Midterm Report

Team 8: Development of The HANSCycle

RLT

Members

Darren Beckford dbb11c@my.fsu.edu

Nicholas Khayata nak12@my.fsu.edu

Ali Pustelniac agp12@my.fsu.edu

Michael Roddenberry mkr14b@my.fsu.edu

Faculty Advisor

Keith Larson

Sponsor

Gordon Hansen

Instructors

Dr. Nikhil Gupta

Dr. Chiang Shih

Due 10/21/16

Table of Contents

Table of Figures

1. Introduction

This project is aimed at improving the design of the traditional bicycle mechanism, which may offer a more efficient bicycle experience. Traditional bicycle mechanisms have two "dead" spots, where power is lost and potential joint harm can be done to the user. These "dead" spots are located at the top and bottom of the crank mechanism, and are not ideal for optimum energy-to-power ratios. This means that while pedaling on a standard bicycle, the user is not only losing power, but also potentially causing harm to themselves in two places for each full pedal rotation. This loss of power and joint harm is especially magnified when the bicycle is used on an increasing grade, or sloped path. For these reasons, the Reciprocating Lever Transmission (RLT) design has been introduced.

The sponsor of this project, Gordon Hansen, has proposed the new bicycle design which must be built and tested. This design utilizes the Reciprocating Lever Transmission, which consists of two pedals connected to a drive shaft with one-way clutches. This optimizes power efficiency because as one pedal is pushed downwards, the other pedal is simultaneously pushed upwards, by means of the RLT mechanism. In addition to this, the pedal cranks will be longer than the 7" cranks of Traditional bicycles. This will not only make pedaling easier, but will also create more torque. However, it should be noted that last year's HANSCycle team had trouble getting the longer cranks to successfully work with the gears and assembly. This year's team will be working to design a system that successfully functions.

Possible problems that could be encountered include the functionality of the pedal system, and testing of the final product. Because of the longer crank arms, stronger shafts and clutches must be used to be able to support the increased torque. The team must analyze the material, size, and shape of last year's design, to find a way to improve the function of the mechanism. Testing the functioning design will also be an important challenge. Because RLT's are uncommon, testing and data are not well documented. The team will need to acquire an accurate testing method, to then compare results with traditional bicycle mechanisms.

2. Problem Statement

Team 8 has been tasked with developing a working Reciprocating Lever Transmission bicycle. Then the team must test the prototype and compare values such as torque, cadence rate, work, and speed, with values of a Traditional Bicycle. This project hopes to prove that a reciprocating lever bicycle can obtain similar results in performance compared to a traditional bicycle but also cause less stress and damage to the rider's joints.

"A traditional bicycle is difficult to ride up hill due to its limited torque output and can also be damaging to a rider's joints."

3. Project Scope

Gordon Hansen, the HANSCycle sponsor, believes his redesign of the traditional bicycle will lead to a new age of bicycling. He has redesigned the traditional bicycle in an effort to maximize efficiency and ease stress on the user's joints. He believes that the two "dead spots" on a traditional bicycle mechanism cause joint harm and are unconducive to an efficient ascent uphill. He believes that the short crank arms on traditional bikes require more work from the bicycle rider, and has therefore patented his redesign. The new design consists of an RLT mechanism that makes bicycling more efficient and less stress-inducing to the rider.

Below, Figure 1 displays the disassembled bicycle components that were used to construct the bicycle last year.

Figure 1: Disassembled bicycle components

The bicycle is still intact with the above parts, but certain aspects require improvement. Specifically, the driveshaft and clutches must be made stronger, in order to support the increased torque from the longer cranks and Reciprocating Lever Transmission, seen below in Figure 2.

