LAMPIRAN 2 Perhitungan Torsi, daya, dan efisiensi turbin Darrieus NACA 0012

2.1 Perhitungan Torsi

- **Kecepatan 2**

  Dik:

  U =2 m/s **ω = 29.23 rad/s** **C_{L1} = 1.142 sin (2.065x)**

  H = 0.8 m **ρ = 998.2 kg/m^3** **C_{L2} = 1.749 sin (2.435x)**

  c = 0.18 m **R = 0.3 m** **C_D =$1.145\sin(0.2695x + 1.571) + 1.13\sin(4.611x - 1.571)$**

Torsi Lift

$$\frac{\frac{1}{\pi}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}\rho(0.5)(W)^2A.\mathrm{CL}.\left(R\sin(x)\right)dx + \frac{1}{\pi}\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}}\rho(0.5)(W)^2A.\mathrm{CL}.\left(R\sin(x)\right)dx}{2}$$

Sudu 1

$$T_{L1} = \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}\rho(0.5)(W)^2A.\mathrm{CL}.\left(R\sin(x)\right)dx\right)$$

$$= \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}998.2(0.5)(U+(-\omega R))^2(H)(c)\left(1.142\sin(2.065x)\right)\left(\mathrm{R}\sin(x)\right)dx\right)$$

$$= \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)(2 + ((-29.23)(0.3))^2(0.8)(0.18)\big(1.142\sin(2.065x)\big)\big(0.3\sin(x)\big)dx\right)$$

$$= \frac{1}{\pi}.\,998.2(0.5)(2 + ((-29.23)(0.3))^2(1.142)(0.8)(0.18)(0.3)\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \sin(x)\sin(2.065x)dx$$

$$= \frac{1}{\pi}(499.1\ )(45.819)\ (1.142)(0.8)(0.18)(0.3)\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \sin(x)\sin(2.065x)dx$$

$$= 359.115\ \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \sin(x)\sin(2.065x)dx$$

$$= (351.115)\ (1.259)$$

$$= 452.126\ \text{Nm}$$

$$T_{L2} = \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \rho(0.5)(W)^2 A.\,\text{CL}.\,\big(R\sin(x)\big)dx\right)$$

$$= \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} 998.2(0.5)\big(U + (-\omega R)\big)^2(H)(c)\big(1.749\sin(2.435x)\big)\big(0.3\sin(x)\big)dx\right)$$

$$= \frac{1}{\pi}(499.1)(\ 45.819)\ (1.749)(0.8)(0.18)(0.3)\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \sin(2.435x)\sin(x)dx\right)$$

$$= 549.993\ \left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \sin(2.435x)\sin(x)dx\right)$$

$= (549.993\ )\ (-0.2)$

$= -109.999$ Nm

Sudu 2

$T_{L1} = \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)(2+((-29.23)(0.3))^2(H)(c)\left(1.142\sin\left(2.065(x+\frac{2\pi}{3})\right)\right)\left(0.3\sin(x+2\pi/3)\right)dx\right)$

$=(351.115)\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}\sin(x+2\pi/3)\sin(2.065x+1.376\pi)dx$

$=((351.115))\ (-0.249)$

$= -87.428$ Nm

$T_{L2} = \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} 998.2(0.5)(2+((-29.23)(0.3))^2(H)(c)\left(1.749\sin(2.435(x+2\pi/3)\right)\left(0.3\sin(x+2\pi/3)\right)dx\right)$

$=549.993\ \left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}}\sin(2.435x+1.623\pi)\sin\left((x+2\pi/3)\right)dx\right)$

$=(549.993\ ).\ (0.327)$

$= 179.848$ Nm

Sudu 3

$$T_{L1} = \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)(2+((-29.23)(0.3))^2(H)(c)\left(1.142\sin\left(2.065(x+\frac{4\pi}{3})\right)\right)\left(0.3\sin(x+4\pi/3)\right)dx\right)$$

$$=(351.115)\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}\sin(x+4\pi/3)\sin(2.065x+2.753\pi)dx$$

$$=((351.115))(0.079)$$

$$=27.738\ Nm$$

$$T_{L2} = \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} 998.2(0.5)(2+((-29.23)(0.3))^2(H)(c)\left(1.749\sin(2.435(x+4\pi/3)\right)\left(0.3\sin(x+4\pi/3)\right)dx\right)$$

$$=(550)\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}}\sin(2.435x+3.246\pi)\sin\left((x+4\pi/3)\right)dx\right)$$

$$=(549.993\ )(-0.023)$$

$$=-12.65\ \text{Nm}$$

T_L total $= ((T_{L1sudu1} + T_{L2sudu1}) + (T_{L1sudu2} + T_{L2sudu2}) + (T_{L1sudu3} + T_{L2sudu3}))/2$

$$= \frac{(452.126-109.999)+(-87.428+179.848)+(27.738-12.65)}{2}$$

$= 224.818$ Nm

Torsi Drag

Sudu 1

$T_D = \frac{1}{2\pi}\int_0^{2\pi} \rho(0.5)(W)^2 A.\,\mathrm{CD}.\,(R\cos(x))dxdx$

$= \frac{1}{2\pi}\int_0^{2\pi} (\rho)(0.5)(2 + ((-29.23)(0.3))^2(A)\,(1.145\sin(0.2695\,\mathrm{x} + 1.571) + 1.13\sin(4.611\mathrm{x} - 1.571))(0.3\cos(x))dx$

$= \frac{1}{2\pi}(998.2)(0.5)(45.819)(0.3)(0.8)(0.18)\int_0^{2\pi}(1.145\sin(0.2695\,\mathrm{x} + 1.571) + 1.13\sin(4.611\mathrm{x} - 1.571))(\cos(x))dx$

$= 157.231\int_0^{2\pi}(1.145\sin(0.2695\,\mathrm{x} + 1.571))(\cos(x)) + (1.13\sin(4.611\mathrm{x} - 1.571))(\cos(x))dx$

$\int_0^{2\pi}(1.145\sin(0.2695\,\mathrm{x} + 1.571))(\cos(x)) + (1.13\sin(4.611\mathrm{x} - 1.571))(\cos(x))dx$

$\int_0^{2\pi}(\sin(\alpha)(\cos(\beta))dx$ **α=40.2695 x + 1.571, β = x,** **α=44.611x − 1.571**

