INTRODUCTION

Background:
- European noise regulations require use of a lower power engine versus the US engine.
- The lower power engine tills poorly when using the current transmission ratio.
- Mismatched Euro engine with US transmission.
- US transmission ratio optimized for US engine.

Goals:
“Design, develop, and fabricate a novel transmission design being cost effective, adjustable variable speed transmission that can operate with different input speeds, from different vertical shaft engines, and still provide a tine speed between 230 to 240 RPM at the output.” - SPI

Solution:
- Change worm and worm gear within current transmission housing to an optimum gear ratio for Euro tiller through the design of an experimental test setup to find an optimum gear ratio.

Project Scope:
- Initial project scope – “Design improved tiller transmission for production”.
- “Change worm and worm gear” concept selection narrows and focuses project scope.
- Optimizing older US transmission design for Euro motor.
- Lower power Euro tiller = lower performance versus US higher power tiller.
- Want to optimize Euro tiller with better gearing.

“Tiller Transmission System” by Team 3: John Artes, LaMont Cannon, Mark Dilullo, John Gangloff, Joseph Walther

PERFORMANCE

- **Design Driver:** Power
  - Power = Torque * RPM
  - Assume input power (motor) = output power (tines) with minimal efficiency losses.
  - Assuming constant input torque and RPM from motor, there is a trade-off between output torque and RPM.
  - Output torque and RPM distribution controlled by gear ratio.

<table>
<thead>
<tr>
<th>Engine Output RPM</th>
<th>Gear Reduction</th>
<th>Time Output RPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>6000 / 6000</td>
<td>102.1 / 205.1</td>
<td>6000 / 6000</td>
</tr>
<tr>
<td>74</td>
<td>42.1 / 31</td>
<td>74 / 74 B-F</td>
</tr>
<tr>
<td>74 / 74</td>
<td>20.1 / 18</td>
<td>74 / 74 B-F</td>
</tr>
</tbody>
</table>

Increasing the RPM by gear ratio causes a reduction in the output torque.

ANALYSIS

- A finite-element analysis (FEA) was performed on the plain carbon steel input pinion that drives the experimental test setup, due to it being a weak point within the system. The results show that the pinion would withstand the 0.74 lb-ft, 6000 RPM input with a theoretical factor of safety at 2.02.

EXPERIMENT

- Testing has been performed on the transmission setup for function and preliminary performance.
- Bench testing using a power drill and sample transmission demonstrated initial functionality of the experiment setup.
- The tiller’s engine RPM during gear variation was measured using an attached tachometer.
- Initial in ground testing has shown that soil is best tilled between low to mid range gearing.
- Soil particle fineness is a function of gear ratio with increased gear ratio correlating with increased soil particle size.

EXPERIMENT

- **How It Works:**
  - Take power from the motor on top of the experimental setup and input it into a continuously-variable transmission (CVT).
  - User varies the selection of different gear ratios for optimal tillage.
  - Power is transmitted from the CVT to the output.
  - From the output, power is transmitted to the current transmission and the tines.
  - Power output from the motor is assumed constant and equivalent to the power output of the tines.

- **NuVinci CVT Subsystem:**
  - Team uses NuVinci CVT purchased from Fallbrook Technologies.
  - NuVinci CVT is the core of the experimental setup.
  - Allows for variable gearing from ratios of 1:0.5 to 1:1.75.
  - CVT outputs at a wide range for testing – from 280 RPM, 18 lb-ft to 80 RPM, 54 lb-ft at the tines.

- **Phase 1:** Design Requirements and Project Scope
- **Phase 2:** Concept Selection and Project Plan
- **Phase 3:** Detailed Design
- **Phase 4:** Performance Validation

- **Performance Evaluation:**
  - Gear ratio.
  - Output torque and RPM distribution controlled by gear ratio.
  - Design evolution.

- **Team:** John Artes, LaMont Cannon, Mark Dilullo, John Gangloff, Joseph Walther

- **Engine Output Torque (B-F):**
  - 6000 B-F

- **Motor Torque (B-F):**
  - 74 B-F

- **Current Motor: 100 HP 1800 RPM ± 5%**

- **Current Motor Current Transmission: 6000 ± 33**

- **Additional SPI and UD Mechanical Engineering Faculty and Staff**

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