

Design Study of a Ring Stiffened Cylinder for use as a Manned Submersible

Ring Yield using Frame Hoop Stress - Comstock, John Paul "Principles of Naval Architecture", 1967, p. 211, Equation [27]

SafetyFactor := 2.0

DesignGoal := 1320·ft·SafetyFactor

DesignGoal = 2640 ft

Design Variables:

Outside Diameter OD := 42·in
 Shell Thickness t := .5·in
 Shell Length Len := 104.25·in
 Number of Rings num := 2
 Ring Depth RD := 2.5·in
 Ring Width RW := 2·in
 Ring Web Thickness b := .375·in, .4375·in... .625·in
 Ring Flange Thickness RFT(b) := b

Constants:

SeaWaterDensity := 64 $\frac{\text{lbf}}{\text{ft}^3}$

Material Properties:

Poissons Ratio μ := .3

Yield Strength σ := 38000 $\frac{\text{lbf}}{\text{in}^2}$

Equations:

$$L := \frac{\frac{1}{3} \cdot \frac{\text{OD}}{2} + \text{Len} + \frac{1}{3} \cdot \frac{\text{OD}}{2}}{\text{num} + 1}$$

Mean Diameter D := OD - t

Mean Radius R := $\frac{D}{2}$

$$\theta := L \cdot \left[\frac{3 \cdot (1 - \mu^2)}{R^2 \cdot t^2} \right]^{\frac{1}{4}} \quad N := \frac{\cosh(\theta) - \cos(\theta)}{\sinh(\theta) - \sin(\theta)}$$

A(b) := RFT(b)·RW + (RD - RFT(b))·b

$$B(b) := \frac{b \cdot t}{A(b) + b \cdot t}$$

$$\beta(b) := \frac{2 \cdot N}{A(b) + b \cdot t} \cdot \left[\frac{1}{3 \cdot (1 - \mu^2)} \right]^{\frac{1}{4}} \cdot (R \cdot t)^{\frac{1}{2}}$$

$$A1(b) := RW \cdot RFT(b) \quad I1(b) := \frac{RFT(b)^3 \cdot RW}{12}$$

$$A2(b) := (RD - RFT(b)) \cdot b \quad I2(b) := \frac{(RD - RFT(b))^3 \cdot b}{12}$$

$$A3(b) := t \cdot b \quad I3(b) := \frac{t^3 \cdot b}{12}$$

$$y(b) := \frac{\left(\frac{RFT(b)}{2}\right) \cdot A1(b) + \left(\frac{RD - RFT(b)}{2} + RFT(b)\right) \cdot A2(b) + \left(RD + \frac{t}{2}\right) \cdot A3(b)}{A1(b) + A2(b) + A3(b)}$$

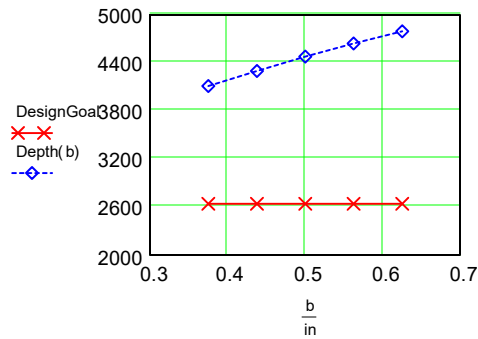
$$Itemp(b) := I1(b) + I2(b) + I3(b) + \left(y(b) - \frac{RFT(b)}{2}\right)^2 \cdot A1(b) + \left[y(b) - \frac{(RD - RFT(b))}{2} - RFT(b)\right]^2 \cdot A2(b)$$

$$I(b) := Itemp(b) + \left(RD + \frac{t}{2} - y(b)\right)^2 \cdot A3(b)$$

$$F(b) := \frac{1}{(1 + \beta(b))} \cdot \left[\left(1 - \frac{1}{2} \cdot \mu\right) \cdot \beta(b) \cdot \left(\frac{A(b)}{t} + b\right) + b \right]$$

$$Df(b) := OD - 2 \cdot (RD + t - y(b))$$

$$Depth(b) := \frac{\sigma \cdot (A(b) + b \cdot t) \cdot 2}{Df(b) \cdot F(b) \cdot SeaWaterDensity}$$



$$\frac{b}{in} =$$

0.375
0.438
0.5
0.563
0.625

$$\frac{Depth(b)}{ft} = \begin{pmatrix} 4108 \\ 4299 \\ 4477 \\ 4642 \\ 4795 \end{pmatrix}$$