Prone, Dual Gear System Triathlon Bicycle

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***Abstract* -- In this paper we are presenting a new design for the standard triathlon bicycle. Its purpose is to reduce the continuous wear on an athlete's muscles, specifically, the muscles that are also used during the running and swimming portion of the race. Through the design process we decided on a prone style bicycle, which has two independent gear systems, one for the legs and one for the arms. The final bicycle will be made of titanium, with a flat rectangular seat. A continuously variable transmission will be utilized for the drive train. Our results show that this bicycle design will perform equal to or better than current triathlon bicycles.**

***Index Terms* -- continuously variable transmission, hand cycle, prone bicycle, triathlon bicycle**

I. Introduction

The major concern facing tri-athletes is the excessive strain placed on their bodies while competing. This results in a shorter competitive lifespan. To extend this lifespan we drastically reduced the muscle activation in the legs and lower back, groups used extensively throughout the entire race. To constrain the final design, a maximum weight of 25lbs and an increase in overall muscle group recruitment were strictly enforced. A consensus was reached to ignore the Canadian Triathlon regulations, enabling us to have more freedom for creativity and innovation.

Current technology [1] utilizes lightweight materials, such as carbon fiber and titanium, to reduce weight and appropriate handle bar and tire design to reduce the aerodynamic drag and frictional drag. These characteristics are adopted into our final design. The bicycle has the ability to use the arms and legs independently or simultaneously to power the bicycle depending on fatigue, power requirements and road conditions.

To ensure the viability of the hand power drive train, investigation into current hand pedal systems was performed [2]. Currently, this method of power generation is only utilized for those with lower-body disabilities, but it has proven a viable method, giving us confidence for success when combined with a conventional leg driven system.

The final milestone of this project was the construction of a physical model, demonstrating the advantages associated with the use of a continuously variable transmission system. Modification of the drive train on a donated bicycle allowed us to display the geometry and overall design of this system.

II. Conceptual Design

A. Overall design

For our final design, we decided to incorporate two ideas together. We used the prone style bicycle, and took advantage of the fact that the rider's upper body was over the front tire. We placed a second gear system on the front tire, so that the arms could also be used for propulsion. The two gear systems each drive a different tire, the legs are used to drive rear tire, whereas the arms are used to drive the front tire.

B. Major components

There were several major components that were designed uniquely for this bicycle. The first and most prominent is the continuously variable transmission (C.V.T.), which we modified to act more closely to a current bicycle gear train. It will allow the rider to have an infinite amount of gear combinations to choose from, instead of the standard 30 gears [1]. The second component we considered was the front handle bars. We employ a dual handlebar system, consisting of a stationary and a rotating handlebar. Next, we considered the design of the seat, where the rider's weight will rest. Lastly, we determined that the best material for the construction of the frame would be titanium [3].

III. Detailed Design

A. Drive Train

Rather than choosing to go with a standard sprocket and chain system, we chose to utilize a C.V.T. The C.V.T. has the same goal as the standard gear system, however, the C.V.T. achieves this in a more efficient and practical manner. The C.V.T. employs the use of a cone to replace the sprockets, as seen in figure 1 (indicated by the arrow). The system also replaces the chain with a reinforced rubber v-belt. This allows the C.V.T. to have

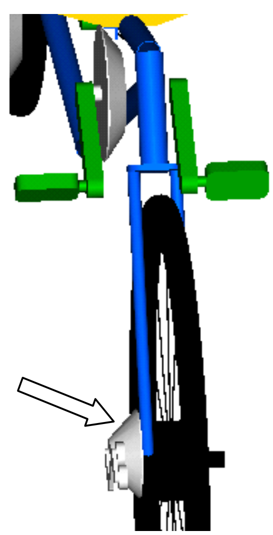

Figure 1: View of handle bar propulsion system and C.V.T. gear disks.

infinite variability between the highest and lowest gears, with no discrete steps or losses during gear shifting [4].

