Reducing Gear Noise with an Orbitless Primary Stage Modeled in SimulationX – 3.9.2

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Outline

• Motivation
  • Noise-Sensitive Applications
  • R&D with unsupported Configurations

• Orbitless Drive
  • Overview
  • Strengths & Weaknesses (vs Planetary)
  • Simulated & Experimental Results
    • MBS Model

• Applications
  • 16mm Orbitless Conventional
  • 100mm Orbitless Compound
Gear-Motors in Human Environments
Orbitless Drive

Ring Gear

Offset Carrier
L. Stocco, “The Orbitless Drive”, 2016 ASME IMECE
Strengths & Weaknesses

Pitch Velocity: \( w=1, M=1, Z_s+Z_p=36 \)

\[
i = 1 + \frac{Z_{\text{planet}}}{Z_{\text{sun}}} \\
i = 2 \left(1 + \frac{Z_{\text{planet}}}{Z_{\text{sun}}} \right)
\]

Large Surface Area
Thin Metal = High Pitch

Chain Reaction
Repulsion
Vibration
Simulation X MBS Models
Model Verification: Pin Force
Predicted Losses

Tooth Friction Losses

- Planetary: 1200 (mW)
- Orbitless: 600

Efficiency

- Planetary: 92%
- Orbitless: 83%
Predicted NVH

Radial Force

Sun Force
Net
Ring Force

Planetary
Orbitless

Teeth mesh at 1243 Hz @ 7,000 RPM

≈ 1200 Hz

≈ White noise
Measured NVH

16mm OD      2.77:1 / 3.9:1
Independently Measured NVH

• OTS Planetary
  • 0 dBA @ 6,000 RPM (ref)
  • -15 dBA @ 2,000 RPM

• Prototype Orbitless
  • -5 dBA @ 6,000 RPM
  • -20 dBA @ 2,000 RPM
<table>
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<tr>
<th>Application (100:1)</th>
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<tr>
<td>Orbitless</td>
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<tr>
<td>• Min Noise</td>
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<tr>
<td>• Min Losses</td>
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<tr>
<td>Planetary</td>
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<tr>
<td>• Max Ratio</td>
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<table>
<thead>
<tr>
<th>ω</th>
<th>τ</th>
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<tbody>
<tr>
<td>10,000</td>
<td>2,500</td>
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<table>
<thead>
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<th>(dBA)</th>
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<td>-5 4:1</td>
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<td>-15 5:1</td>
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<td>-30 5:1</td>
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<th>100 (RPM)</th>
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100 (RPM)
Compound Orbitless Drive

21:1 Worm Drive

100mm Compact Multi-Stage (105:1)

5:1 Compound Orbitless Drive
Simulation X MBS Model
Simulation Results

Input Speed (RPM)

Output Speed (RPM)

Efficiency
• SimulationX enabled us to be able to model unique Orbitless configurations
• High correlation between Simulated and Actual results
• Orbitless is a valid Low Noise 1st stage solution

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