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## LAMPIRAN

**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 | 2.112 | 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. Kondisi *trim* model kapal

- Kondisi even keel



- Kondisi *trim* 1°



- Kondisi *trim* 2°

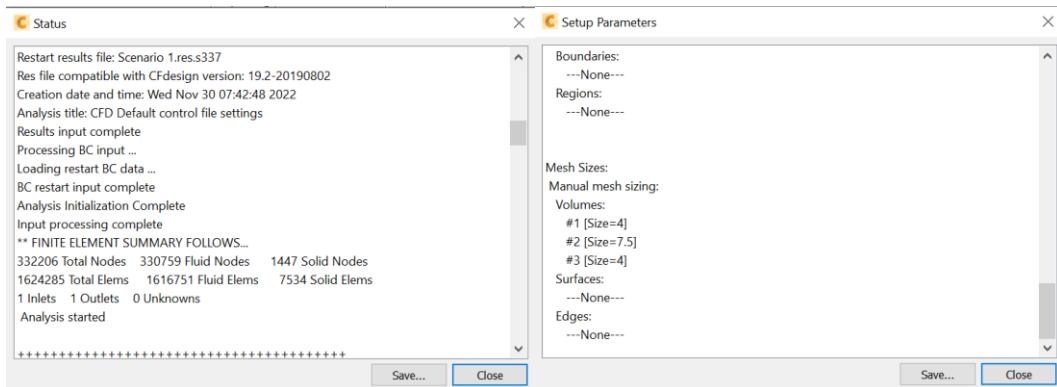


- Kondisi *trim* 3°

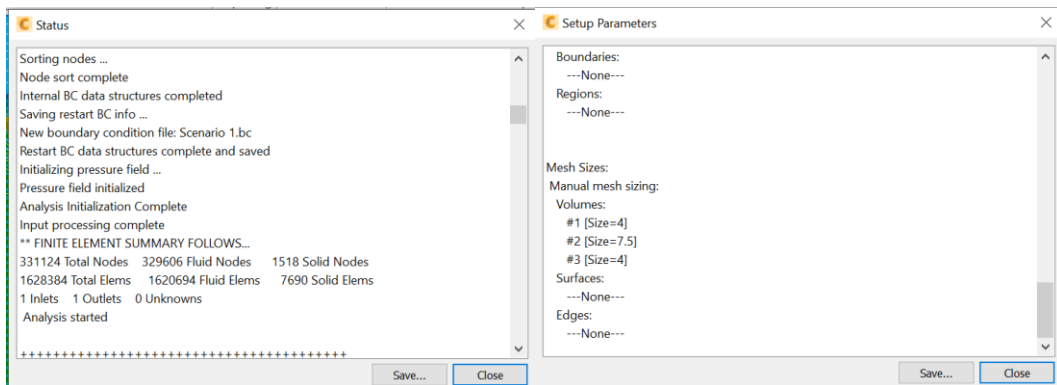


### Lampiran 3. Statistik jumlah *elemen mesh*

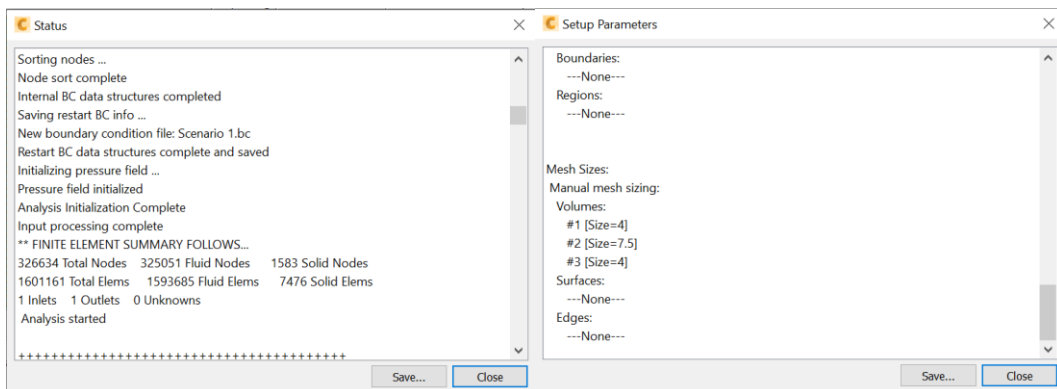
- Statistik *mesh* model kapal tanpa menggunakan *vortex generator* dengan kecepatan 0,75 dan kondisi 0°



