Thesis Project Portfolio

The Smithinator: Recumbent Vehicle Design and Entry for the 2020 ASME Human-Powered Vehicle Challenge

(Technical Report)

Sustainable Welding: Establishing Human-Robot Collaborations Through Implementation in Industry

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

The transportation sector is among the leading contributors of greenhouse gases, which create pollution and are environmentally unsustainable. Human powered vehicles limit the production of these gases because they produce zero emissions during operation; however, through the manufacturing processes, such as welding, there are still significant emissions. My STS and technical projects both focused on the creation of a human powered vehicle, specifically on its performance and conformity to environmental standards. My technical project designed and manufactured a human powered vehicle meeting the American Society of Mechanical Engineers specifications for their annual Human Powered Vehicle Competition. My STS research focused on the critical considerations for successfully implementing sustainable, robotic welding in the manufacturing industry.

The technical portion of my thesis produced a complete design of the human powered vehicle; however, due to classes being moved online, the manufacturing of the vehicle was not completed. To synergize all working parts for the vehicle, the design was broken up into six sub-teams: frame, fairing, drivetrain/biomechanics, safety, innovation, and steering/braking. The vehicle was designed to resemble a recumbent bike, achieving goals of comfort, speed, sustainability, cost-effectiveness, and safety. The frame was designed to be a recumbent style bike and was constructed out of 4130 steel. A full fairing made out of carbon fiber was designed and analyzed to maximize aerodynamics, having a drag coefficient of 0.32 and a drag force of 7.36 N. The biomechanics of the riders were tested and analyzed to determine an optimal design of the drivetrain. Key features to this design included a chain gobbler, which was used to change the chain length for various pedal lengths, and an 11 speed 46 tooth rear cassette. The safety sub-team primarily focused on meeting the specifications of the competition and designed locations to attach the safety components onto the bike. The innovation team, which focused on sustainability, computed the carbon dioxide emissions of manufacturing the bike at 0.37% of the manufacturing emissions of an average sedan. The steering/braking sub-team used the Ackerman Steering analysis to design an indirect, under-seat steering system for the bike.

In my STS research, I focused on finding strategies for successfully implementing robotic welding in manufacturing. Various studies revealed that robotic welding significantly reduces the amount of harmful emissions compared to manual welding; however, implementing robots into an industry creates uncertainty for workers due to them being fearful of losing their jobs, changing job responsibilities, and not understanding how to work alongside a robot. Frank Geels describes how to use a multi-level perspective to uncover the various underlying actors, dimensions, and transitions that are needed to implement sustainability. Additionally, the World Health Organization highlights important features that are needed to create and maintain a healthy work environment. By synthesizing both frameworks (from Geels and the World Health Organization) my research revealed that the greatest success in implementing robotic welding is likely to come from considering the workers' psychosocial workplace environment, which focuses on culture and values of employees, when integrating the sustainable and technical work of the robot, creating a human-robot collaboration.

Reflecting on my technical and STS research projects provided an important teaching experience on digging deeper to discover underlying issues or factors that contribute to failure or success. During the design and manufacturing phases of the human powered vehicle, my team and I had to revert back to our initial designs and knowledge if components were unable to be manufactured or operated as designed. Further, through my STS research, it was critical for me to understand the basics of the human experience in the workplace and to recognize which human aspects and dilemmas contributed to the success and failure of robot implementation. By working and completing the projects simultaneously, I was able to consider the working experience of an individual in the manufacturing industry, while still pushing for optimal design and sustainability. Through the work of both of my projects, I pursued the ethical goal of balancing a concern for worker welfare with a desire to make a manufacturing process more environmentally friendly. Before blindly implementing technical innovation into society, it is important to consider the impact the innovation will have on the livelihood of individuals it is affecting.