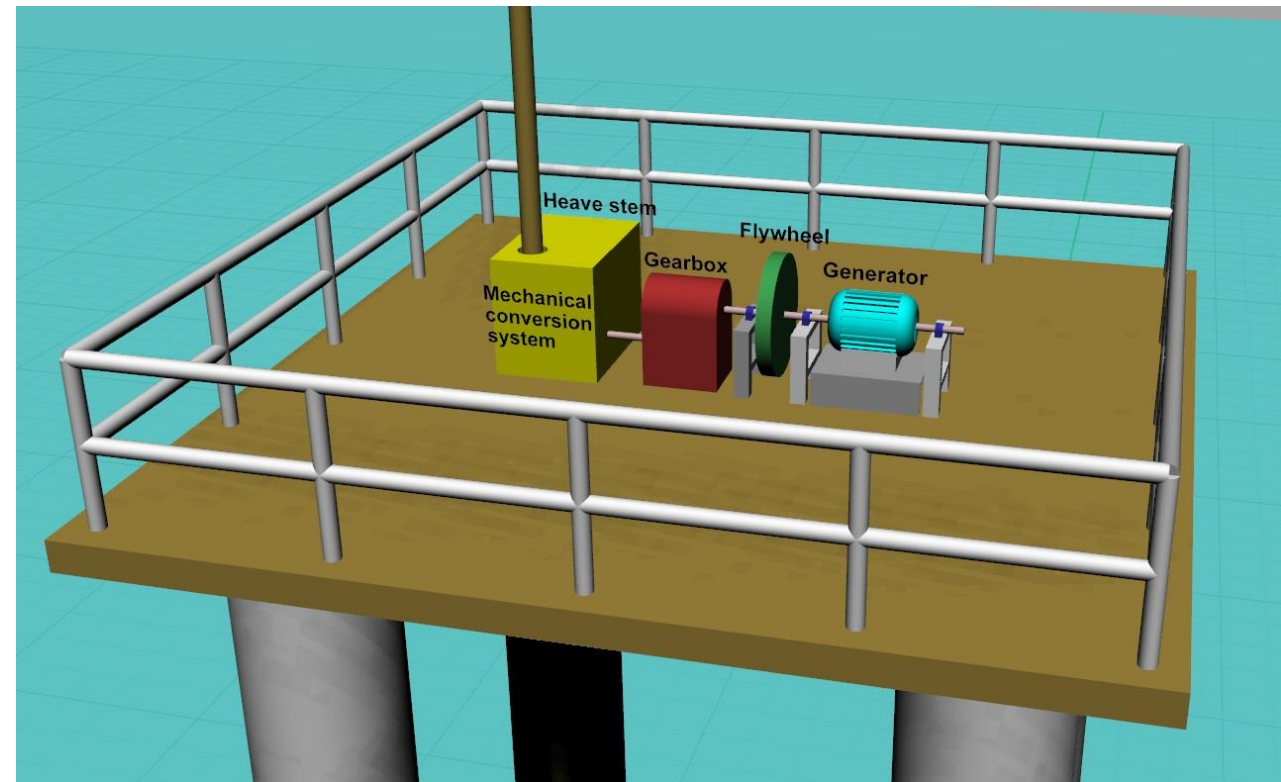
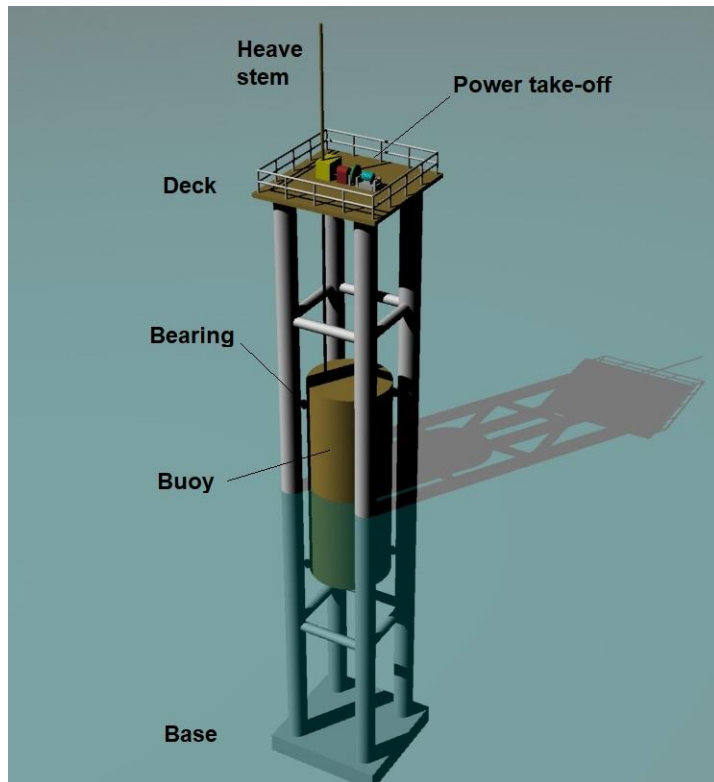
Resultados modelamento não linear



