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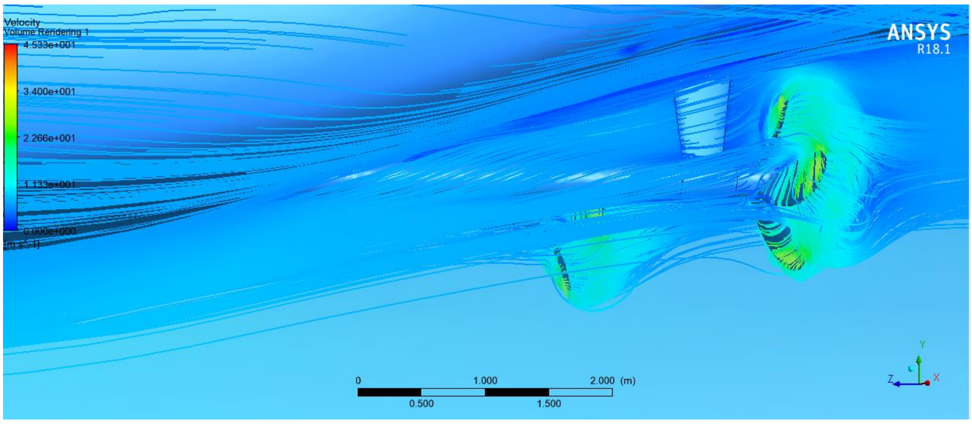
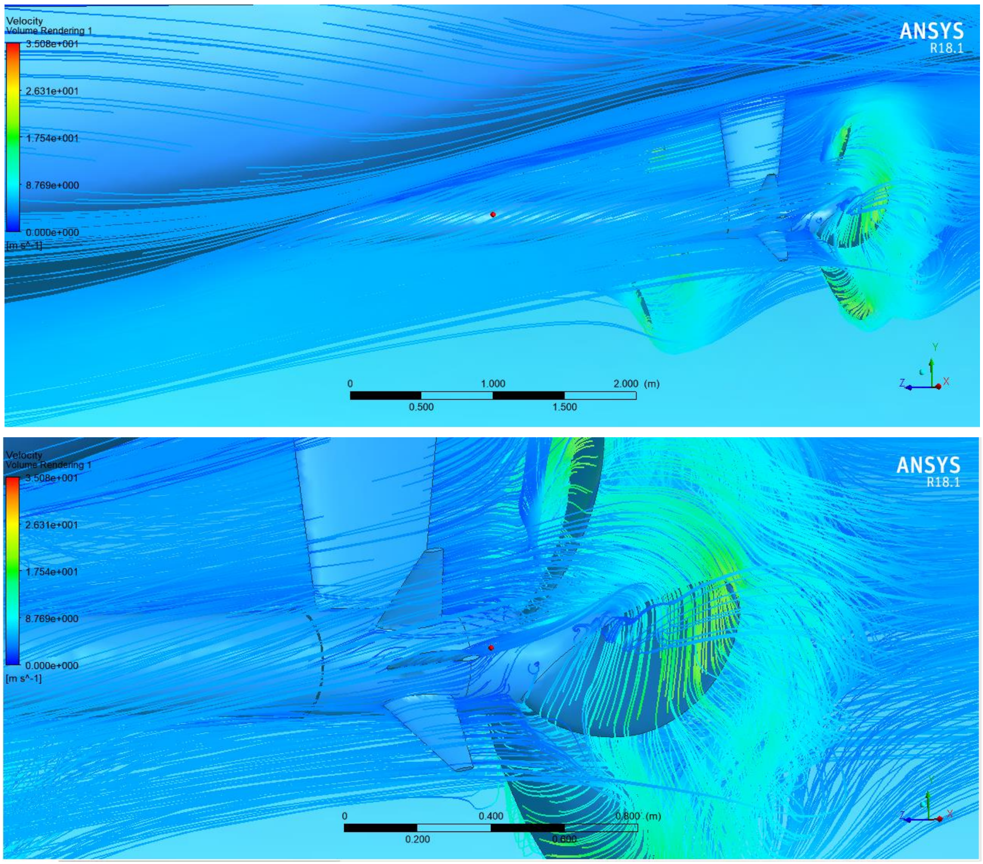
LAMPIRAN

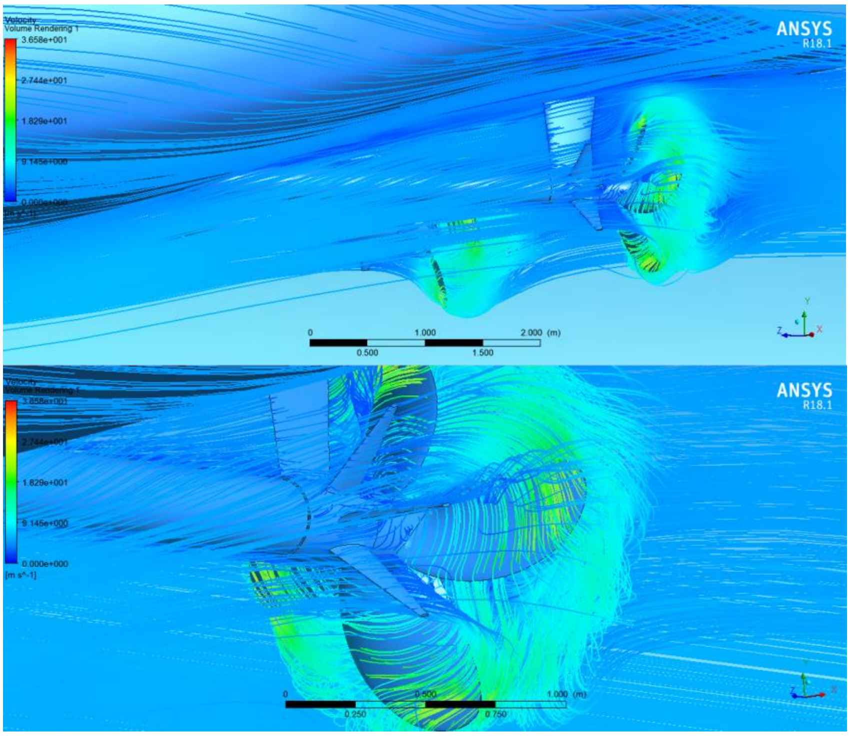
Lampiran 1. Hasil Simulasi dengan Ansys CFX 8.1



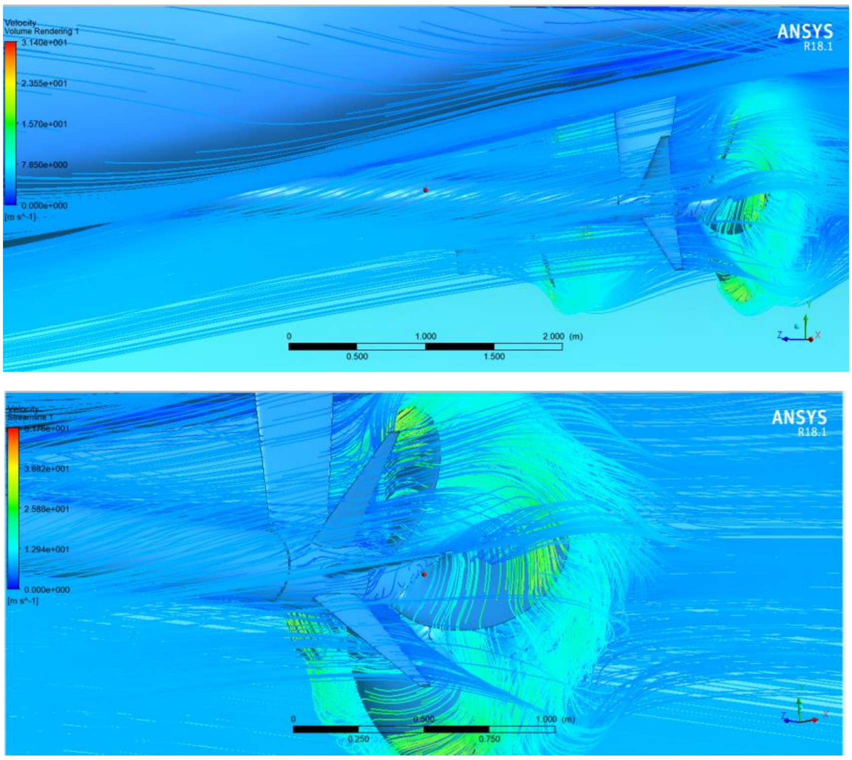
Gambar 1. Visualisasi simulasi lambung dan *propeller* tanpa PSS pada Ansys CFX 8.1



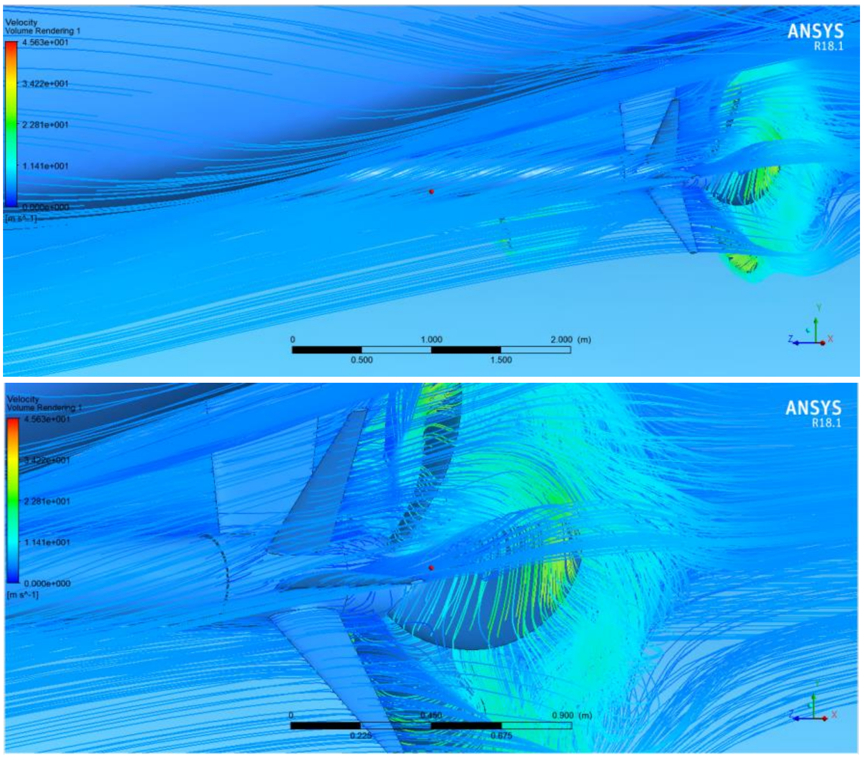
Gambar 2. Visualisasi simulasi lambung kapal dan *propeller* dengan PSS (DS = ½ DP) pada Ansys CFX 8.1



