Development of a Low-tech Pedal-powered Smoothie Maker

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Introduction

Human-powered machines are an alternative to electrical systems. For this project, we developed a pedal-powered smoothie bike to replace the need for an electric blender. We were tasked with developing a safe, effective smoothie bike for a community garden in East Berlin. The bike was designed primarily for children to blend produce harvested from the garden.

The smoothie bike is an example of a low-tech device. Low-tech devices are technologically simple and uncomplicated, while typically being resourceful. Our smoothie bike is an example of a low-tech machine as it's a straightforward construction that reused old bike components.

Energy and Pedal Theory

Energy is the ability to do work; it cannot be created or destroyed, only transferred and transformed. In this project, we developed a pedal-powered blender to eliminate the need for electricity to make a smoothie. We convert the human input energy via the pedals to torque to turn the blender. By developing this bike machine, we reduced electrical energy usage and CO_2 emissions.

	Electrical Blender	Pedal-powered Blender
Power	600 W	150 W
Rotations per Minute	30,000 rpm	6000 rpm
Blending Time	30 s	120 s
Energy to Blend	18,000 J	18,000 J
Electrical Energy	24,000 J @75% efficient	0 J
CO_2 emissions	8.2 g	0 g

For our smoothie bike to function, we convert the mechanical energy of the pedaler to mechanical energy in the blade with a transmission. This transmission converts the torque from the pedals through the wheels to the final blender drive. Our project used a friction drive between the front bike wheel and the axle of the blender. We considered the following parameters during development to ensure our gear ratio was large enough:

- Humans pedal at ~60 rpm
- Blender must operate at 1,000 rpm
- Child-sized pedals were to be used

Input	Size	Rotations per Minute
Pedals	27 teeth	60 rpm
Front Sprocket	18 teeth	90 rpm
Front Wheel	28 in	90 rpm
Friction Drive	2 in	1,260 rpm
Blender Blade	3 in	1,260 rpm

Friction drive contacting front wheel

Design Thinking

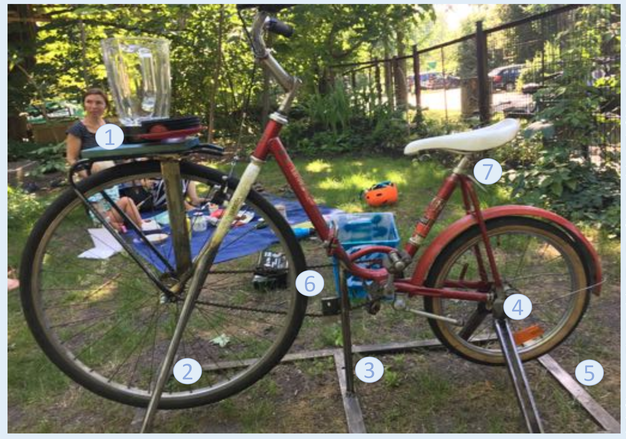
During the development of our smoothie bike, we adopted a user-centric methodology called design thinking. The steps in the design thinking process are detailed below:

- **Emphasize** – We conducted an interview with our garden contact in order to fully understand what they wanted from a smoothie bike.
- **Define** – We analyzed the interview responses to determine what kind of smoothie bike we would be building: *an adjustable, stationary bike for children to use and see the smoothie blending while riding*.
- **Ideate** – We designed the smoothie bike around the use of a child's bicycle. We planned to use the front wheel of an adult bike and to have a friction drive against the front wheel to spin the blender.
- **Prototype** – We built the smoothie in metal and bike shops utilizing old materials that we repurposed for our project.
- **Test** – We made various smoothies with the children of the garden to ensure they fit on the bike machine and that the blender functioned properly.

Design

We established main design goals for our bike machine.

- Children able to pedal and operate bike
- Stationary bike; never needs to operate for transportation
- Blender in front of bicycle
- Safe for user
- Efficient drive system
- Comfort and operation volume not prioritized
- Style with paint
- Simple to use, maintain, and repair

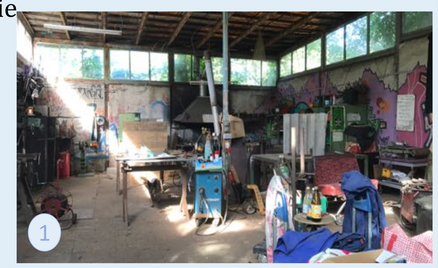


(1) Smoothie stand and blender with drive
(2) Front bike support welded to bottom square frame
(3) Middle support
(4) Rear support
(5) Bottom square frame
(6) Chain with tensioner
(7) Adjustable seat and handlebars

Construction

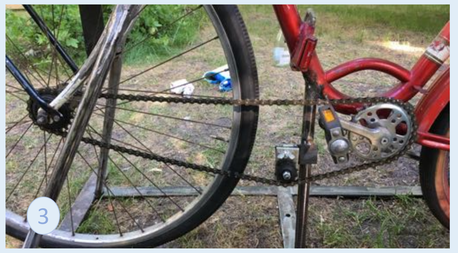
We constructed the smoothie bike using various metal shop techniques including:

- Mig welding
- Sawing
- Drilling
- Grinding



Key challenges we faced during construction include:

- Tensioning chain properly – added chain tensioner
- Drive misalignment – used caster wheel for proper spacing
- Frame rigidity – added additional filler during welding to add structural support



(1) Lineinhof metal shop
(2) Rear frame welded to bike and bottom square
(3) Chain to front wheel with tensioner

Conclusions

The smoothie bike successfully blended multiple smoothies during testing. Additionally, the children of the garden fit on the bike and were able to easily reach the pedals. They seemed to truly enjoy making the smoothies with the bike, and the structure held up well to their pedaling speeds.

For future iterations, we would investigate changing the caster wheel to something with additional friction. Also, we would work to better line up the drive shaft vertically against the bike wheel to reduce inefficiencies.

Special Thanks

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