Retrofitting an Existing Bicycle for Individuals with a Unilateral Lower Extremity Amputation

Team 25

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Abstract

- This project aims to improve the mountain biking experience for right-legged amputees through a pedal-locking system and custom oblong chainring.
- The pedal-locking system can support a 200 lb rider landing flat from a 5 ft drop. The chainring can support a Tour de France rider in full sprint.
- The custom oblong chainring achieves a 20.7 % increase in pedalling efficiency from baseline, as measured by power to heart rate ratios during testing.
- Through innovative design and testing, this project enables a more enjoyable and accessible mountain biking experience.

Introduction

Amputee mountain bike riders confront substantial challenges that current solutions inadequately address. Two pivotal challenges impede accessibility for amputees: insufficient power for steep ascents and pedal positioning during descents, corners, and jumps. Our solution focuses on developing an oblong chainring to optimize the rider power curve to:

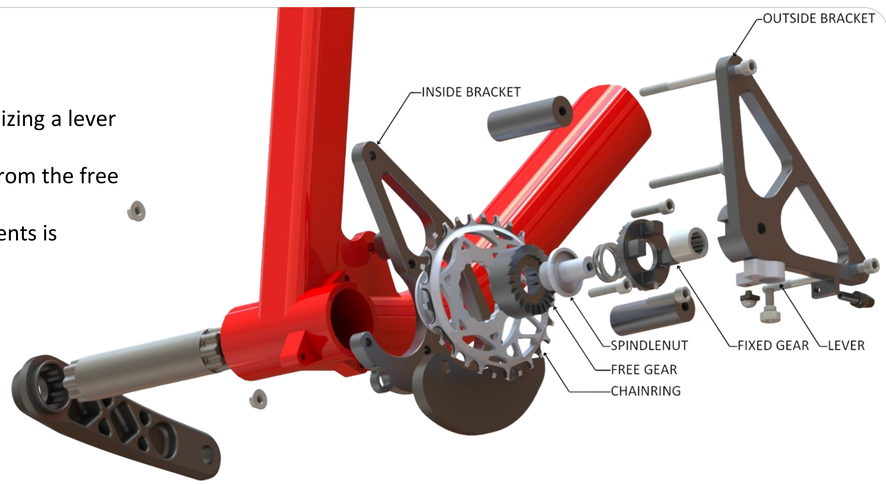
- Increase power output on the downstroke.
- Minimize resistance on the upstroke.

Additionally, a pedal-locking system allows the rider to keep the pedals level which mitigates the risk of bottoming-out and improves body positioning and handling. Our design differentiates itself from sit-down bikes and electronic enhancements by:

- Seamlessly retrofitting to standard bicycles.
- Maintaining the traditional mountain biking experience.

Discussion and Conclusions

- Dog clutch gear mechanism interlocks a free and fixed gear utilizing a lever mechanism.
- The design requires backpedaling to disengage the fixed gear from the free gear, prioritizing safety and ease of use for the target users.
- Compatibility with existing mountain bike frames and components is ensured, with accessibility and user feedback guiding iterative improvements throughout the design process.



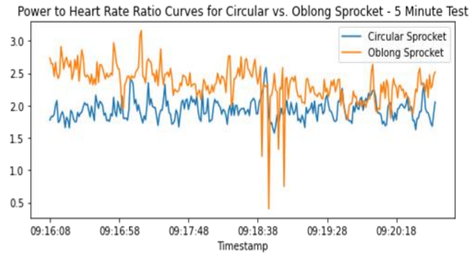
Future Work

- Modify the design for bilateral retrofitability to accommodate both left and right legged amputees.
- Improve the disengagement mechanism so that the pedals can be unlocked without backpedaling.
- Incorporate bidirectional locking to accommodate various riding styles.
- Upgrade the lever actuation mechanism to electronic control to improve user experience.
- Design the pedal-locking mechanism to be compliant to reduce impact forces on the rider's leg.

Results

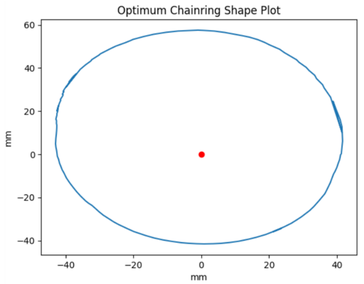
The oblong chainring was tested using a Garmin Tacx Trainer in an isolated environment which yielded:

- A 20.7 % improvement over its standard circular counterpart.
- An average power output increase from 188 W to 234 W while constantly maintaining a 100 bpm heart rate for 5-minutes.



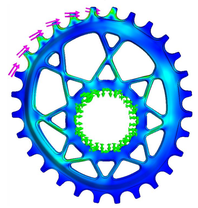
Methods and Materials

Python was utilized to develop the chainring shape based on the instantaneous radius method. The power output of the rider was scaled across a 80 - 115 mm chainring diameter. Using tangent splines, the chainring shape was smoothed into a consistent profile.



SolidWorks was used to generate detailed models of the functional system. Through static simulations, finite element analysis, and a topology study, the design was further revised for strength and weight reduction.

Physical testing identified unseen issues, which were modified to meet project requirements. A combination of 7075 and 6061 aluminum alloys were chosen to provide a high strength-to-weight ratio, and prevent surface corrosion.



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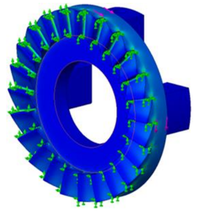

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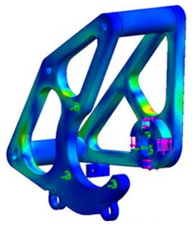

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Acknowledgements

Thank you to our faculty advisor **Dr. Ahmad Ghasemloonia** for his critical feedback and suggestions. Thank you to our industry sponsors **Ivan Chow**, **Ben Primeau**, and **Doug Murphy**, for their technical and manufacturing support.

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