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

Weight and Displacement of a Ring Stiffened Cylinder
This does not include the Volume and Weight of the Conning Tower or Battery Box

Design Variables:

Outside Diameter	$OD := 42.0 \cdot in$
Shell Thickness	$t := .375 \cdot in, .4375 \cdot in .. .625 \cdot in$
Head Thickness	$h := .625 \cdot in$
Shell Length	$Len := 96.0 \cdot in$
Number of Rings	$num := 2$
Ring Depth	$RD := 2.5 \cdot in$
Ring Width	$RW := 2.0 \cdot in$
Ring Web Thickness	$b := 0.5 \cdot in$
Ring Flange Thickness	$RFT := 0.5 \cdot in$

Constants:

$$MaterialDensity := .2833333 \cdot \frac{lb}{in^3}$$

$$SeaWaterDensity := 64 \cdot \frac{lb}{ft^3}$$

Equations:

$$V1(t) := \left[\pi \cdot \left(\frac{OD}{2} \right)^2 - \pi \cdot \left(\frac{OD - 2 \cdot t}{2} \right)^2 \right] \cdot Len$$ Volume of the Skin

$$V2(t) := \left[\pi \cdot \left(\frac{OD - 2 \cdot t}{2} \right)^2 - \pi \cdot \left(\frac{OD - 2 \cdot t - 2 \cdot RD + 2 \cdot RFT}{2} \right)^2 \right] \cdot b$$ Volume of the Ring Web

$$V3(t) := \left[\pi \cdot \left(\frac{OD - 2 \cdot t - 2 \cdot RD + 2 \cdot RFT}{2} \right)^2 - \pi \cdot \left(\frac{OD - 2 \cdot t - 2 \cdot RD}{2} \right)^2 \right] \cdot RW$$ Volume of the Ring Flange

$$V4(t) := \left[\pi \cdot \left(\frac{\frac{OD}{.9} + 3 \cdot in}{2} \right)^2 \right] \cdot h$$ Volume of the Semi-Eliptical Head

$$ShellVolume(t) := V1(t) + num \cdot V2(t) + num \cdot V3(t) + 2 \cdot V4(t)$$

$$Weight(t) := ShellVolume(t) \cdot MaterialDensity$$

$$\frac{Weight(t)}{lb} = \begin{pmatrix} 2155 \\ 2375 \\ 2594 \\ 2812 \\ 3029 \end{pmatrix} \qquad \frac{t}{in} = \begin{pmatrix} 0.375 \\ 0.4375 \\ 0.5 \\ 0.5625 \\ 0.625 \end{pmatrix}$$

$$V5 := \pi \cdot \left(\frac{OD}{2}\right)^2 \cdot Len$$

Volume of the Shell

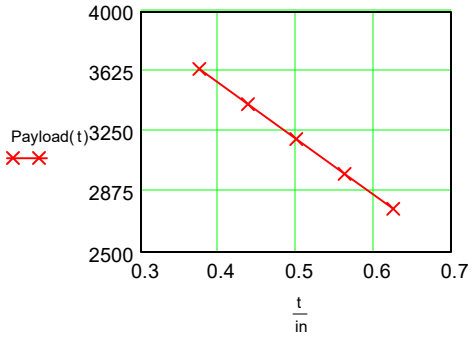
$$V6 := \frac{\pi \cdot OD^3}{24} + \pi \cdot \left(\frac{OD}{2}\right)^2 \cdot 1.5 \cdot in$$

Volume of the Heads (1.5" Flange)

$$Displacement := (V5 + 2 \cdot V6) \cdot SeaWaterDensity$$

$$Displacement = 5798\,lb$$

$$Payload(t) := Displacement - Weight(t)$$



$$\frac{Payload(t)}{lb} = \begin{pmatrix} 3643 \\ 3424 \\ 3205 \\ 2986 \\ 2769 \end{pmatrix}$$

$\frac{t}{in} =$
0.375
0.438
0.5
0.563
0.625

$OD := 39 \cdot in, 40 \cdot in .. 45 \cdot in$

$t := .5 \cdot in$

$$V1(OD) := \left[\pi \cdot \left(\frac{OD}{2} \right)^2 - \pi \cdot \left(\frac{OD - 2 \cdot t}{2} \right)^2 \right] \cdot Len$$

$$V2(OD) := \left[\pi \cdot \left(\frac{OD - 2 \cdot t}{2} \right)^2 - \pi \cdot \left(\frac{OD - 2 \cdot t - 2 \cdot RD + 2 \cdot RFT}{2} \right)^2 \right] \cdot b$$

$$V3(OD) := \left[\pi \cdot \left(\frac{OD - 2 \cdot t - 2 \cdot RD + 2 \cdot RFT}{2} \right)^2 - \pi \cdot \left(\frac{OD - 2 \cdot t - 2 \cdot RD}{2} \right)^2 \right] \cdot RW$$

$$V4(OD) := \left[\pi \cdot \left(\frac{\frac{OD}{.9} + 3 \cdot in}{2} \right)^2 \right] \cdot t$$

$ShellVolume(OD) := V1(OD) + num \cdot V2(OD) + num \cdot V3(OD) + 2 \cdot V4(OD)$

$Weight(OD) := ShellVolume(OD) \cdot MaterialDensity$

$$V5(OD) := \pi \cdot \left(\frac{OD}{2} \right)^2 \cdot Len$$

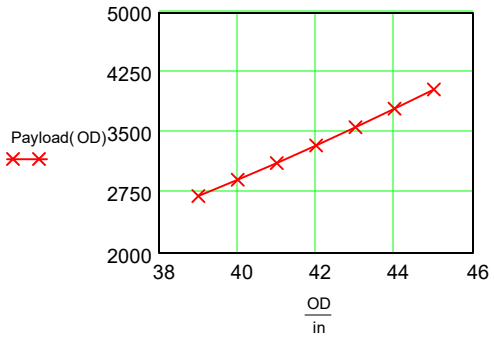
Outer Volume of the Shell

$$V6(OD) := \frac{\pi \cdot OD^3}{24} + \pi \cdot \left(\frac{OD}{2} \right)^2 \cdot 1.5 \cdot in$$

Outer Volume of the Semi-Eliptical Head

$Displacement(OD) := \left(V5(OD) + 2 \cdot V6(OD) \right) \cdot SeaWaterDensity$

$Payload(OD) := Displacement(OD) - Weight(OD)$



$$\frac{OD}{in} = \begin{bmatrix} 39 \\ 40 \\ 41 \\ 42 \\ 43 \\ 44 \\ 45 \end{bmatrix}$$

$$\frac{Payload(OD)}{lb} = \begin{pmatrix} 2709 \\ 2912 \\ 3123 \\ 3342 \\ 3568 \\ 3802 \\ 4044 \end{pmatrix}$$