

DAFTAR PUSTAKA

- Adji, Suryo W. 2009. “Resistance & Propulsion Modul 1: Introduction to Ship Resistance”. Surabaya
- Aji., Rizky Purnama 2020, “Analisis Penambahan Vortex Generator Terhadap Performa Sayap Uav Mohinder”. Surabaya.
- Aprianto, Agung. 2019. Studi Tahanan Kapal Semi Displacement. Makassar: Departemen Teknik Perkapalan Universitas Hasanuddin.
- Arwini, 2018. “Studi Pengaruh Perubahan Bentuk Lambung Kapal Feri Terhadap Kecepatan Kapal”. Makassar: Jurusan Teknik Perkapalan Fakultas Teknik Universitas Hasanuddin.
- Arsip Data Tugas Prarancangan Kapal, Lines Plan, Dan Konstruksi Kapal Harvald, Sv. Aa. 1974. Resistance and Propulsion of Ships. Copenhagen: Akademisk Forlag.
- Autodesk CFD. (2015, 28 Desember). Autodesk Knowledge Networks. Diperoleh 10 April 2018, dari <https://knowledge.autodesk.com/support/cfd/learn/explore/caas/CloudHelp/cloudhelp/2014/ENU/SimCFD/files/GUID-46AC3A14-5C6E-485D-95BA-E174F1BC1A47-htm.html>.
- Azmi, Ulul. “Studi Eksperimen dan Numerik Pengaruh Penambahan Vortex Generator pada Airfoil NASA LS-0417”. Diss. Institut Teknologi Sepuluh Nopember, 2017.
- Chinniyampalayam, Coimbatore. "Numerical Analysis of Drag Reduction Method Using Vortex Generator on Symmetric Aerofoil".
- Djabbar M.A. & Rosmani. 2011. *Hibah Penulisan Buku Ajar Tahanan Kapal*. Departemen Teknik Perkapalan, Makassar: Universitas Hasanuddin.
- Mustari, Nurul Awaliyah. 2021. “Studi Prediksi Tahanan Kapal Semi Planning Hull Pada Kecepatan Tinggi Akibat Trim Buritan”. Makassar: Departement Teknik Perkapalan Universitas Hasanuddin.
- Rosmani, Muhammad, A, H., & Algan, M., 2013. Prediksi Tahanan Kapal Cepat
 pin Dengan Metode Eksperimen. Makassar: Jurnal Teknik Universitas
 sanuddin.
 D.2003."Mekanika Fluida". Bandung: Art pro Bandung.



- Setyo Hariyadi dan Ramadhan Pradana Mahaputra, 2020 "Studi Eksperimen Pengaruh Penggunaan Vortex Generator Pada Airfoil Naca 0012 Dengan Smoke Generator", Jurusan Teknik Pesawat Udara, Fakultas Teknik Penerbangan, Politeknik Penerbangan Surabaya
- Dana Herdiana dan Firman Hartono, 2020 "Analysis of Vortex Generator Selection For LSU-05 Aircraft Using Numerical Methods", Teknologi Penerbangan, Institut Teknologi Bandung
- Muhammad Ikbar Abdul Baqi, 2018 "Perancangan *Vortex Generator* Untuk *Ballast Water Treatment* Dengan Menggunakan Metode CFD (*Computational Fluid Dynamic*)", Departemen Teknik Sistem Perkapalan, Fakultas Teknologi Kelautan, Institut Teknologi Sepuluh November Surabaya
- Harvald. A, 1998. "Tahanan dan Propulsi Kapal". Surabaya: Airlangga University Press.
- Tagliaferro, B; Mancini, S; Roperio-Giralda, P; Domínguez J. M.; Crespo A.J.C; viccione G. 2021. "Performance Assesment of a Planning Hull Using the Smoothed Particle Hydrodynamic Method". J.Mar. Sci. Eng.
- Todd,F.H,"The Fundamentals of Ship Form", Trans IME, London, 1945.
- Rosmani, Suandar Baso, Heri Saputra, Muhammad Akbar Asis, Lukman Bochary, Sopyan Chalil, 2013 "*Study of the Impact of Biofouling on Ship Resistence Using Autodesk CFD*". International Journal of Metacentre.



LAMPİRAN



Optimization Software:
www.balesio.com

Lampiran 1. Tabel Offset Lines Plan Model Kapal

WL	Draft	Offset Table										
		0	1	2	3	4	5	6	7	8	9	10
BL	0	0.383	0.445	0.486	0.506	0.511	0.511	0.511	0.511	0.468	0.24	-
1	0.075	0.591	0.706	0.797	0.851	0.869	0.869	0.869	0.839	0.726	0.404	-
2	0.15	0.796	0.967	1.107	1.195	1.228	1.228	1.228	1.172	0.985	0.568	-
3	0.225	1.005	1.225	1.417	1.538	1.587	1.587	1.587	1.51	1.238	0.731	-
4	0.3	1.213	1.482	1.723	1.881	1.945	1.945	1.945	1.84	1.488	0.895	-
5	0.375	1.42	1.739	1.952	1.976	1.982	1.982	1.982	1.947	1.738	1.059	-
6	0.45	1.672	1.9	1.967	1.99	1.996	1.996	1.996	1.962	1.824	1.223	-
9	0.675	1.829	1.948	2.013	2.034	2.039	2.039	2.039	2.006	1.887	1.518	0.236
12	0.9	1.88	1.996	2.058	2.077	2.062	2.062	2.062	2.053	1.949	1.605	0.458
15	1.123	1.931	2.045	2.103	2.12	2.124	2.124	2.124	2.099	2.012	1.691	0.622
18	1.35	1.962	2.093	2.148	2.163	2.167	2.167	2.167	2.144	2.075	1.777	0.785
21	1.575	2.033	2.141	2.193	2.206	2.21	2.21	2.21	2.19	2.137	1.864	0.934
24	1.8	2.084	2.189	2.238	2.25	2.252	2.252	2.252	2.237	2.02	1.95	1.076
	Deck	2.084	2.189	2.238	2.25	2.252	2.252	2.252	2.251	2.244	2.059	1.359



