4Runner 22.8mm OEM A-Arms Load Capacity .mcdx

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01/09/2022

GIVEN: Torsion bar geometry values and suspension travel range for the 2nd Gen 4Runner (y)

- Torsion bars functional length (L) = 37.00 (41.875 inches Sway-A-Way)
- Torsion bar diameter (D): OEM = 22.8mm, OME = 23.4mm, SAW = 25mm, Downey = 26mm
- Upper A-Arm length (A) without Blazeland installed is 8.5" OEM = 12.0-3.5 = 8.5inches
- Suspension travel range (y) approximatley 8 inches.

FIND:

- Angular deflection as a function of the wheel travel
- Find the effective forshortening of the A-arm as it deviates from horizontal orientation.
- Torsional Deflection as a function of angular movement based on travel range.
- The effective spring rate (K) with forshortened A-arm length superimposed.
- The load capacity (LC) of two torsion bars for various compressed distances and plot curve.

ASSUMPTIONS:

- Material Chrome Vanadium UNS G61500 or Chrome Silicon UNS G92540
- The shear modulus (G) for Chrome Vanadium and Chrome Silicon (c/o Murphy & Read Spring Mfg.) 11,500,000 psi
- A-Arm at horizontal to ground establishes full arm length (A)

SOLUTION: Variables $L := 37\ in$ $D := 22.8\ mm$ $G := 11500000\ psi$ $A := 8.5\ in$

$D = 0.9\ in$

$$y := \begin{bmatrix} 8.0 \\ 7.0 \\ 6.0 \\ 5.0 \\ 4.5 \\ 4.0 \\ 3.0 \\ 2.5 \\ 2.0 \\ 1.5 \\ 1.0 \\ 0.01 \end{bmatrix} in \qquad \alpha := \operatorname{asin}\left(\frac{y}{A}\right)$$

$$y' := \begin{bmatrix} 5.0 \\ 4.0 \\ 3.0 \\ 2.0 \\ 1.0 \\ 0.01 \\ 1.0 \\ 2.0 \\ 3.0 \\ 4.0 \\ 5.0 \\ 6.0 \end{bmatrix} in$$

y' value sets values from horizontal as 0.01. Top-out is 6.0 and bottom-out is 5.0

$$\alpha' := \operatorname{asin}\left(\frac{y'}{A}\right) \qquad A' := \cos(\alpha') \cdot A = \begin{bmatrix} 6.87 \\ 7.5 \\ 7.95 \\ 8.26 \\ 8.44 \\ 8.5 \\ 8.44 \\ 8.26 \\ 7.95 \\ 7.5 \\ 6.87 \\ 6.02 \end{bmatrix} in$$

A' is the foresohortened length of the A-arm for angles that deviate from horizontal.

ANSWER: Torsional deflection for a torsion bar (Engineering Tool Box), Force developed with forshortenend effective A-Arm length, Spring rate (K) with F calculated using A', Load Capacity (LC). All as a function of wheel travel (y).

$$T := \frac{\alpha \cdot G \cdot \pi \cdot D^4}{32 \cdot L} \qquad F := \frac{T}{A'} \qquad K := \frac{F}{y} \qquad LC := 2\ F$$

$$y = \begin{bmatrix} 8 \\ 7 \\ 6 \\ 5 \\ 4.5 \\ 4 \\ 3 \\ 2.5 \\ 2 \\ 1.5 \\ 1 \\ 0.01 \end{bmatrix} in \qquad T = \begin{bmatrix} 2024 \\ 1597 \\ 1294 \\ 1038 \\ 921 \\ 809 \\ 595 \\ 493 \\ 392 \\ 293 \\ 195 \\ 2 \end{bmatrix} ft \cdot lbf \qquad F = \begin{bmatrix} 3534 \\ 2556 \\ 1952 \\ 1508 \\ 1309 \\ 1142 \\ 847 \\ 716 \\ 592 \\ 469 \\ 340 \\ 4 \end{bmatrix} lbf$$

$$K = \begin{bmatrix} 441.7 \\ 365.1 \\ 325.4 \\ 301.6 \\ 291 \\ 285.5 \\ 282.2 \\ 286.4 \\ 295.8 \\ 312.4 \\ 339.9 \\ 387.1 \end{bmatrix} \frac{lbf}{in} \qquad LC = \begin{bmatrix} 7067 \\ 5112 \\ 3904 \\ 3016 \\ 2619 \\ 2284 \\ 1693 \\ 1432 \\ 1183 \\ 937 \\ 680 \\ 8 \end{bmatrix} lbf$$