Detail Perhitungan Hidrostatik Kapal

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Daftar Simbol

$A_{station}$	Luas station (m^2)
A_{WP}	Luas garis air (m^2)
B	Lebar kapal (m)
C_b	Koefisien blok
T	Sarat air (m)
Δ	Displacement (ton)
I_T	Momen inersia transversal (m)
KM	Tinggi metasentrik (m)

1. Perhitungan Volume dan Displacement

Rumus

$$\text{Volume} = \int_0^{L_{pp}} A(x)\,dx \approx \Delta_L \sum_{i=1}^{n} \text{coeff}_i A_i$$

$$\Delta = \rho \cdot \text{Volume}$$

Implementasi Kode

```
% Line 95-96
volume = delta_station * sum(coeff_stations .* A_station);
displacement = volume * rho;
```

2. Pusat Buoyansi Vertikal (KB)

Rumus

$$KB = \frac{\int z \cdot dV}{\text{Volume}} \approx \frac{\sum \text{coeff}_i A_i z_{ci}}{\text{Volume}}$$

$$z_{ci} = \frac{\sum w_k z_k}{\sum w_k}$$

Implementasi Kode

```
% Line 89-92
z_vals = drafts(1:wl);
sum_z = sum(coeff .* z_vals);
z_centroid = sum_z / sum(coeff);
momen_KB(i) = A_station(i) * z_centroid;
```

3. Momen Inersia Transversal (BM)

Rumus

$$I_T = \frac{2}{3}\int y^3 dx \approx \frac{2}{3}\Delta_L \sum \text{coeff}_i y_i^3$$

$$BM = \frac{I_T}{\text{Volume}}$$

Implementasi Kode

```
% Line 188-189
I_T = delta_station * sum(coeff_stations .* ((2/3) * y_waterline.^3)');
BM = I_T / volume;
```

4. Tinggi Metasentrik (KM)

Rumus

$$KM = KB + BM$$

Implementasi Kode

```
% Line 192
KM = KB + BM;
```

5. LCB dan LCF

Rumus

$$LCB = \frac{\int x \cdot A(x) dx}{\text{Volume}} - x_{mid}$$

$$LCF = \frac{\int x \cdot y(x) dx}{\int y(x) dx} - x_{mid}$$

Implementasi Kode

```
% Line 128-135 (LCB)
momen_LCB = A_station .* stations;
total_momen_LCB = delta_station * sum(coeff_stations .* momen_LCB);
LCB = total_momen_LCB / volume - midship_pos;

% Line 136-139 (LCF)
momen_LCF = y_waterline .* stations';
total_momen_LCF = 2 * delta_station * sum(coeff_stations .* momen_LCF');
LCF = total_momen_LCF / luas_garis_air - midship_pos;
```

6. Wetted Surface Area (WSA)

Rumus

$$WSA = 2\int \sqrt{1 + \left(\frac{dy}{dz}\right)^2} dx \approx 2\Delta_L \sum \text{coeff}_i G_i$$

$$G_i = \sum \sqrt{\Delta_{WL}^2 + (\Delta y)^2}$$

Implementasi Kode

```
% Line 108-109
g = sum(sqrt(delta_WL^2 + diff(y).^2));
G_station(i) = 2 * g;
```

7. Ton Per Centimeter (TPC)

Rumus

$$TPC = \frac{\rho \cdot A_{WP}}{100}$$

$$A_{WP} = 2\int ydx \approx 2\Delta_L \sum \text{coeff}_i y_i$$

Implementasi Kode

```
% Line 140-141
luas_garis_air = 2 * delta_station * sum(coeff_stations .* y_waterline');
TPC = (luas_garis_air * rho) / 100;
```

8. Momen Perubahan Trim (MCT)

Rumus

$$MCT = \frac{\Delta \cdot BML}{L_{pp}}$$

$$BML = \frac{I_L}{\text{Volume}}$$

$$I_L = 2\int yx^2dx \approx 2\Delta_L \sum \text{coeff}_i y_i x_i^2$$

Implementasi Kode

```
% Line 143-145
x_midship = stations - midship_pos;
I_L = delta_station * sum(coeff_stations .* (2 * y_waterline .* x_midship'.^2)');
MCT = (displacement * BML) / Lpp;
```

9. Koefisien Bentuk Kapal

Rumus

$$C_b = \frac{\nabla}{L_{pp} \cdot B \cdot T}$$

$$C_m = \frac{A_m}{B \cdot T}$$

$$C_p = \frac{\nabla}{A_m \cdot L_{pp}}$$

$$C_w = \frac{A_{WP}}{L_{pp} \cdot B}$$

Implementasi Kode

```
% Line 153-164
B = 2 * max(y_waterline);
Cb = volume / (Lpp * B * T);
Cm = Am / (B * T);
Cp = volume / (Am * Lpp);
Cw = luas_garis_air / (Lpp * B);
```

Diagram Alir Perhitungan

Figure 1: Diagram alir proses perhitungan hidrostatik

Validasi Numerik

- **Presisi Ganda**: Semua perhitungan menggunakan double precision
- **Error Simpson's Rule**:

$$\text{Error} \approx \frac{\Delta_L^4}{180} \max |f^{(4)}(x)|$$

- **Konsistensi Volume**: Cross-check dengan metode alternatif