SENIOR CAPSTONE/
SENIOR DESIGN EXPERIENCE
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Purdue Quarter Scale Driveline

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Executive Summary

The Purdue Quarter Scale Tractor Team requested an upgrade to their existing driveline design to minimize the risk of clutch slippage during competition and optimize the mounting system of the driveline. The constraints and criteria for the project were defined after analyzing the performance data from previous competitions, the current competition rulebook, and speaking to the sponsor. Afterwards, the team identified five topics to research. This led to the use of a decision matrix before proposing one solution to the sponsor. The proposed solution was then validated utilizing computer simulations and with a real-world torque performance test.

Project Research & Context

Team's Key Areas of Research:

1. Torque Amplifiers
2. Types of Clutches
3. Types of Transmissions
4. An Electric Driveline
5. In-line Gearbox

Based on these topic areas, the team was able to theorize a multitude of design combinations. However, from further research, there were only six viable design options.

Characteristics & Limits

Constraints

- Must not exceed a budget of $2000
- Must use a Cub Cadet transaxle
- Must use a 31 HP Briggs & Stratton engine
- Must be able to be disconnected/reconnected within 2 minutes

Criteria

- High amount of power efficiency
- More hours of use with few hours of service
- Don't break under expected forces and stresses

Codes, Standards, Rules

- Clutches must rotate at the speed of the engine or slower
- Clutches cannot act as an energy-storing device
- Shielding must cover any rotating driveline parts, excluding bare shafts, but including couplers

Project Deliverables

- Complete CAD model of the driveline design
- List of parts needed for assembly
- A detailed cost analysis of the design

Project Value Proposition

- Sponsor can gain more points in the pulling portion of the competition
- A more compact driveline mounting system will reduce the overall weight of the tractor
- Sponsor's customers can have more superior design ideas in the market
- Part manufacturers will have more sales and an increase to their reputation

Solution Ideas & Selection

1. Super Cub Mechanical 4-Puck Clutch
2. **Super Cub Mechanical 5-Puck Clutch**
3. Super Cub Mechanical Clutch w/In-line Gearbox
4. Centrifugal Clutch
5. Hydraulic Belt-Driven CVT
6. Electric CVT

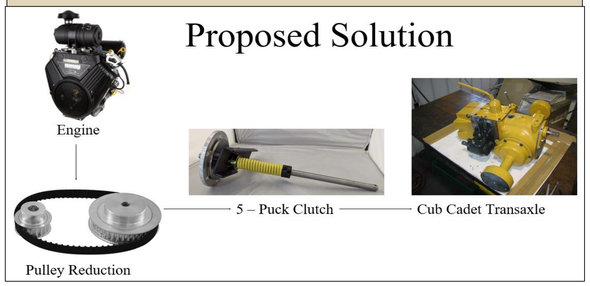

Figure 1: Simple diagram of proposed solution

Design & Development

The final solution proposed to the sponsor was to upgrade to a Super Cub Mechanical 5-Puck Clutch. This solution was chosen based on torque calculations and the performance of last year's 4-puck clutch design. To optimize the mounting system, an FEA analysis was performed on several components in the driveline. It was discovered that the current clutch bracketing system was overbuilt.

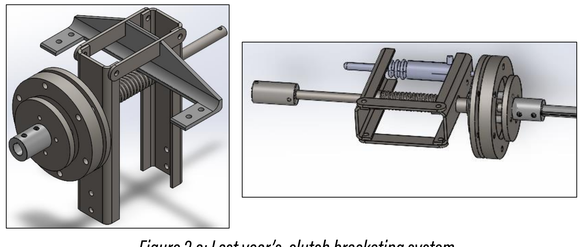

Figure 2.a: Last year's clutch bracketing system
Figure 2.b: The newly optimized bracketing system

Prototype Testing & Customer Feedback

To further validate the proposed solution, the team tested the Super Cub Mechanical 4-Puck Clutch and the Super Cub Mechanical 5-Puck Clutch using a torque wrench. The frame of last year's tractor was used to hold both clutches and an adapter was built to go on the front of the driveline. A digital torque wrench was used to send torque through the driveline to test what torque value would slip the clutch. The sponsor was present for the testing of both clutches.

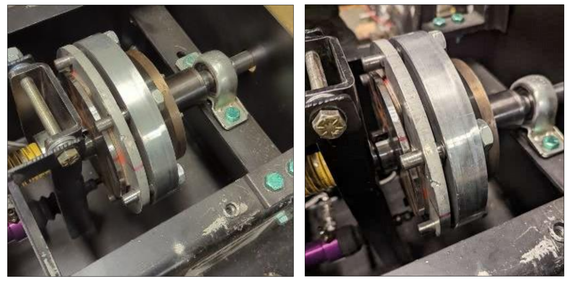

Figure 3.a: The clutch before the torque wrench test, where the marks are aligned.
Figure 3.b: The clutch after the torque wrench test, where the marks are clearly unaligned.

Conclusion & Impact

Currently, the team has validated the need for a clutch upgrade using performance data and a real-world test. As for redesigning the mounting system, a computer model was created for the sponsor to assemble the new system. Moving forward, the team will create a working prototype of the entire driveline design with the sponsor before the end of the semester and will perform further testing in conjunction with the sponsor's tractor design this year.

Acknowledgements

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Sources

2024 ASABE International Quarter-Scale Tractor Student Design Competition Rules