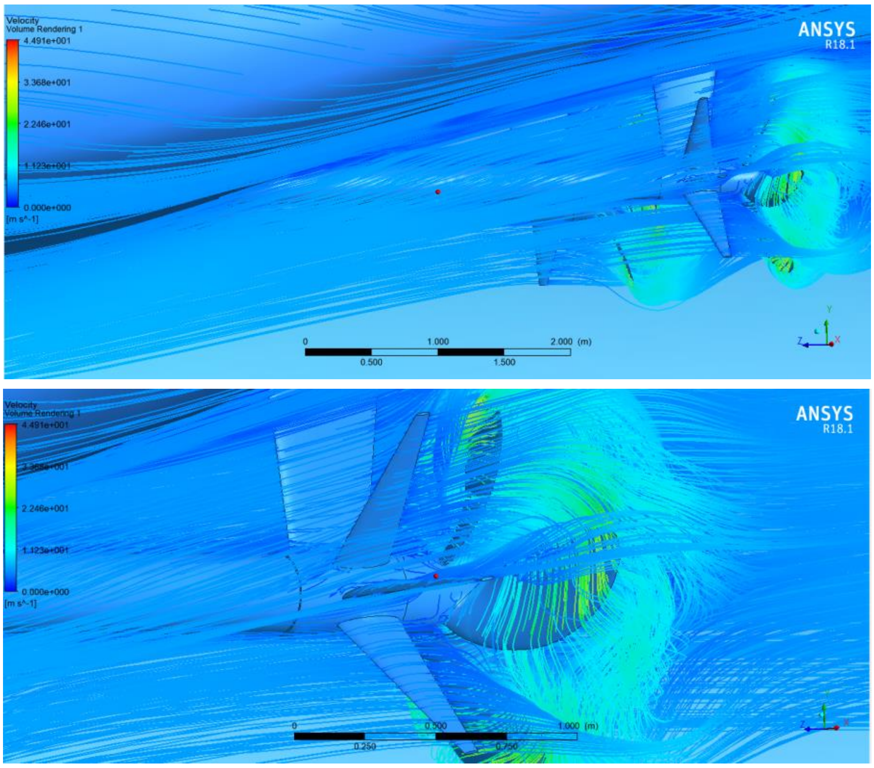
Gambar 3. Visualisasi simulasi lambung dan *propeller* dengan
PSS (DS = ¾ DP) pada Ansys CFX 8.1



Gambar 4. Visualisasi simulasi lambung dan *propeller* dengan
PSS (DS = DP) pada Ansys CFX 8.1

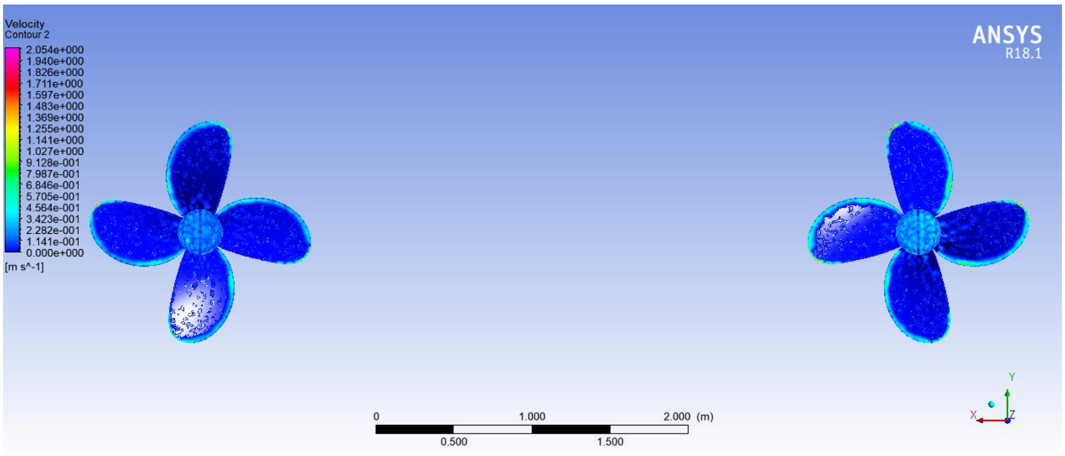


Gambar 5. Visualisasi simulasi lambung kapal dan *propeller* dengan PSS (DS = 1.1 DP) pada Ansys CFX 8.1

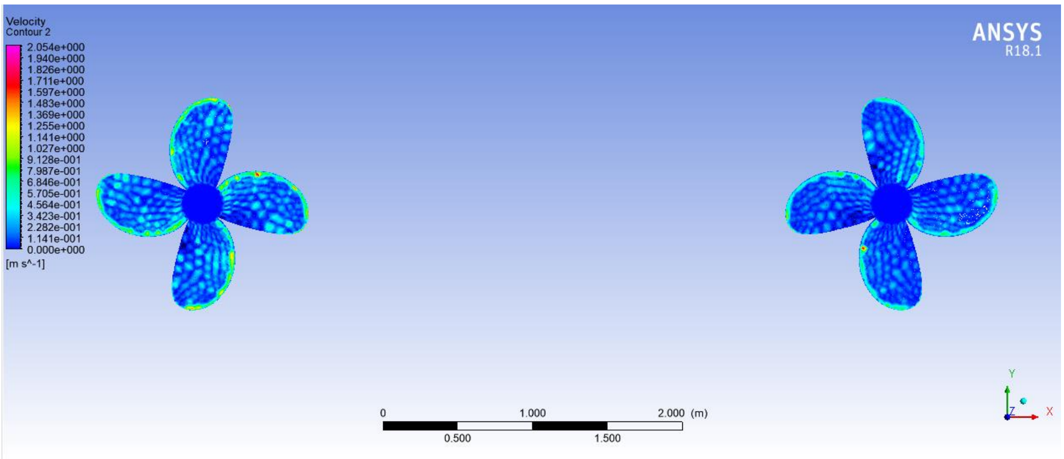


Gambar 6. Visualisasi simulasi lambung kapal dan *propeller* dengan PSS (DS = 1.2 DP) pada Ansys CFX 8.1

Lampiran 2. Hasil Simulasi dengan Ansys CFX 8.1 (*Contour*)

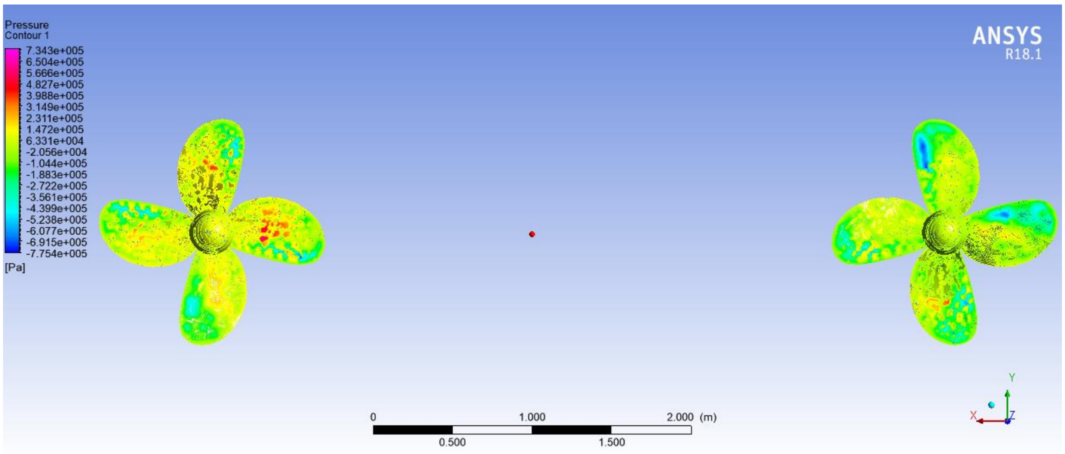


(a)

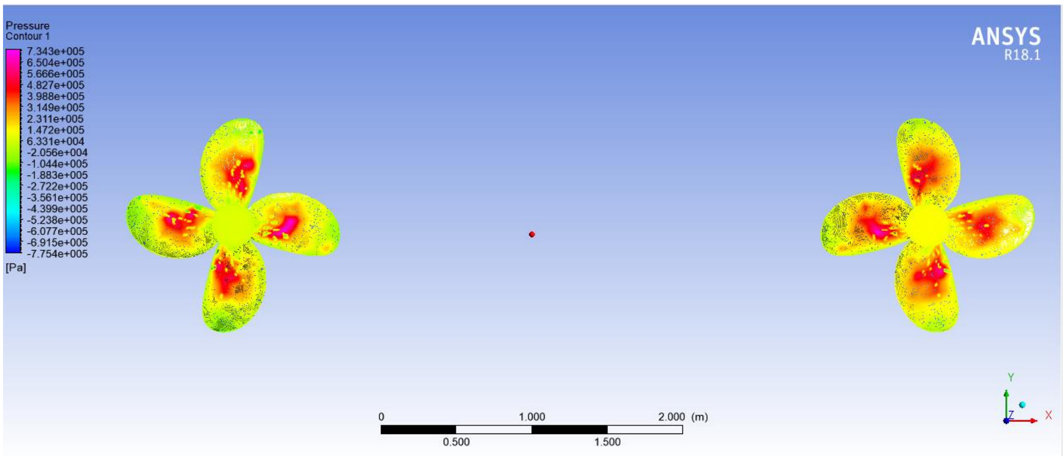


(b)

Gambar 7. Visualisasi *velocity* pada simulasi *propeller* tanpa lambung dengan *contour:* (a) *Downstream side*, (b) *Upstream side*

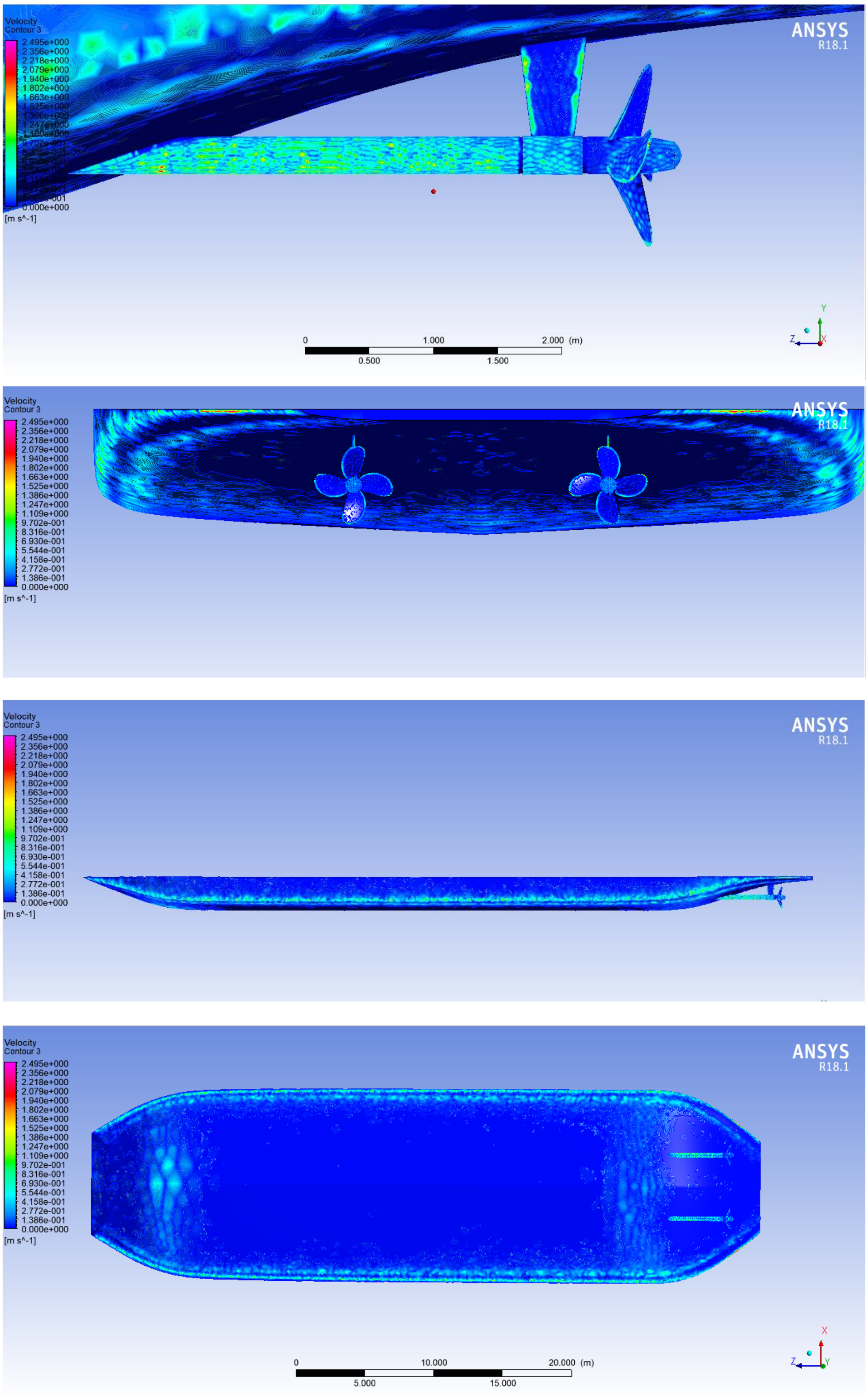


(a)