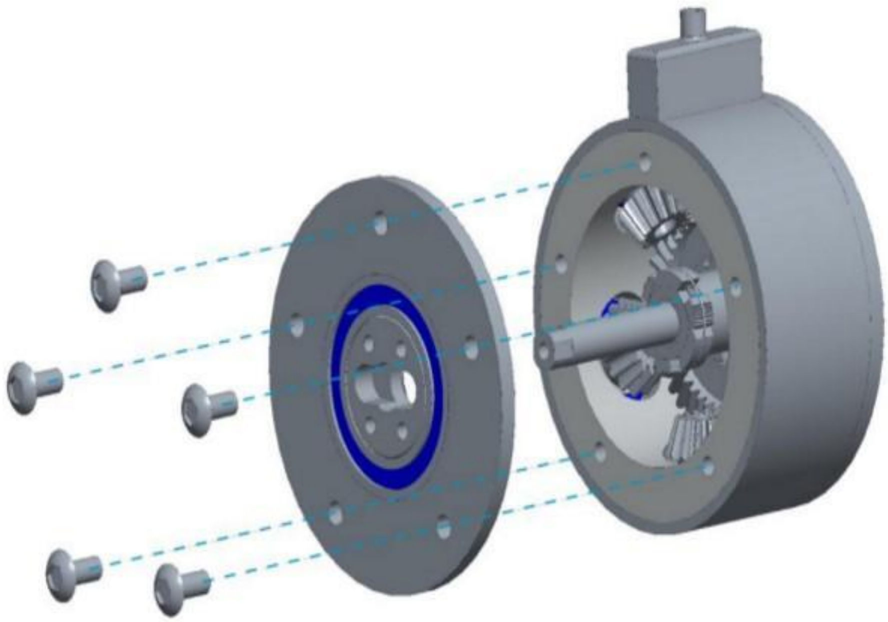


Figure 2: Reciprocating Lever Transmission CAD exploded view

Gordon Hansen has also requested, if possible, that the team try to find a way to alter the position of the bike rider. Currently, the seat and handlebars are at a position that causes the rider to lean forward. For optimum comfort and use, an upright position is favored. While this is a request from the sponsor, it was not one of his priorities, so the team will focus on the actual function of the mechanism before adjusting the design for rider comfort.

4. Project Objective

One primary objective is to design and test a new bicycle design using up to 12” crank arms that reciprocate in arcs no greater than 100 degrees. The new design should improve the comfortability of uphill riding. Building on the work of last year’s team, team 8 will redesign the reciprocating lever transmission (RLT). The new reciprocating lever transmission should be designed so the clutch will be able to drive the bicycle forward and backwards. Using the test rig to provide performance data of the bicycle is another important objective. The test rig will provide data on the power output, which will be able to give a good estimate of how much power is needed to ride uphill. The second objective is to include the new drivetrain in a bicycle frame that includes cargo-mounting stations that can be used for shopping errands and daily commuting in cities with hills. This bicycle design should fit in a standard shipping box with the dimensions of 26”x26”x10” when disassembled, to save on shipping costs.

4.1 Constraints

- The bicycle must be designed for use with 26” wheels
- Bicycle must disassemble into a 26”x26”x10” packaging box
- Utilize crank arms 12” or longer, with an arc of no more than 100 degrees

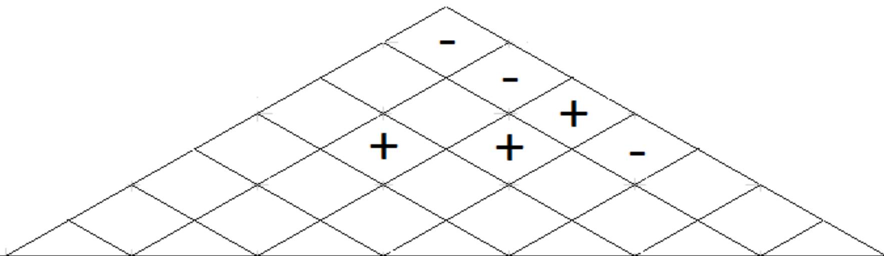
4.2 Methodology

In order to successfully complete this project, Team 8 has agreed upon various methods of organization, planning, and communication. Nicholas Khayata has been designated as the Team Leader. As Team Leader, he oversees delegating tasks to fellow group members, along with keeping in close contact with the sponsor, finalizing purchase orders, and ensuring an overall productive work environment. Darren Beckford, the Financial Advisor, is responsible for creating purchase orders, managing the budget, and keeping a record of all costs throughout the project.

Michael Roddenberry, the Lead Mechanical Engineer, is responsible for knowing and justifying all mechanical design decisions, and relaying the information to fellow team members, advisor, and sponsor. As the Organizational Lead and Webmaster, Alison Pustelniac is in charge of recording minutes and details of all group, advisor, and sponsor meetings, along with keeping the Google Drive and website up to date, where all project documents will be kept in an orderly fashion.

All team members are responsible for working in a cooperative and professional manner, as well as fulfilling all designated duties. This includes good communication between the group, advisor, and sponsor throughout the project span. Communication between group members will primarily be through a group text message, along with weekly meetings. Group meetings will consist of finalizing any deliverables or necessary assignments, discussing upcoming tasks, and voicing questions or concerns. Bi-weekly meetings will occur with Dr. Gupta and Dr. Shih on Tuesdays at 4:15pm, where project status will be discussed and input and advice will be given. Bi-weekly meetings will also be held on Thursdays with the sponsor, Gordon Hansen, to discuss progress, receive input, and ask any questions. Any additional meetings or discussions will be arranged on a necessary-need-basis.

