The Pericyclic Mechanical Transmission

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Project Overview

In the future, rotorcraft manufacturers will demand lighter transmissions which improve the weight to power ratio and enable significantly enhanced rotorcraft performance.

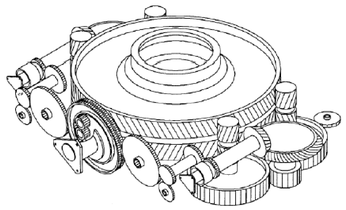


Figure 1: Layout of a typical helicopter transmission

The pericyclic mechanical transmission (PMT) represents a significant improvement over traditional configurations. Utilizing the conjugate meshing of two or more face gears (FGs), this design concept accomplishes something never attempted before.

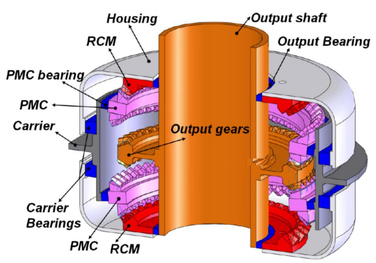


Figure 2: Potential helicopter configuration

Face Gear Principles

Pericyclic behavior consists of two possible motion components: rotation and nutation. These are expressed in the dynamics of the Pericyclic Motion Converter (PMC) as it interfaces with the Reaction Control Member (RCM) and the output.

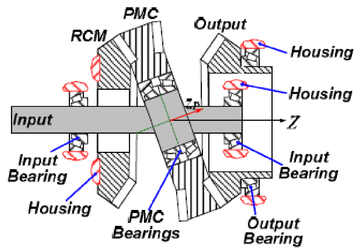


Figure 3: Cross-section of a basic pericyclic transmission

Conjugate teeth were successfully developed for both external and internal face gears. This was achieved by an imaginary shaper in the form of a spur gear, which generated the tooth forms simultaneously.

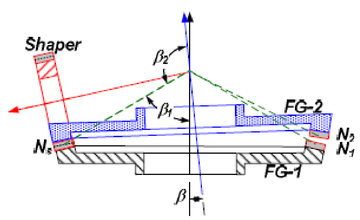


Figure 4: The shaper process being applied

Transmission Error Analysis

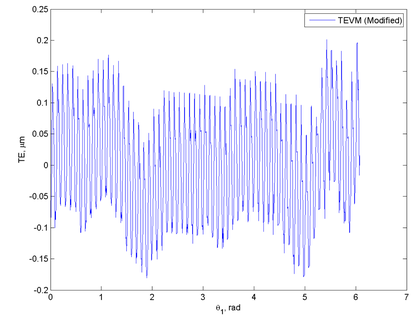


Figure 5: TE for a FG pair

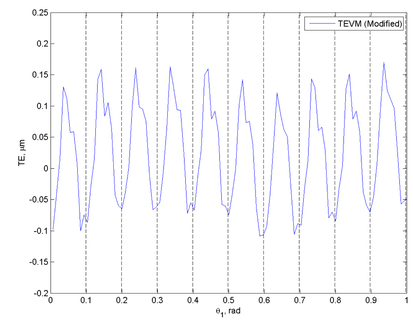


Figure 6: TE with tooth period indicators

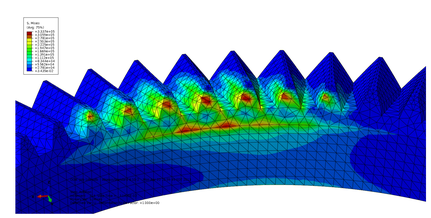


Figure 7: Stress on an internal FG

Transmission error (TE) is a key indicator of gear performance but has never been collected for a FG system. For future development of the PMT, it is critical that this information is available and understood.

TE represents the deviation between the actual position of the driven gear and the ideal position of the same gear in a perfect mesh condition. It is caused by deflections, geometric errors, and geometric modifications.

Mathematically, TE can be represented as:

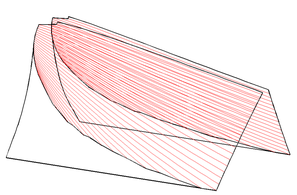
$$TE = rp_1\theta_1 - rp_2\theta_2 = rp_1\theta_1 - rp_1\frac{N_2}{N_1}\theta_2$$

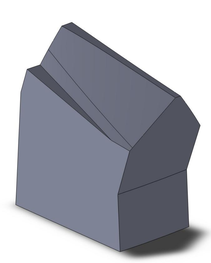
This equation takes into account the angular displacement (θ_1, θ_2), the number of teeth (N_1, N_2) and pitch circle radius (rp_1, rp_2) of the driver and driven gear respectively.

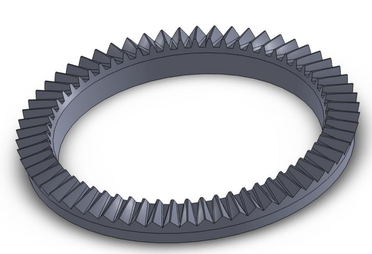
Using a 3D vector representation of this classic equation in combination with angular position information from the Abaqus simulation, TE data for the FG pair was computationally generated.

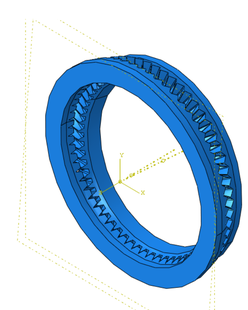
It was found that a FG pair is able to produce a peak-to-peak TE of 0.382 microns. This is better than precision gears in industry today (≥1 micron).

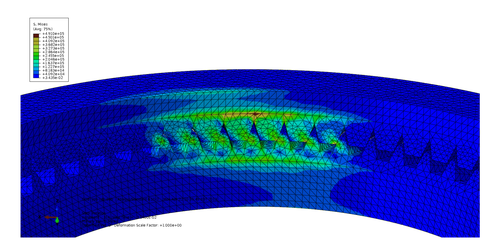
Modeling Process











Contact Line Generation (MatLab) → Tooth Design (SolidWorks) → FG Assembly (SolidWorks) → Simulation Development (Abaqus) → Realistic Model