$\int_0^{2\pi}\frac{1}{2}(\sin(\alpha-\beta) + (\sin(\alpha+\beta))dx$

$= 157.231\int_0^{2\pi}\frac{1}{2}1.145((\sin(1.2695\,\mathrm{x} + 1.571) + (\sin(-0.731\,x + 1.571))dx + \int_0^{2\pi}\frac{1}{2}1.13((\sin(3.611\,\mathrm{x} - 1.571) + (\sin(5.611\,x - 1.571))dx$

$=157.231 \int_0^{2\pi} \frac{1}{2} 1.145((\sin(1.27\,x + 0.00643\pi) + (\sin(-0.73\,x + 0.00643\pi))dx + \int_0^{2\pi} \frac{1}{2} 1.13((\sin(3.61\,x - 0.00643\pi) + (\sin(5.61\,x - 0.00643\pi))dx$

$= (157.231)(0.081)$

$= 12.736\ Nm$

Sudu 2

$T_D = \frac{1}{2\pi} \int_0^{2\pi} (998.2)(0.5)(45.819)(0.3)(0.8)(0.18)(1.145 \sin\left(0.2695\,(x + \frac{2\pi}{3}) + 1.571\right) + 1.13\sin\left(4.611(x + \frac{2\pi}{3}) - 1.571\right))\left(0.3\cos(x + \frac{2\pi}{3})\right) dx$

$= 157.231 \int_0^{2\pi} (1.145 \sin(0.2695x + 0.186\pi) + 1.13\sin(4.611x + 3.068\pi)\cos(x + \frac{2\pi}{3}) dx$

$= 157.231 \int_0^{2\pi} 1.145(\sin(0.2695x + 0.186\pi)\cos(x + \frac{2\pi}{3}) + 1.13\sin(4.611x + 3.068\pi)\cos(x + \frac{2\pi}{3}) dx$

$= 157.231 \int_0^{2\pi} \frac{1}{2} 1.145((\sin(1.2695\,x + 0.856\pi) + (\sin(-0.731\,x - 0.484\pi))dx + \int_0^{2\pi} \frac{1}{2} 1.13((\sin(3.611\,x + 2.398\pi) + (\sin(5.611\,x + 3.738\pi))dx$

$= (157.231)\,(0.633)$

$= 99.527\text{Nm}$

Sudu 3

$$T_D = \frac{1}{2\pi}\int_0^{2\pi} (998.2)(0.5)(45.819)(0.3)(0.8)(0.18)\left(1.145\sin\left(0.2695\left(x+\frac{4\pi}{3}\right)+1.571\right)+1.13\sin\left(4.611\left(x+\frac{4\pi}{3}\right)-1.571\right)\right)\left(0.3\cos\left(x+\frac{4\pi}{3}\right)\right)dx$$

$$= 157.231\int_0^{2\pi} (1.145\sin(0.2695x+0.365\pi)+1.13\sin(4.611x+6.126\pi)\cos\left(x+\frac{4\pi}{3}\right)dx$$

$$= 157.231\int_0^{2\pi} 1.145\sin(0.2695x+0.365\pi)\cos\left(x+\frac{4\pi}{3}\right)+1.13\sin(4.611x+6.126\pi)\cos\left(x+\frac{4\pi}{3}\right)dx$$

$$= 157.231\int_0^{2\pi}\frac{1}{2}1.145((\sin(1.2695x+1.695\pi)+(\sin(-0.731x-0.965\pi))dx + \int_0^{2\pi}\frac{1}{2}1.13((\sin(3.611x+4.796\pi)+(\sin(5.611x+7.456\pi))dx$$

$$= (157.231)(0.639)$$

$$= 100.471 \text{ Nm}$$

T_D total = (T_{Dsudu1}+ T_{Dsudu2}+ T_{Dsudu3})

$= 12.736 + 99.527 + 100.471$

$= 212.734$ Nm

T_{TOTAL} =($T_L$total - $T_D$total)

$=(224.818) - (212.734)$

=12.084 Nm

Kecepatan 2.5 m/s

Dik:

U = 2.5 m/s **ω = 37.738 rad/s** **C_{L1} = 1.29 *sin* (2.11*x*)**

H = 0.8 m **ρ = 998.2 kg/m^3** **C_{L2} = 1.745 sin(2.417*x*)**

c = 0.18 m **R = 0.3 m** **C_D = 1.157*sin*(0.2497 *x* + 1.571) + 1.143*sin*(4.631 *x* − 1.571**

Torsi Lift

Sudu 1

$$T_{L1} = \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \rho(0.5)(W)^2 A.\,\mathrm{CL1}.\left(R\sin(x)\right)dx\right)$$

$$= \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)\left(U + (-\omega R)\right)^2 (H)(c)\left(1.29\sin(2.11x)\right)\left(0.3\sin(x)\right)dx\right)$$

$$= \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)(2.5 + ((-37.738\ )(0.3))^2(0.8)(0.18)\left(1.29\sin(2.11x)\right)\left(0.3\sin(x)\right)dx\right)$$

$$= \frac{1}{\pi}.998.2(0.5)(2.5 + ((-37.738\ )(0.3))^2(0.8)(0.18)(1.29)(0.3)\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \sin(x)\sin(2.11x)dx$$

$$= \frac{1}{\pi}(499.1\ )(\ 81.046)(0.8)(0.18)(1.29)(0.3)\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \sin(x)\sin(2.11x)dx$$

$= (717.534)(1)$

$= 861\ Nm$

$$T_{L2} = \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \rho(0.5)(W)^2 A.\,CL2.\,(R\sin(x))dx\right)$$

$$T_{L2} = \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} 998.2(0.5)\left(U + (-\omega R)\right)^2 (H)(c)\left(1.745\sin(2.417x)\right)\left(0.3\sin(x)\right)dx\right)$$

$$T_{L2} = \frac{1}{\pi}(499.1\ )(\ 81.046)(0.8)(0.18)(1.745)(0.3)\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \sin(2.417x)\sin(x)dx\right)$$

$$T_{L2} = (970.618)(-0.21)$$

$$T_{L2} = -203.8\ Nm$$

Sudu 2

$$T_{L1} = \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)(2.5 + ((-37.738\ )(0.3))^2 (H)(c)\left(1.29\sin\left(2.11\ (x + \frac{2\pi}{3})\right)\right)\left(0.3\sin(x + 2\pi/3)\right)dx\right)$$

$$=(717.534)\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \sin(x+2\pi/3)\sin(2.11x+1.41\pi)dx$$

