Pokagon Trail Maintenance Machine

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INTRODUCTION

The objective of this project was to design and fabricate an original machine that has the capability to pickup, redistribute and grade material that has been washed off of hiking trails at Pokagon State Park. The trail maintenance machine that the team designed consists of a frame, bucket, torsion unit wheels, and a row of box shanks. This unit will be pulled behind a small tractor. Hydraulic controls were added to help the user tilt the bucket while still seated on the tractor. This device is original in the sense of its size and application. Similar devices exist that are larger and must be pulled behind heavy equipment. A width of 5 feet was requested by Pokagon management so the machine can easily be maneuvered on most of the traveled trails. The gross weight of the device was also an important factor due to trail bridges. The 3 point hitch system on the tractor has a lifting capacity of 850 lbs., so the machine had to be designed such that the tongue weight did not exceed this value.

TRAIL TITAN

PROBLEM STATEMENT

The team was challenged to develop a device that would help to maintain Pokagon trails with the least possible amount of manual labor. Pokagon State Park has a limited number of employees that can be dispatched at one time to work in the trails, much of the trail resurfacing was done by volunteers.

CUSTOMER NEEDS

The design team identified with Pokagon the following needs in Table 1 below for the trail maintenance machine.

Table 1: Trail machine needs

Machine Requirements
Unit will be pulled by a tractor
Must pick up and spread materials
Grade and compact trails
Keep trail depth consistency
User friendly
Multi functioning machine

INITIAL DESIGNS

The team used a brainstorming method to generate different concepts. Each member came up with different ideas. These ideas ranged from a simple dump trailer (Figure 1) to a complex Harley rake and paddle wheel design (Figures 2 and 3).

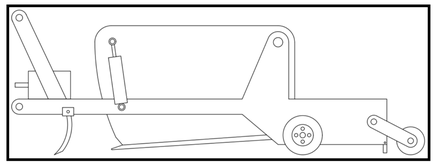


Figure 1 – Concept #1

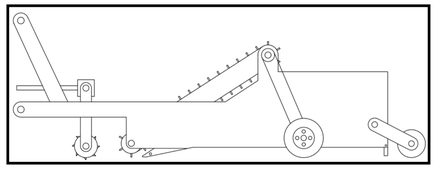


Figure 2 - Concept #2

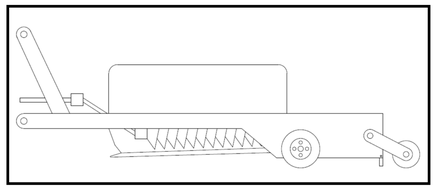
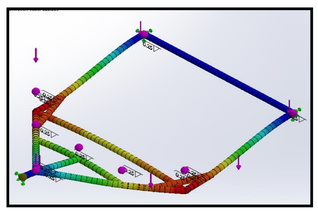


Figure 3 - Concept #3

The team was not very focused on practicality on some of the designs as the team wanted to cover an entire range of possible outcomes for the designs. This gave the team broad range of ideas to choose from. The main two designs that the team came down to the dump and paddle wheel style.

TEST RESULTS - FRAME

The frame in Figure 4 was loaded with a 2000 lbf. across the top of the frame where the bucket will cause the most stress on the frame. When the force was applied to the frame was displaced 0.004”

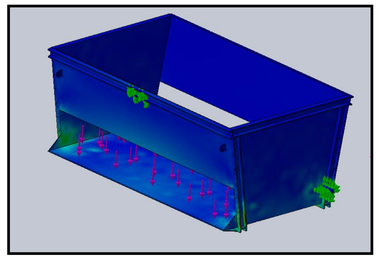


Load: 2000 lbf
Displacement: 0.004”

Figure 4 - Frame Analysis

TEST RESULTS - BUCKET

The FEA Analysis in Figure 5 shows the bucket with 2500 lbs inside. The force is placed solely on the bottom of the bucket where most of the weight will be held. This force only creates a max force of 3,808 psi which is well below the 31,000-psi yield strength of the material.

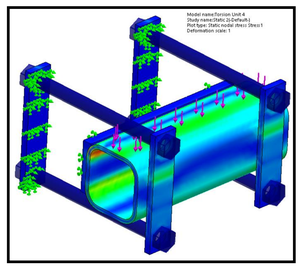


Load: 2500 lbf
Yield Strength: 31,000 psi

Figure 5 - Bucket Analysis

TEST RESULTS – TORSION UNITS

In Figure 6 the max stress came out to be 5,185 psi is much lower than the group expected. The Max yield strength of A36 steel is upwards of 80,000 psi, along with the max yield strength of ½ inch grade 8 bolts being around 100,000 psi.



Max Stress: 5,185 psi
FOS: 6.99

NOTE: The team changed the mounting method from bolts to welded straight to the frame. This test however is still valid for in the case the customer decides to bolt the units to the machine.

Figure 6 - Torsion Unit Analysis

FINAL DESIGN

The team has built the trail maintenance machine seen in Figure 7 that satisfies or exceeds current customer needs. The machine is designed to be pulled behind a small tractor using a hitch pin, the tractors hydraulic 3-point hitch system lent the capability to raise and lower the height of the machine. Five box shanks are placed at the front of the machine to loosen and break up hard ground surfaces. Additional hydraulic controls have been added to tilt the material holding bucket. The bucket can be tilted downward to dig into the trail and pick up material. The dimensions of the frame are 6.5 feet wide by 7 feet long.

Along the top of the frame there are slots and round tubing welded to the 3”x 3” member where the bar shanks will be inserted and held in place.

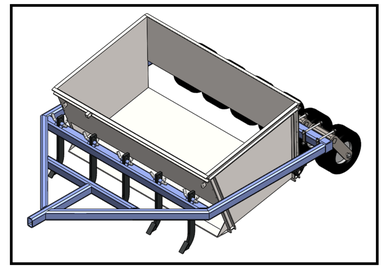


Figure 7 - Final Machine Assembly

Conclusion

Over six phases of design the team created a trail maintenance machine to aid Pokagon State Park in the maintenance and quality of the park’s historic trails. This machine will free up human labor that would spend hours cleaning and repairing the miles of trail system in the park. This machine can break up, redistribute, add, and smooth trail material all in a single tow behind machine.

Lessons Learned

Throughout the design process the team learned good project management skills as well as the details needed for final designs. The main skills learned from the project include:

• Accountability	• Communication
• Teamwork	• Time management
• Safety is paramount	• Preparing for failure

Acknowledgements

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