This calculation was conducted in order to determine the maximum allowable torque capacity being exposed to drill pipe under tension load 180,000 lbf. The calculation then slightly developed by showing the effect of increasing tension on pipe being torqued.

Known:
- OD 5.490 in: drill pipe outer diameter
- ID 4.879 in: drill pipe inner diameter
- σ_y 105,000 PSI: material yield strength
- P 180,000 lbf: tension load

\[ A = \frac{\pi}{4} \cdot (OD^2 - ID^2) \]
\[ J = \frac{\pi}{32} \cdot (OD^4 - ID^4) \]

\[ A = 4.98 \text{ in}^2 \]
\[ J = 33.55 \text{ in}^4 \]

Minimum torsional yield strength \((Q_T)\) under tension \(P\):
\[
Q_T = \left(0.096167 \frac{J}{OD} \cdot \sqrt{\sigma_y^2 - \left(\frac{P}{A}\right)^2}\right)
\]
\[
Q_T = \left(0.096167 \times 33.55 \div 5.490 \cdot \sqrt{105,000^2 - (180,000 \div 4.98)^2}\right)
\]
\[
Q_T = 57,934 \text{ lbf ft}
\]

Torsional capacity \((Q)\) based on pure torsion case with \(\sigma_y\) as limit for shear
\[
Q = \left(0.096167 \cdot J \cdot \sigma_y \div OD\right)
\]
\[
Q = \left(0.096167 \times 33.55 \times 105,000 \div 5.490\right)
\]
\[
Q = 61,712 \text{ lbf ft}
\]

Torsional load % with respect to Torsional capacity
\[ \frac{(Q_T)}{Q} \times 100\% \]
\[ = 93.88\% \]

According to the graph illustrated, pipe under torsional load without tension will have maximum torque capability \((Q_T = Q)\). As the tension load \((P)\) increases, the torque capability will be lower until it reaches the lowest value. In that extreme condition, tension pipe will fail once the pipe was given some torque load on it.

Reference
* API RP7G, 16th Edition, page 135