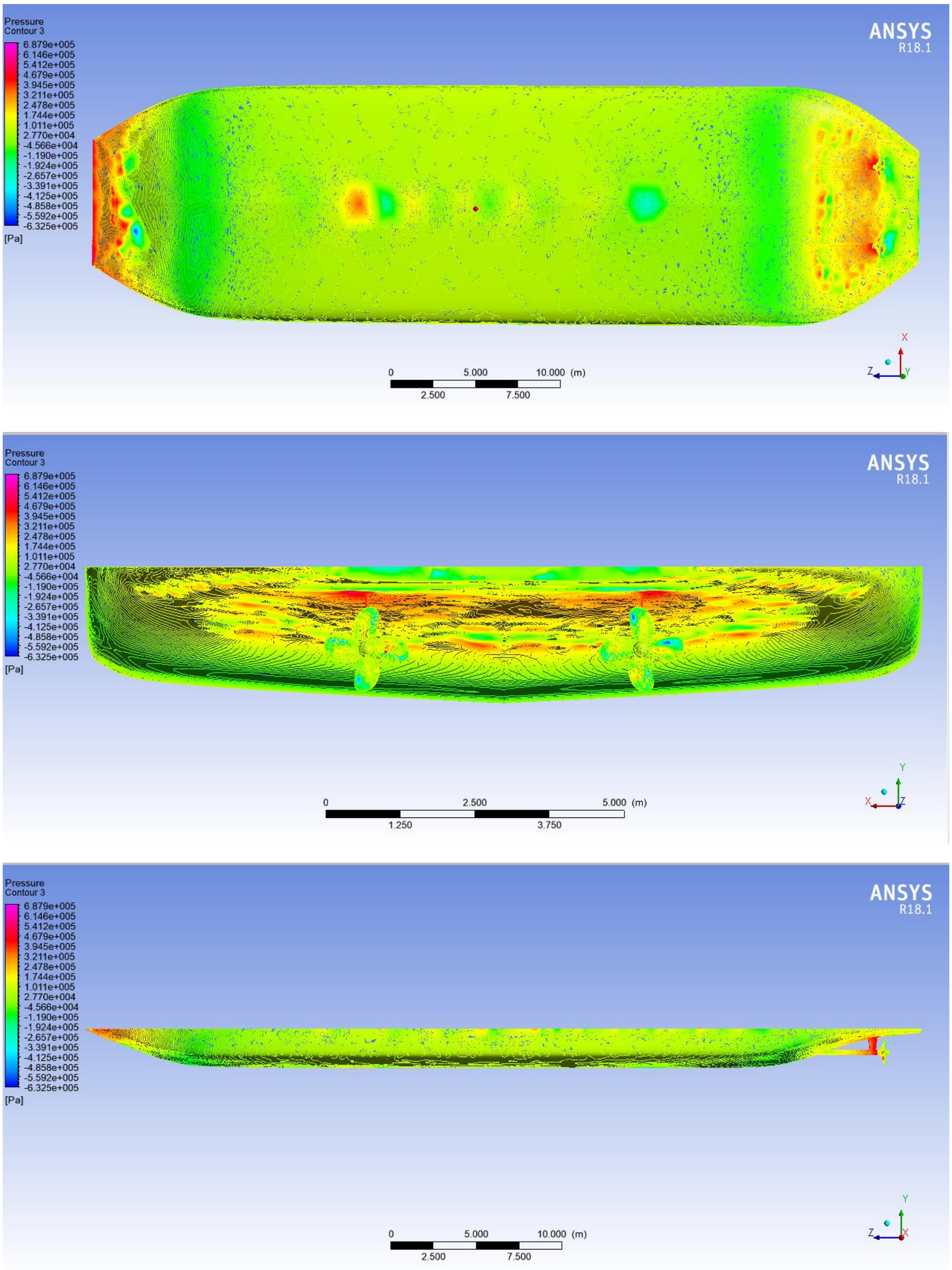


(b)

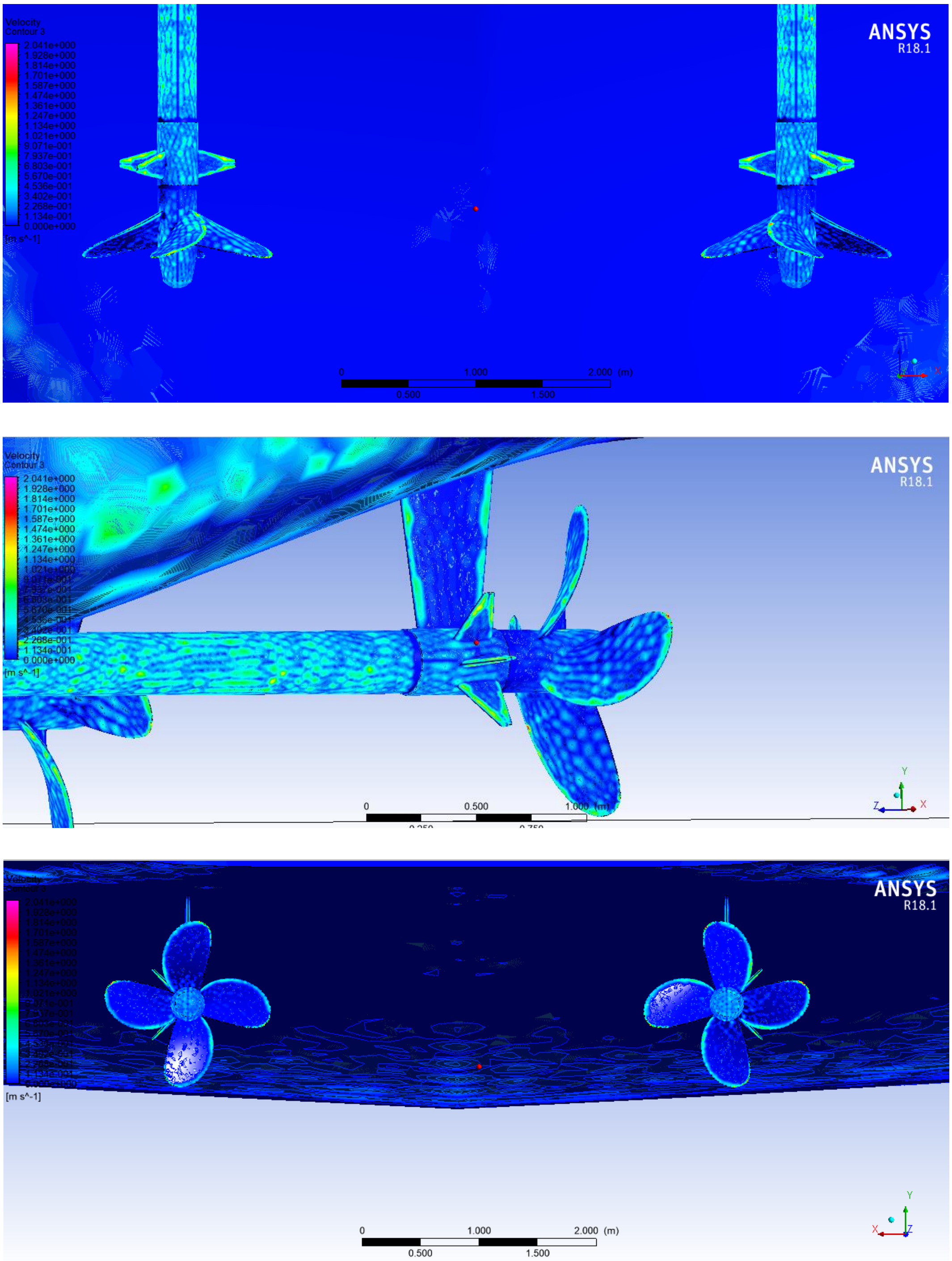
Gambar 9. Visualisasi *Presuare* pada simulasi *propeller* tanpa lambung dengan *contour:* (a) *Upstream side*, (b) *Downstream side*



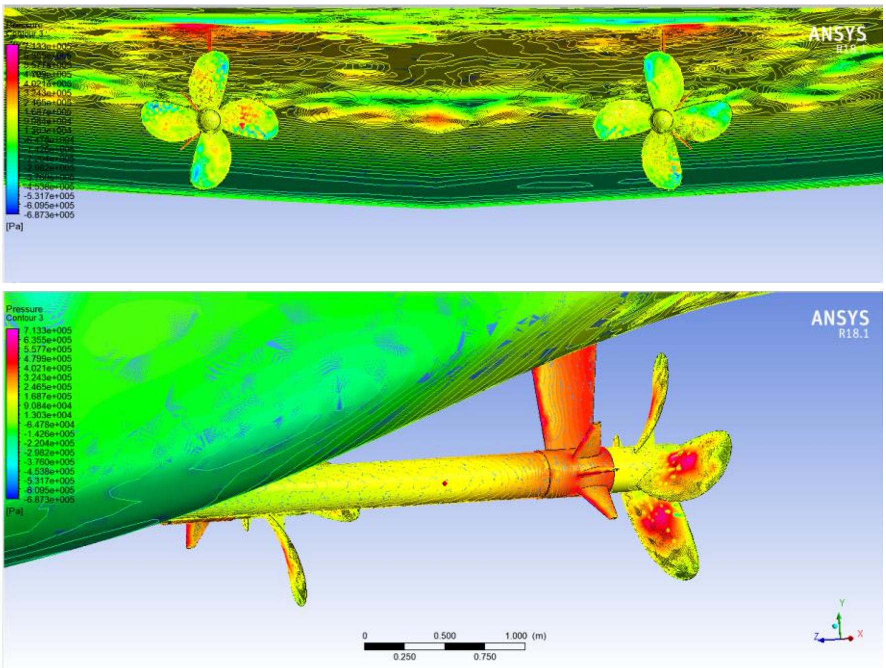
Gambar 10. Visualisasi *Velocity* pada simulasi *propeller* dan lambung dengan *contour*