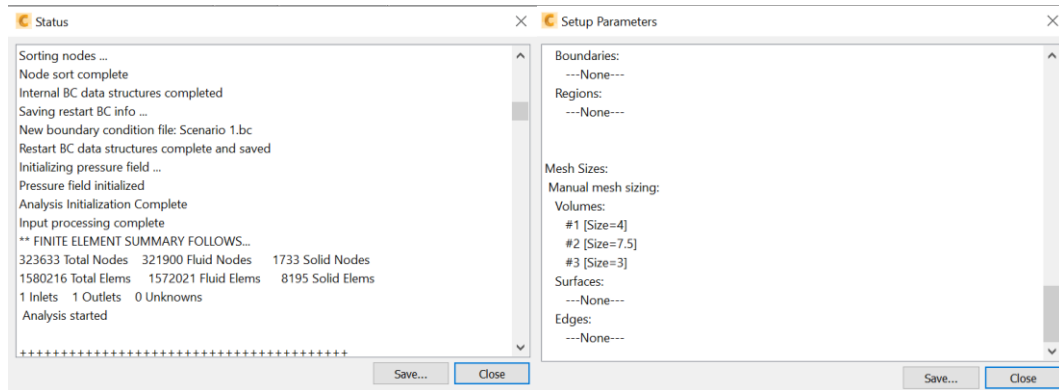
- Statistik *mesh* model kapal tanpa menggunakan *vortex generator* dengan kecepatan 1,513 dan trim 1°



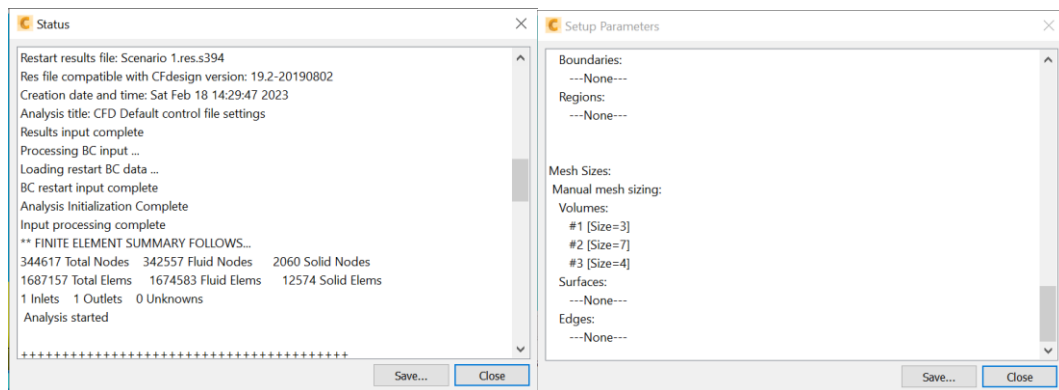
- Statistik *mesh* model kapal tanpa menggunakan *vortex generator* dengan kecepatan 2,016 dan trim 2°



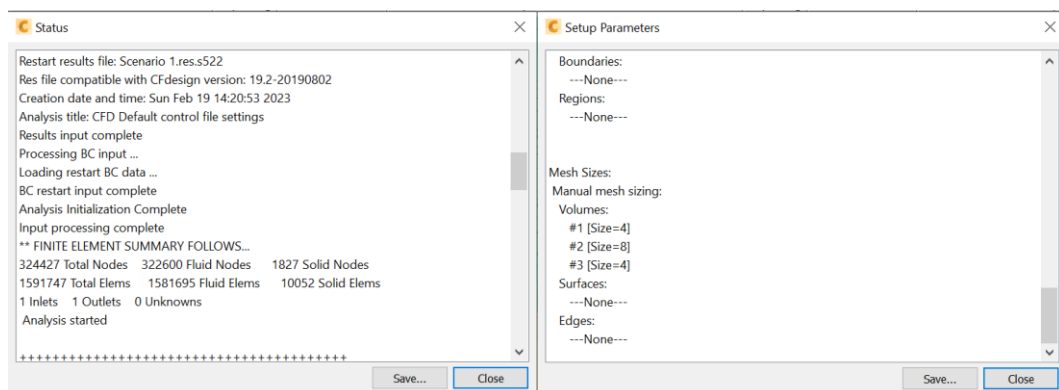
- Statistik *mesh* model kapal tanpa menggunakan *vortex generator* dengan kecepatan 2,762 dan trim 3°