B. Handle Bars

Due to the incorporation of a hand-powered gear train, the conventional handle bars had to be redesigned. The result was a two-part handle bar system that combines the rotating hand pedals and a stationary set, or aero handle bars, for the rider to rest their arms upon when they are not pedaling with them. The hand pedals, as seen in figure 1, extend out to either side of the bicycle and rotate in phase in order to maintain rider stability.

C. Seat

To accommodate the rider's prone position, the seating apparatus had to be redesigned. The new seat consists of a rectangular shaped, flat-topped surface which is cushioned for support. The rider rests their torso on this device, doing so with optimal proximity to both the hand and foot pedals, ensuring maximum comfort. When determining the angle of rise of the top tube, it was found that the force of gravity acting down on the rider was more than sufficient to hold the rider on the seat and prevent them from sliding backward.

D. Frame Material

The choice of frame material was the most crucial decision that was made for this design project, since the frame makes up over 70% of the mass of the bicycle. Titanium was chosen as the best material since it is has the best weight to strength ratio when compared to relative cost. The diameter of the frame was calculated to be approximately 30mm, with a 2mm wall thickness. From additional calculations we found that a cross-sectional area of less than 5 mm2 was needed to support the expected forces acting at any point on the frame. The dimensions of the frame, such as length of the individual segments were calculated using an athlete height of 178cm (5'10"). Anthropometric tables [5] were used with the assumed height to give us the approximate length of the top portion of the bicycle (labeled "A" in figure 2) and the length of the front section (labeled "B" in figure 2). The remaining dimensions were calculated using geometric relations.

IV. Discussion

Throughout this design process we have learnt a great deal about the triathlon competition. From details about the racing conditions, we were able to conceptualize the amount of strain that an athlete's body is subjected to. Given more time for this design project a few other components of a bicycle could have been considered, such as tire design, the possible use of disk brake technology, a more detailed analysis of the seat design and support system for the rider, and the integration of an improved gear shifting mechanism.

Some errors that may have an affect on our results were that we did not consider the bicycle under various loading conditions according to terrain. Our analysis was limited to constant velocity on flat ground, and uphill or downhill travel with acceleration was not considered.

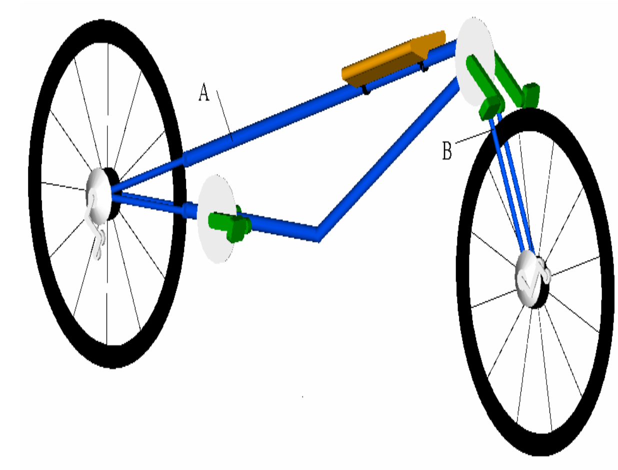

Figure 2: Prone bicycle with dual gear transmission for legs and arms

Our first recommendation pertains to the design of the seat. An improved design may call for additional support put in place if the rider finds that after long distances and continual perspiration that they begin to lose their position. Another area of the bicycle that has room for improvement would be the handlebars. Depending on the rider, they may feel they would get more momentum if the pedals were out of phase, opposite to each other, like the foot pedals. Therefore, the design should be open to the possibility of having the hand pedals either in or out of phase.

V. Conclusion

Through out this design process we considered multiple aspects of the design of a new triathlon bicycle. We redesigned it so that the athlete would use their legs less over the course of the race. This was done by adding a second gear system that would be propelled by the athlete's arms. By adding this second system and placing the rider in a prone position, we are reducing the wear on the athlete's legs and lower back, so they are able to compete more effectively during the running portion of the race and for a greater portion of their lives.

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