Lampiran 2. Keterangan Bar Warna Hasil Simulasi

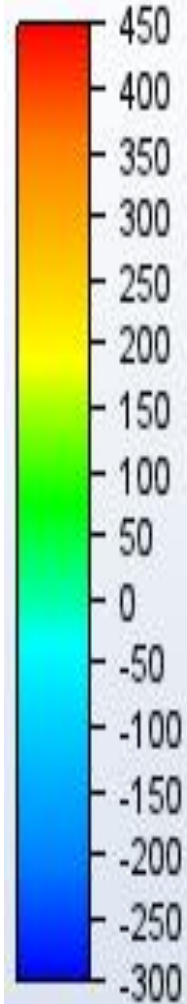
➤ Velocity Magnitude

(1) Velocity Magnitude - m/s



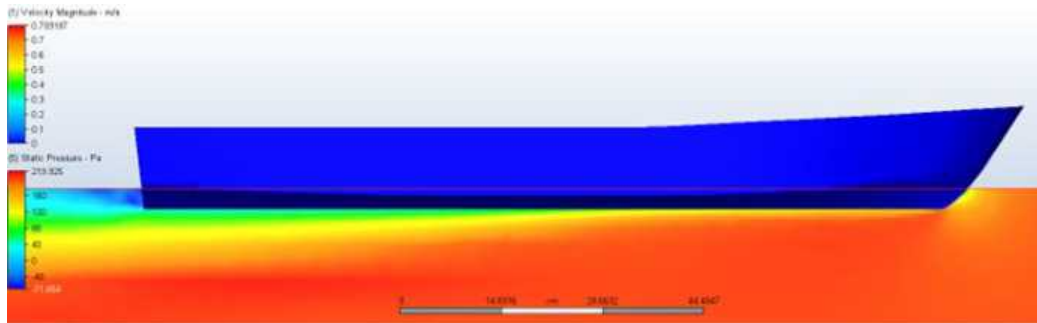
➤ Static Pressure

(5) Static Pressure - Pa

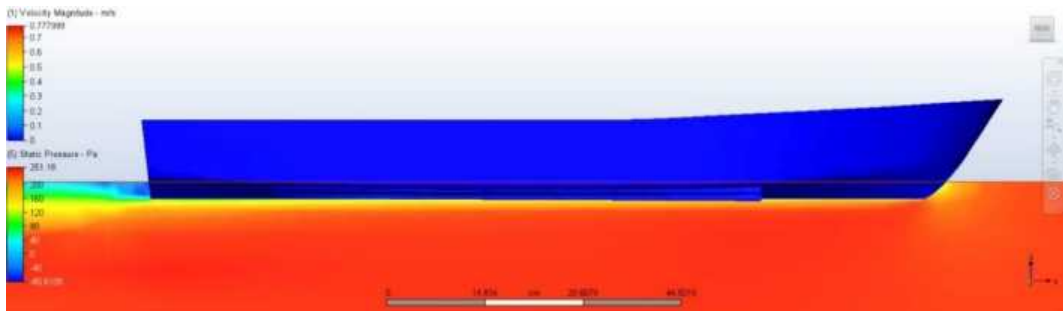


Lampiran 3. Visualisasi Velocity Magnitude

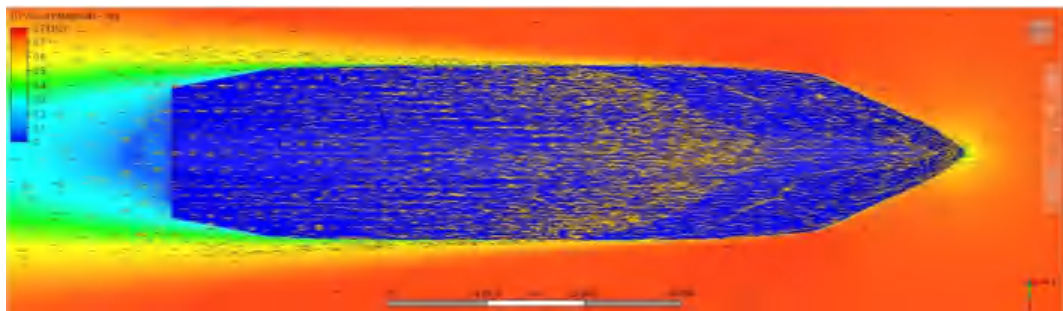
- Kecepatan 0,75 m/s dengan Trim 0°



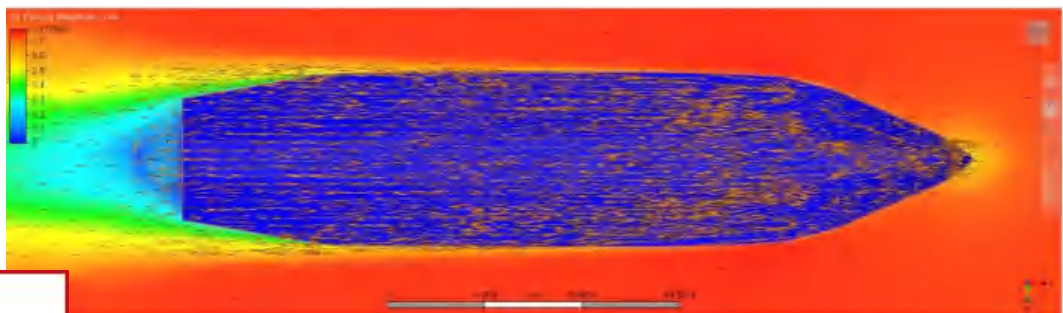
Tampak Samping Tanpa Vortex Generator



Tampak Samping Menggunakan Vortex Generator



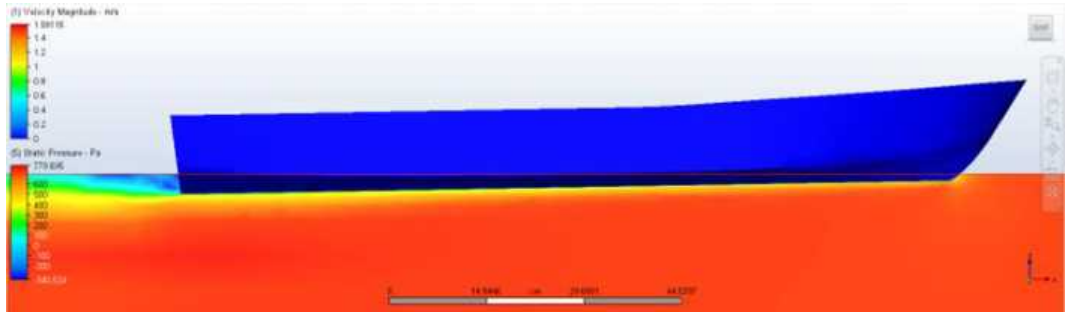
Tampak bawah Tanpa Vortex Generator



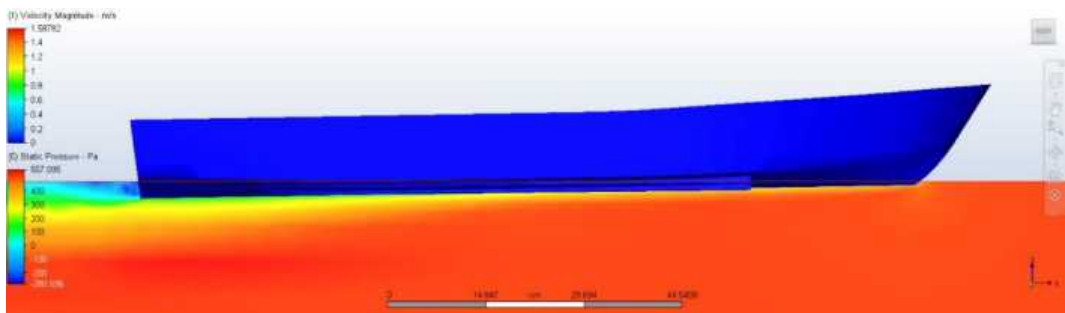
Tampak Bawah Menggunakan Vortex Generator



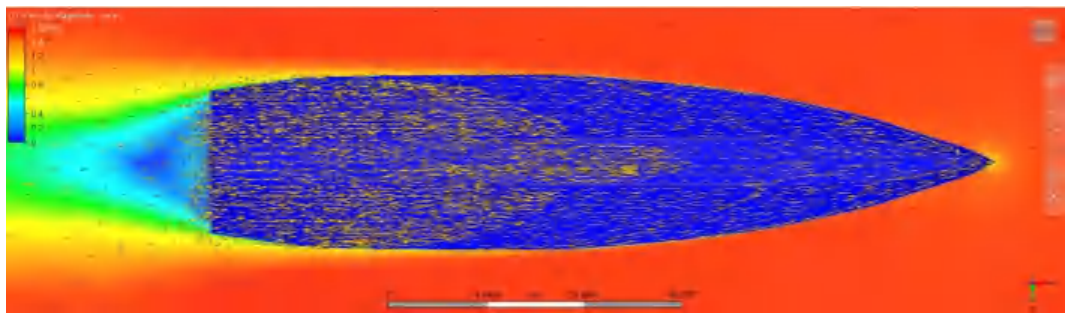
- Kecepatan 1,513 m/s dengan Trim 1°



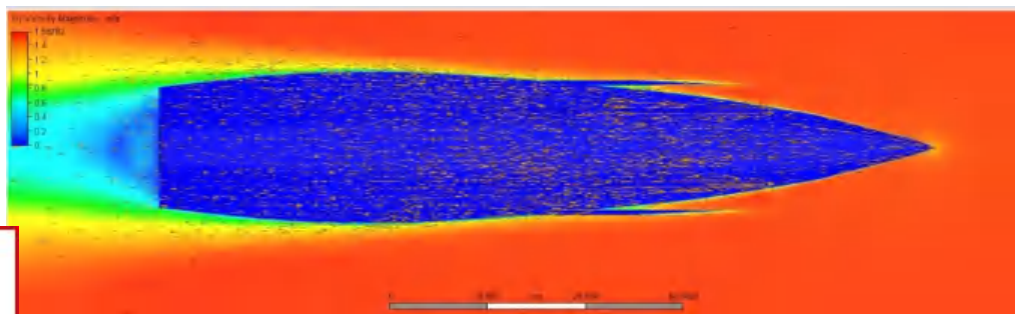
Tampak Samping Tanpa Vortex Generator



Tampak Samping Menggunakan Vortex Generator



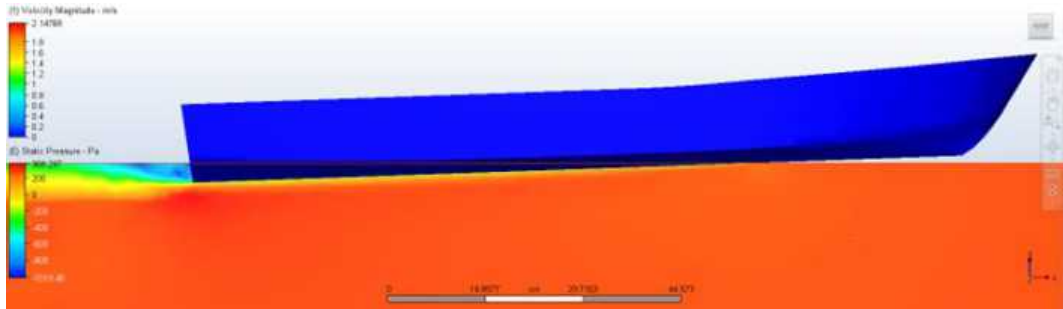
Tampak Bawah Tanpa Vortex Generator



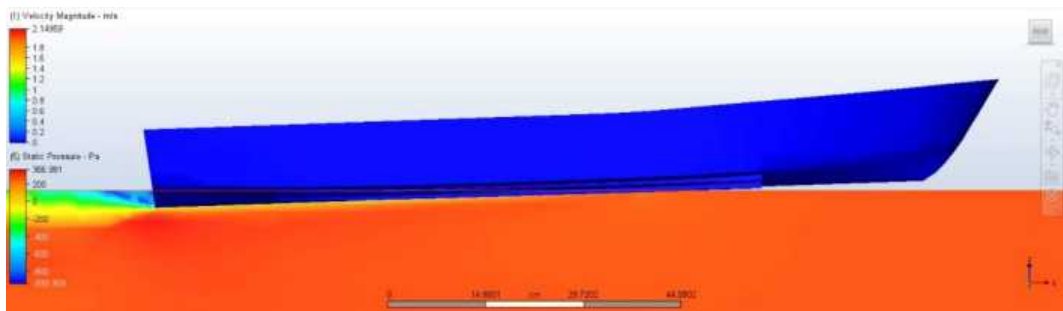
Tampak Bawah Menggunakan Vortex Generator



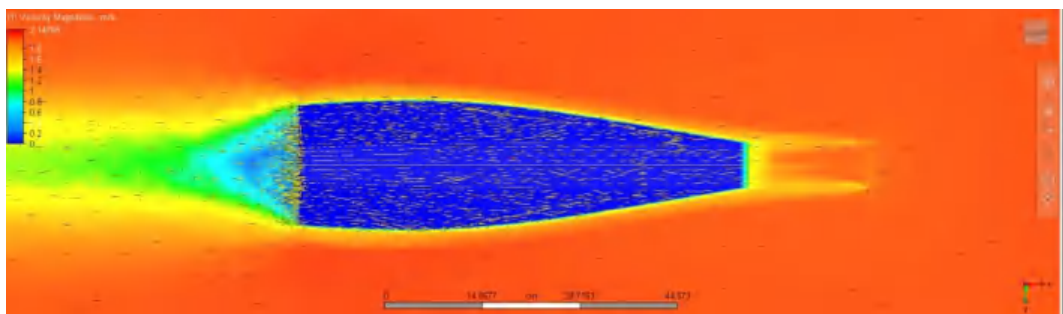
- Kecepatan 2,016 m/s dengan Trim 2°



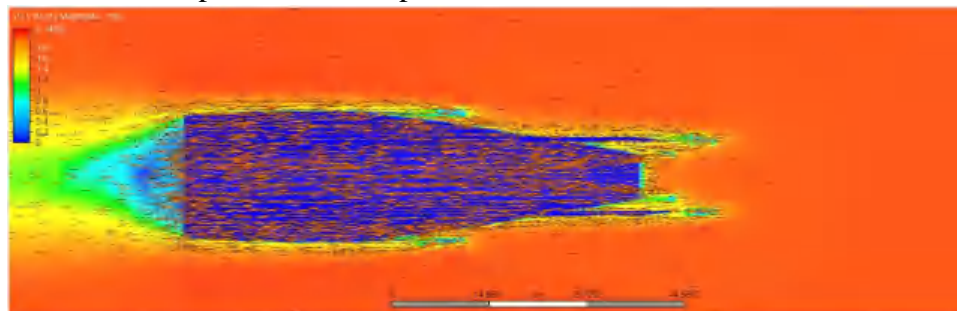
Tampak Samping Tanpa Vortex Generator



Tampak Samping Menggunakan Vortex Generator



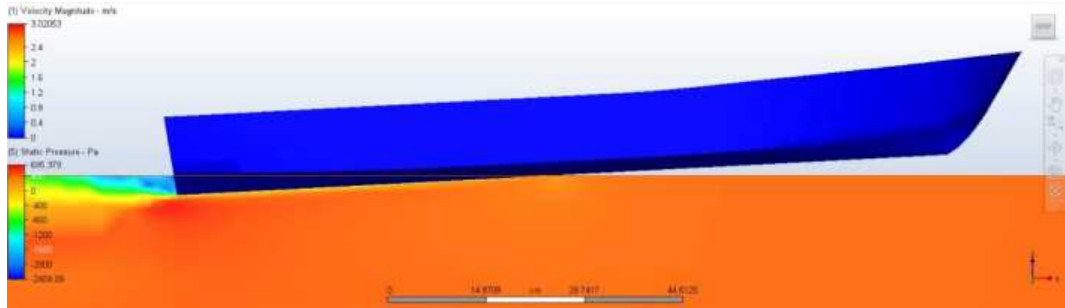
Tampak Bawah Tanpa Vortex Generator



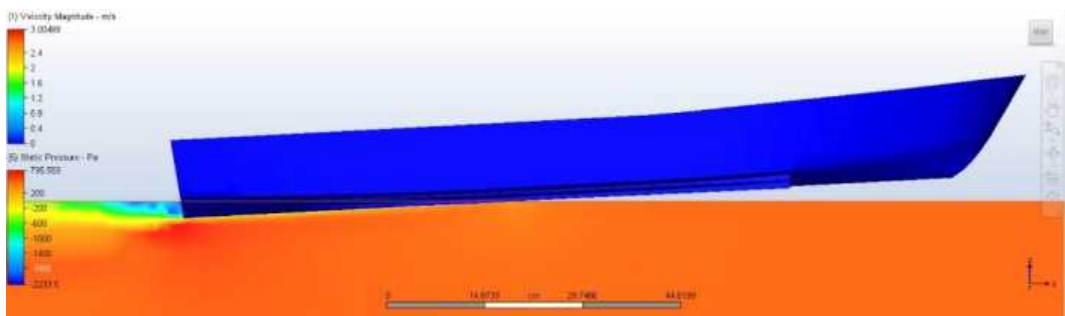
Tampak Bawah Menggunakan Vortex Generator