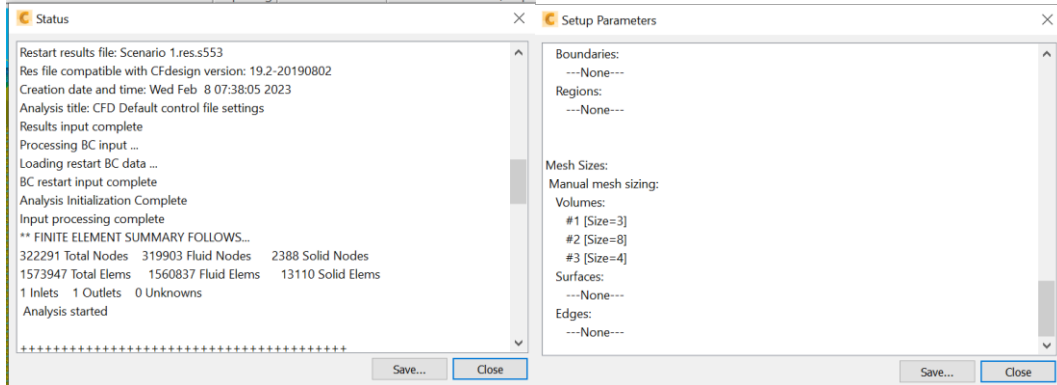
- Statistik *mesh* model kapal menggunakan *vortex generator* dengan kecepatan 0,75 dan kondisi even keel



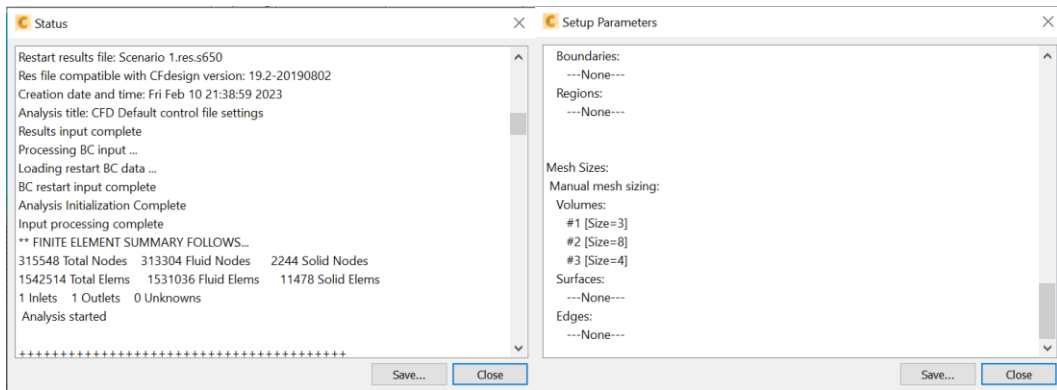
- Statistik *mesh* model kapal menggunakan *vortex generator* dengan kecepatan 1,513 dan trim 1°



- Statistik *mesh* model kapal menggunakan *vortex generator* dengan kecepatan 2,016 dan trim 2°