$= (717.534)\ (-0.31)$

$= -222.4\ Nm$

$$T_{L2} = \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} 998.2(0.5)(2.5 + ((-136.9231)(0.3))^2(H)(c)\big(1.745\sin(2.417(x + 2\pi/3)\big)\big(0.3\sin(x + 2\pi/3)\big)dx\right)$$

$$= (970.618)\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \sin(2.435x + 1.611\pi)\sin\big((x+2\pi/3)\big)dx\right)$$

$= (970.618)(0.33)$

$= 320.304\ Nm$

Sudu 3

$$T_{L1} = \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)(2.5 + ((-37.738\ )(0.3))^2 c\left(1.29\sin\left(2.11(x + \frac{4\pi}{3}\right)\right)\big(0.3\sin(x + 4\pi/3)\big)dx\right)$$

$$= (717.534)\ \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \sin(x+4\pi/3)\sin(2.11x+2.813\pi)dx$$

$= (717.534)\ (\ 0.2)$

$= 143.50\ Nm$

$$T_{L2} = \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} 998.2(0.5)(2.5 + ((-37.738\ )(0.3))^2 c\left(1.745\sin(2.417(x + 4\pi/3)\right)\left(0.3\sin(x + 4\pi/3)\right)dx\right)$$

$$=(485.309)\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \sin(2.417x + 3.223\pi)\sin\left((x+4\pi/3)\right)dx\right)$$

$$=(970.618)(-0.088)$$

$$= -85.414\ Nm$$

T_L total $= ((T_{L1sudu1} + T_{L2sudu1}) + (T_{L1sudu2} + T_{L2sudu2}) + (T_{L1sudu3} + T_{L2sudu3}))/2$

$$= \frac{(657.2)+(-222.283+320.304)+(143.5-85.414)}{2}$$

$= 406.65$ Nm

Torsi Drag

Sudu 1

$T_D = \frac{1}{2\pi}\int_0^{2\pi} \rho(0.5)(W)^2 A.\,\mathrm{CD}.\left(R\cos(x)\right)dx$

$= \frac{1}{2\pi}\int_0^{2\pi} (\rho)(0.5)(2.5 + ((-37.738\,)(0.3))^2 (H)(c)(\,1.157sin(0.2497\,x + 1.571) + 1.143sin(4.631\,x - 1.571)\left(0.3\cos(x)\right)dx$

$= \frac{1}{2\pi}(998.2)(0.5)(\,81.046)(0.8)(0.18)(0.3\,)\int_0^{2\pi}((\,1.157sin(0.2497\,x + 1.571) + 1.143sin(4.631\,x - 1.571)(\cos(x))dx$

$= 278.114\int_0^{2\pi} 1.157sin(0.2497\,x + 1.571)\left(\cos(x)\right) + (1.143sin(4.631\,x - 1.571))\left(\cos(x)\right)dx$

$= 278.114\int_0^{2\pi \frac{1}{2}} 1.157((\sin(1.2497\,\mathrm{x} + 1.571) + (\sin(-0.7503\,x + 1.571))dx + \int_0^{2\pi \frac{1}{2}} 1.143((\sin(3.631\,\mathrm{x} - 1.571) + (\sin(5.631\,x - 1.571))dx$

$= (278.114)(0.13)$

$= 13.268\,Nm$

Sudu 2

$T_D = \frac{1}{2\pi}\int_0^{2\pi} (998.2)(0.5)(81.046)(0.8)(0.18)(1.157sin(0.2497\,(x + \frac{2\pi}{3}) + 1.571) + 1.143sin(4.631\,(x + \frac{2\pi}{3}) - 1.571)\left(0.3\cos\left(x + \frac{2\pi}{3}\right)\right)dx$

$= 278.114\int_0^{2\pi} (1.157\sin(0.2497\mathrm{x} + 0.173\pi) + 1.143\sin(4.631\mathrm{x} + 3.087\pi)\cos(\mathrm{x} + \frac{2\pi}{3})dx$

$$= 278.114 \int_0^{2\pi} 1.157(\sin(0.2497x + 0.173\pi)\cos(x + \frac{2\pi}{3}) + 1.143\sin(4.631x + 3.087\pi)\cos(x + \frac{2\pi}{3})dx$$

$$= 278.114 \int_0^{2\pi} \frac{1}{2} 1.157((\sin(1.2497\,x + 0.833\pi) + (\sin(-0.75x - 0.487\pi))dx + \int_0^{2\pi} \frac{1}{2} 1.143((\sin(3.631\,x + 2.421\pi) + (\sin(5.631\,x + 3.753\pi))dx$$

$$= (278.114)(0.681)$$

$$= 189.396\text{Nm}$$

Sudu 3

$$T_D = \frac{1}{2\pi} \int_0^{2\pi} (998.2)(0.5)(81.046)(0.8)(0.1)(1.157sin(0.2497\,(x + \frac{4\pi}{3}) + 1.571) + 1.143sin(4.631\,(x + \frac{4\pi}{3}) - 1.571\left(0.3\cos\left(x + \frac{4\pi}{3}\right)\right)dx$$

$$= 278.114 \int_0^{2\pi} (1.157\sin(0.2497x + 0.339\pi) + 1.143\sin(4.631x + 9.268\pi)\cos(x + \frac{4\pi}{3})dx$$

$$= 278.114 \int_0^{2\pi} 1.157\sin(0.2497x + 0.339\pi)\cos(x + \frac{4\pi}{3}) + 1.143\sin(4.631x + 9.268\pi)\cos(x + \frac{4\pi}{3})dx$$

$$= 278.114 \int_0^{2\pi} \frac{1}{2} 1.157((\sin(1.2497\,x + 1.669\pi) + (\sin(-0.75x - 0.994\pi))dx + \int_0^{2\pi} \frac{1}{2} 1.143((\sin(3.631\,x + 7.935\pi) + (\sin(5.631\,x + 10.601\pi))dx$$

$$= (278.114)(0.647)$$

$$= 179.94\text{Nm}$$

T_D total = (T_{Dsudu1}+ $T_{Dsudu2+}$ T_{Dsudu3})

= $13.268 + 189.396 + 179.94$

$= 382.604\ Nm$

T_{TOTAL} =($T_L$total+$T_D$total)

=$(406.65) - (382.604)$

=24.05 Nm

Kecepatan 3 m/s

Dik:

U	**= 3 m/s**	**ω**	**= 46.246 rad/s**	$\mathbf{C_{L1}}$	$= 1.265\ sin\ (2.124x)$
H	**= 0.8 m**	**ρ**	**= 998.2 kg/m^3**	$\mathbf{C_{L2}}$	$= 1.745 \sin\ (2.417x)$
c	**= 0.18 m**	**R**	**= 0.3 m**	$\mathbf{C_D}$	**= 1.171sin(0.2409x+1.571) + 1.157sin(4.639x-1.571)**

Torsi Lift

Sudu 1

$$T_{L1} = \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \rho(0.5)(W)^2 A.\,\mathrm{CL1}.\left(R\sin(x)\right)dx\right)$$

$$= \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)\left(U + (-\omega R)\right)^2 (H)(c)\left(1.265\,\sin(2.124x)\right)\left(0.3\,\sin(x)\right)dx\right)$$

$$= \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)(3 + ((-46.246)(0.3))^2(\,0.8)(\,0.18)\left(1.265\,\sin(2.124x)\right)\left(0.3\,\sin(x)\right)dx\right)$$

$$= \frac{1}{\pi}(499.1\,)(\,118.244)(\,0.8)(\,0.18)\,(1.265)(0.3)\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \sin(x)\sin(2.124x)dx$$

$$= (1026.58)(1.186)$$

$$= 1217.52\ Nm$$

$$T_{L2} = \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \rho(0.5)(W)^2 A.\,CL2.\,(R\sin(x))dx\right)$$

$$= \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} 998.2(0.5)\big(U + (-\omega R)\big)^2 (H)(c)\big(1.745\sin(2.417x)\big)\big(0.3\sin(x)\big)dx\right)$$

$$= \frac{1}{\pi}(499.1)(118.244)(0.8)(0.18)(1.745)(0.3)\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \sin(2.417x)\sin(x)dx\right)$$

$$= (1416.11)(-0.205)$$

$$= -290.33 \text{ Nm}$$

Sudu 2

$$T_{L1} = \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)(3 + ((-46.246)(0.3))^2 (H)(c)\left(1.265\sin\left(2.124\left(x + \frac{2\pi}{3}\right)\right)\right)\big(0.3\sin(x + 2\pi/3)\big)dx\right)$$

$$= (1026.58)\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \sin(x+2\pi/3)\sin(2.124x+1.416\pi)dx$$

$$= (1026.58)\ (-0.314)$$

$$= -322.35 \text{ Nm}$$

$$T_{L2} = \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} 998.2(0.5)(3 + ((-46.246)(0.3))^2(H)(c)\left(1.745\sin(2.417(x + 2\pi/3)\right)\left(0.3\sin(x + 2\pi/3)\right)dx\right)$$

$$= (1416.11)\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \sin(2.435x + 1.611\pi)\sin\left((x+2\pi/3)\right)dx\right)$$

$$= (1416.11)\ (0.3)$$

$$= 424.833\ \text{Nm}$$

Sudu 3

$$T_{L1} = \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)(3 + ((-46.246)(0.3))^2(H)(c)\left(1.265\sin\left(2.124(x + \frac{4\pi}{3}\right)\right)\left(0.3\sin(x + 4\pi/3)\right)dx\right)$$

$$=(1026.58)\ \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \sin(x+4\pi/3)\sin(2.124x+2.832\pi)dx$$

$$= (1026.58)\ (0.2)$$

$$= 205.316\ Nm$$

$$T_{L2} = \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} 998.2(0.5)(3 + ((-56.897)(0.3))^2(H)(c)\big(1.745\sin(2.417(x + 4\pi/3)\big)\big(0.3\sin(x + 4\pi/3)\big)dx\right)$$

$$=(1416.11)\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \sin(2.417x + 3.223\pi)\sin\big((x+4\pi/3)\big)dx\right)$$

$$=(1416.11)\ (-0.089)$$

$$= -126.04\ Nm$$

T_L total = $((T_{L1sudu1} + T_{L2sudu1}) + (T_{L1sudu2} + T_{L2sudu2}) + (T_{L1sudu3} + T_{L2sudu3}))/2$

$$= \frac{(1217.52-290.33)+(-322.35+424.833)+(205.316-126.04)}{2})$$

$$= 554.474\ Nm$$

Torsi Drag

Sudu 1

$$T_D = \frac{1}{2\pi}\int_0^{2\pi} \rho(0.5)(W)^2 A.\,\mathrm{CD}.\left(R\cos(x)\right)dxdx$$

$$= \frac{1}{2\pi}\int_0^{2\pi} (998.2)(0.5)(3+(-46.246)(0.3))^2(H)(c)(1.171\sin(0.2409x+1.571) + 1.157\sin(4.639x-1.571))\left(0.3\cos(x)\right)dx$$

$$= \frac{1}{2\pi}(998.2)(0.5)(118.244)(0.8)(0.18)(0.3)\int_0^{2\pi}((1.171\,sin(0.2409\,x+1.571) + 1.157sin(4.639x-1.571)(\cos(x))dx$$

$$= (405.967)\int_0^{2\pi} 1.171sin(0.2409\,x+1.571)\left(\cos(x)\right) + (1.157sin(4.639\,x-1.571))\left(\cos(x)\right)dx$$

$$= (405.967)\int_0^{2\pi}\frac{1}{2}1.171((\sin(1.2409\,x+1.571)+(\sin(-0.7591\,x+1.571))dx + \int_0^{2\pi}\frac{1}{2}1.157((\sin(3.639\,x-1.571)+(\sin(5.639x-1.571))dx$$

$$= (405.967)(0.151)$$

$$= 61.301\,Nm$$

Sudu 2

$$T_D = \frac{1}{2\pi}\int_0^{2\pi} \rho(0.5)(W)^2 A\ (1.171\sin\left(0.2409\left(x+\frac{2\pi}{3}\right)+1.571\right) + 1.157\sin\left(4.639\left(x+\frac{2\pi}{3}\right)-1.571\right))\left(0.3\cos\left(\left(x+\frac{2\pi}{3}\right)\right)\right)dx$$

$$= 405.967\int_0^{2\pi}(1.171\sin(0.2409x+0.167\pi)+1.157\sin(4.639x+3.086\pi)\cos(x+\frac{2\pi}{3})dx$$