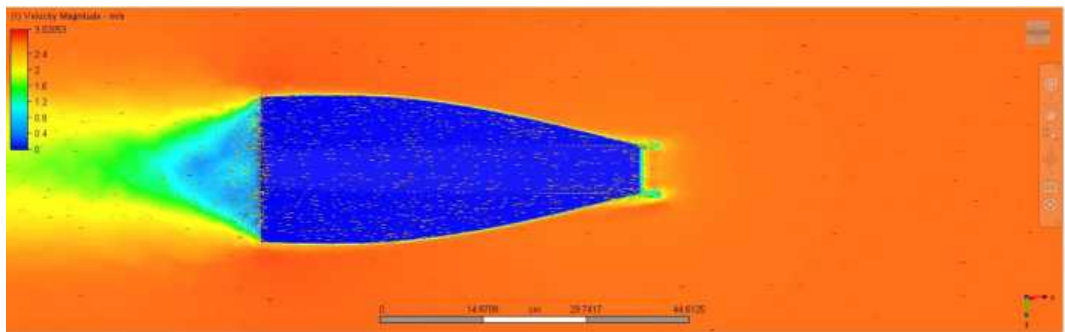
- Kecepatan 2,762 m/s dengan Trim 3°



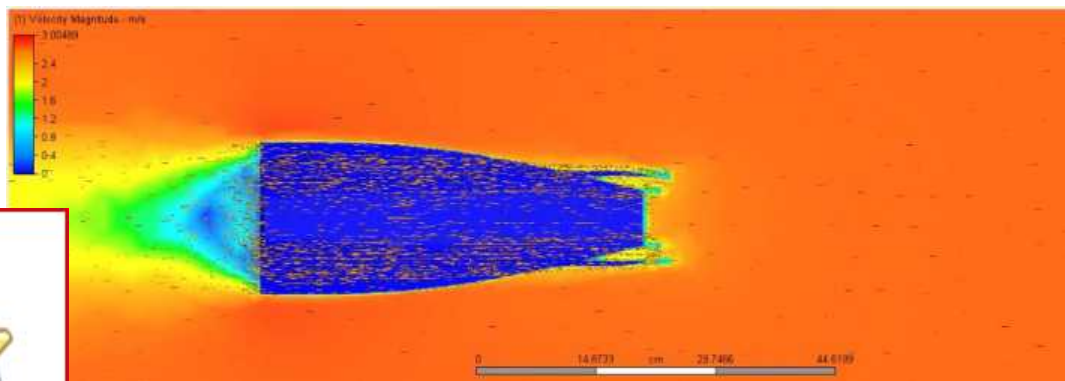
Tampak Samping Tanpa Vortex Generator



Tampak Samping Menggunakan Vortex Generator



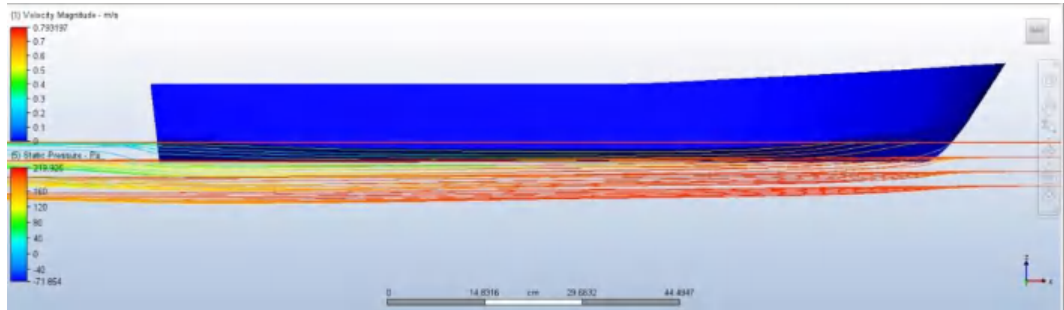
Tampak Bawah Tanpa Vortex Generator



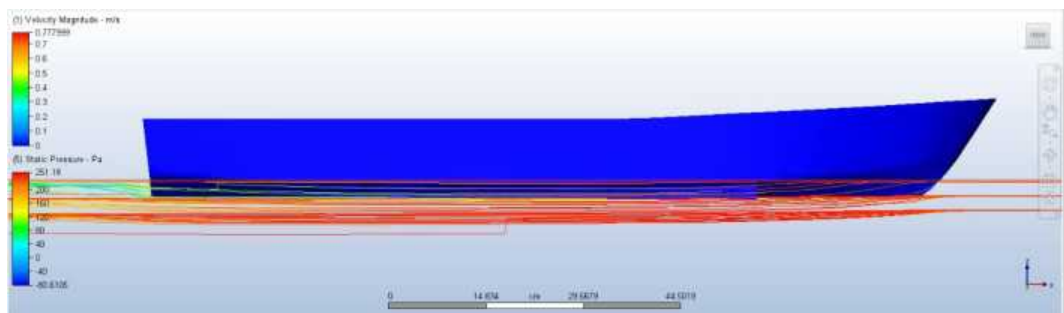
Tampak Bawah Menggunakan Vortex Generator