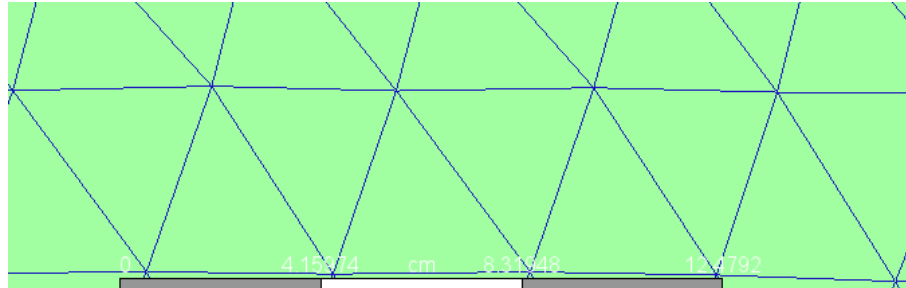
- Statistik *mesh* model kapal menggunakan *vortex generator* dengan kecepatan 2,762 dan trim 3°



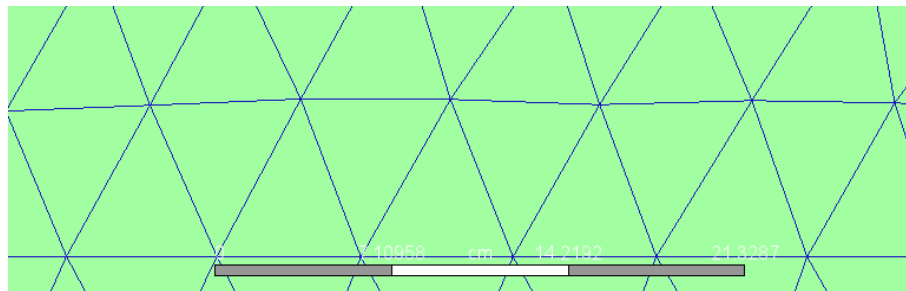


#### Lampiran 4. Visualisasi *mesh sizing*

- Ukuran dan bentuk *mesh* pada bodi kapal



- Ukuran dan bentuk *mesh* pada kolam



**Lampiran 5.** Hasil *residual in* dan *residual out* model

➤ kecepatan 0,75 m/s dengan trim 0°

| Iteration | Residual In |
|-----------|-------------|
| 333       | 1.8872e+00  |
| 334       | 1.8768e+00  |
| 335       | 1.8662e+00  |
| 336       | 1.8627e+00  |
| 337       | 1.8539e+00  |
| 338       | 1.8562e+00  |
| 339       | 1.8437e+00  |
| 340       | 1.8291e+00  |

*Residual In*

| Iteration | Residual Out |
|-----------|--------------|
| 333       | 2.1833e-08   |
| 334       | 2.0159e-08   |
| 335       | 2.1590e-08   |
| 336       | 2.5622e-08   |
| 337       | 1.9909e-08   |
| 338       | 2.3263e-08   |
| 339       | 2.0526e-08   |
| 340       | 2.0826e-08   |

*Residual Out*

Model kapal tanpa menggunakan *vortex generator*

| Iteration | Residual In |
|-----------|-------------|
| 388       | 1.7368e+00  |
| 389       | 1.7446e+00  |
| 390       | 1.7445e+00  |
| 391       | 1.7297e+00  |
| 392       | 1.7477e+00  |
| 393       | 1.6432e+00  |
| 394       | 1.6775e+00  |
| 395       | 1.6529e+00  |

*Residual In*

| Iteration | Residual Out |
|-----------|--------------|
| 388       | 2.3180e-08   |
| 389       | 2.1343e-08   |
| 390       | 2.0451e-08   |
| 391       | 1.8656e-08   |
| 392       | 2.3244e-08   |
| 393       | 2.3684e-08   |
| 394       | 1.6992e-08   |
| 395       | 1.7152e-08   |

*Residual Out*

Model kapal tanpa menggunakan *vortex generator*

➤ Kecepatan 1,513 dengan trim 1°

| Iteration | Residual In |
|-----------|-------------|
| 484       | 1.4852e+00  |
| 485       | 1.4666e+00  |
| 486       | 1.4583e+00  |
| 487       | 1.4563e+00  |
| 488       | 1.4694e+00  |
| 489       | 2.1155e+00  |
| 490       | 2.0815e+00  |
| 491       | 1.8926e+00  |