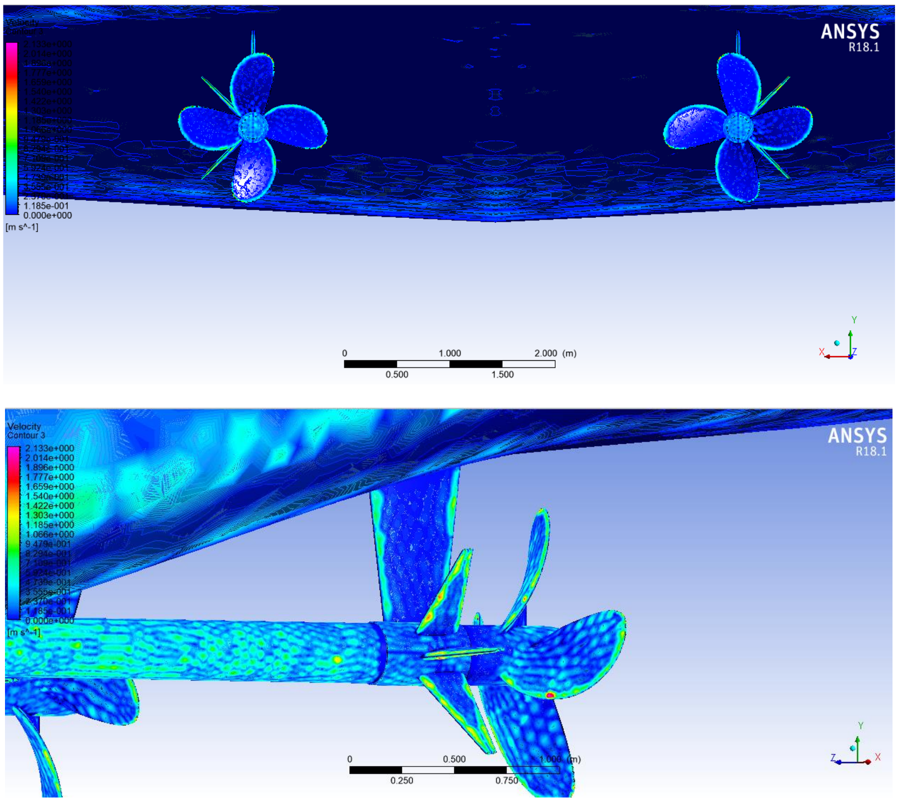
Gambar 11. Visualisasi *presuare* pada simulasi *propeller* dan lambung dengan *contour*



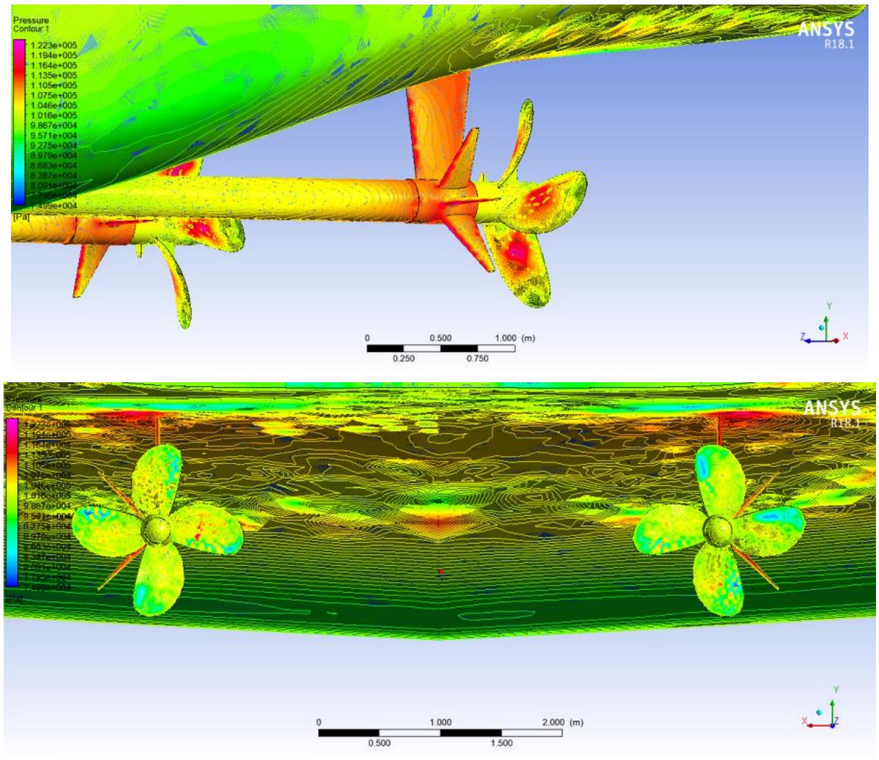
Gambar 12. Visualisasi v*elocity* pada simulasi *propeller* dan stator (DS = ½ DP) dengan *contour*



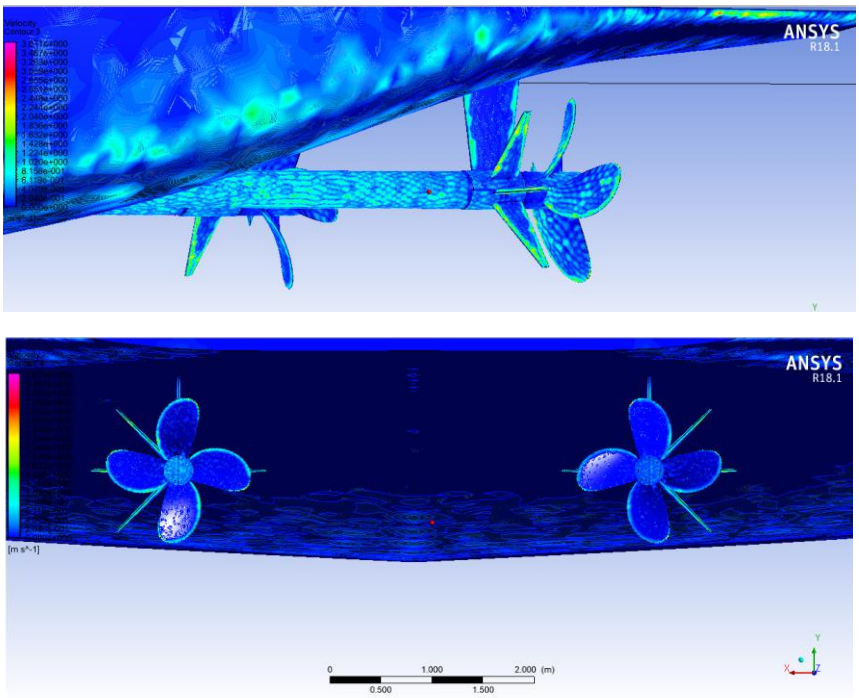
Gambar 13. Visualisasi *preasure* pada simulasi *propeller* dan stator (DS = ½ DP) dengan *contour*



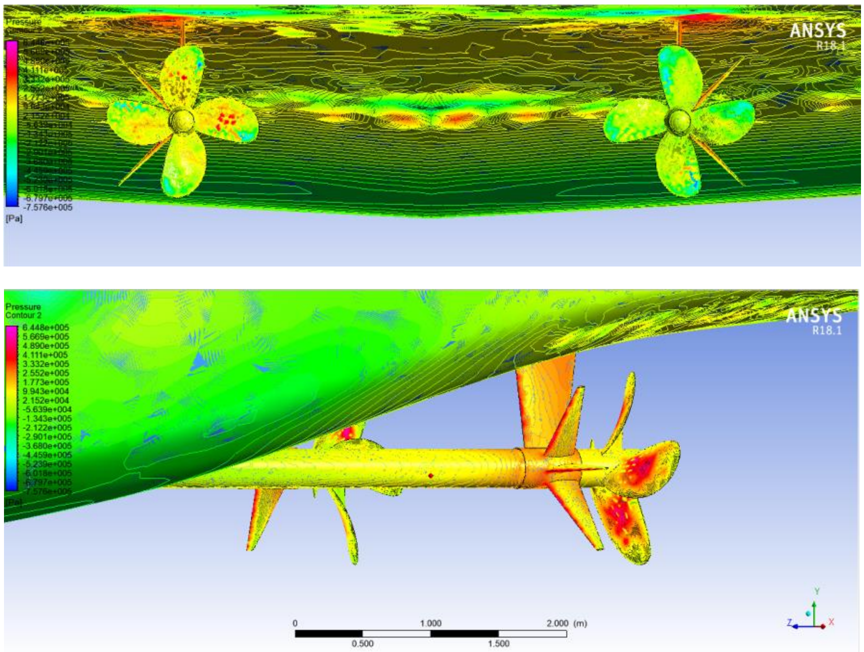
Gambar 14. Visualisasi v*elocity* pada simulasi *propeller* dan stator (DS = DP) dengan *contour*



Gambar 14. Visualisasi *preasure* pada simulasi *propeller* dan stator (DS = DP) dengan *contour*

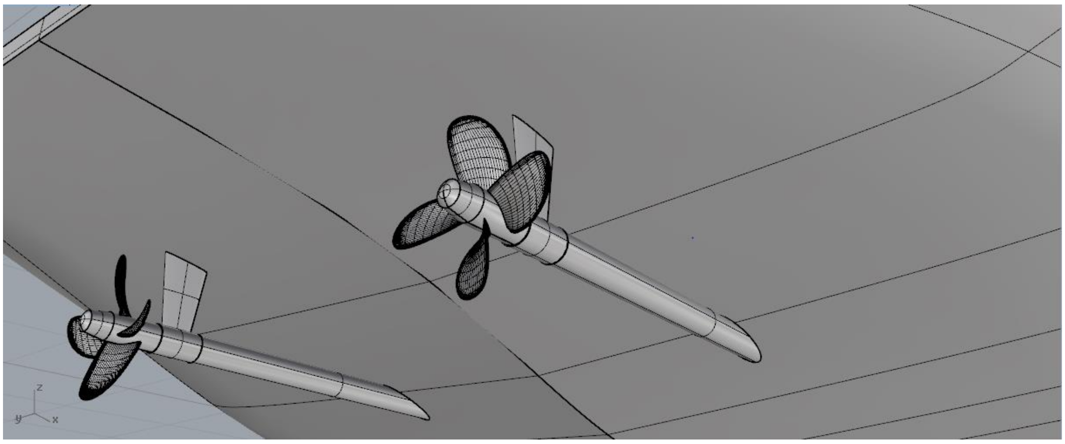


Gambar 15. Visualisasi *velocity* pada simulasi *propeller* dan stator (DS = 1.2 DP) dengan *contour*

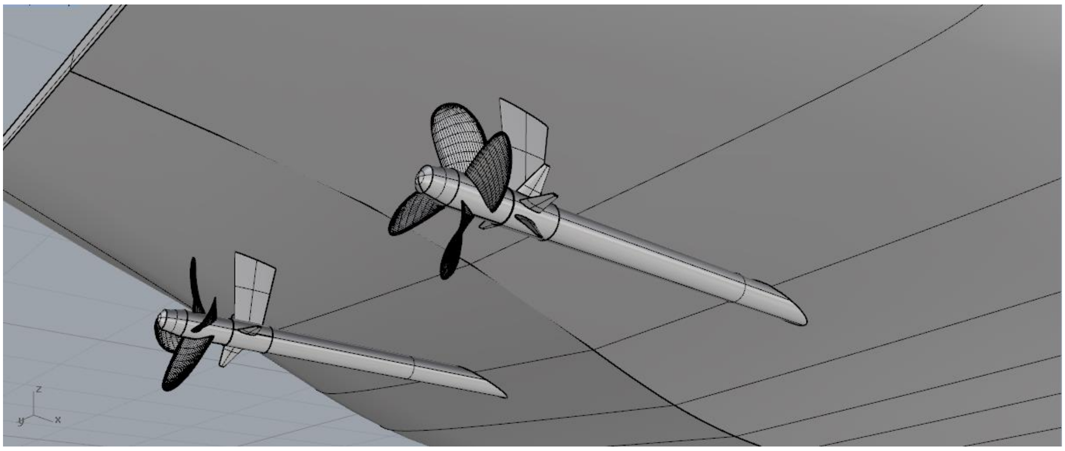


Gambar 16. Visualisasi *preasure* pada simulasi *propeller* dan stator (DS = 1.2 DP) dengan *contour*