$$= 405.967 \int_0^{2\pi} 1.171(\sin(0.2409x + 0.167\pi)\cos\left(x + \frac{2\pi}{3}\right) + 1.157\sin(4.639x + 3.086\pi)\cos(x + \frac{2\pi}{3})dx$$

$$= 405.967 \int_0^{2\pi} \frac{1}{2} 1.171((\sin(1.2409\,x + 0.833\pi) + (\sin(-0.75x - 0.499\pi))dx + \int_0^{2\pi} \frac{1}{2} 1.157((\sin(3.639\,x + 2.42\pi) + (\sin(5.639\,x + 3.752\pi))dx$$

$$= (405.967)(0.751)$$

$$= 304.881 \text{ Nm}$$

Sudu 3

$$T_D = \frac{1}{2\pi} \int_0^{2\pi} \rho(0.5)(W)^2 A\ (1.171\sin\left(0.2409\left(x + \frac{4\pi}{3}\right) + 1.571\right) + 1.157\sin\left(4.639\left(x + \frac{4\pi}{3}\right) - 1.571\right))\left(0.3\cos\left(\left(x + \frac{4\pi}{3}\right)\right)\right)dx$$

$$= 405.967 \int_0^{2\pi} (1.171\sin(0.2409x + 0.327\pi) + 1.157\sin(4.639x + 6.179\pi)\cos(x + \frac{4\pi}{3})dx$$

$$= 405.967 \int_0^{2\pi} 1.171(\sin(0.2409x + 0.327\pi)\cos\left(x + \frac{4\pi}{3}\right) + 1.157\sin(4.639x + 6.179\pi)\cos(x + \frac{4\pi}{3})dx$$

$$= 405.967 \int_0^{2\pi} \frac{1}{2} 1.171((\sin(1.2409\,x + 1.66\pi) + (\sin(-0.75x - 1.006\pi))dx + \int_0^{2\pi} \frac{1}{2} 1.157((\sin(3.639\,x + 4.846\pi) + (\sin(5.639\,x + 7.512\pi))dx$$

$$= (405.967)(0.385)$$

$$= 156.297\text{Nm}$$

T_D total = (T_{Dsudu1}+ $T_{Dsudu2+}$ T_{Dsudu3})

=61.301 + 304.881 + 156.297

=522.479 Nm

T_{TOTAL} =($T_L$total+$T_D$total)

=(554.4745) −(522.479)

=31.996 Nm

Kecepatan 3.5 m/s

Dik:

U =3.5 m/s **ω = 54.755 rad/s** **C_{L1} = 1.277 sin (2.093x)**

H = 0.8 m **ρ = 998.2 kg/m^3** **C_{L2} =1.698 sin(2.421x)**

c = 0.18 m **R = 0.3 m** **C_D = 1.173 sin(0.358x+1.571) + 1.159 sin(4.522x-1.571)**

Torsi Lift

Sudu 1

$$T_{L1} = \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \rho(0.5)(W)^2 A.\,\mathrm{CL1}.\left(R\sin(x)\right)dx\right)$$

$$= \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)\left(U+(-\omega R)\right)^2(H)(c)\left(1.277\sin(2.093x)\right)\left(0.3\sin(x)\right)dx\right)$$

$$= \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)(3.5+((-54.755\,)(0.3))^2(0.8)(0.18)\left(1.277\sin(2.093x)\right)\left(0.3\sin(x)\right)dx\right)$$

$$= \frac{1}{\pi}.998.2(0.5)(3.5+((-54.755\,)(0.3))^2(0.8)(0.18)(1.277)(0.3)c\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}\sin(x)\sin(2.093x)dx$$

$$= \frac{1}{\pi}(499.1\,)(\,167.107)\,(0.8)(0.18)(1.277)(0.3)\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}\sin(x)\sin(2.093x)dx$$

$= (1464.56)(1.2)$

$= 1757.47\ Nm$

$T_{L2} = \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \rho(0.5)(W)^2 A.\,\mathrm{CL2}.\left(R\sin(x)\right)dx\right)$

$= \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} 998.2(0.5)\left(U + (-\omega R)\right)^2 (H)(c)\left(1.698\sin(2.421x)\right)\left(0.3\sin(x)\right)dx\right)$

$= \frac{1}{\pi}(499.1\ )(\ 167.107)(0.8)(0.18)(1.698)(0.3)\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \sin(2.421x)\sin(x)dx\right)$

$=(1947.39)\ \ (-0.194)$

$= -377.8$ Nm

Sudu 2

$T_{L1} = \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)(3.5 + ((-54.755\ )(0.3))^2 (H)(c)\left(1.277\sin\left(2.093\ (x + \frac{2\pi}{3})\right)\right)\left(0.3\sin(x + 2\pi/3)\right)dx\right)$

$=(1464.56)(-0.283)$

$= -414.5\ Nm$

$$T_{L2} = \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} 998.2(0.5)(3.5 + ((-54.755\ )(0.3))^2(H)(c)\big(1.698\sin(2.421(x + 2\pi/3)\big)\big(0.3\ \sin(x + 2\pi/3)\big)dx\right)$$

$$=(1947.39)\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \sin(2.421x + 1.614\pi)\sin\big((x+2\pi/3)\big)dx\right)$$

$$= \ (1947.39)\ (0.35)$$

$$= 681.5\ Nm$$

Sudu 3

$$T_{L1} = \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)(3.5 + ((-54.755\ )(0.3))^2(0.8)(0.18)\left(1.277\sin\left(2.093(x + \frac{4\pi}{3}\right)\right)\big(0.3\ \sin(x + 4\pi/3)\big)dx\right)$$

$$=(1464.56)\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}\sin(x+4\pi/3)\sin(2.093x+2.790\boldsymbol{\pi})dx$$

$$= (1464.56)(\ 0.173)$$

$$= 253.36\ Nm$$

$$T_{L2} = \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} 998.2(0.5)(3.5 + ((-54.755\ )(0.3))^2(0.8)(0.18)\big(1.698\sin(2.421(x+4\pi/3)\big)\big(0.3\sin(x+4\pi/3)\big)dx\right)$$

$$=(1947.39)\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \sin(2.421x+3.228\pi)\sin\big((x+4\pi/3)\big)dx\right)$$

$$=(1947.39)(-0.074)$$

$$=-144.11\ Nm$$

T_L total $= ((T_{L1sudu1} + T_{L2sudu1}) + (T_{L1sudu2} + T_{L2sudu2}) + (T_{L1sudu3} + T_{L2sudu3}))/2$

$$= \frac{(1757.47-377.8)+(-414.5+681.5)+(253.36-144.11)}{2}$$

$$= 877.96\ Nm$$

Torsi Drag

Sudu 1

$T_D = \frac{1}{2\pi}\int_0^{2\pi} \rho(0.5)(W)^2 A.\,\mathrm{CD}.\left(R\cos(x)\right)dxdx$