*Residual In*

| Iteration | Residual Out |
|-----------|--------------|
| 460       | 2.1064e-08   |
| 461       | 2.0487e-08   |
| 462       | 1.9826e-08   |
| 463       | 1.9281e-08   |
| 464       | 1.8857e-08   |
| 465       | 1.8380e-08   |
| 466       | 3.1429e-08   |
| 467       | 3.0845e-08   |
| 491       | 1.9613e-03   |

*Residual Out*

Model kapal tanpa menggunakan *vortex generator*

| Iteration | Residual In |
|-----------|-------------|
| 516       | 1.9368e+00  |
| 517       | 2.0377e+00  |
| 518       | 1.8232e+00  |
| 519       | 1.8834e+00  |
| 520       | 1.8882e+00  |
| 521       | 1.8385e+00  |
| 522       | 1.8044e+00  |
| 523       | 1.8670e+00  |

*Residual In*

| Iteration | Residual Out |
|-----------|--------------|
| 516       | 1.9623e-08   |
| 517       | 3.2801e-08   |
| 518       | 2.1852e-08   |
| 519       | 1.9707e-08   |
| 520       | 1.9196e-08   |
| 521       | 2.2254e-08   |
| 522       | 1.8481e-08   |
| 523       | 2.5966e-08   |

*Residual Out*

Model kapal menggunakan *vortex generator*

➤ 2,016 m/s dengan trim 2°

| Iteration | Residual In |
|-----------|-------------|
| 485       | 3.7743e+00  |
| 486       | 3.0133e+00  |
| 487       | 2.2399e+00  |
| 488       | 1.7087e+00  |
| 489       | 1.4104e+00  |
| 490       | 1.3004e+00  |
| 491       | 1.2692e+00  |
| 492       | 1.3047e+00  |

Residual In

| Iteration | Residual Out |
|-----------|--------------|
| 470       | 1.4721e-08   |
| 471       | 1.4108e-08   |
| 472       | 1.3291e-08   |
| 473       | 1.3540e-08   |
| 474       | 1.7099e-08   |
| 475       | 1.8892e-08   |
| 476       | 1.3333e-08   |
| 477       | 1.4862e-08   |

Residual Out

Model kapal tanpa menggunakan *vortex generator*

| Iteration | Residual In |
|-----------|-------------|
| 544       | 1.5579e+00  |
| 545       | 1.5532e+00  |
| 546       | 4.5229e+00  |
| 547       | 3.9026e+00  |
| 548       | 2.8528e+00  |
| 549       | 2.4241e+00  |
| 550       | 2.7003e+00  |
| 551       | 3.7112e+00  |

Residual In

| Iteration | Residual Out |
|-----------|--------------|
| 544       | 2.0981e-08   |
| 545       | 1.6414e-08   |
| 546       | 5.3413e-08   |
| 547       | 4.2864e-08   |
| 548       | 3.5192e-08   |
| 549       | 2.5115e-08   |
| 550       | 3.5772e-08   |
| 551       | 3.9392e-08   |

Residual Out

Model kapal menggunakan *vortex generator*

➤ kecepatan 2,762 m/s dengan trim 3°

| Iteration | Residual In |
|-----------|-------------|
| 485       | 1.7878e+00  |
| 486       | 1.7544e+00  |
| 487       | 1.8971e+00  |
| 488       | 4.9739e+00  |
| 489       | 5.4974e+00  |
| 490       | 4.7308e+00  |
| 491       | 3.7417e+00  |
| 492       | 2.8888e+00  |

Residual In

| Iteration | Residual Out |
|-----------|--------------|
| 491       | 5.2213e-08   |
| 492       | 4.4333e-08   |
| 493       | 2.5931e-08   |
| 494       | 2.5451e-08   |
| 495       | 2.0623e-08   |
| 496       | 1.9022e-08   |
| 497       | 2.6081e-08   |
| 498       | 2.2258e-08   |