Lampiran 4. Visualisasi Pola Aliran Pada Autodesk CFD

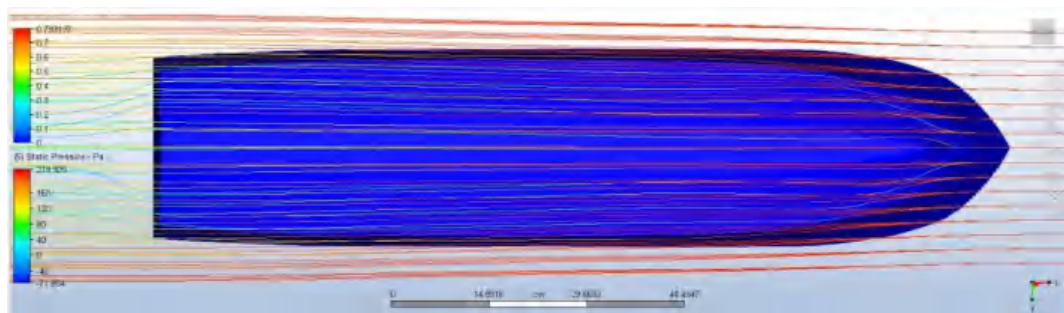
- Kecepatan 0,75 m/s dengan Trim 0°



Tampak Samping Tanpa Vortex Generator

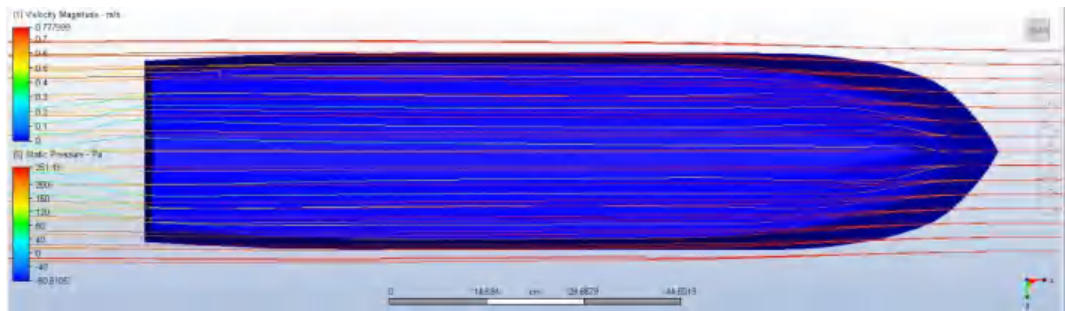


Tampak Samping Menggunakan Vortex Generator

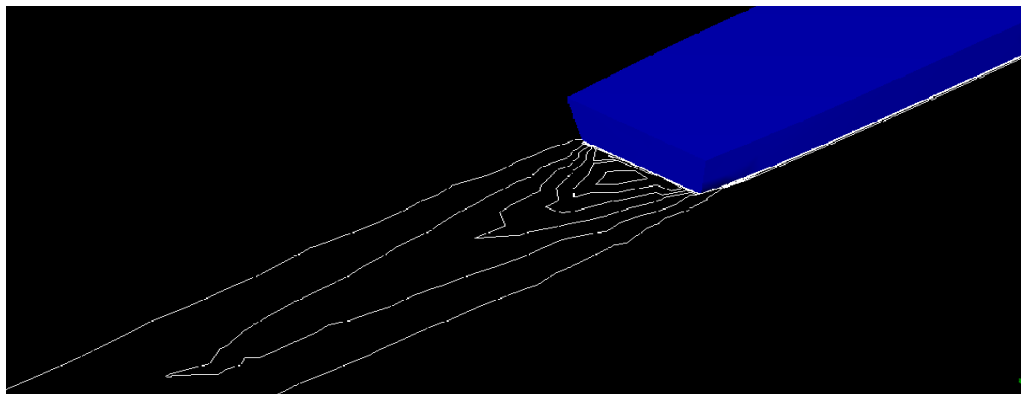


Tampak Bawah Tanpa Vortex Generator

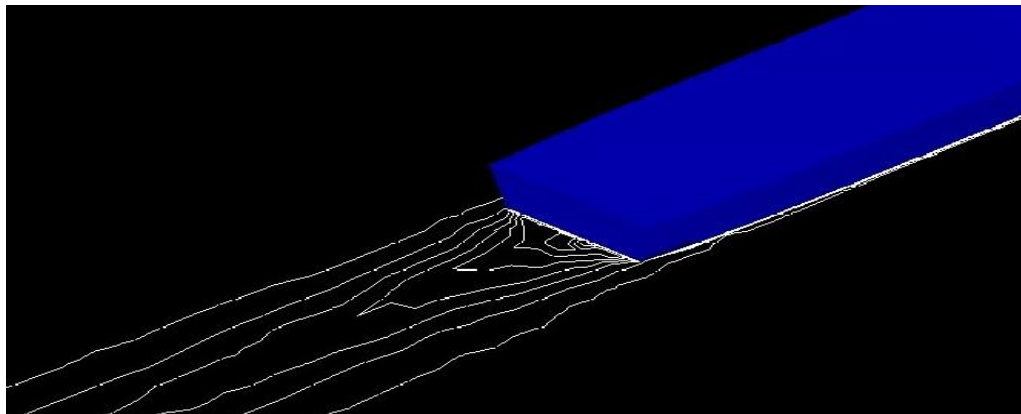




Tampak Bawah Menggunakan Vortex Generator

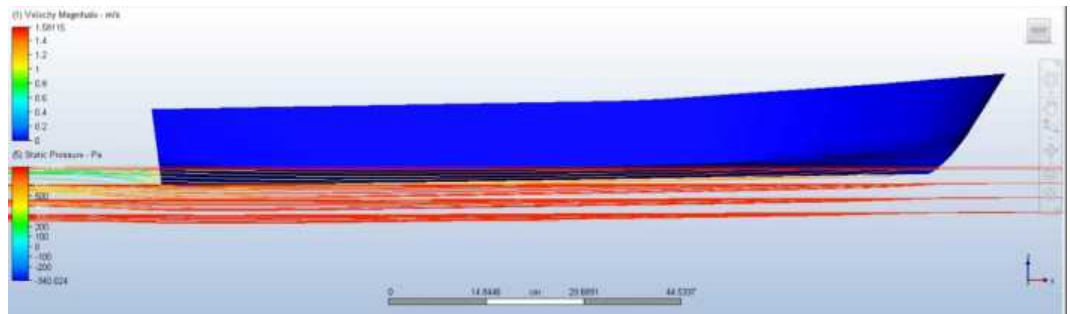


Tampak Atas Tanpa Vortex Generator

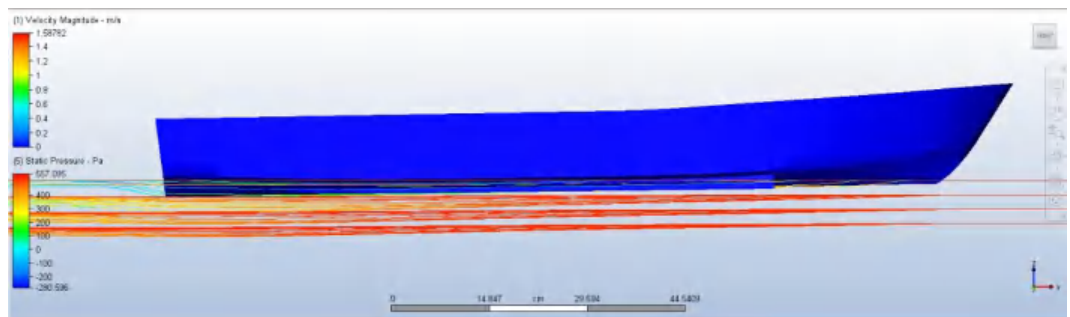


Tampak Atas Menggunakan Vortex Generator

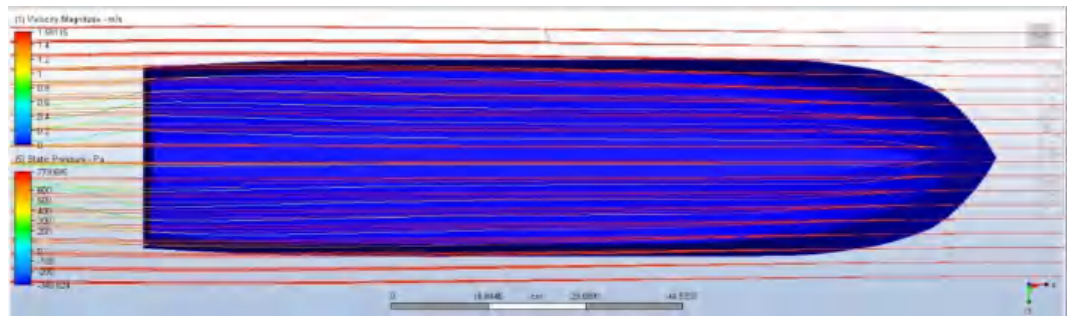
➤ Kecepatan 1,513 m/s dengan Trim 1°



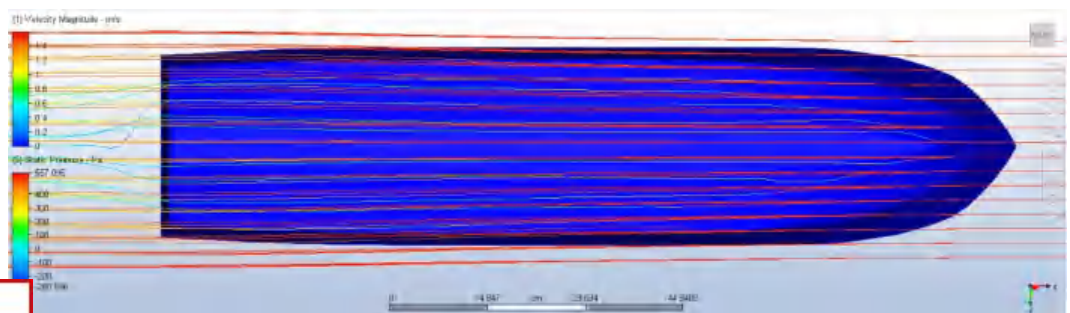
Tampak Samping Tanpa Vortex Generator



Tampak Samping Menggunakan Vortex Generator

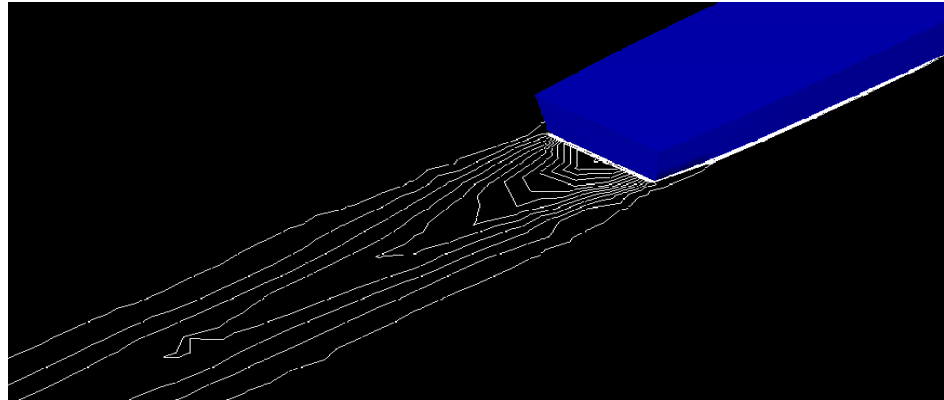


Tampak Bawah Tanpa Vortex Generator

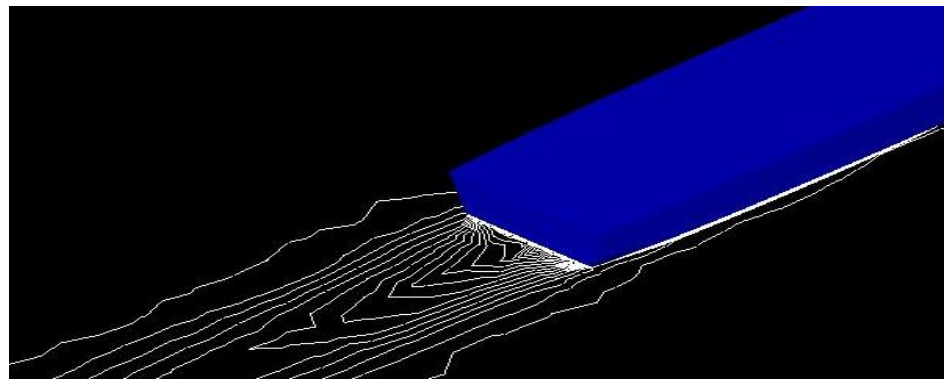