In addition to communication, the methodology and planning of this project is very important to have a successful project. A House of Quality (HOQ), a type of priority matrix which relates various customer requirements and prioritizes all elements, can be seen below in Figure 3.



	Wheel Size	Weight	RLT	Component Choice	Material Choice	Torque Output	Frame Design	Total	Rank
Ergonomics	4	6	9	10	2		10	41	2
Cost	1	1	8	8	9		2	29	4
Performance	6	7	8	6	7	10	4	48	1
Size	9	8	2	1	1	5	8	34	3
Wheel Size	10	2				4	5	21	5
Reliability			6	3	9			18	6
Total	30	24	33	28	28	19	29		
Rank	2	6	1	4	5	7	3		

Figure 3: House of Quality (HOQ)

Important aspects have been listed, rated, and related to one another, in an effort to determine importance. The HOQ will assist the team in prioritizing various aspects of the project, thus maximizing productivity. Additionally, a Gantt Chart, seen in Figure 4, has been created, to show a timeline of the various steps throughout this project, and when they are expected to be completed.

5. Deliverables & Assigned Resources

As discussed in the Methodology section of this report, the HANSCycle team has designated certain responsibilities to certain team members, to be followed throughout the course of this project. To ensure that the project stays on track, the team has created a Gantt chart to track required class deliverables. Additionally, the team has made a tentative schedule for progress, which will be followed as best as possible and adjusted when needed.

The team has been meeting one to two times each week to discuss upcoming class deliverables, as well as work on design concepts and various approaches for the project. The team is also meeting with the sponsor, Gordon Hansen, biweekly in order to keep him up to date, as well as get his input on various project plans. Biweekly meetings are also held with class instructors Dr. Gupta and Dr. Shih to present the latest design progress and ensure the project is on track. The team has met with Keith Larson, the project advisor, as needed, and will continue to do so. His input is very helpful in the design and manufacturing of any parts that must be made or modified.

The deliverable schedule has been set by the instructors, and is as follows:

-Code of Conduct due 9/16/16: Set team member expectations and responsibilities for the project year

-Needs Assessment due 9/30: Met with sponsor, understand project objectives, and chose critical design features. Established Gantt chart schedule, set design timelines, and identified important deadlines. Analysis of necessary components and improvements to be made.

-Midterm Presentation 10/10/16: Presented by Darren Beckford, Nick Khayata, Ali Pustelniac. Project progress up to this point was discussed, as well as conceptual design options.

-Midterm 1 Report due 10/21/16: Milestone: conceptual design report and presentation completed. Future plans established.

-Initial Web Page Design due 10/21/16: Web page is designed and deliverables are uploaded by Ali Pustelniac, webmaster.

-Midterm 2 Presentations 11/14-11/20: Update of project progress to be discussed.

-Final Web Page Design due 11/22/16: Ali Pustelniac to upload all completed deliverables and other necessary documentation, as well as improve and finalize web design.

-Poster Presentation 12/1/16: Summary of progress to be discussed as well as future plans for second semester.

-Final Report due 12/5/16: Final summary and explanation of project progress thus far, and second semester plans and goals to be discussed.

The Gantt chart below in Figure 4 displays the team's desired progress and work timeline, which is more flexible than the schedule of required deliverables.