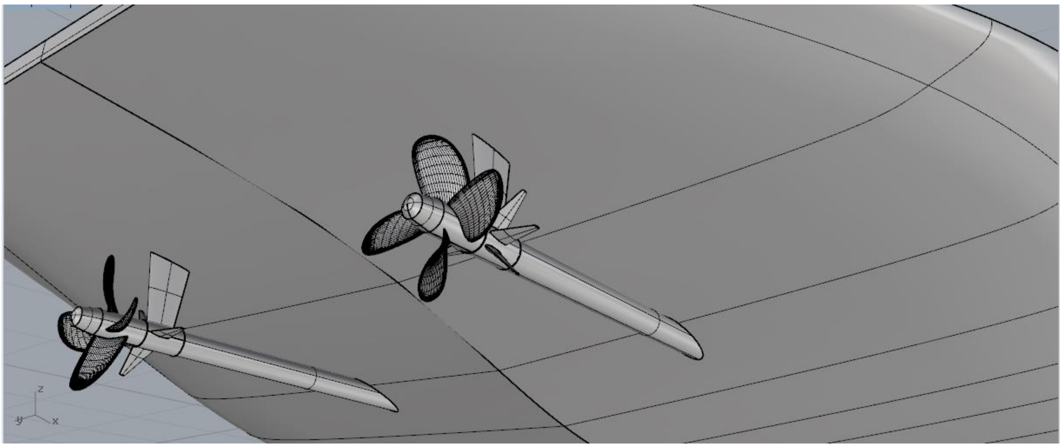
Lampiran 3. Desain Model pre-swirl pada *propeller*



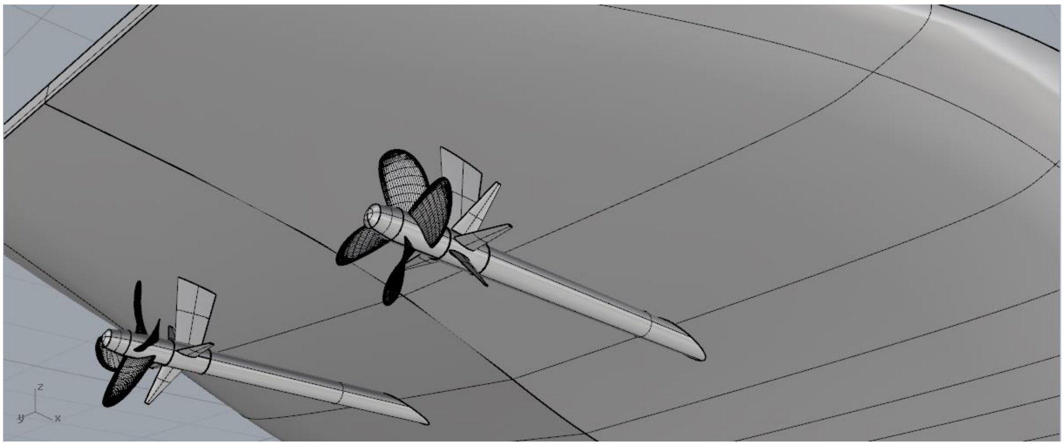
Gambar 17. Model tanpa PSS



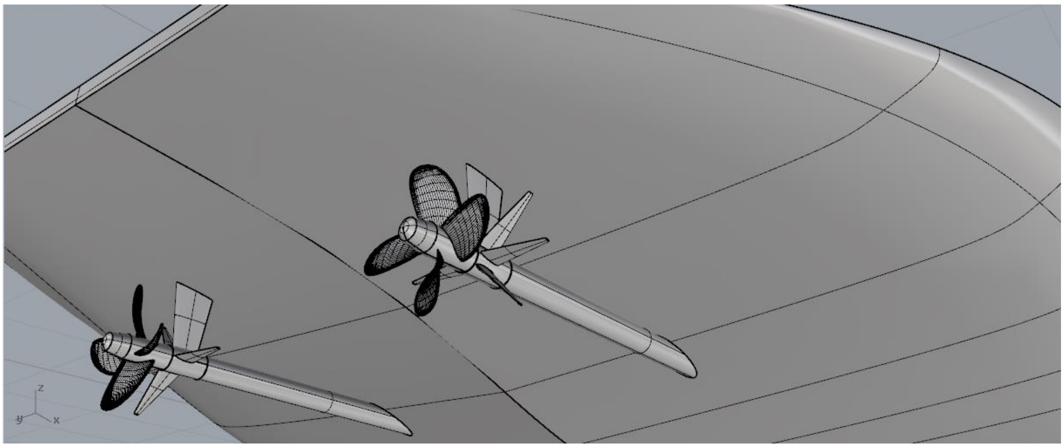
Gambar 18. Model dengan PSS (DS = ½ DP)



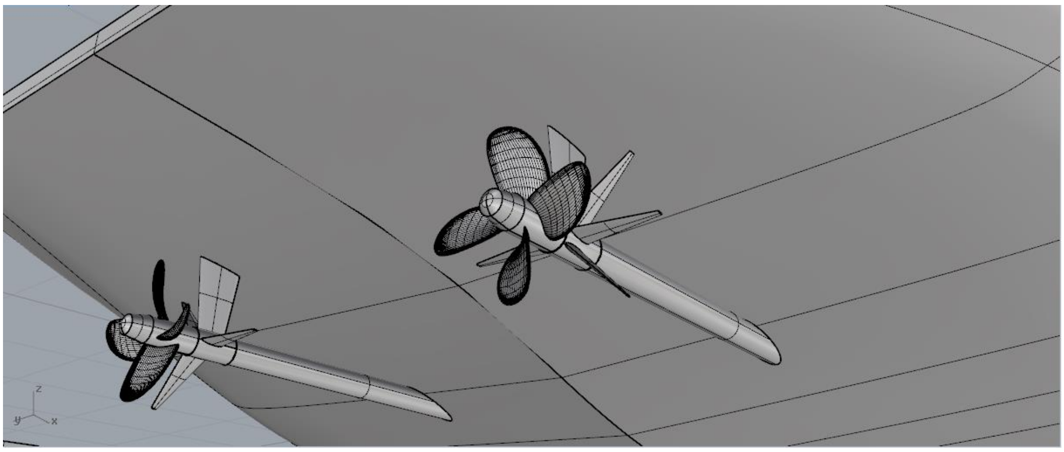
Gambar 19. Model dengan PSS (DS = ¾ DP)



Gambar 20. Model dengan PSS (DS = DP)



Gambar 21. Model dengan PSS (DS = 1.1 DP)



Gambar 22. Model dengan PSS (DS = 1.2 DP)

Lampiran 4. Perhitungan Engine Matching

ENGINE MATCHING

1. Data Utama Kapal

LWL	=	49.348	m
LBP	=	47.45	m
B	=	14	m
H	=	3.4	m
T	=	2.45	m
V	=	12.865 knot	
	=	6.618	m/s
Δ	=	1148 ton	
Cb	=	0.72	
Cm	=	0.98	
Cw	=	0.82	
Cph	=	0.730097482	
Cpv	=	0.877899878	
B/L	=	0.283699441	
Dp	=	1.422	m
Z	=	4	

Froud Number

Fn $= \frac{Vs}{\sqrt{g\ x\ Lpp}}$

Dimana :

Vs = Kecepatan dinas kapal (m/s)

g = Percepatan gravitasi bumi sebesar 9.81 (m/s2)

Lpp = Panjang kapal yang diukur dari AP ke FP (m)

Reynod Number

$$Rn = \frac{Vs\ x\ Lwl}{\vartheta\ air\ laut}$$

Dimana :

Vs = Kecepatan dinas kapal (m/s)

υair laut = Viskositas kinematis pada air laut dengan suhu 15ºC sebesar 1.1883x10-6 (m2/s)

Lwl = Panjang kapal saat sarat penuh (m)

2. **Data Utama *Propeller* Dan Mesin**

Dimensi Jumlah daun propeler (Z)	= 2 x 4
Diameter propeler (DP)	= 1,422 m
Putaran propeler (nP)	= 8,764 put/s
Tinggi daun kemudi (H)	= 1,550 m
Panjang daun kemudi (CL)	= 0,900 m
Luas daun kemudi (AR)	= 2 x 1,395 m^2
Daya motor (PB)	= 2 x 1000 HP
Putaran motor (nE)	= 1850 put/m

3. **Perhitungan tahanan**
   1. Perhitungan Hambatan Gesek (Rf)
      a. Harga Koefisien gesek (formula ITTC 1957)

      Cf = $0,075/(\log_{10}Rn – 2)^2$

      = 0.001809

      b. Panjang bagian kapal yang mengalami hambatan langsung (Length of Run), LR ditentukan dengan formula ;

      LR = Lwl.{1-Cp + [0,06.Cp.%LCB)/(4.Cp -1]}

      = 11.76645472

      c. Harga faktor lambung (1 + k_1) ditentukan dengan formula ;

      $(1+k_1)=C_{13}(0,93+C_{12}(B/LR)^{0,92497}(0,95\text{-}cp)^{-0,521448}(1$

      $cp+0,025Lcb)^{0,6906})$

      = 1.258

      c_{12} = $(T/L)^{0.2328446}$

      = 0.51214

      c_{13} = $1 + 0.003C_{stern}$

      =1.03

      d. Menghitung luas bidang basah (S)

$$S = L(2T+B)\sqrt{C_M}\left(0.453+0.4425C_B+(-0.2862C_M)+\left(-0.003467\frac{B}{T}\right)+0.3696C_{WP}\right)+2.38\ {ABT}/{C_B}$$

      = 724.78

      S_{total} = 724.78 + (0.1 x 724.78)

      = 797.2580208 m^2

      Harga Hambatan gesek (Rf) ditentukan dengan formula ;

R_F = C_F x 0.5 x ρ x S x V_s^2

= 32.378 kN

2. Perhitungan bagian tambahan (R_{AP})

a. Harga faktor bagian hambatan (1+k_2)

Bagian	Ada =1,tidak = 0	Faktor	Produk
Konvensional stern dan kemudi	1	1,5	1,5
Kemudi dan skeg	0	2	0
Kemudi kembar	1	2,8	0
Y Braket	0	3	0
Skeg	0	2	0
Shaft Bossing	1	3	0
Shell Bossing	0	2	0
Shaft telanjang	1	4	0
Sirip Bilga	0	2,8	0
Dome	0	2,7	0
Lunas Bilga	1	1,4	1,4
Total	$\sum_1$= 5		$\sum_2$= 12.7

Harga hambatan bagian tambahan (R_{AP})