Tampak Bawah Menggunakan Vortex Generator



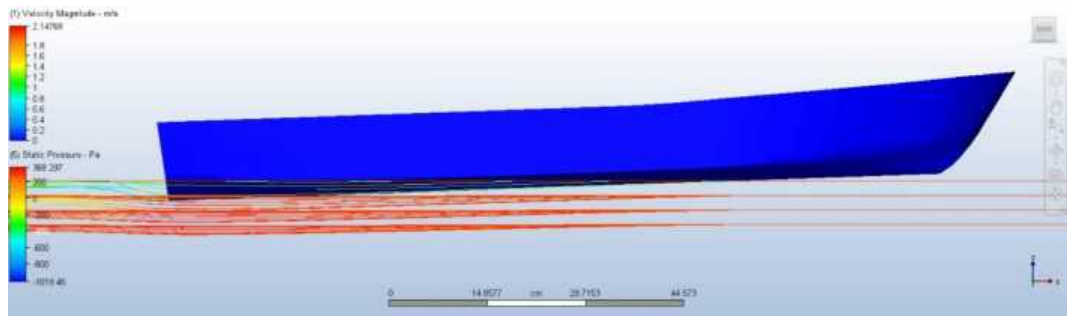


Tampak Atas Tanpa Vortex Generator

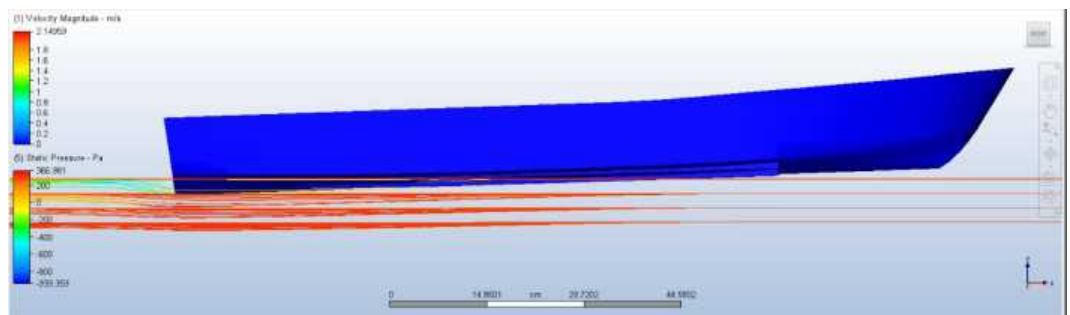


Tampak Atas Menggunakan Vortex Generator

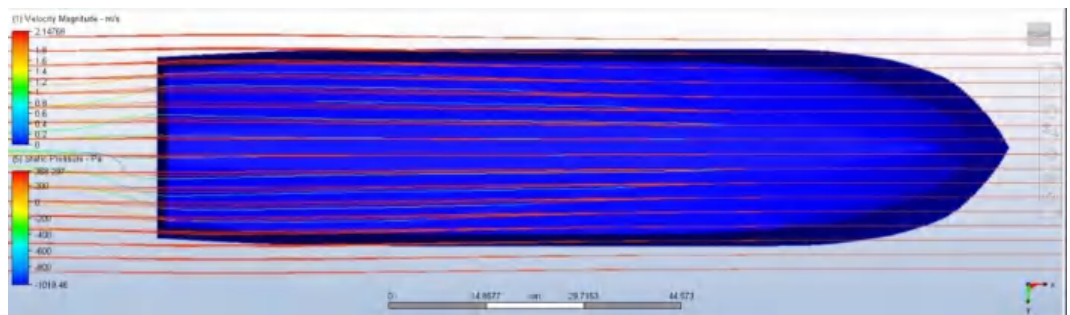
➤ Kecepatan 2,016 m/s dengan Trim 2°



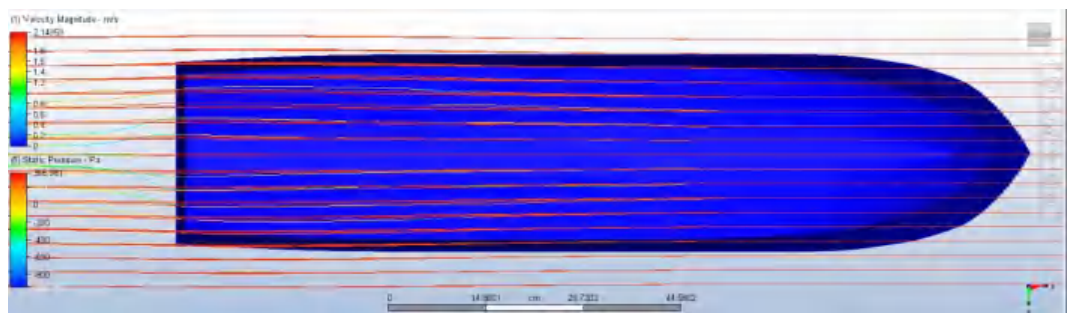
Tampak Samping Tanpa Vortex Generator



Tampak Samping Menggunakan Vortex Generator

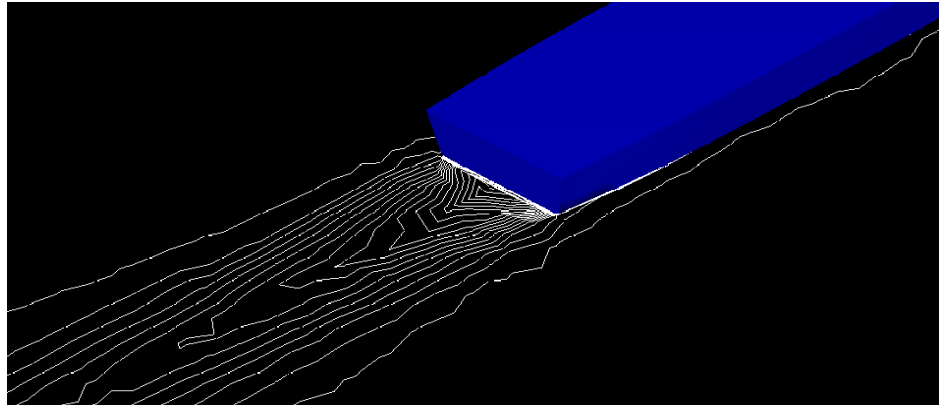


Tampak Bawah Tanpa Vortex Generator

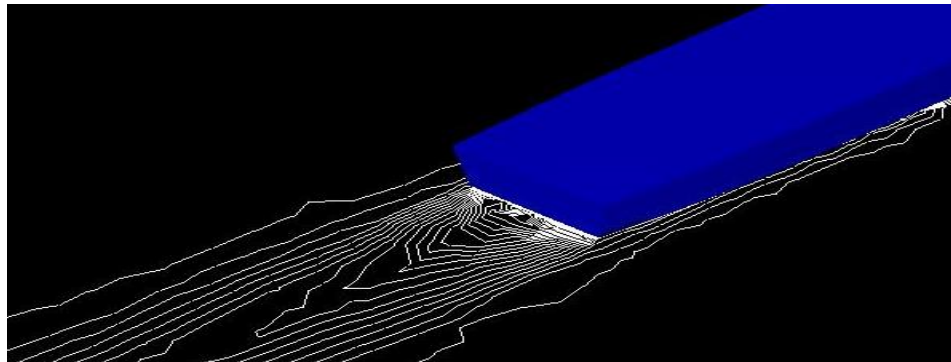


Tampak Bawah Menggunakan Vortex Generator



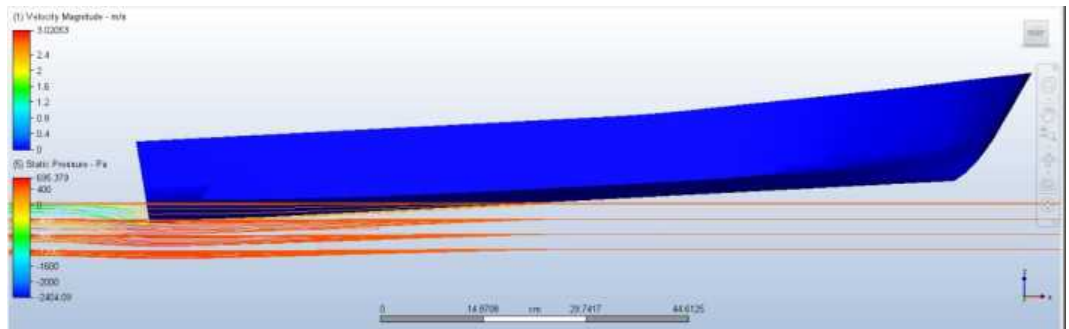


Tampak Atas Tanpa Vortex Generator

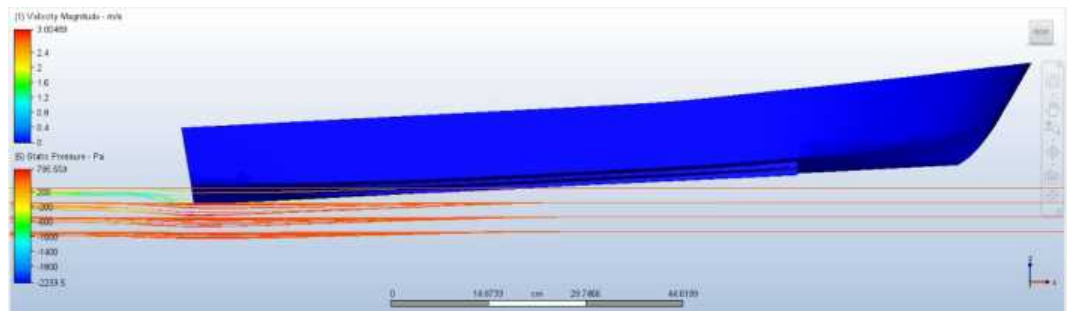


Tampak Atas Menggunakan Vortex Generator

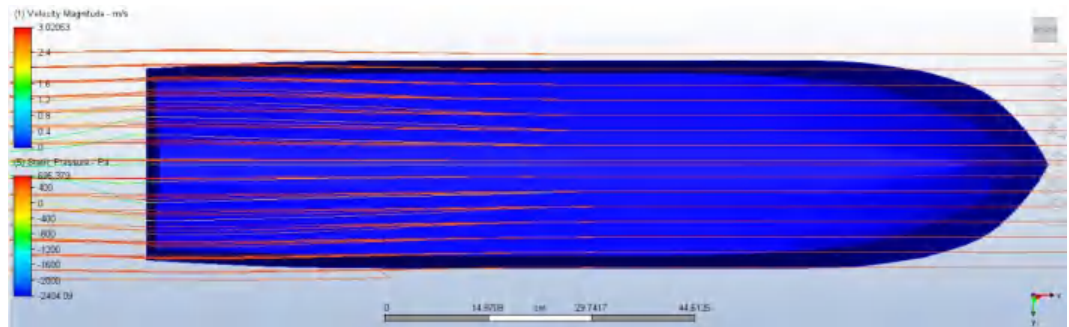
➤ Kecepatan 2,762 m/s dengan Trim 3°



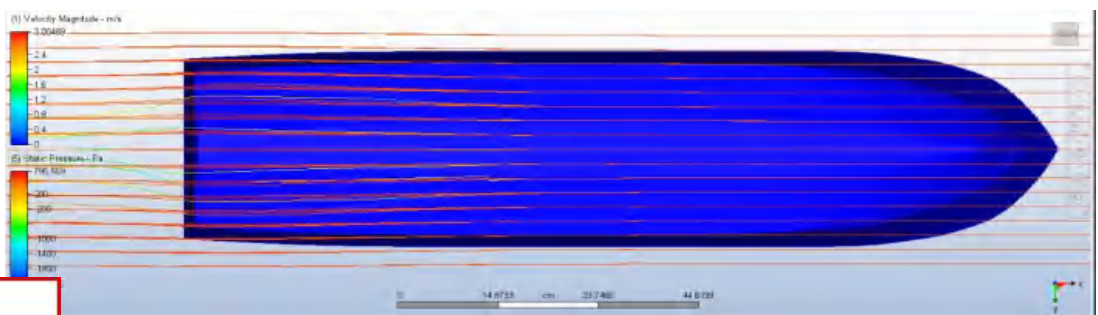
Tampak Samping Menggunakan Vortex Generator