Residual Out

Model kapal tanpa menggunakan *vortex generator*

| Iteration | Residual In |
|-----------|-------------|
| 617       | 1.8530e+00  |
| 618       | 1.7445e+00  |
| 619       | 1.6941e+00  |
| 620       | 1.6578e+00  |
| 621       | 1.1274e+01  |
| 622       | 1.0310e+01  |
| 623       | 7.5541e+00  |
| 624       | 5.3272e+00  |

Residual In

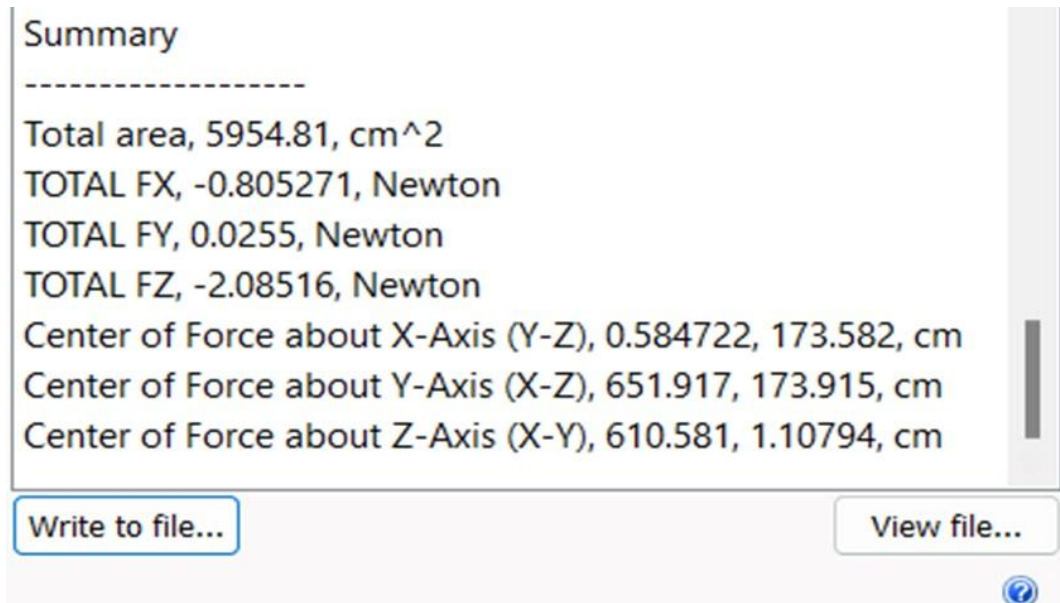
| Iteration | Residual Out |
|-----------|--------------|
| 644       | 2.6741e-08   |
| 645       | 3.4062e-08   |
| 646       | 2.0649e-08   |
| 647       | 2.2967e-08   |
| 648       | 1.9701e-08   |
| 649       | 1.8984e-08   |
| 650       | 2.2591e-08   |
| 651       | 1.9038e-08   |

Residual Out

Model kapal menggunakan *vortex generator*

**Lampiran 6.** Hasil *wall calculator drag force* model

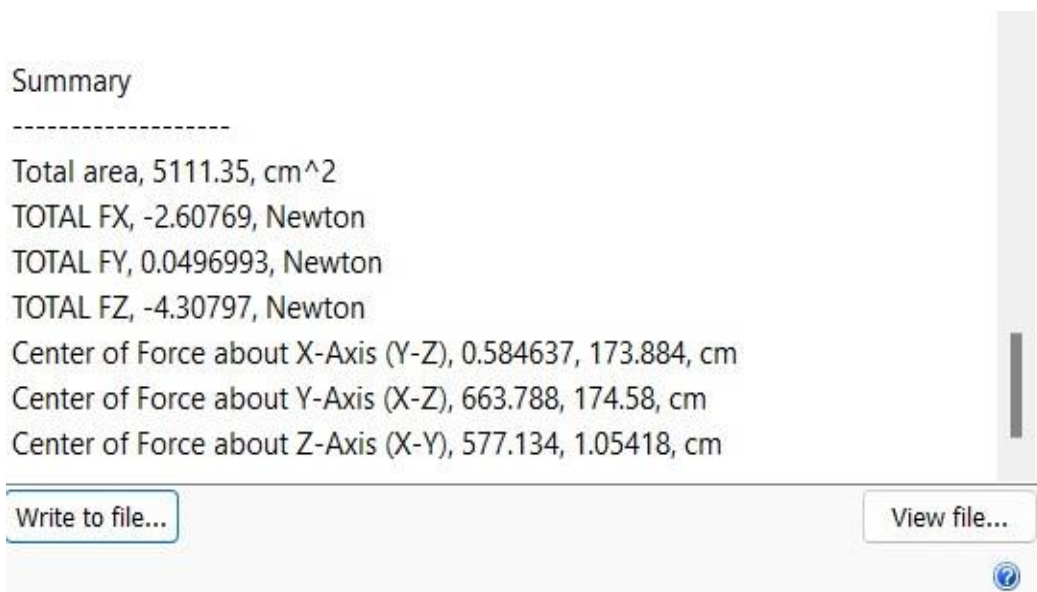
- Model kapal tanpa menggunakan *vortex generator* kecepatan 0,75 m/s dengan kondisi *trim* 0°