$= \frac{1}{2\pi}\int_0^{2\pi}(998.2)(0.5)(3.5 + ((-54.755\,)(0.3))^2(0.8)(0.18)(1.173\sin(0.358\mathrm{x} + 1.571) + 1.159\sin(4.522\mathrm{x} - 1.571)\left(0.3\cos(x)\right)dx$

$= \frac{1}{2\pi}(998.2)(0.5)(\,167.107)(0.8)(0.18)(0.3\,)\int_0^{2\pi}((\,1.173\,sin(0.358x + 1.571) + 1.159sin(4.522x - 1.571)(\cos(x))dx$

$= (573.438)\int_0^{2\pi} 1.173sin(0.358x + 1.571)\left(\cos(x)\right) + (1.159sin(4.522\,x - 1.571))\left(\cos(x)\right)dx$

$= (573.438)\int_0^{2\pi}\frac{1}{2}1.173((\sin(1.358\,\mathrm{x} + 1.571) + (\sin(-0.642x + 1.571))dx + \int_0^{2\pi}\frac{1}{2}1.159((\sin(3.522\,\mathrm{x} - 1.571) + (\sin(5.522x - 1.571))dx$

$= (573.438)(-0.254)$

$= -145.653$

Sudu 2

$T_D = \frac{1}{2\pi}\int_0^{2\pi}(998.2)(0.5)(167.107)(0.8)(0.18)(1.173\sin(0.358(\mathrm{x} + \frac{2\pi}{3}) + 1.571) + 1.159\sin(4.522(\mathrm{x} + \frac{2\pi}{3}) - 1.571)\left(0.3\cos\left((\mathrm{x} + \frac{2\pi}{3})\right)\right)dx$

$= 573.438\int_0^{2\pi}(1.173\sin(0.358(\mathrm{x} + \frac{2\pi}{3}) + 1.571) + 1.159\sin(4.522(\mathrm{x} + \frac{2\pi}{3}) - 1.571)\cos(\mathrm{x} + \frac{2\pi}{3})dx$

$$= 573.438 \int_0^{2\pi} 1.173(\sin(0.358x + 0.245\pi)\cos\left(x + \frac{2\pi}{3}\right) + 1.159\ \sin(4.522x + 3.008\pi)\cos(x + \frac{2\pi}{3})dx$$

$$= 573.438 \int_0^{2\pi} \frac{1}{2} 1.173((\sin(1.358\,x + 0.912\pi) + (\sin(-0.642x - 0.421\pi))dx + \int_0^{2\pi} \frac{1}{2} 1.159\ ((\sin(3.522\,x + 2.34\pi) + (\sin(5.522\,x + 3.674\pi))dx$$

$$= (573.438)(-0.003)$$

$$= -1.72 \text{ Nm}$$

Sudu 3

$$T_D = \frac{1}{2\pi} \int_0^{2\pi} (998.2)(0.5)(167.107)(H)(c)(1.173\sin\left(0.358(x + \frac{4\pi}{3}) + 1.571\right) + \ 1.159\sin\left(4.522(x + \frac{4\pi}{3}) - 1.571\right))\left(0.3\cos\left(x + \frac{4\pi}{3}\right)\right)dx$$

$$= 573.438 \int_0^{2\pi} (1.173\sin(0.358(x + \frac{4\pi}{3}) + 1.571) \ + \ 1.159\ \sin(4.522(x + \frac{4\pi}{3}) - 1.571)\cos(x + \frac{4\pi}{3})dx$$

$$= 573.438 \int_0^{2\pi} 1.173(\sin(0.358x + 0.484\pi)\cos\left(x + \frac{4\pi}{3}\right) + 1.159\ \sin(4.522x + 6.029\pi)\cos(x + \frac{4\pi}{3})dx$$

$$= 573.438 \int_0^{2\pi} \frac{1}{2} 1.173((\sin(1.358\,x + 1.817\pi) + (\sin(-0.642x - 0.849))dx + \int_0^{2\pi} \frac{1}{2} 1.159\ ((\sin(3.522\,x + 4.696\pi) + (\sin(5.522\,x + 7.362\pi))dx$$

$$= (573.438)(1.729)$$

$$= 991.474 \text{ Nm}$$

T_D total = (T_{Dsudu1}+ $T_{Dsudu2+}$ T_{Dsudu3})

= $-145.653 - 1.72 + 991.474$

=844.101 Nm

T_{TOTAL} =($T_L$total +$T_D$total)

=$(877.96) - (844.101)$

=33.859 Nm

Kecepatan 4 m/s

Dik:

U	**=4 m/s**	**ω**	**$= -63.263$ rad/s**	C_{L1}	**$= 1.102 \sin(2.27x)$**
H	**$= 0.8636$ m**	**ρ**	**= 998.2 kg/m^3**	C_{L2}	**=1.683 sin (2.432x)**
c	**$= 0.1778$ m**	**R**	**= 0.3 m**	C_D	**= 1.161sin(0.27x+1.571) + 1.136sin(4.1x-1.571)**

Torsi Lift

Sudu 1

$$T_{L1} = \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \rho(0.5)(W)^2 A.\,CL1.\,(R\sin(x))dx\right)$$

$$= \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)\big(U + (-\omega R)\big)^2 (H)(c)\big(1.102\sin(2.27x)\big)\big(0.3\sin(x)\big)dx\right)$$

$$= \frac{1}{\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)(4 + ((-63.263)(0.3))^2(0.8)(0.18)\big(1.102\sin(2.27x)\big)\big(0.3\sin(x)\big)dx\right)$$

$$= \frac{1}{\pi}.\,998.2(0.5)(4 + ((-63.263\ \ )(0.3))^2(0.8)(0.18)(1.102)(0.3)\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \sin(x)\sin(2.27x)dx$$

$$= \frac{1}{\pi}\,(499.1\ )(\ 233.57)(0.8)(0.18)\ (1.102)(0.3)\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \sin(x)\sin(2.27x)dx$$