Tampak Samping Menggunakan Vortex Generator

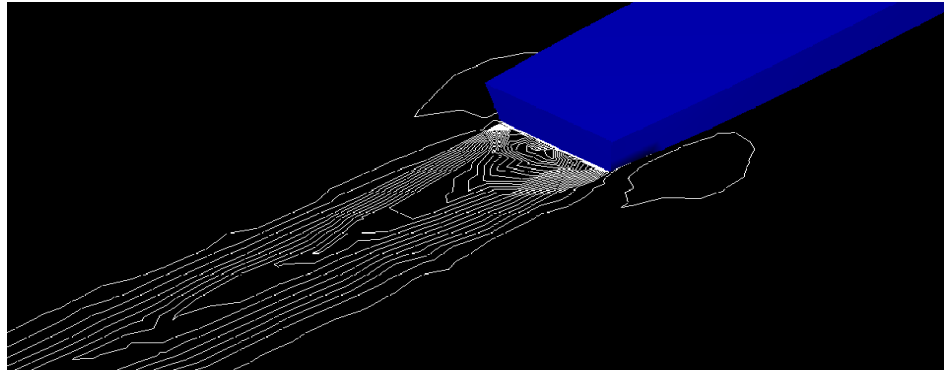


Tampak Bawah Tanpa Vortex Generator

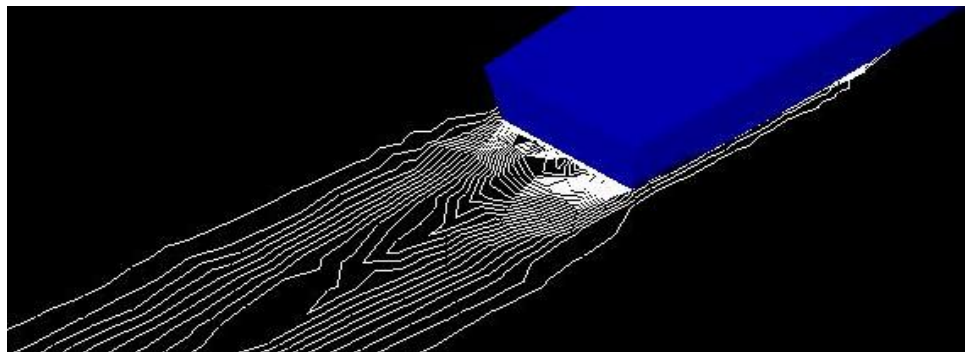


Tampak Bawah Menggunakan Vortex Generator





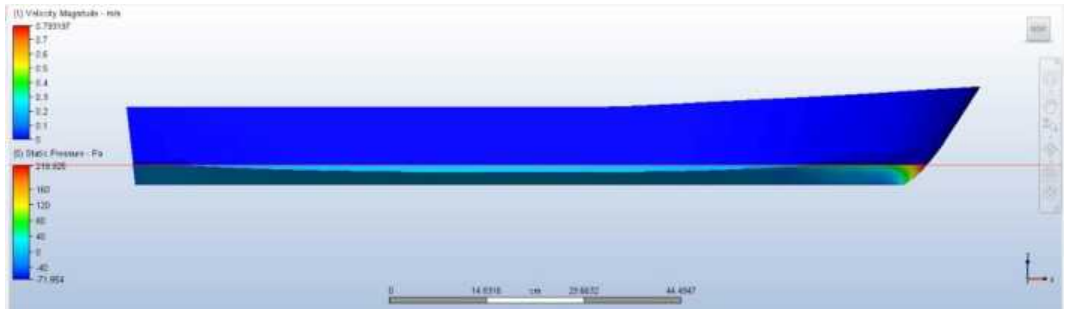
Tampak Atas Tanpa Vortex Generator



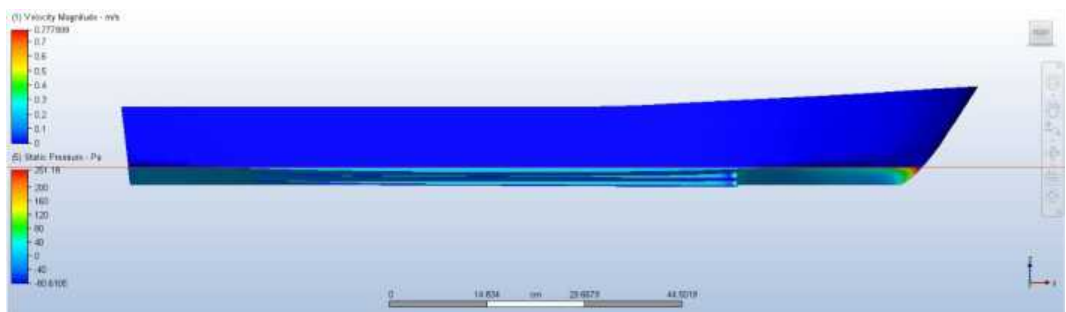
Tampak Atas Menggunakan Vortex Generator

Lampiran 5. Visualisasi Static Pressure

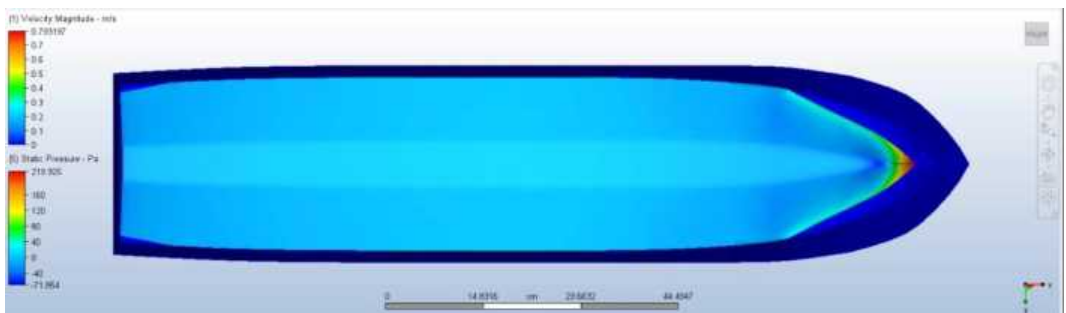
➤ Kecepatan 0,75 m/s dengan Trim 0°



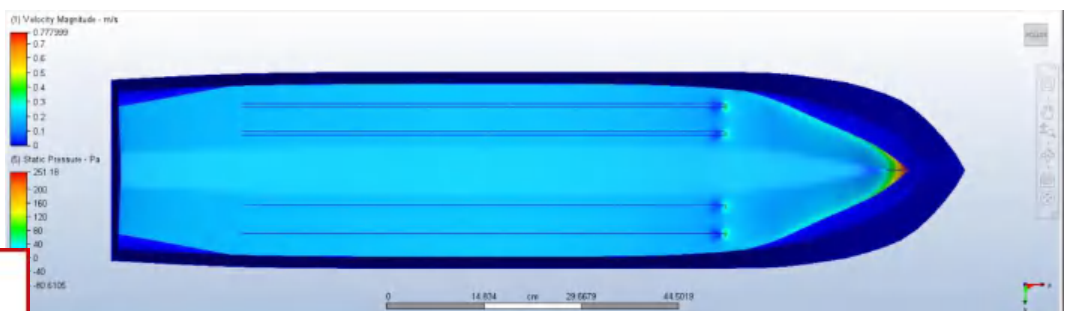
Tampak Samping Tanpa Vortex Generator



Tampak Samping Menggunakan Vortex Generator



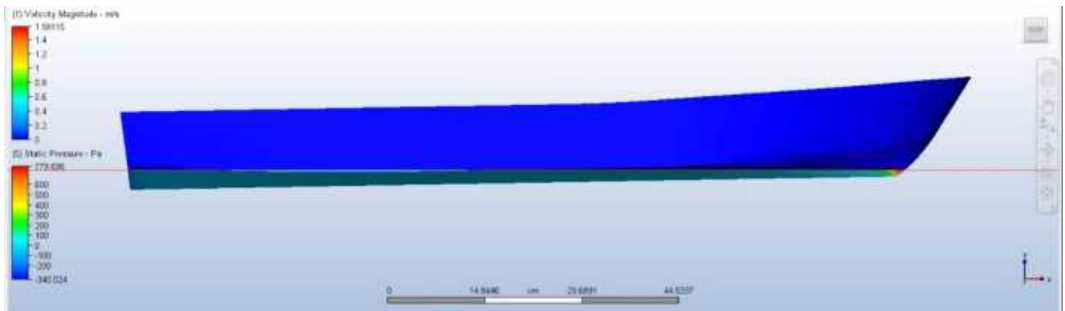
Tampak Bawah Tanpa Vortex Generator



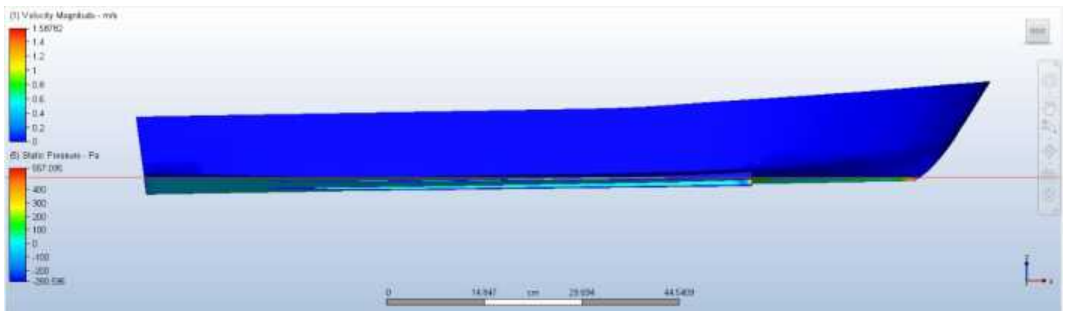
Tampak Bawah Menggunakan Vortex Generator