R_{AP} = $\rho/2.Vs^2.As(1+k_2)eq.Cf$ Dimana ρ = 1,025 kg/m^3

= 0.67966254 kN

3. Perhitungan hambatan akibat gelombang

a. Besar sudut enterance

iE = 38 degress (°)

b. Harga koefisien λ

λ = 1,446Cp-0,03L/B (untuk L/B < 12) dimana L/B=3.525

λ = 0.875647155

c. Harga koefisien C_1

Jika Fn < 0,55 maka, untuk 0,11 < B/Lwl ≤ 0,25

$C_1 = 2223105.(T/B)^{1,07961}/(90-\alpha)^{1,37565}$

= 3.0295

d. Harga koefisien C_3 (Reduksi haluan gembung)

C_3 = $0,56.ABT^{1,5}/(B.T(0,31\sqrt{ABT}+Tf-hb)$

= 0.056455731

e. Harga koefisien C_2

Ditentukan dengan formula,

C_2 $= 1/[e^{1,89.\sqrt{C_3}}]$

$= 0.638220248$

f. Harga Koefisien M_1

M_1 $= [0,0140407(Lwl/T)]-[1,75254.(\nabla^{1/3}/Lwl)]-[4,49323.(B/Lwl)]-[1,73014-(0,7067. Cp)]$

$=-0.563237654$

g. Harga Koefisien M_2

Jika $Lwl^3/\nabla < 512$; maka $c_{15} = -1.69385$

m_2 $= c_{15}c_p^2 \exp(-0.1Fn^{-2})$

$= -0.299295588$

Harga hambatan akibat gelombang (Rw),

Rw $=C_1.C_2.P_5.\nabla.\rho.g.e^{\{M_1/Fn^{0,9)}+(M_2\cos(\lambda/Fn^2)}$

$= 112.394$ kN

4. Perhitungan hambatan akibat adanya haluan gembung(RB)

a. Harga koefisien darurat haluan gembung (PB)

$$PB = \frac{0,56\ (ABT)1/2}{TF - 1,5HB}$$

$= -4.195$

b. Harga bilangan foude akibat ketenggelaman haluan gembung

$$Fni = Vs/\sqrt{g/(TF - HB - 0,25\sqrt{ABT} + 0,15.Vs^2}$$

$= 2.233$

$$FnT = V/\sqrt{2gA_T/(B + BC_{WP}}$$

$= 4.847523464$

Ks $= 150$ µm

$= 0.00015$ m

c. Harga koefisien korelasi model (C_A)

C_A $= (0.105Ks^{1/3} - 0.005579)/L^{1/3}$

$= 0.000590818$

C_A $=\{0,006/(Lwl+100)^{0,16}\}-0,00205+\{0,0\sqrt{Lwl/7,5}.Cb^4.C_2.(0,04-C_4\}$

c_4 $=0.04$ untuk $T_F > 0.04$

$= 0.000643267$

$C_{ATotal} = 0.001234085$

Harga hambatan akibat adanya haluan gembung (RB)

$$RB = 0{,}11 \cdot \rho \cdot g \cdot \left[\frac{ABT^{2/3}}{e^{(3/Pb)}}\right] \cdot \left[\frac{Fni^3}{(1+Fn)^2}\right]$$

$= 9.188$ kN

d. menghitung nilai tahanan transom

$R_{TR} = 0.5\rho V^2 A_T C_6$, dimana $c_6 = 0.21(1-0.2F_{Nt})$ Untuk $F_{nT}<5$

$= 0.331$

e. Menghitung nilai tahanan angin

S (Luas bidang tangkap angin) = 637.983 m^2

$R_A = 1/2\ \rho\ v^2 S C_A$

$= 11.683$

Perhitungan hambatan total (R_T)

Harga hambatan total ditentukan dengan formula ;

$R_{Total} = R_F(1+k1) + R_{APP} + R_W + R_B + R_{TR} + R_A$

$= 134.277$ kN

4. Perhitungan Daya

Daya efektif (EHP) dalam satuan HP ditentukan dengan menggunakan formula

Rt = 134.28 kN

EHP = 888.64 kW

= 1191 HP

$$BHP_{csr} = \frac{EHP}{Ef\ Propulsi}$$

$$= \frac{888.64\ \text{kW}}{0.7}$$

= 1269.486 kW

$$BHP_{mcr} = \frac{1269.486\ \text{kW}}{0.85}$$

= 1493.513 kW

5. Pemilihan Daun dan Tipe *Propeller*

a) Perhitungan Diameter Maksimal

Diameter max *propeller* "tahanan dan propulsi kapal" hal. 137

D = 2/3 × **T** (**m**)

b) Menentukan Nilai Diameter Maksimal (DB)

DB = 0.97 x DO (Twin screw *propeller*)

Penelitian ini diameter *propeller* yang digunakan diambil dari data *propeller* kapal yaitu 1.422 m.

c) Jarak sumbu poros ke lunas (E) "principle of naval architecture vol II" hal. 159

E = 0.045T + 0.5Dp

= 0.821 m

d) Tinggi air di atas *propeller* "tahanan dan propulsi kapal" hal. 196

h = (T - E) + 0,0075Lbp

= 1.984 m

e) Tekanan pada poros *propeller* "tahanan dan propulsi kapal" hal 196

Po-Pv = 99.60 – (10.05 x h)

= 79.65 KN/m^2

f) Nilai Ae/Ao (Rasio luas bentang daun *propeller*) "principle of naval architecture" hal. 183

Ae/Ao = $\{((1.3+(0.3 X Z) X T)/((Po – Pv) x Dp^2)\} + k$

Dimana, k = (0~0.1) untuk kapal twin screw

Ae/Ao = 0.55

g) Menentukan Nilai BP1

Dalam buku Prinpciples of Naval Architecture (Lewis, 1988), diberitahukan rumus untuk mencari nilai BP adalah sebagai berikut :

BP1 = N*propeller* x $PD^{0.5}/ VA^{2.5}$

= 38.087

0,1739 x $\sqrt{Bp1}$ = 1.073

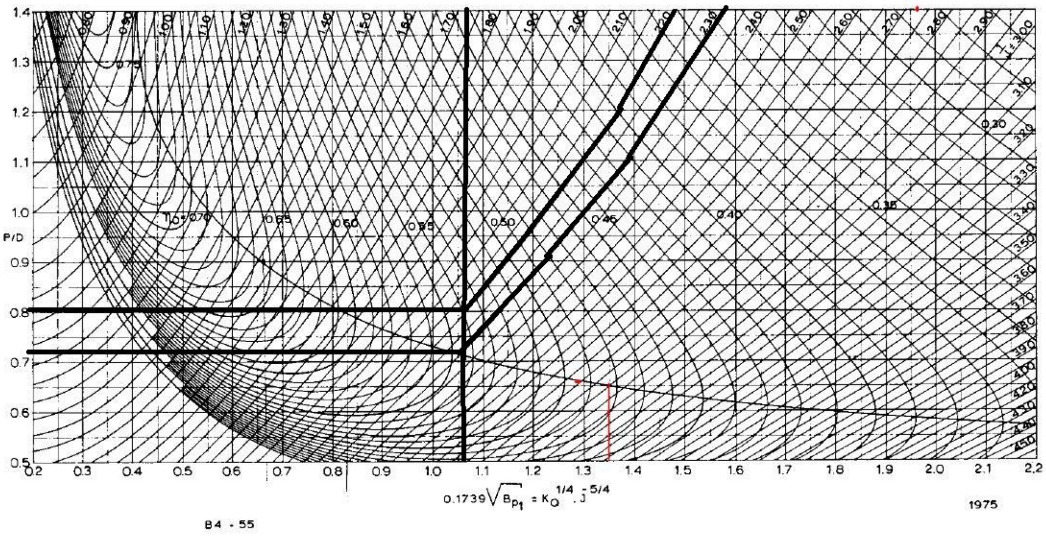
Dimana :

N*propeller* = RPM

PD = Delivered power at *propeller* (DHP)

VA = Speed of advance

Pembacaan Diagram BP1



dari permbacaan grafik B4-55 diperoleh nilai P/Do,1/Jo,P/Db, η

P/Do = 0.72

1/Jo = 2.3

Do = 4.9 m

1/Jb = 2.21 m

P/Db = 0.8

η = 0.55

δ0 = (1/JO)/0.009875

= 223.59

ΔB = (N*propeller* x DB)/VA

1/JB = δB x 0.009875

6. Perhitungan Resiko Kavitasi

a) Data *Propeller*

(Rpm) baling – baling = 1/J x VA/Dp x 60

N = 525.84 RPM

n = 8.764 RPS

P/D = 0.800

D = 1.422

P = 1.1376 m

Pitch Distribution = 0.181 m

ηo = 0.46

Va = 5.69 m/s

= 11.058 knot

Ae/Ao = 0.546

Ao = 1.587

Ae = Ao x (Ae/Ao)

= 0.867

b) Menentukan A0 (Luasan Optimum), AE/A0, AE

AO = 1/4 x π x DB^2

= 1.829494544

AE = Ao x (Ae/Ao)

= 0.731797818

c) Menentukan Nilai AP, VR^2, T, τccal

Ap = AD x (1,067 - 0,229(P/D))

= 0.63000474

R^2 = Va2 + $(0,7 \times \pi \times N \times Db)^2$

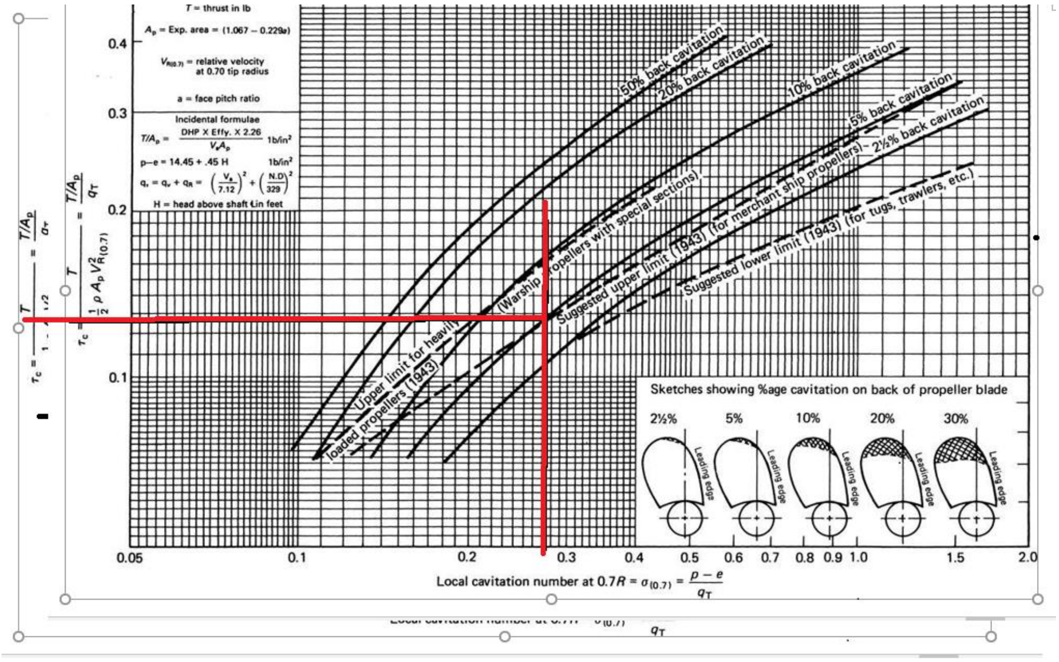
= 782.7

$$\tau_C = \frac{T}{Ap x 0,5 x \rho x (Vr)^2}$$

= 0.26

$$\sigma 0,7R = \frac{188,2 + 19,62H}{Va^2 + 4,836 n^2 D^2}$$

= 0.29



Jenis *Propeller*	A0	Ae=Ad	Ap(m2)	Vr^2	Tc max	σ 0.7R	Tc Burril	kavitasi
B4 - 100	1.83	0.732	0.63	227.831	1.964	0.29	0.13	tidak kavitasi