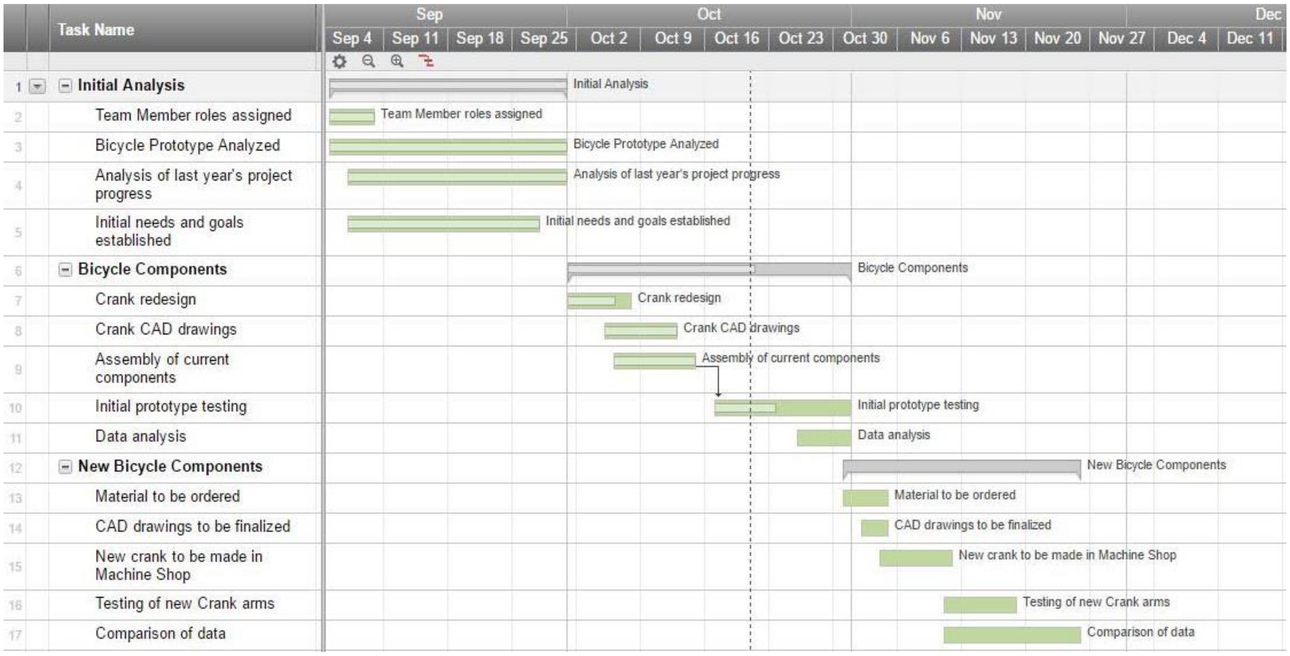


Figure 4: Project Progress Gantt Chart

The above Gantt chart will assist the team in ensuring that the project stays on track, while also being flexible enough to be adjusted as needed. The team hopes that the listed strategies and schedules will assist in making this a successful project.

6. Product Specifications

The long lever bicycle as a whole, needs to perform as well as or better than a traditional bicycle, while causing less taxing pressure on the user's joints. It must also implement the RLT which allows for reciprocating motion; meaning it can produce power in both the upward and downward stroke. Overall it must be an everyday means of transportation while being both user friendly and high performing.

6.1 Design Specifications

The long lever bicycle must be designed for everyday use such as commuting to work, but also must be able to generate enough power to climb hills. The bicycle frame on the current long lever bicycle is very similar to that of a mountain bike. Pending the results of the testing data, Team 8 may redesign the frame to be more like a recumbent frame. The hope is that a recumbent style frame may give the user a more comfortable seated position while also being able to generate more power and torque than the mountain bike frame.

The crank arms must be redesigned to fit the current prototype. The current crank arms have shearing components that must be fixed. On top of the shearing the holes drilled into the crank arms do not line up. With the new design of the crank arms, the drawing will be fixed so that the holes will be lined up. Due to the shearing pieces on the current crank arms, Team 8 will properly re-machine the crank arms to improve the shearing pieces. Another idea will be to completely redesign the crank arms to have press fit keys or use a different material that will better withstand the shearing.

6.2 Performance Specifications

The main performance specification is to get the long lever bicycle to produce enough torque and power to have the ability to climb a hill. By using the newly designed adjustable crank arms, Team 8 will be able to test the long lever bicycle to see which length will produce the best results.

Another important design specification is to get the long lever bicycle to move backward. This is a vital aspect in making the long lever bicycle more consumer friendly. As of now, there is a ratchet and pawl design in the RLT transmission that is prohibiting the long lever bicycle from being able to move backward. Team 8 is in the process of finding a way to utilize one-way bearings to replace the ratchet and pawl. The one-way bearing may allow the bicycle to move backwards.

7. Conceptual Design

The first aspect of the HANSCycle that Team 8 has chosen to focus on are the crank arms that failed due to improper construction. The new crank arms implement a very similar design but fix the underlying issues that plagued the previous rendition. The most important aspect that has been fixed are the mounting components. The new design has properly dimensioned holes and is toleranced better for this application. The new crank arms also implement multiple holes for varying pedal location. The cad model of the crank arm as well as the drawing can be seen in figure 5 below. A larger version of the drawing is available in Appendix A.