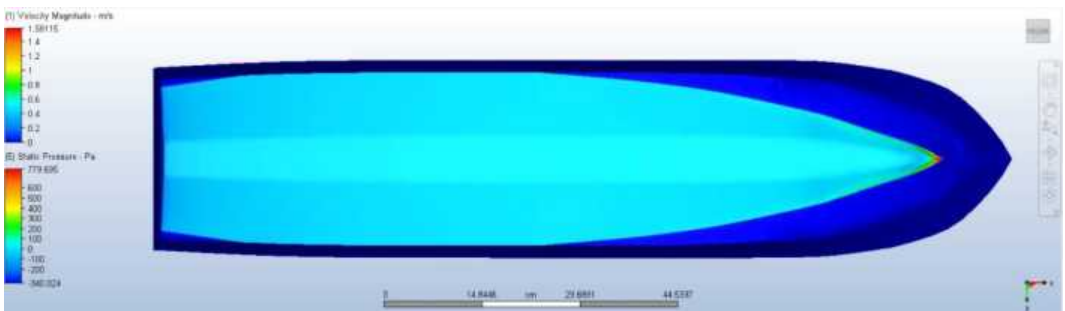
➤ Kecepatan 1,513 m/s dengan Trim 1°



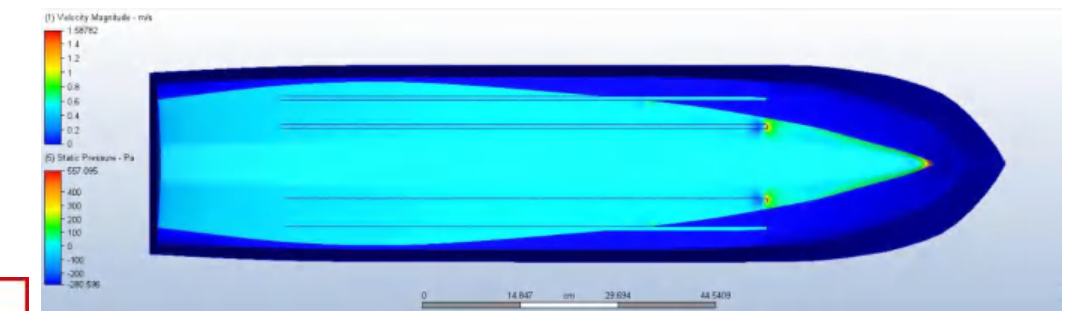
Tampak Samping Tanpa Vortex Generator



Tampak Samping Menggunakan Vortex Generator



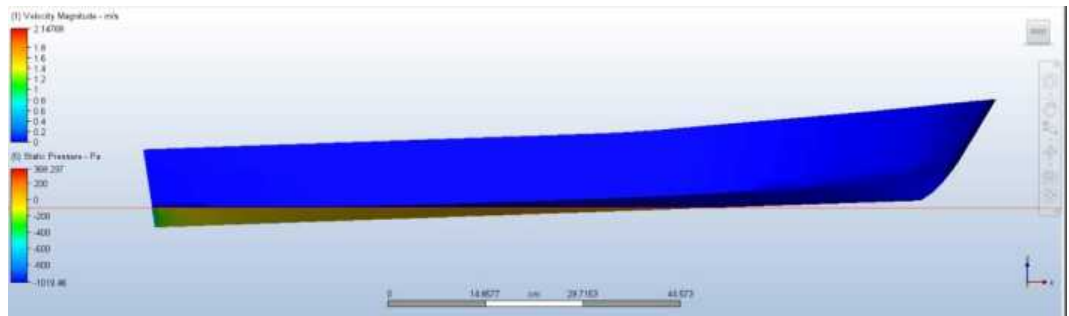
Tampak Bawah Tanpa Vortex Generator



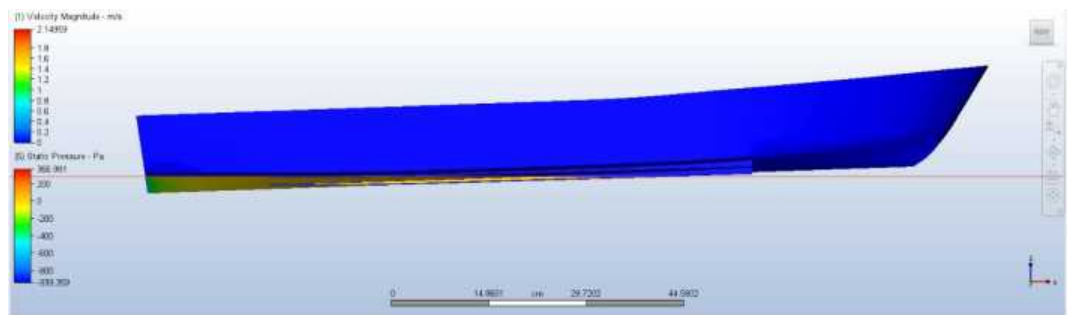
Tampak Bawah Menggunakan Vortex Generator



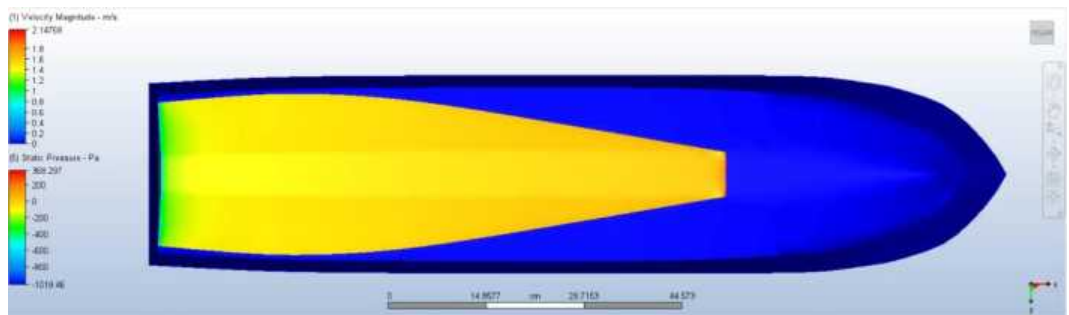
➤ Kecepatan 2,016 m/s dengan Trim 2°



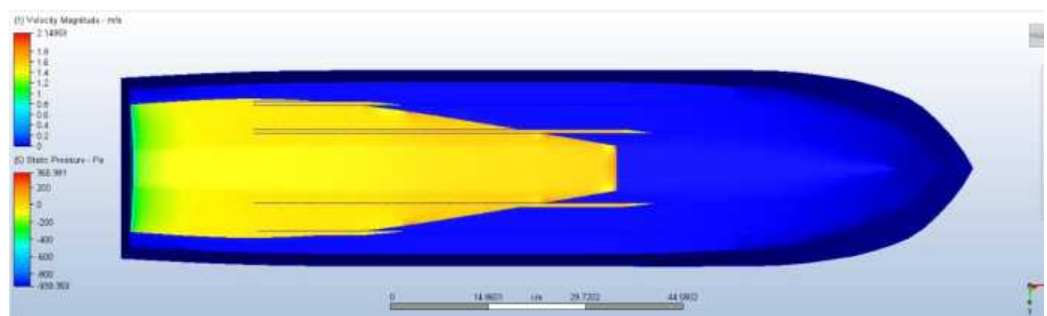
Tampak Samping Tanpa Vortex Generator



Tampak Samping Menggunakan Vortex Generator



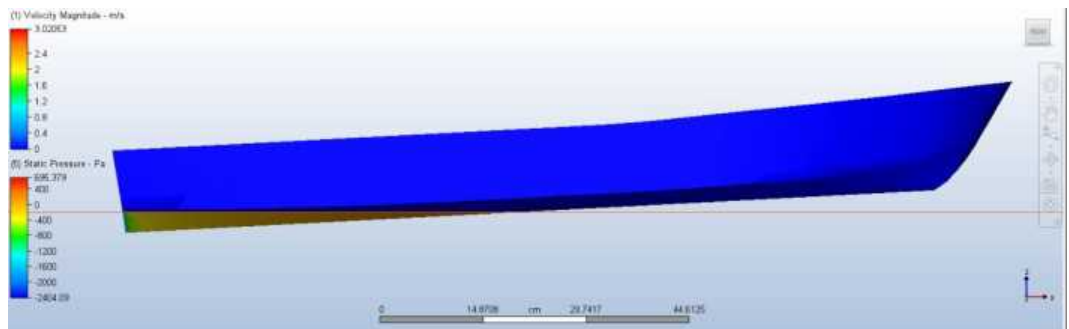
Tampak Bawah Tanpa Vortex Generator



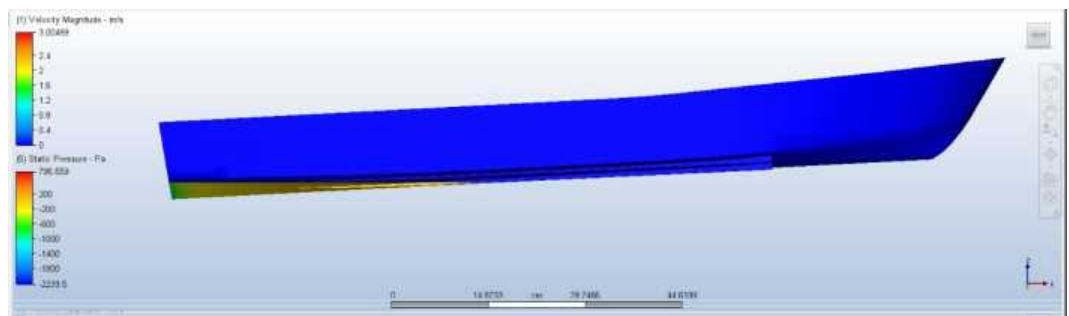
Tampak Bawah Menggunakan Vortex Generator



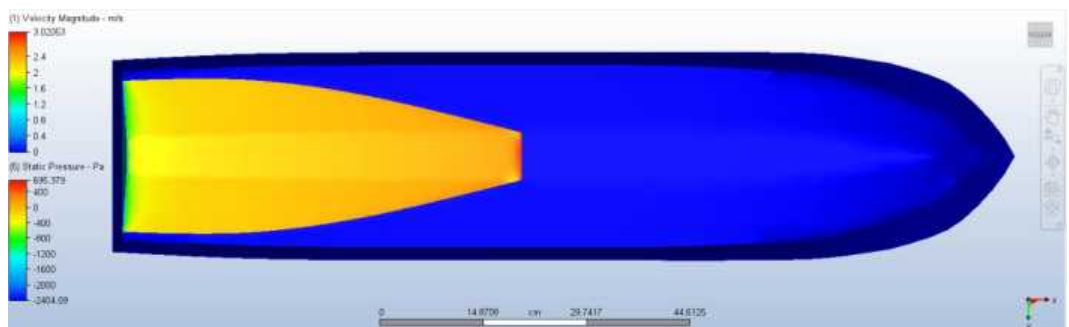
➤ Kecepatan 3,762 m/s dengan Trim 3°



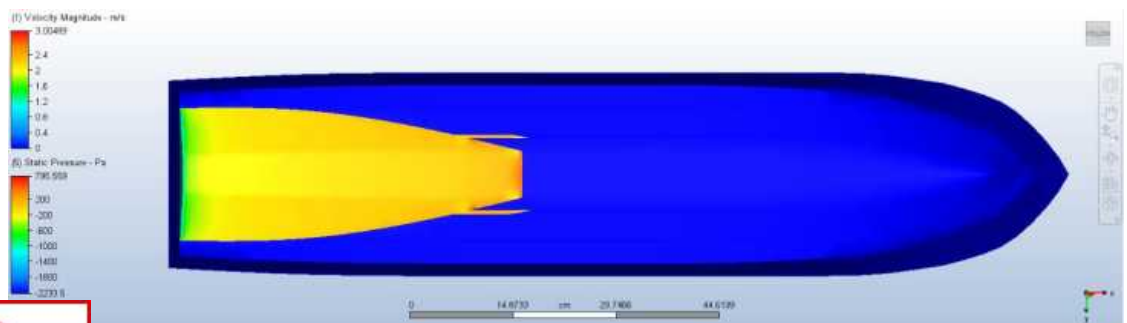
Tampak Samping Tanpa Vortex Generator



Tampak Samping Menggunakan Vortex Generator



Tampak Bawah Tanpa Vortex Generator



Tampak Bawah Menggunakan Vortex Generator



Lampiran 6. Nilai *Static Pressure*

➤ Tanpa menggunakan *Vortex Generator*

a. Kecepatan 0,75 m/s

Var	Mean	at	Max	at	Min
Vx Vel	-7.22772e+01	56379	+1.39308e+01	261201	-7.82827e+01 cm/s
Vy Vel	-2.63338e-03	55813	+3.11703e+01	55761	-3.18307e+01 cm/s
Vz Vel	-1.00496e-01	85033	+5.99493e+00	68772	-2.91658e+01 cm/s
Press	-5.93545e+00	1040	+2.19925e+03	1483	-7.18540e+02 dyne/cm ²
Temp	+1.97283e+01	2290	+2.09600e+01	63755	+0.00000e+00 C
TurbK	+5.67778e+00	85018	+1.32550e+02	1043	+1.14040e-05 cm ² /s ²
TurbD	+7.51401e+01	2478	+1.14505e+04	266034	+7.39743e-03 cm ² /s ³