$= (1766.526)(0.99)$

$=1748.86\ Nm$

$T_{L2} = \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \rho(0.5)(W)^2 A.\,\mathrm{CL2}.\left(R\sin(x)\right)dx\right)$

$= \frac{1}{\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} 998.2(0.5)\left(U + (-\omega R)\right)^2 (H)(c)(1.683\sin(2.432\mathrm{x}))\left(0.3\sin(x)\right)dx\right)$

$= \frac{1}{\pi}(499.1\ )(\ 233.57)\ (0.8)(0.18)(1.683)(0.3)\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \sin(2.432x)\sin(x)dx\right)$

$= (2697.88)(-0.164)$

$= -442.453\ Nm$

Sudu 2

$T_{L1} = \frac{1}{2\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)(4 + ((-95.203\ \ )(0.3))^2(0.8)(0.18)\left(1.102\sin\left(2.27\ (x + \frac{2\pi}{3})\right)\right)\left(0.3\sin(x + 2\pi/3)\right)dx\right)$

$= (1766.526)(-0.6)$

$= -1059.92\ Nm$

$$T_{L2} = \frac{1}{2\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} 998.2(0.5)(4 + ((-95.203\ \ )(0.3))^2(0.8)(0.18)\left(1.683\sin(2.432(x + 2\pi/3)\right)\left(0.3\sin(x + 2\pi/3)\right)dx\right)$$

$$=(2697.88)\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \sin(2.432x + 1.621\pi)\sin\left((x+2\pi/3)\right)dx\right)$$

$$=(2697.88)(\ 0.33)$$

$$= 890.3\ \ Nm$$

Sudu 3

$$T_{L1} = \frac{1}{2\pi}\left(\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} 998.2(0.5)(4 + ((-95.203\ \ )(0.3))^2(0.8)(0.18)\left(1.102\sin\left(2.27(x + \frac{4\pi}{3}\right)\right)\left(0.3\sin(x + 4\pi/3)\right)dx\right)$$

$$=(1766.526)\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}\sin(x+4\pi/3)\sin(2.27x+3.026\pi)dx$$

$$= (1766.526)\ \ (0.52)$$

$$= 918.5\ Nm$$

$$T_{L2} = \frac{1}{2\pi}\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} 998.2(0.5)(4 + ((-95.203\ \ )(0.3))^2(0.8)(0.18)\left(1.683\sin(2.432(x + 4\pi/3)\right)\left(0.3\sin(x + 4\pi/3)\right)dx\right)$$

$$=(2697.88)\left(\int_{\frac{\pi}{2}}^{\frac{3\pi}{2}} \sin(2.432x + 3.242\pi)\sin\left((x+4\pi/3)\right)dx\right)$$

$$=(2697.88)(-0.034)$$

$$=-91.728\ Nm$$

T_L total = $(T_{L1sudu1} + T_{L2sudu1}) + (T_{L1sudu2} + T_{L2sudu2}) + (T_{L1sudu3} + T_{L2sudu3})$

$$= \frac{(1748.86-442.453)+(-1059.92+890.3)+(918.5-91.728)}{2}$$

$$= 981.779\ Nm$$

Torsi Drag

Sudu 1

$$T_D = \frac{1}{2\pi}\int_0^{2\pi} \rho(0.5)(W)^2 A.\,\mathrm{CD}.\left(R\cos(x)\right)dxdx$$

$$T_D = \frac{1}{2\pi}\int_0^{2\pi} (998.2)(0.5)(4+((-63.263\ \ )(0.3))^2(0.8)(0.18)\ (1.161\sin(0.27x+1.571)+\ 1.136\sin(4.1x-1.571))\left(0.3\cos(x)\right)dx$$

$$T_D = \frac{1}{2\pi}(998.2)(0.5)(233.57)(0.8)(0.18)(0.3\ )\ \int_0^{2\pi}(1.161\sin(0.27x+1.571)\ +\ 1.136\sin(4.1x-1.571))(\cos(x))dx$$

$$=(801.509)\ \int_0^{2\pi}(1.161\sin(0.27x+1.571)(\cos(x))\ +\ 1.136\sin(4.1x-1.571))(\cos(x))dx$$

$$=(801.509)\int_0^{2\pi}\frac{1}{2}1.161((\sin(1.27\,x+1.571)+(\sin(-0.73\,x+1.571))dx+\int_0^{2\pi}\frac{1}{2}1.136((\sin(3.1\,x-1.571)+(\sin(5.1\,x-1.571))dx$$

$$=(801.509)\int_0^{2\pi}\frac{1}{2}1.161((\sin(1.27\,x+0.00643\pi)+(\sin(-0.73\,x+0.00643\pi))dx+\int_0^{2\pi}\frac{1}{2}1.136((\sin(3.1\,x-0.00643\pi)+(\sin(5.1x-0.00643\pi))dx$$

$$=(801.509)(-0.334)$$

$$=-267.704\ Nm$$

Sudu 2

$$T_D = \frac{1}{2\pi}\int_0^{2\pi} (998.2)(0.5)(4+((-63.263\ \ )(0.3))^2(H)(c)\ (1.161\sin\left(0.27(x+\tfrac{2\pi}{3})+1.571\right)+\ 1.136\sin\left(4.1(x+\tfrac{2\pi}{3})-1.571\right)\left(0.3\cos\left(\left(x+x+\tfrac{2\pi}{3}\right)\right)\right)dx$$

$$=(801.509)\int_0^{2\pi}(1.161\sin(0.27x+0.18\pi)+\ 1.136\sin(4.1x+2.73\pi)\cos(x+\frac{2\pi}{3})dx$$

$$= (801.509) \int_0^{2\pi} 1.161(\sin(0.27x + 0.18\pi)\cos(x + \frac{2\pi}{3}) + 1.136\sin(4.1x + 2.73\pi)\cos(x + \frac{2\pi}{3})dx$$

$$= (801.509) \int_0^{2\pi} \frac{1}{2} 1.161((\sin(1.27\,x + 0.84\pi) + (\sin(-0.73x - 0.48\pi))dx + \int_0^{2\pi} \frac{1}{2} 1.136((\sin(3.1\,x + 2.07\pi) + (\sin(5.1\,x + 3.39\pi))dx$$