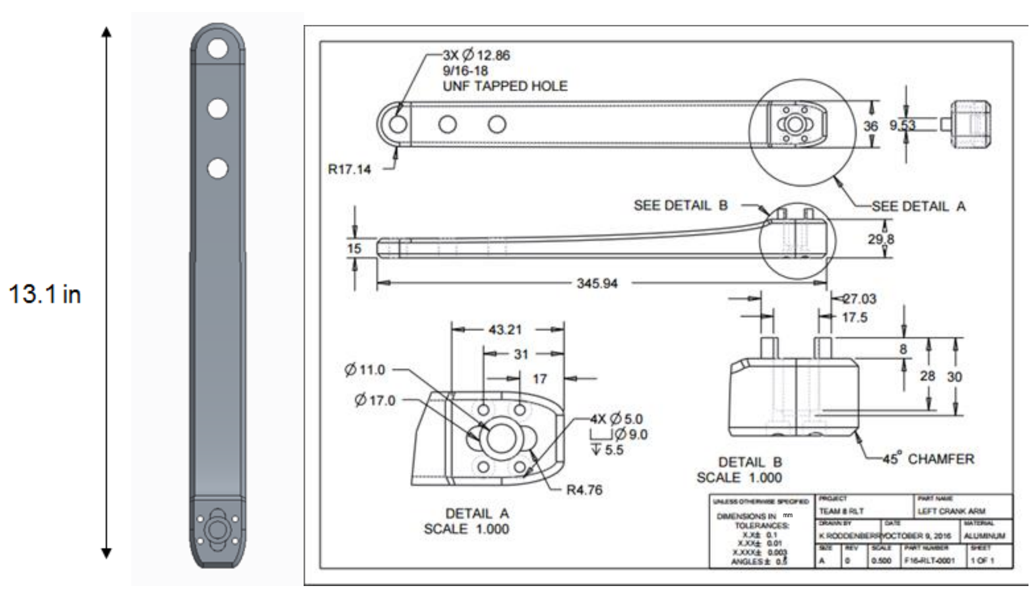


Figure 5: Revised crank arms with multiple pedal locations. (More detailed in Appendix A)

The next area that Team 8 has decided to focus on is the output shaft. The current output shaft is made of multiple materials because it failed last year during testing. It also has a lot of play in all directions because it is not properly sized or within tolerance. To fix this problem, the proper material needs to be applied. After some research and looking at similar applications, two main materials have been chosen. The first is titanium, which has one the greatest strength to weight ratios and would work well because of the small size of the output shaft. However, titanium can be very expensive and difficult to machine properly. The other material choice is 8620 case hardened steel. The benefits of 8620 is that it has great torsional strength but can be case hardened. The main issue with 8620 is the weight and the added necessity to heat treat and case harden it.

8. Conclusion

The RLT transmission is a redesign of the generic bicycle transmission with the intent of eliminating the "dead' spots on the top and bottom of each stroke in a traditional crank mechanism. At these "dead" spots, no work is done and joint injury is possible for individuals with bad knees or other previous ailments. The RLT eliminates these "dead" spots with the use of a stepping motion which also allows for a greater amount of torque to be produced because longer lever arms can be utilized. With some changes and more research Team 8 will take the progress that was made last year and create a working model and a testing setup to gather the information required by Gordon Hansen.

Team 8 will work closely with both Gordon Hansen and Mr. Larson to properly continue moving forward in the research and development of the HANSCycle. Using a designated work schedule, good communication and set expectations Team 8 plans to take the previous prototype and move towards a more practical model that is capable of meeting all of Gordon Hansen's expectations. These include but are not limited to: packaging within a 26"x26"x10" box, allowing for the transmission to be back driven allowing for reverse motion, a higher torque output for easier hill climbs, an ergonomic, easy to ride design, and integrated storage.

Currently Team 8 has a primary goal of getting the RLT to work correctly. One improvement that has been made to stabilize the RLT, was to create an additional mounting tab to reduce torque and play within the system. The original design was just one steel tab welded to the frame, and one steel tab welded to the RLT. These two tabs were bolted together, but the torque from the crank arms distorted the orientation of the system. To eliminate this play, another steel tab was cut by water jet, then welded to the RLT casing beside the other tab. This allowed the single tab welded to the frame to fit snuggly between the two when bolted together.