Summary  
-----  
Total area, 5954.81, cm<sup>2</sup>  
TOTAL FX, -0.805271, Newton  
TOTAL FY, 0.0255, Newton  
TOTAL FZ, -2.08516, Newton  
Center of Force about X-Axis (Y-Z), 0.584722, 173.582, cm  
Center of Force about Y-Axis (X-Z), 651.917, 173.915, cm  
Center of Force about Z-Axis (X-Y), 610.581, 1.10794, cm

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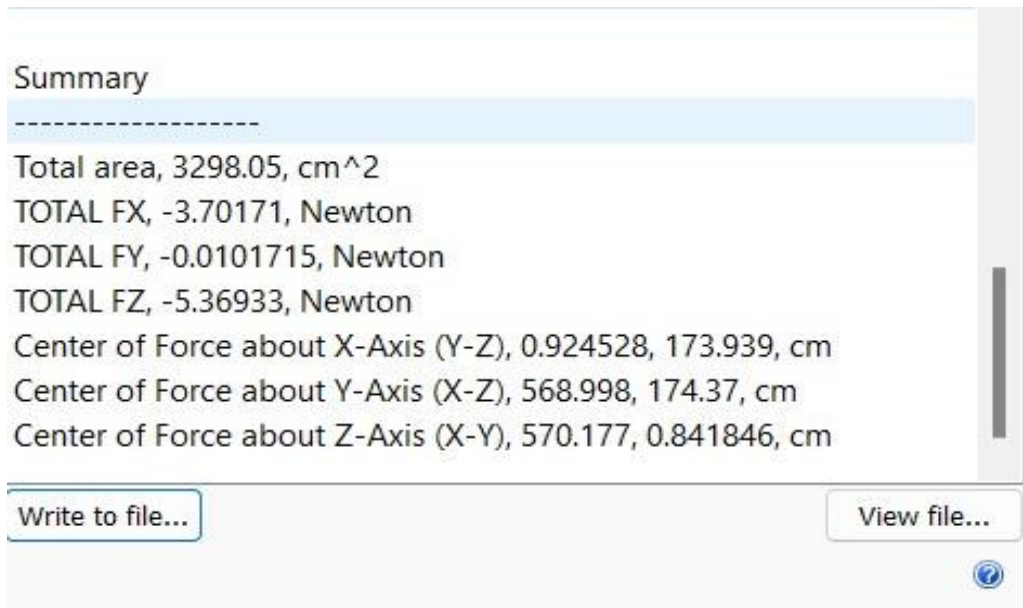
- Model kapal tanpa menggunakan *vortex generator* Kecepatan 1,513 dengan kondisi *trim* 1°



Summary  
-----  
Total area, 5111.35, cm<sup>2</sup>  
TOTAL FX, -2.60769, Newton  
TOTAL FY, 0.0496993, Newton  
TOTAL FZ, -4.30797, Newton  
Center of Force about X-Axis (Y-Z), 0.584637, 173.884, cm  
Center of Force about Y-Axis (X-Z), 663.788, 174.58, cm  
Center of Force about Z-Axis (X-Y), 577.134, 1.05418, cm