Modelo proposto

$$F_v = -\frac{1}{2} \rho \beta A (u - \dot{z}) |u - \dot{z}|^\alpha$$

Protótipo



Protótipo

PTO linear

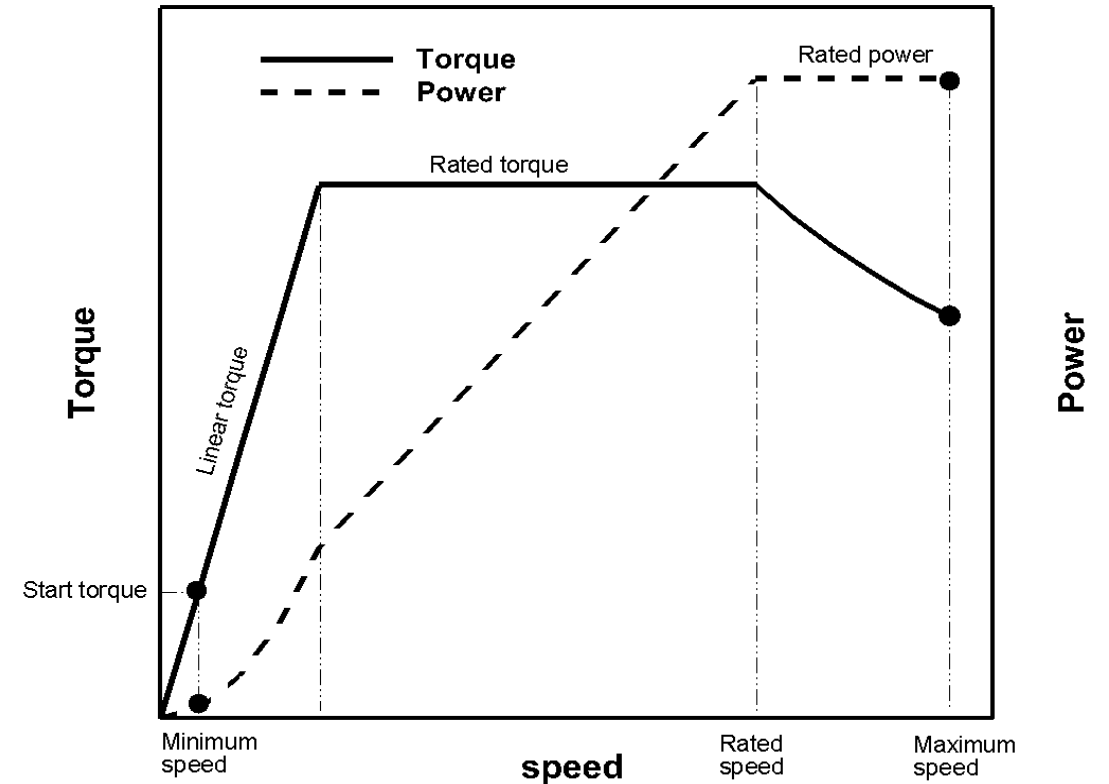
$$F_p = -b_{PTO} \dot{z}$$

$$P_m = \frac{1}{T} \int_0^T b_{PTO} \dot{z}^2 dt$$

PTO Mecânico

$$F_p = \begin{cases} - \left(\frac{J_1}{r^2} + \frac{\eta c^2 J_2}{r^2} \right) \ddot{z} - \frac{\eta c (T_g + 3 T_b)}{r}, & \text{for } \omega < \frac{c \dot{z}}{r} \\ 0, & \text{for otherwise} \end{cases}$$

$$P_g = T_g \omega$$



Protótipo

Inércia do volante

Relação da caixa da velocidade

	5	10	15	20	25	30
5	19.99283	20.07434	20.19629	20.32924	20.53028	20.80196
10	19.73927	20.52715	21.07783	21.80695	22.32926	23.03595
15	22.57768	23.57019	22.13819	23.18684	24.09146	25.00595
20	24.95515	26.23774	25.96446	27.11629	28.07721	27.32574
25	27.57021	28.17305	29.314	29.54752	30.27479	30.88396
30	27.77107	27.15458	27.72052	29.94423	31.39276	29.27757
35	26.10693	27.40453	28.0563	19.23048	23.0117	23.82374
40	23.3406	24.0874	18.24872	21.08439	24.34912	25.283
45	21.50621	24.50771	20.37635	20.84425	23.80843	24.46663
50	18.57607	22.43082	20.70018	21.47838	21.80529	22.47966
55	16.52266	21.56276	18.79062	20.13548	20.46175	21.93287
60	14.93895	19.08133	16.56742	17.3175	20.07218	19.7899

Obrigado

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