PURDUE UNIVERSITY | Agricultural and Biological Engineering

CAPSTONE/SENIOR DESIGN EXPERIENCE 2022

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Title: Tire Ablation Device

Executive Summary

Environmentalists are consistently concerned with automobile emissions, but could our vehicles be producing another emission of environmental concern? The problem this project works to address is the need for further research into tire dust and the effects it has on the environment. A tire ablation device is how the SB-7 team has chosen to address this problem. The tire ablation device spins a tire against a road surface to create dust from tire wear.

Project Scope

- Create a device capable of creating tire dust to be used for further research at Purdue University
- Two studies found: First study by the EPA in 1981
- Dust from tire wear study done in Japan in 2013:
  - 79 million recorded vehicles on the road
  - Tire wear dust accumulation of approximately 1.4 times the volume of the Tokyo Dome annually or 1747245.4
- Other research conducted found harmful compounds in tire dust and size of particulates have potential harm to humans
- Existing tire ablation devices are large and complex.
- One previous design and test conducted at Purdue University.
  - Axle shaft was held with one bearing and was not very stable.

Nature and Boundaries of the Problem

Codes and Standards

- Tread depth minimum of 2/32 of an inch
- PTO safety shielding standards
- Standards for selecting bearings by sizes, load ratings, and rotational speeds

Constraints

- 540 PTO driven
- Use existing previous project frame, axle shaft, hub, and tire

Criteria

- Ensure device is stable and safe
- Easy to setup and operate
- The device can be easily moved
- Ability to apply consistent load
- Allow for future project expansion
- Tire spins at road speeds

Deliverables

- Functioning and stable device that can produce a tire dust sample
- The device is simple and can be expanded upon in the future

Ideas/Potential Solutions

- 4 initial designs to explore various ways of stabilizing the tire
  - Rough sketches made on paper
- Most used a mechanical means of load bearing
  - Use of gears to raise and lower the tire holding mechanism
  - This would not allow for consistent load throughout testing
- A true design matrix was not used for deciding on a final design
  - Each design was combed through and the final design includes aspects from each design
  - Overall, the design was graded on its' stability, functionality, cost, and complexity to construct

Final Design and Development

- Technical drawing/blueprint drawn using AutoCAD
- Utilizes 2 bearings to stabilize the axle and 2 bearings to hold the lever arm
  - Pillow block bearings using 1" shafts for axle and lever arm pivot points
- Use of a lever arm allows tractor suitcase weights to be added for load
  - Lever arm ratio is approximately 2:1 (half the weight to reach desired load)
  - The lever arm is constructed of 2" x 2" steel tube welded together
- Uses existing materials and is PTO driven

Testing and Feedback

Initial test: successful in some areas, other areas have flaws.

- Axle shaft was very stable and the frame did not hop at all.
- When weight was applied the frame was not heavy enough to counterbalance it.
  - Needs to be tied down or counterbalance applied.

Feedback: Sponsors very happy with design and functionality.

- Sponsors have future plans to use and expand the device.

Economic Analysis

- The tire ablation device will not be manufactured or sold.
  - The customer of this project is also the sponsors of this project.
- This project allows for the sponsors to apply for grants/funding for future work on this topic.

Timeline

- Project selection Aug 21
- Research Sept 21
- Idea drafting Oct-Dec 21
- Feasibility presentation Dec 21
- Final Design Feb 22
- Construction Mar 22
- Testing Mar 22

Commercialization, Implementation, and Launch

- Continued test runs and sample collection
- Analysis of samples and data collection

Long-term

- Addition of a dust collection system to capture fine particulates
- Addition of a free spinning wheel under the tire to better represent vehicle travel on the road
- Calculate the environmental impact based on samples collected and analysis of particulates

References

Sponsors: Dr. Stwalley and Dr. Ambrose
Instructor: Dr. Lumkes
Acknowledgements: ABE and ADM staff

- Tire regulations USA and CANADA: Tire size, thread depth, width and snow chains regulations. Tire regulations USA and Canada | Tire size, thread depth, width and snow chains regulations. (n.d.). Retrieved September 23, 2021, from https://oversize.io/regulations/tire- regulations-by-state.
- Yamashita, M., & Yamanaka, S. (2013, June 17). Dust resulting from tire wear and the risk of health hazards. SCIRP Open Access. Retrieved September 24, 2021, from https://www.scirp.org/html/1-6701865_33102.htm.
- Bogdan, L. (1981, November). Charterazation of Tire Wear Particulates. Ann Arbor; Environmental Protection Agency.
- Kruszelnicki, K. S. (2012, July 30). How dangerous is rubber dust? ABC (Australian Broadcasting Corporation). Retrieved September 24, 2021, from https://www.abc.net.au/science/articles/2012/07/31/3554997.htm.