Fermilab

Particle Physics Division
Mechanical Department Engineering Note

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Project Internal Reference:

Project: Solar Tracker

Title: Acceptable load on Solar Tracker gears

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Reviewer(s):

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Applicable Codes:

Abstract Summary:

The following analyzes the acceptable maximum load allowed on two identical worm gears present in a salvaged solar tracker.

Summary/Discussion

The following salvaged solar tracker contains two identical worm gears due to its two degrees of freedom, which regulate the motion of the tracker. Since the worm is always stronger than the gear, the gear will be analyzed to determine the maximum allowable force on one of the teeth (equivalent to the maximum allowable force on the system).

The following has been approximately measured:

- Number of teeth on gear; N_{TG} = 180 teeth
- Number of teeth on worm; N_{TW} = 8 teeth
- Pitch Diameter of gear; d_G = 5.75''
- Pitch Diameter of worm; d_W = 0.96''
- Width of gear; b = 0.375''

The following has been assumed:

- The pressure angle θ = 20°
- The circular axial pitch is approximately equal to the circular pitch
- The gear is made from 6061-T6 aluminum, with σ_{yeild} = 36,000 psi

Using a safety factor of 3; the maximum allowable stress on the gear tooth σ_{max} = 12,000 psi

The force on the tooth is $F = \frac{SYb}{P_{nG}}$; where

- S is the stress
- Y is the Lewis factor
- b is the width of the gear
- P_{nG} is the normal diametral pitch

-S is set to σ_{max} = 12,000 psi;

-Y is obtained from the Lewis chart value corresponding to the pressure angle θ = 20°;
Y = 0.392;

-b = 0.375;

-$P_{nG} = \frac{P_G}{\cos(\psi_G)}$;

-P_G is the diametral pitch in the transverse plane; $P_G = \frac{N_{TG}}{d_G} = \frac{180\ teeth}{5.75\ inches} = 31.3$;

-p_G is the circular pitch; $p_{G=\frac{\pi}{P_G}} = \frac{3.1415}{31.3} = 0.1$

-ψ_G is the helix angle where $\psi_G = \lambda_W = \frac{l}{\pi d_W}$

-l is the lead, $l = N_{TW} * p_G$ = 8 teeth * 0.1 = 0.8

-$\psi_G = \frac{0.8}{\pi(0.96)} = 14.8°$

-$P_{nG} = \frac{31.3}{\cos(14.8°)} = 32.3$

The maximum allowable force F = $\frac{SYb}{P_{nG}}$;

-F = $\frac{(12{,}000\ psi)*(0.392)*(0.375)}{32.3}$ = 54.6 lb

Max allowable Torque;

-T = F * $\frac{d_G}{2}$ = 54.6 * $\frac{5.75''}{2}$ = 157 in*lb = 13 ft*lbs