7. Engine *Propeller* Matching

a) Tahanan kapal dan Kecepatan service

Rt (Tahanan Total) = 134.346 KN

b) Gaya Dorong Kapal (Tship)

w = 0.7 x Cp - 0,3 + (0.3 x 0.4 - $\frac{a}{B}$)

= 0.1405

k = 0.5

t = k x w

= 0.07025

T = R/(1-t)

= 144.497 KN

c) Karakteristik Baling-baling Kapal

KT = Tprop /ρn2 D4

KQ = Qprop/ρn2 D5

J = Va / n D

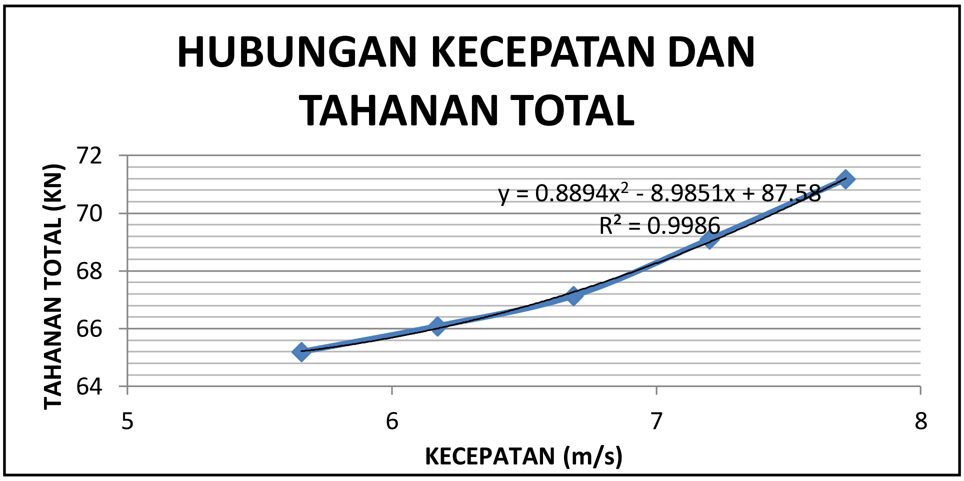
ηo = J x KT / 2π x KQ

dimana, T ship = T *propeller*

Thrust untuk masing-masing *propeller*

$$\frac{Tship}{2} = \frac{144.497}{2} = 72.25\ KN$$

d) Perhitungan KT/J2



KT = β x J2

αtrial = Rt trial / Vs2

αservice = Rt service / Vs2

βtrial = αtrial /(1-t)(1-w)2ρDb

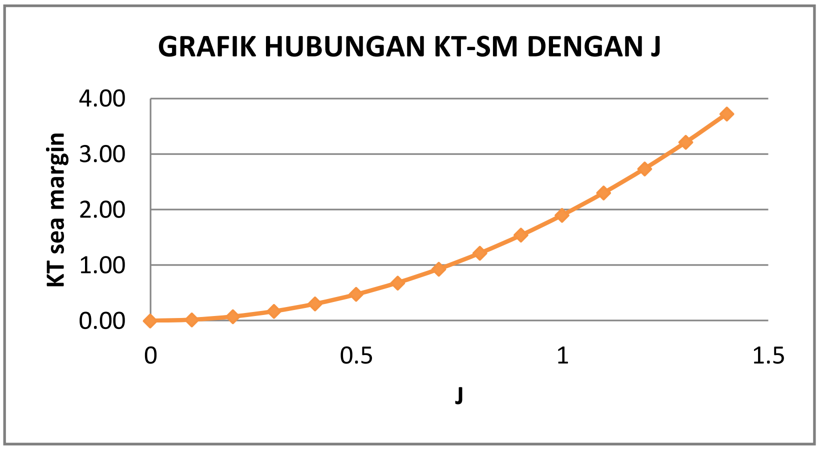
βservice = αservice /(1-t)(1-w)2ρDb

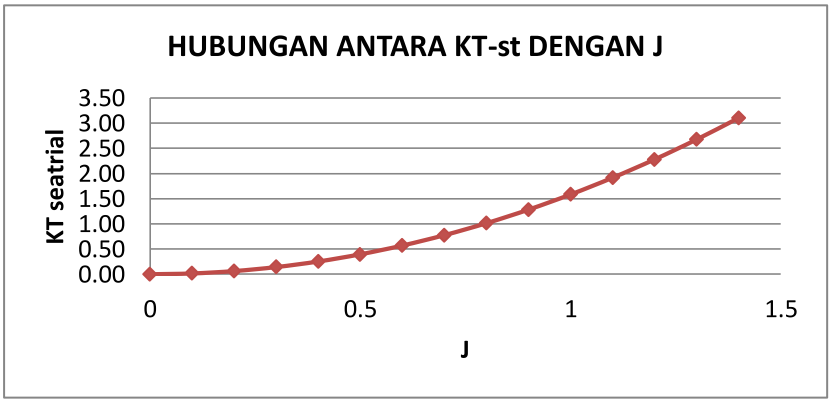
KT seatrial = 1.584402 x J^2

KT sea margin = 2.68088 x J^2

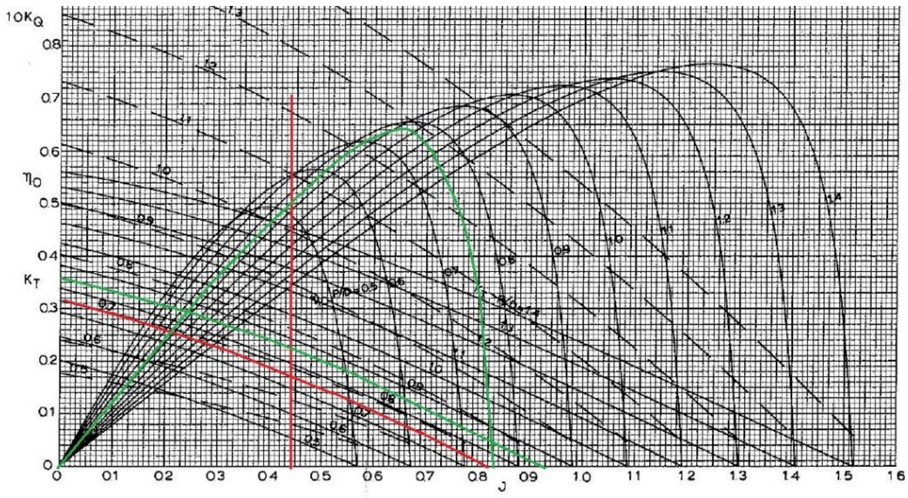
J	J^2	KT seatrial	KT sea margin
0	0	0.00	0.00
0.1	0.01	0.02	0.02
0.2	0.04	0.06	0.08
0.3	0.09	0.14	0.17
0.4	0.16	0.25	0.30
0.5	0.25	0.40	0.48
0.6	0.36	0.57	0.68
0.7	0.49	0.78	0.93
0.8	0.64	1.01	1.22
0.9	0.81	1.28	1.54
1	1	1.58	1.90

1.1	1.21	1.92	2.30
1.2	1.44	2.28	2.74
1.3	1.69	2.68	3.21
1.4	1.96	3.11	3.73



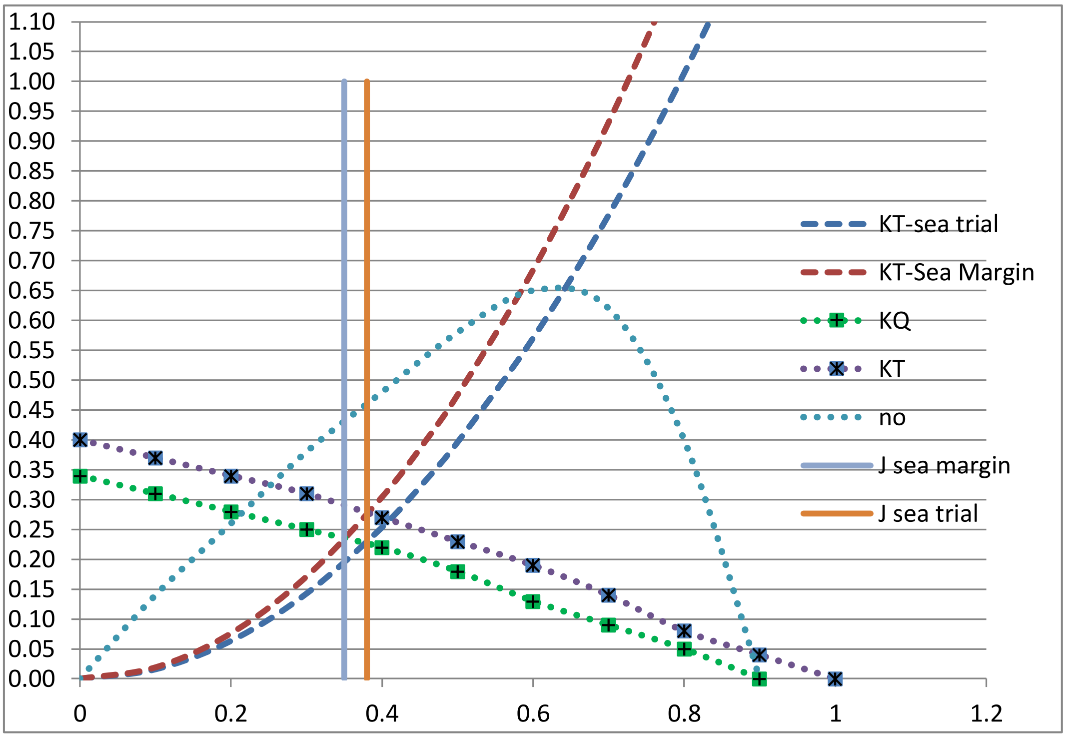


e) Pemilihan Tipe *Propeller*



Dalam pemilihan *propeller* yang memenuhi kriteria dan kecocokan dengan engine dilakukan dengan cara memplotkan P/D dengan kurva *open water test* sehingga didapatkan data KT, KQ, J, dan η pada tipe *propeller* B4-55 P/D = 0.75, AE/AO = 0.55

