CAPSTONE EXPERIENCE 2014
Hydraulically-Powered Grain Cart Axle with Tracks and Variable Motors

Problem Statement/Objective
As the size and capability of grain carts continue to increase, a need for improved tractive ability and reduced tractive footprint arises. Consequently, some manufacturers began to offer models equipped with free-rolling tracks. However, due to tractive limitations, free-rolling tracks have reached the pinnacle of their utility. Thus, Terra Drive Systems (TDS), recognizing a business opportunity in which they could further expand their Mud Hog brand, decided to offer a universal hydraulically-powered tracked axle system. Considering the numerous grain cart manufacturers, designing for a universal platform is becoming more difficult and even more crucial in areas of performance, manufacturability, and ease of installation. The objective of this project is to assist with the completion of the axle system and to provide an analysis of the work that has previously been completed.

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Figure 1: Existing prototype

Figure 2: Free-Body Diagram of relevant forces

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Figure 3: Some of the calculated outputs and the anticipated resulting tractive performance

Figure 4: This is the final hydraulic schematic. To the left, the triangles represent connections to the tractor. The dashed lines surrounding the three groups of valves in the middle distinguish the separate valve bodies. To the right, the motors will then connect to the drive wheels of the tracks.

Figure 5: Axle and Spindle Assembly under Loading Scenario 2

Figure 6: Spindle Support Stress Concentrations for Load Scenario 2

Figure 7: Spindle Stress Concentrations for Load Scenario 2

Axle and Spindle Assembly Finite Element Analysis Overview
In order to assess the probable range of stresses and deformations in the axle and spindle, four loading scenarios were created to project forces likely to arise during operation.

• Load Scenario 1: forces due to fully-loaded grain bin
• Load Scenario 2: forces due to fully-loaded grain bin and maximum drawbar pull
• Load Scenario 3: forces due to fully-loaded grain bin on slope and maximum drawbar pull
• Load Scenario 4: forces due to sudden stop with fully-loaded grain bin

Hydraulic System Overview
To start off, an interesting problem arose: the worst case scenario for the system (mud) is not the same as the worst case loading (firm soil). Force from the motors was stipulated to be 26% of the total propulsive force needed. The loaded cart weight is 71,080 lbs., which translates to 33,185 lbs per track after subtracting the weight on the drawbar. The tractor translates to 33,185 lbs per track after subtracting the weight on the drawbar. The tractor

Performance
• Motor Chosen – SAI Hydraulics TV 3.5 1,000-0 cc
• Displacement Required = 895 cc for worst loading

Possible Improvements/Recommendations for Future Work
• Ttractive Model
  • Add two wires/connectors to wire harness for extra solenoid valves
  • Add outputs to control program for the extra two solenoid valves
  • Increase axle and spindle components to reduce areas of stress concentrations based on Finite Element Analysis
  • Cycle analysis for load scenarios that exceed material yield strength