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- Model kapal tanpa menggunakan *vortex generator* kecepatan 2,016 m/s dengan kondisi *trim* 2°



- Model kapal tanpa menggunakan *vortex generator* kecepatan 2,762 m/s Dengan kondisi *trim* 3°

## Summary

---

Total area, 2110.41, cm<sup>2</sup>

TOTAL FX, -6.36098, Newton

TOTAL FY, -0.0229614, Newton

TOTAL FZ, -7.78293, Newton

Center of Force about X-Axis (Y-Z), 0.95932, 173.912, cm

Center of Force about Y-Axis (X-Z), 626.086, 175.099, cm

Center of Force about Z-Axis (X-Y), 559.738, 0.770404, cm

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- Model kapal menggunakan *vortex generator* kecepatan 0,75 m/s dengan kondisi *trim* 0°

Summary  
-----  
Total area, 6444.59, cm<sup>2</sup>  
TOTAL FX, -0.754324, Newton  
TOTAL FY, 0.0221264, Newton  
TOTAL FZ, -2.15068, Newton  
Center of Force about X-Axis (Y-Z), 460.205, 173.519, cm  
Center of Force about Y-Axis (X-Z), 783.872, 173.544, cm  
Center of Force about Z-Axis (X-Y), 720.899, 460.316, cm

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ⓘ

- Model kapal menggunakan *Vortex Generator* kecepatan 1.513 m/s dengan kondisi *trim* 1°

Summary  
-----  
Total area, 5611.85, cm<sup>2</sup>  
TOTAL FX, -2.36233, Newton  
TOTAL FY, 0.0132381, Newton  
TOTAL FZ, -4.91837, Newton  
Center of Force about X-Axis (Y-Z), 460.195, 173.8, cm  
Center of Force about Y-Axis (X-Z), 825.238, 174.03, cm  
Center of Force about Z-Axis (X-Y), 690.299, 460.281, cm

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ⓘ

- Model kapal menggunakan *Vortex Generator* kecepatan 2.016 m/s dengan kondisi *trim* 2°

Summary

-----

Total area, 3758.71, cm<sup>2</sup>  
TOTAL FX, -3.18293, Newton  
TOTAL FY, 0.0402309, Newton  
TOTAL FZ, -6.39714, Newton  
Center of Force about X-Axis (Y-Z), 460.243, 173.88, cm  
Center of Force about Y-Axis (X-Z), 685.505, 173.841, cm  
Center of Force about Z-Axis (X-Y), 681.574, 460.274, cm

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- Model kapal menggunakan *Vortex Generator* kecepatan 2.762 m/s dengan kondisi *trim* 3°

Summary

-----

Total area, 2404.41, cm<sup>2</sup>  
TOTAL FX, -5.9871, Newton  
TOTAL FY, -0.0537817, Newton  
TOTAL FZ, -9.75085, Newton  
Center of Force about X-Axis (Y-Z), 460.143, 173.873, cm  
Center of Force about Y-Axis (X-Z), 691.826, 173.619, cm  
Center of Force about Z-Axis (X-Y), 678.716, 460.179, cm

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### Lampiran 7. Penentuan skala model

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

$$B_m < (1/10) B \text{ Tangki}$$

Diketahui:

$$\begin{aligned} B \text{ tangki} &= 3,54 \text{ m} \\ &= (1/10) \times 3,54 \\ &= 0,354 \text{ m} \end{aligned}$$

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

$$B_m < 0,354$$

Berdasarkan perhitungan dari persamaan diatas, maka penentuan skala model kapal dapat ditentukan melalui tabel berikut:

| Bs  | Skala | Bm(m) |
|-----|-------|-------|
| 4,5 | 1:10  | 0,45  |
| 4,5 | 1:15  | 0,30  |
| 4,5 | 1:20  | 0,23  |
| 4,5 | 1:25  | 0,18  |

Dari tabel diatas ukuran lebar model kapal maksimal yang memenuhi kriteria yaitu 0,30 sehingga skala yang digunakan untuk ukuran model kapal yaitu 1:15.