Moving forward, the RLT must be fitted with new crank arms. The current crank arms experience shearing within the keys, and the crank bolt holes do not line up with the holes drilled into the RLT. Another issue the team will have to face is internal slippage. While pedaling the HANSCycle, the rack and pinion system slips, which causes a grinding-like sound, because it skips many teeth before it catches. In addition to the increase in robustness, Team 8 would like to design it in a manner that allows for backwards motion.

9. References

1. Hansen, Gordon Harold. Reciprocating Lever Transmission. Gordon Hansen, assignee. Patent US20130205928 A1. 15 Aug. 2013. Print.
2. Holland, Connor. *Needs Assessment: Team 20: HANS Cycles*. Rep. 2015. Print.

10. Appendix A

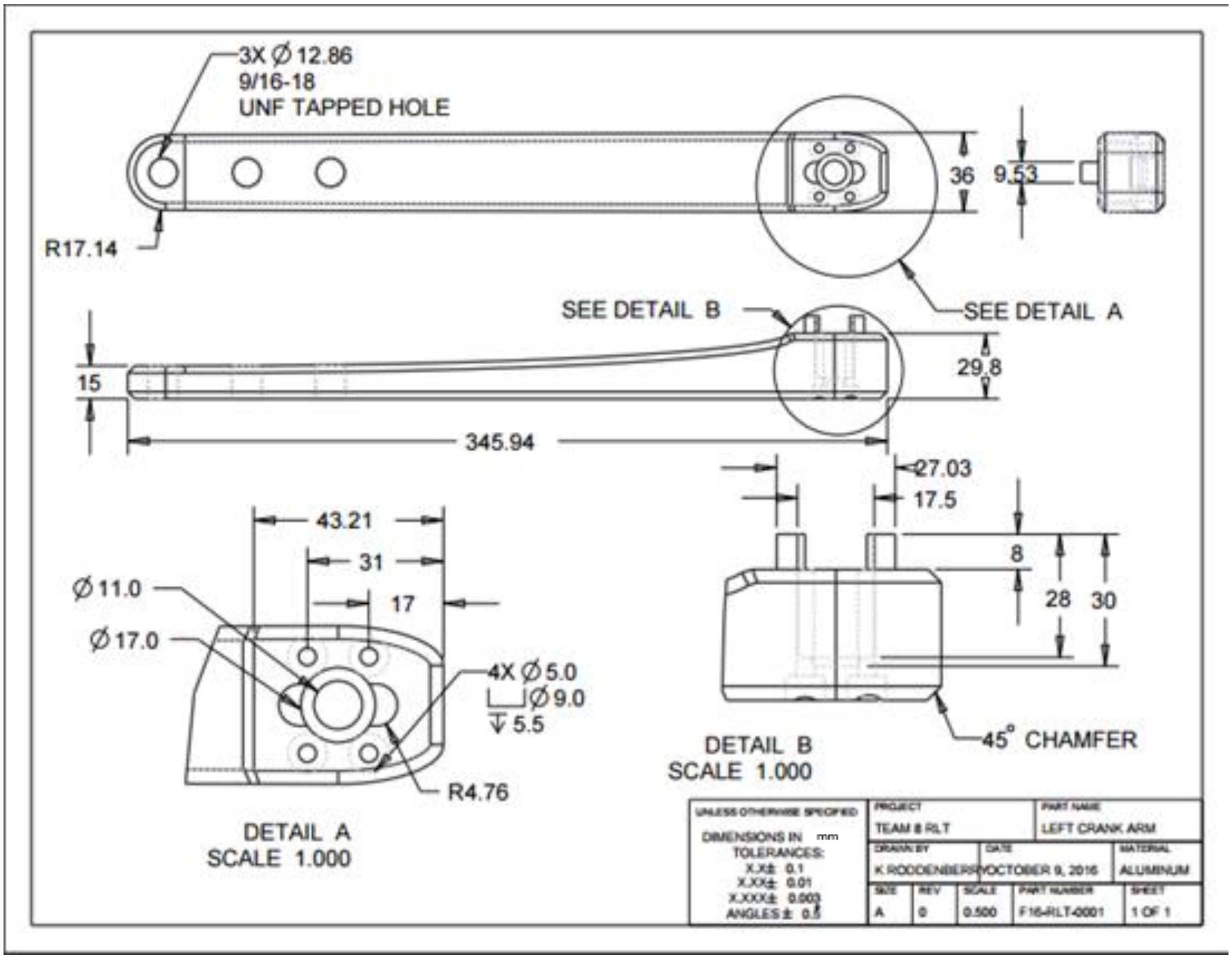


Figure 6: Detailed drawing of the revised crank arms.