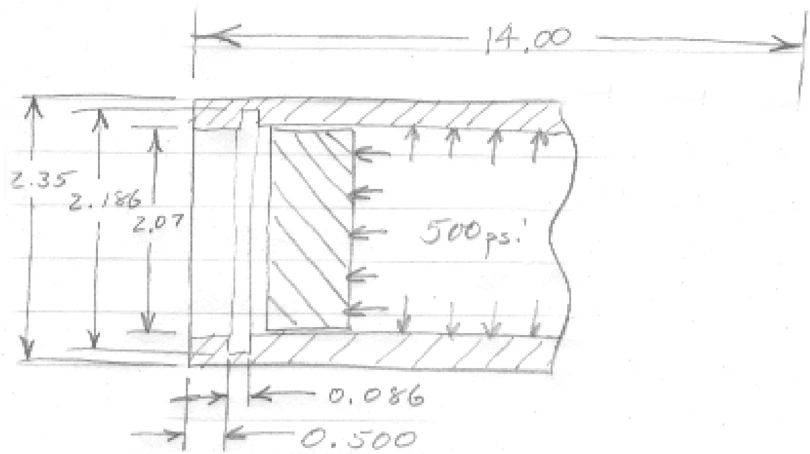
Hybrid Combustion Chamber Snap Ring Analysis



Given : Gen 2 hybrid combustion chamber

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Find : 1) Allowable load on snap ring.
2) Allowable load on snap ring groove.
3) Minimum edge margin to groove.
4) Calculate minimum wall thickness at groove

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Assumptions :

Tube Material : 6061-T6 Aluminum
room temperature properties

$S_y := 40 \cdot 10^3 psi$ $\quad S_u := 45 \cdot 10^3 psi$ $\quad S_{su} := 30 \cdot 10^3 psi$

$S_f := 13.5 \cdot 10^3 psi$

Snap Ring : Waldes Truarc N5000-206 international

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Analysis :

1) Allowable load on snap ring.

Actual axial load on snap ring:

$$F_{service} = P \cdot A$$

$$F_{service} := 500psi \cdot \left[\pi \cdot \frac{(2.07in)^2}{4} \right]$$

$F_{service} = 1.683 \times 10^{3}\,lbf$

Allowable axial load on snap ring, from Waldes Truarc design Manual:

$P_{ring} := 22750lbf$ $\qquad$ $SafetyFactor := 4$

$P_{ringMax} := P_{ring} \cdot SafetyFactor$

$P_{ringMax} = 9.1 \times 10^{4}\,lbf$

$$ActualSafetyFactor := \frac{P_{ringMax}}{F_{service}}$$

$ActualSafetyFactor = 54.081$

Snap ring is adequate for load.

2) Allowable load on snap ring groove:

Actual axial load on the groove is the same as the axial load on the ring:

$F_{service} = 1.683 \times 10^{3}\,lbf$

Allowable axial load on groove, from Waldes Truarc Design Manual:

$$P_g = \frac{C_F \cdot S \cdot d \cdot \pi \cdot S_y}{SF}$$

$$P_g := \frac{1.2 \cdot (2.07 \cdot in) \cdot (.058 \cdot in) \cdot \pi \cdot \left(40 \cdot 10^{3} \cdot psi\right)}{2}$$

$P_g = 9.052 \times 10^{3}\,lbf$

$P_g > F_{service}$ $\qquad$ therfore acceptable

actual factor of safety:

$$SF = \frac{C_F \cdot S \cdot d \cdot \pi \cdot S_y}{F_{service}}$$

$$SF := \frac{18100lbf}{F_{service}}$$

$SF = 10.8$

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3) Minimum edge margin

$$z = 3 \cdot d$$

$$z := 3 \cdot (.062in)$$

$$z = 0.186\,in$$

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4) Minimum wall thickness:

$$w = \sqrt{\frac{3 \cdot C_F \cdot S \cdot d \cdot S_y}{S_u} + \frac{G^2}{4}} - \frac{S}{2}$$

$$w := \sqrt{\frac{3 \cdot 1.2 \cdot (2.07 \cdot in) \cdot (.058 \cdot in) \cdot \left(40 \cdot 10^3 \cdot psi\right)}{45 \cdot 10^3 psi} + \frac{(2.186in)^2}{4}} - \frac{2.07in}{2}$$

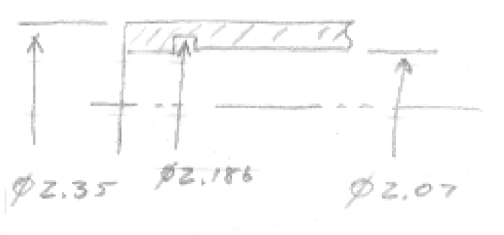
$$w = 0.222\,in$$

$$DesignWallThickness := \frac{2.35in - 2.07in}{2}$$

$$DesignWallThickness = 0.14\,in$$

Calculated minimum wall thickness is for maximum allowable groove load of 9000 lbf. Actual load will be only 1680 lbf.

Axial stress in wall adjacent to groove.



$$Force := 1.68 \cdot 10^3 lbf$$

$$Area := \frac{\pi}{4} \cdot \left[(2.35in)^2 - (2.186in)^2\right]$$

$$\text{Area} = 0.584\,\text{in}^2$$

$$\sigma := \frac{\text{Force}}{\text{Area}}$$

$$\sigma = 2.875 \times 10^3\,\text{psi}$$

Assume $K_T := 2.4$ (from Shigley Fig. A-26-5 for D/d =1.7 and r/d =0.12)

$$\sigma_{prime} := \sigma \cdot K_T$$

$$\sigma_{prime} = 6.901 \times 10^3\,\text{psi}$$

Factor of safety in yield:

$$SF := \frac{S_y}{\sigma_{prime}}$$

$$SF = 5.796$$

Wall thickness appears to be acceptable

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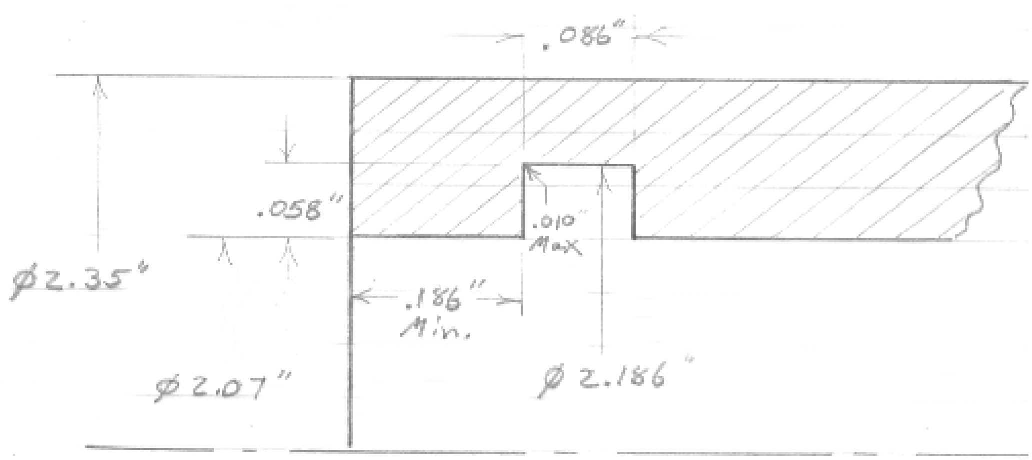
Final Snap Ring Groove Dimensions:



Note : Injector bulkead must have square corners where it abutts snap ring, chamfers or radii are not acceptable.