b. Kecepatan 1,513 m/s

Var	Mean	at	Max	at	Min
Vx Vel	-1.47652e+02	53449	+5.55982e+01	258012	-1.55986e+02 cm/s
Vy Vel	-2.77259e-03	53763	+5.07360e+01	53801	-4.54392e+01 cm/s
Vz Vel	-1.44168e-01	324945	+1.63953e+01	75722	-5.10464e+01 cm/s
Press	-5.78750e+00	935	+7.79695e+03	646	-3.40024e+03 dyne/cm ²
Temp	+2.00849e+01	1750	+2.09600e+01	606718	+0.00000e+00 C
TurbK	+1.23576e+01	324517	+7.90692e+02	934	+1.14040e-05 cm ² /s ²
TurbD	+4.64683e+02	929	+6.62734e+04	266364	+2.61353e-02 cm ² /s ³

c. Kecepatan 2,016

Var	Mean	at	Max	at	Min
Vx Vel	-1.98856e+02	48976	+9.00972e+01	249723	-2.14755e+02 cm/s
Vy Vel	-3.25954e-03	48948	+4.25570e+01	39893	-3.72410e+01 cm/s
Vz Vel	-1.50800e-01	65578	+2.96862e+01	60225	-5.12436e+01 cm/s
Press	-1.32192e+01	42387	+3.68297e+03	470	-1.01946e+04 dyne/cm ²
Temp	+2.04080e+01	1460	+2.09600e+01	53781	+0.00000e+00 C
TurbK	+1.45429e+01	306988	+2.35682e+03	1	+1.14040e-05 cm ² /s ²
TurbD	+6.89890e+02	54678	+1.26615e+05	309387	+2.72664e-02 cm ² /s ³

d. Kecepatan 2,762

Var	Mean	at	Max	at	Min
Vx Vel	-2.73849e+02	46165	+1.39345e+02	243765	-3.02031e+02 cm/s
Vy Vel	-8.75123e-04	46137	+5.95342e+01	46427	-5.27916e+01 cm/s
Vz Vel	-1.77201e-01	57076	+4.08755e+01	53571	-8.21775e+01 cm/s
Press	-3.48222e+01	46570	+6.95379e+03	46166	-2.40409e+04 dyne/cm ²
Temp	+2.04882e+01	116127	+2.09600e+01	563551	-1.68087e+01 C
TurbK	+2.05251e+01	39678	+3.91336e+03	1	+1.14040e-05 cm ² /s ²
TurbD	+1.23777e+03	50160	+2.78830e+05	242318	+1.69008e-01 cm ² /s ³



➤ Dengan menggunakan *Vortex Generator*

a. Kecepatan 0,75 m/s

Var	Mean	at	Max	at	Min
Vx Vel	-7.25940e+01	54880	+2.02507e+01	281008	-7.77056e+01 cm/s
Vy Vel	+1.21678e-03	55206	+3.01258e+01	55240	-2.73610e+01 cm/s
Vz Vel	-1.07401e-01	79834	+7.08496e+00	87178	-2.92181e+01 cm/s
Press	+2.60161e+00	2375	+2.51180e+03	5512	-8.06105e+02 dyne/cm ²
Temp	+1.98821e+01	73560	+2.13441e+01	616772	-2.22546e+01 C
TurbK	+4.34225e+00	55253	+1.44636e+02	7497	+1.14040e-05 cm ² /s ²
TurbD	+7.81614e+01	2499	+1.06343e+04	271475	+1.33702e-02 cm ² /s ³

b. Kecepatan 1,513

Var	Mean	at	Max	at	Min
Vx Vel	-1.47241e+02	52788	+4.81179e+01	254382	-1.57898e+02 cm/s
Vy Vel	-2.20071e-03	52336	+5.08374e+01	52362	-4.86907e+01 cm/s
Vz Vel	-1.18848e-01	63287	+1.46414e+01	75077	-3.75790e+01 cm/s
Press	-7.91062e-01	137	+5.57095e+03	4212	-2.80596e+03 dyne/cm ²
Temp	+2.02906e+01	2384	+2.09600e+01	55142	+0.00000e+00 C
TurbK	+1.16536e+01	75066	+5.30933e+02	20	+1.14040e-05 cm ² /s ²
TurbD	+3.73473e+02	1300	+2.49640e+06	261763	+4.69482e-02 cm ² /s ³

c. Kecepatan 2,016

Var	Mean	at	Max	at	Min
Vx Vel	-1.98803e+02	48467	+8.60614e+01	302778	-2.14869e+02 cm/s
Vy Vel	-1.05851e-03	48906	+4.49870e+01	48919	-3.37570e+01 cm/s
Vz Vel	-1.22985e-01	302817	+2.63548e+01	58026	-4.95646e+01 cm/s
Press	-9.92379e+00	16	+3.66981e+03	1286	-9.39359e+03 dyne/cm ²
Temp	+2.05078e+01	2206	+2.09600e+01	574753	+0.00000e+00 C
TurbK	+1.53406e+01	245631	+2.06222e+03	14	+1.14040e-05 cm ² /s ²
TurbD	+5.70420e+02	122	+1.13448e+06	245376	+2.63111e-02 cm ² /s ³

d. Kecepatan 2,762

Var	Mean	at	Max	at	Min
Vx Vel	-2.74080e+02	45652	+1.35741e+02	240621	-3.00472e+02 cm/s
Vy Vel	-8.05056e-03	45940	+5.39286e+01	45953	-6.01858e+01 cm/s
Vz Vel	-1.80027e-01	296483	+4.10850e+01	52259	-7.56104e+01 cm/s
Press	-2.16837e+01	7	+7.95559e+03	45653	-2.23350e+04 dyne/cm ²
Temp	+2.05461e+01	831	+2.09600e+01	558816	+0.00000e+00 C
	+2.60951e+01	553901	+3.14471e+03	23	+1.14040e-05 cm ² /s ²
	+1.03988e+03	714	+1.10354e+06	297855	+4.19008e-02 cm ² /s ³



Lampiran 7. Hasil nilai perhitungan *wall calculator* tahanan model kapal di setiap variasi kecepatan menggunakan *software CFD (Computational Fluid Dynamic)*

➤ Tanpa menggunakan *Vortex Generator*

a. Kecepatan 0,75 m/s

Summary

```
-----  
Total area, 5957.32, cm^2  
TOTAL FX, -0.590641, Newton  
TOTAL FY, 0.00235215, Newton  
TOTAL FZ, -1.83322, Newton  
Center of Force about X-Axis (Y-Z), 271.7, 189.57, cm  
Center of Force about Y-Axis (X-Z), 968.266, 189.331, cm  
Center of Force about Z-Axis (X-Y), 985.3, 271.767, cm
```

b. Kecepatan 1,513 m/s

Summary

```
-----  
Total area, 5105.34, cm^2  
TOTAL FX, -2.1051, Newton  
TOTAL FY, -0.010476, Newton  
TOTAL FZ, -4.06008, Newton  
Center of Force about X-Axis (Y-Z), 271.718, 189.85, cm  
Center of Force about Y-Axis (X-Z), 1048.59, 190.455, cm  
Center of Force about Z-Axis (X-Y), 950.615, 271.729, cm
```

c. Kecepatan 2,016 m/s

Summary

```
-----  
Total area, 3272.49, cm^2  
TOTAL FX, -3.42582, Newton  
TOTAL FY, 0.00294845, Newton  
TOTAL FZ, -5.28744, Newton  
Center of Force about X-Axis (Y-Z), 271.738, 189.909, cm  
Center of Force about Y-Axis (X-Z), 921.424, 190.723, cm  
Center of Force about Z-Axis (X-Y), 929.547, 271.739, cm
```



d. Kecepatan 2,762 m/s

Summary

Total area, 2083.27, cm²
TOTAL FX, -6.09394, Newton
TOTAL FY, -0.010316, Newton
TOTAL FZ, -8.40352, Newton
Center of Force about X-Axis (Y-Z), 271.796, 189.919, cm
Center of Force about Y-Axis (X-Z), 941.535, 190.255, cm
Center of Force about Z-Axis (X-Y), 929.011, 271.702, cm

➤ Dengan menggunakan *Vortex Generator*

a. Kecepatan 0,75 m/s

Summary

Total area, 4676.41, cm²
TOTAL FX, -1.56516, Newton
TOTAL FY, 0.00173324, Newton
TOTAL FZ, -2.1674, Newton
Center of Force about X-Axis (Y-Z), 973.329, 256.255, cm
Center of Force about Y-Axis (X-Z), 1286.96, 257.234, cm
Center of Force about Z-Axis (X-Y), 1098.57, 973.341, cm

b. Kecepatan 1,513 m/s

Summary

Total area, 4676.41, cm²
TOTAL FX, -1.56516, Newton
TOTAL FY, 0.00173324, Newton
TOTAL FZ, -2.1674, Newton
Center of Force about X-Axis (Y-Z), 973.329, 256.255, cm
Center of Force about Y-Axis (X-Z), 1286.96, 257.234, cm
Center of Force about Z-Axis (X-Y), 1098.57, 973.341, cm



c. Kecepatan 2,016 m/s

Summary

Total area, 2659.04, cm²
TOTAL FX, -2.63562, Newton
TOTAL FY, -0.00784151, Newton
TOTAL FZ, -4.31707, Newton
Center of Force about X-Axis (Y-Z), 973.229, 256.219, cm
Center of Force about Y-Axis (X-Z), 1119.31, 255.841, cm
Center of Force about Z-Axis (X-Y), 1105.96, 973.311, cm

d. Kecepatan 2,762

Summary

Total area, 1650.4, cm²
TOTAL FX, -4.92512, Newton
TOTAL FY, 0.00963272, Newton
TOTAL FZ, -6.5529, Newton
Center of Force about X-Axis (Y-Z), 973.284, 256.222, cm
Center of Force about Y-Axis (X-Z), 1109.46, 255.916, cm
Center of Force about Z-Axis (X-Y), 1102.6, 973.354, cm



Lampiran 8. Penentuan Skala Model

Penentuan skala model dilakukan untuk menghindari terjadinya ombak pada dinding tangki atau yang disebut dengan *blockage effect*, dimana model harus disesuaikan dengan ukuran tangki serta tinggi air dalam tangki dengan sarat model. Menurut Harvard, penentuan lebar model (B_m) adalah sebagai berikut :

$$B_m < 1/10 B_{\text{Tangki}}$$

Diketahui :

$$\begin{aligned} B_{\text{Tangki}} &= 4,07 \text{ m} \\ &= (1/10) \times 4,07 \text{ m} \\ &= 0,407 \text{ m} \end{aligned}$$

Maka lebar model yang digunakan agar tidak menimbulkan *blockage effect* dan dapat digunakan untuk pengujian model di *towing tank* yaitu :

$$B_m < 0,407$$

Berdasarkan perhitungan dari persamaan diatas, maka penentuan ukuran lebar model kapal (B_m) maksimal yang memenuhi kriteria yaitu 0,3 sehingga skala yang digunakan untuk ukuran model kapal yaitu skala 1:15.