$$= (801.509)\ (0.488)$$

$$= 391.136 \text{ Nm}$$

Sudu 3

$$T_D = \frac{1}{2\pi} \int_0^{2\pi} (998.2)(0.5)(4 + ((-63.263\ \ )(0.3))^2(H)(c)(1.161\sin\left(0.27(x + \frac{4\pi}{3}) + 1.571\right) + 1.136\sin\left(4.1(x + \frac{4\pi}{3}) - 1.571\right)\left(0.3\cos\left(x + \frac{4\pi}{3}\right)\right)dx$$

$$= (801.509) \int_0^{2\pi} (1.161\ \sin(0.27x + 0.366\pi) + 1.136\sin(4.1x + 5.46\pi)\cos(x + \frac{4\pi}{3})dx$$

$$= (801.509) \int_0^{2\pi} (1.161\ \sin(0.27x + 0.366\pi)\cos(x + \frac{4\pi}{3}) + (\ 1.136\sin(4.1x + 5.46\pi)\cos(x + \frac{4\pi}{3})dx$$

$$= (801.509) \int_0^{2\pi} \frac{1}{2} 1.161((\sin(1.27x + 1.699\pi) + (\sin(-0.73x - 0.964\pi))dx + \int_0^{2\pi} \frac{1}{2} 1.136((\sin(3.1\,x + 4.13\pi) + (\sin(5.1\,x + 6.79\pi))dx$$

$$= (801.509)\ (1.01)$$

$$= 809.524 \text{ Nm}$$

T_D total = (T_{Dsudu1}+ $T_{Dsudu2+}$ T_{Dsudu3})

= $-267.704 + 391.136 + 809.524$

=$932.956\ Nm$

T_{TOTAL} =($T_L$total + $T_D$total)

=$(981.779) - (932.956)$

=48.823 Nm

2.2 Perhitungan Daya Turbin

Rumus: $P_t = T.\omega$

U = 2 m/s ω = 29.23 Rad/s T = 12.084 *Nm*

P_t = T. ω

P_t = 12.084. 29.23

P_t = 353.215Watt

U = 2.5 m/s ω = 37.738 Rad/s T = 24.05 Nm

P_t = T. ω

P_t = 24.05. 37.738

P_t = 907.6 Watt

U = 3 m/s ω = 46.246Rad/s T = 31.996 *Nm*

P_t = T. ω

P_t = 31.996. 46.246

P_t = 1479.687 Watt

U = 3.5 m/s ω = 54.755 Rad/s T = 33.859 Nm

P_t = T. ω

P_t = 33.859 . 54.755

P_t = 1853.95 Watt

U = 4 m/s ω = 63.263 Rad/s T = 48.823 *Nm*

P_t = T. ω

P_t = 48.823. 63.263

P_t = 3088.689 Watt

2.3 Perhitungan Daya Hidrolis

Rumus : $P_h = \rho\, g\, Q\, H$

$= \rho\, g\, (A\, U)(\frac{U^2}{2.g})$

$= \rho\, (A)(\frac{U^3}{2})$

$= \rho\, (H)(D)(\frac{U^3}{2})$

U = 2 m/s H = 0.8 m D= 0.6 ρ = 998.2 kg/m^3

$P_h = \rho\, (H)(D)(\frac{U^3}{2})$

$P_h = (998.2)\,(0.8)(\,0.6)(\frac{2^3}{2})$

P_h = 1916.544 Watt

U = 2.5 m/sH = 0.8 m D= 0.6 ρ = 998.2 kg/m^3

$P_h = \rho\, (H)(D)(\frac{U^3}{2})$

$P_h = (998.2)\,(0.8)(\,0.6)\,(\frac{2.5^3}{2})$

P_h = 3743.25 Watt

U = 3 m/s H = 0.8 m D= 0.6 ρ = 998.2 kg/m^3

$P_h = \rho\, (H)(D)(\frac{U^3}{2})$

$P_h = (998.2)\,(0.8)(\,0.6)\,(\frac{3^3}{2.})$

P_h = 6468.336 Watt

U = 3.5 m/s H = 0.8 m D= 0.6 ρ = 998.2 kg/m^3

$P_h = \rho\, (H)(D)(\frac{U^3}{2})$

$P_h = (998.2)\,(0.8)(\,0.6)\,(\frac{3.5^3}{2.})$

P_h = 10271.478 Watt

U = 4 m/s H = 0.8 m D= 0.6 ρ = 998.2 kg/m^3

$P_h = \rho\, (H)(D)(\frac{U^3}{2})$

$P_h = (998.2)\,(0.8)(\,0.6)\,(\frac{4^3}{2})$

P_h = 15332.352 Watt

2.4 Perhitungan Efisiensi Turbin (ηT)

Rumus : $\eta T = \frac{P_t}{P_h} \times 100\%$

1. Kecepatan aliran 2 m/s

   P_T = 353.215 Watt P_H = 1916.544 Watt

   $\eta T = \frac{P_t}{P_h} \times 100\%$

   $\eta T = \frac{353.215 \text{ Watt}}{1916.544 \text{ Watt}} \times 100\%$

   ηT = 18.4 %

2. Kecepatan aliran 2.5 m/s

   P_T = 1658.396 Watt P_H = 3743.25 Watt

   $\eta T = \frac{P_t}{P_h} \times 100\%$

   $\eta T = \frac{907.6 \text{ Watt}}{3743.25 \text{ Watt}} \times 100\%$

   ηT = 24.2 %

3. Kecepatan aliran 3 m/s

   P_T = 2931.904 Watt P_H = 6468.336 Watt

   $\eta T = \frac{P_t}{P_h} \times 100\%$

   $\eta T = \frac{1479.687\ \text{Watt}}{6468.336\ \text{Watt}} \times 100\%$

   ηT = 22.9 %

4. Kecepatan aliran 3.5 m/s

   P_T = 3566.795 Watt P_H= 10271.478 Watt

   $\eta T = \frac{P_t}{P_h} \times 100\%$

   $\eta T = \frac{1853.95\text{Watt}}{10271.478\ \text{Watt}} \times 100\%$

   ηT = 18.049 %

5. Kecepatan aliran 4 m/s

   P_T = 5530.198 Watt P_H= 15332.352 Watt

   $\eta T = \frac{P_t}{P_h} \times 100\%$

   $\eta T = \frac{3088.689\text{Watt}}{15332.352\ \text{Watt}} \times 100\%$

   ηT = 20.145 %