J	KT	10KQ	η
0	0.34	0.4	0
0.1	0.31	0.37	0.14
0.2	0.28	0.34	0.26
0.3	0.25	0.31	0.38
0.4	0.22	0.27	0.48
0.5	0.18	0.23	0.58
0.6	0.13	0.19	0.65
0.7	0.09	0.14	0.62
0.8	0.05	0.08	0.5
0.9	0	0.04	0
1		0	



sea trial

J	=	0.38
KT	=	0.22
10KQ	=	0.24
η	=	0.45

sea margin

J	=	0.35
KT	=	0.24
10KQ	=	0.28
η	=	0.42

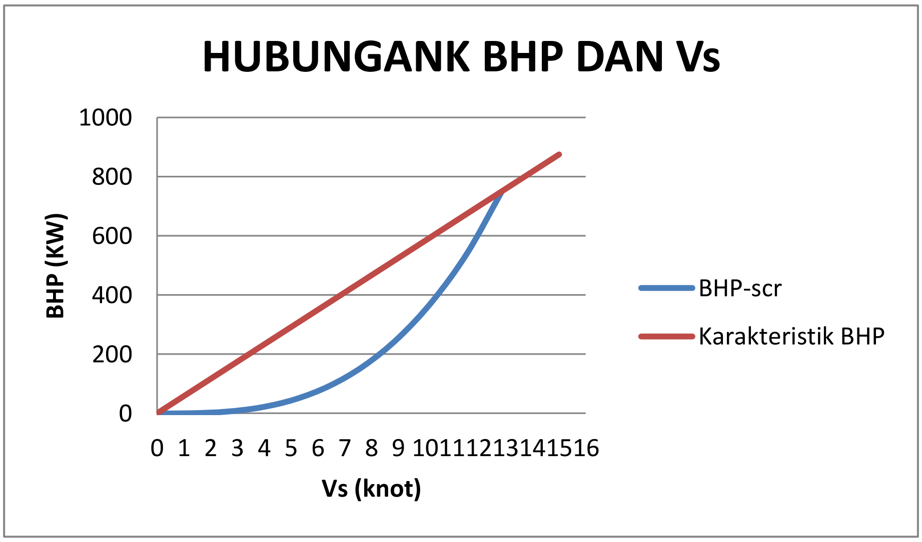
f) Tabel karakteristik beban *propeller*

Trial Condition

%Rpm	Rpm Engine	Rps Engine	Rpm *Propeller*	Rps *propeller*	(n_p) *propeller*^{2}	Q $_{Prop}$	P *propeller*	DHP (kw)	SHP (KW)	BHP (KW)	% BHP
0%	0	0	0	0.00	0	0	0	0	0	0	0.00
10%	185	3.08333	52.857	0.88	0.77	0.11	0.10	0.61	0.62	0.63	0.09
20%	370	6.16667	105.71	1.76	3.09	0.44	0.78	4.87	4.97	5.07	0.68
30%	555	9.25	158.57	2.64	6.94	0.99	2.62	16.44	16.78	17.12	2.30
40%	740	12.3333	211.43	3.51	12.35	1.77	6.21	38.97	39.76	40.58	5.44
50%	925	15.4167	264.29	4.39	19.29	2.76	12.12	76.11	77.66	79.25	10.63
60%	1110	18.5	317.14	5.27	27.78	3.97	20.94	131.52	134.20	136.94	18.36
70%	1295	21.5833	370	6.15	37.81	5.41	33.26	208.85	213.11	217.46	29.16
80%	1480	24.6667	422.86	7.03	49.39	7.06	49.64	311.75	318.11	324.60	43.53
90%	1665	27.75	475.71	7.91	62.50	8.94	70.68	443.87	452.93	462.18	61.98
100%	1850	30.8333	528.57	8.78	77.17	11.04	96.96	608.88	621.31	633.99	85.02

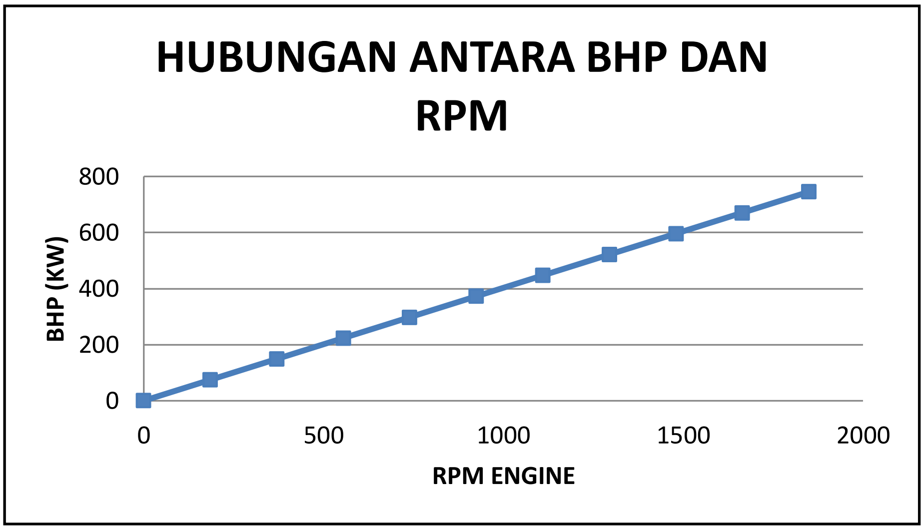
Service Condition

%Rpm	Rpm Engine	Rps Engine	Rpm *Propeller*	Rps *propeller*	(n_p) *propeller*^{2}	Q $_{Prop}$	P *propeller*	DHP (kw)	SHP (KW)	BHP (KW)	%BHP
0%	0	0	0	0.00	0.00	0	0	0	0	0	0.00
10%	185	3.083	52.86	0.88	0.77	0.13	0.11	0.71	0.72	0.74	0.10
20%	370	6.167	105.71	1.76	3.09	0.52	0.90	5.68	5.80	5.92	0.79
30%	555	9.250	158.57	2.64	6.94	1.16	3.05	19.18	19.57	19.97	2.68
40%	740	12.33	211.43	3.51	12.35	2.06	7.24	45.46	46.39	47.34	6.35
50%	925	15.42	264.29	4.39	19.29	3.22	14.14	88.80	90.61	92.46	12.40
60%	1110	18.50	317.14	5.27	27.78	4.64	24.43	153.44	156.57	159.76	21.42
70%	1295	21.58	370	6.15	37.81	6.31	38.80	243.65	248.63	253.70	34.02
80%	1480	24.67	422.86	7.03	49.39	8.24	57.91	363.71	371.13	378.70	50.78
90%	1665	27.75	475.71	7.91	62.50	10.43	82.46	517.85	528.42	539.21	72.31
100%	1850	30.83	528.57	8.78	77.17	12.88	113.11	710.36	724.86	739.65	99.19

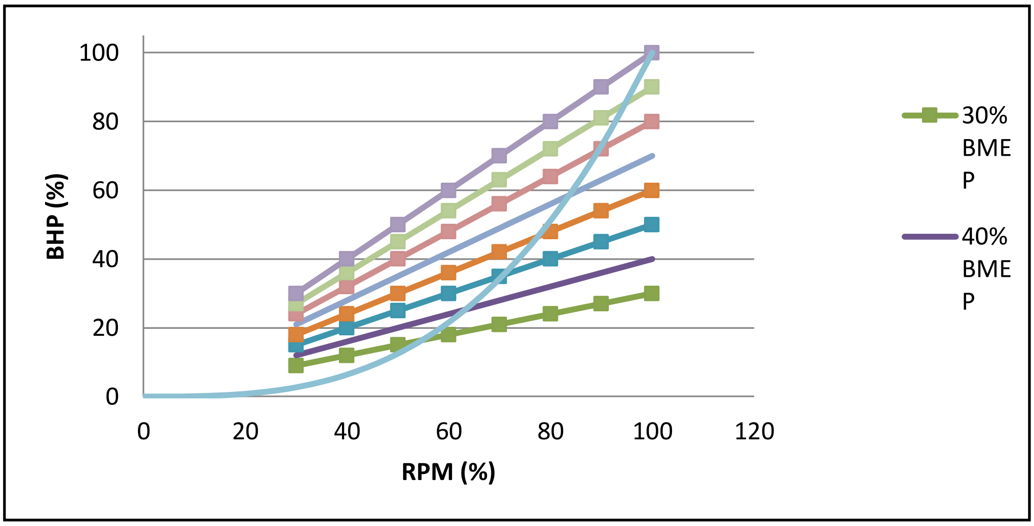


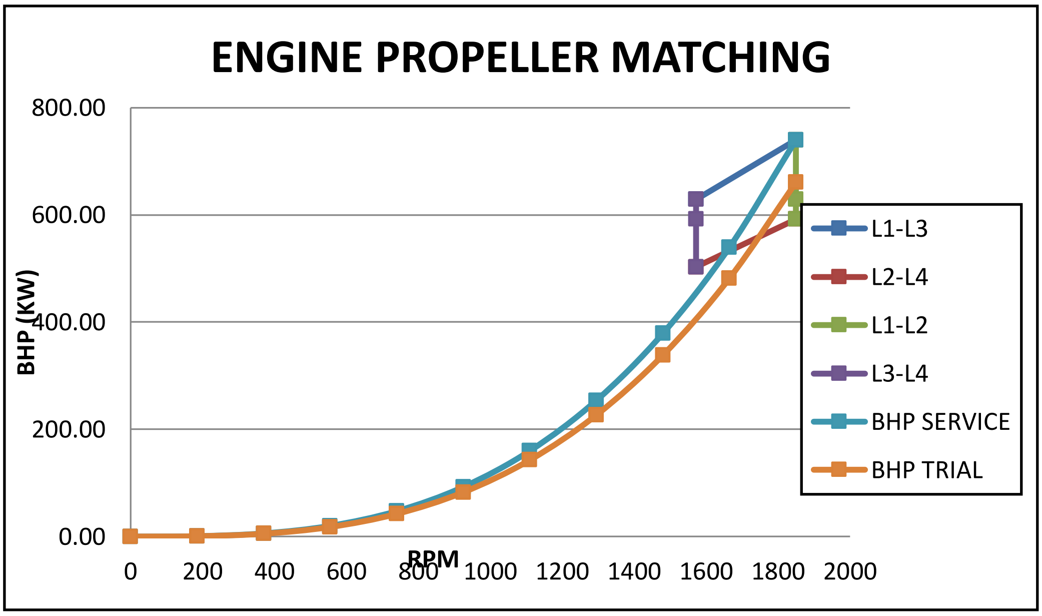
g) Tabel BHP mesin berdasarkan rpm

%	Rpm	Rps	BHP (KW)	BHP (HP)	BMEP (Psi)
0%	0	0	0	0.00	0
10%	185	3.08333	74.571	100.00	4.94
20%	370	6.16667	149.14	200.00	9.87
30%	555	9.25	223.71	300.00	14.81
40%	740	12.3333	298.28	400.00	19.74
50%	925	15.4167	372.86	500.00	24.68
60%	1110	18.5	447.43	600.00	29.61
70%	1295	21.5833	522	700.00	34.55
80%	1480	24.6667	596.57	800.00	39.48
90%	1665	27.75	671.14	900.00	44.42
100%	1850	30.8333	745.71	1000.00	49.35



%	30% BMEP	40% BMEP	50% BMEP	60% BMEP	70% BMEP	80% BMEP	90% BMEP	100% BMEP	P *propeller*
0	0	0	0	0	0	0	0	0	0
10	3	4	5	6	7	8	9	10	0.1
20	6	8	10	12	14	16	18	20	0.8
30	9	12	15	18	21	24	27	30	2.7
40	12	16	20	24	28	32	36	40	6.4
50	15	20	25	30	35	40	45	50	12.5
60	18	24	30	36	42	48	54	60	21.6
70	21	28	35	42	49	56	63	70	34.3
80	24	32	40	48	56	64	72	80	51.2
90	27	36	45	54	63	72	81	90	72.9
100	30	40	50	60	70	80	90	100	100


100
80
60
40
20
0
BHP (%)
0
20
40
60
80
100
120
RPM (%)
30% BMEP
40% BMEP


ENGINE PROPELLER MATCHING
800.00
600.00
400.00
200.00
0.00
BHP (KW)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
RPM
L1-L3
L2-L4
L1-L2
L3-L4
BHP SERVICE
BHP TRIAL