Race Electric Vehicle Drivetrain Chain Tensioning System

[2]Mohamed Wagiealla , J. W. Kysar[2,1]
[1] Otolaryngology/Head & Neck Surgery, [2]Mechanical Engineering

Columbia Engineering
The Fu Foundation School of Engineering and Applied Science

amazon

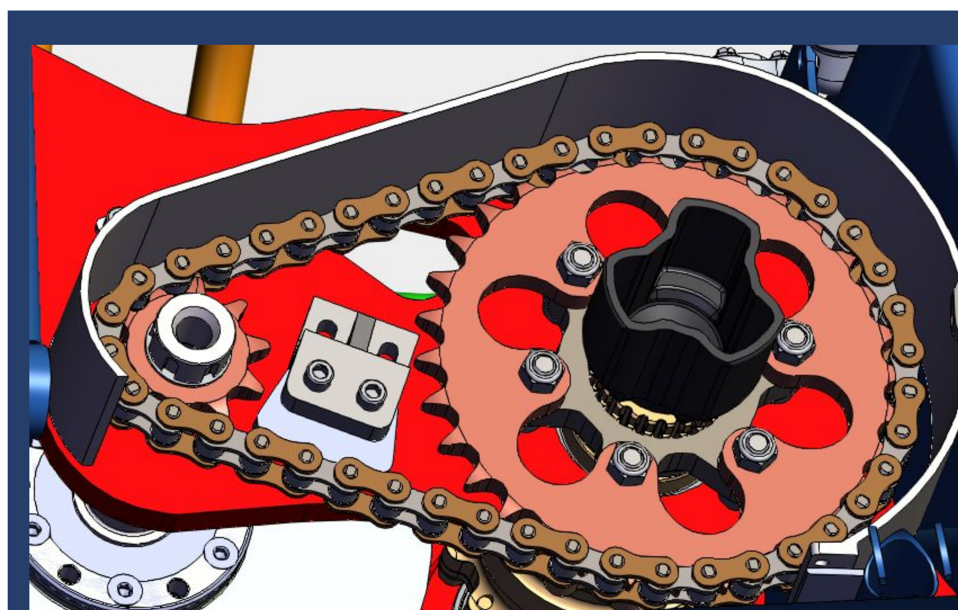
Background

- There is one main difference between an Electric Vehicle (EV) and a conventional vehicle; one has an electric motor and another has a combustion engine.
- Unlike conventional vehicles, which use a multi-gear transmission, EVs are designed to operate with only one gear. This is due to the fact that it is easier and more efficient to regulate the motor itself than to regulate its output with an external system.
- The FSAE team at Columbia University is designing and making an EV race car for a national competition.
- The electric motor is directly connected to the car's differential (a part used to allow the left and right drive wheels to spin at different speeds when cornering), rather than through a transmission as is done in a conventional car.
- The FSAE team a sprocket and chain design to connect the motor to the differential.
- When using the chain system, we must ensure that the is chain tensioned properly so that the torque can get transferred uniformly which allows for a more secure and smooth drive.
- Having the chain tensioned increases stability and life of the components since more teeth from the sprocket come into contact with the chain, reducing the stress in each tooth.

Potential Designs

Several different mechanisms have been used as chain tensioners in EVs.

1. An external pulley or sprocket that will be placed to apply load at a certain point on the chain. Similar to a belt tensioner on an automobile where the pulley is spring loaded to apply a constant force that changes as the belt loosens over time. Often this is referred to as an "idler".
2. An eccentric mounting system that will move the differential away from the motor when rotated. This allows for the chain to be tensioned without the use of an external pulley or sprocket as mentioned in the first design. It uses numerous holes around the mounting plate and by selecting different holes to use will determine the tension applied on the chain.
3. Using threaded rods to accomplish the same task as the second design, but in this case allowing for an infinitely adjustable system. This design allows for greatest precision when selecting the amount of tension desired.

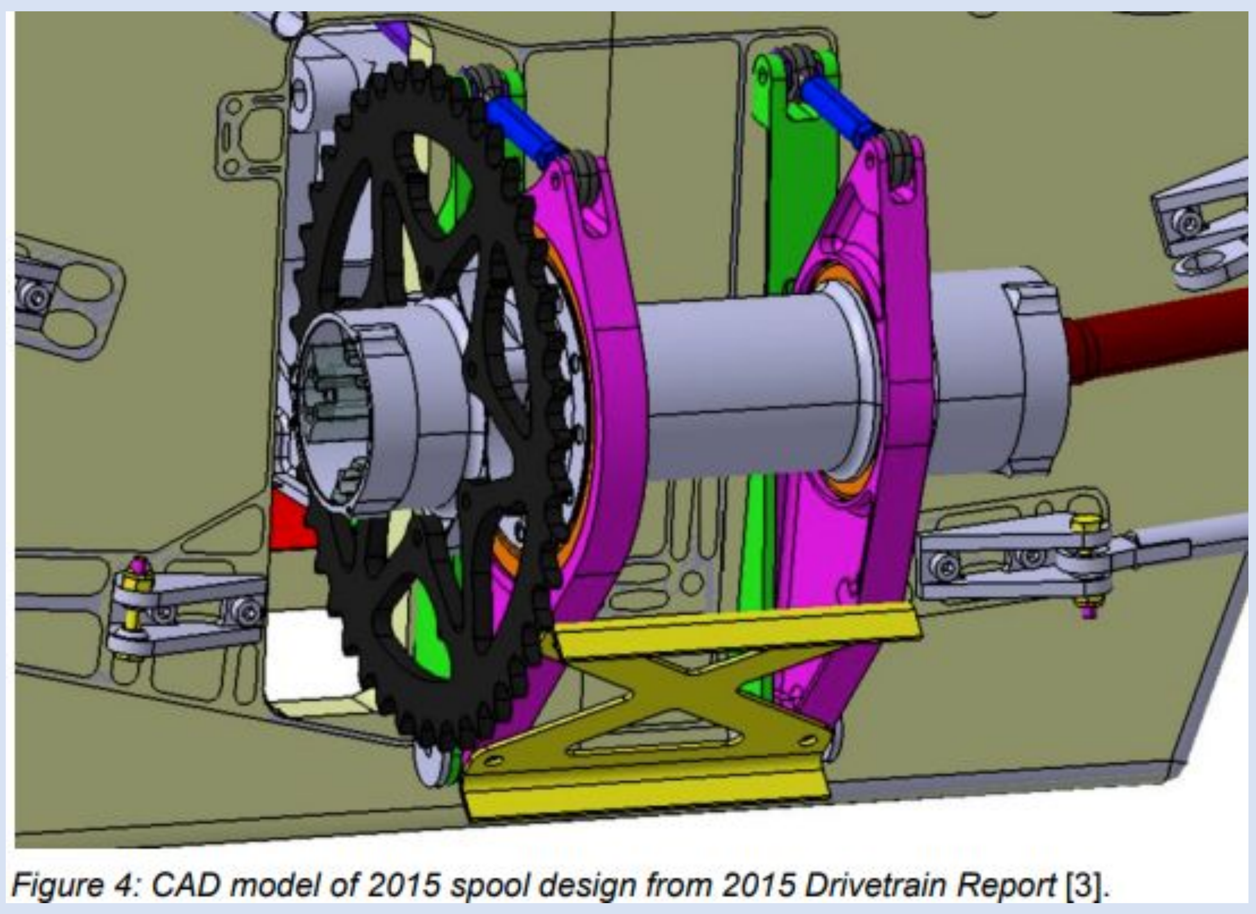


Current Design of Sprocket and Chain System with a tensioner by CUFR Team

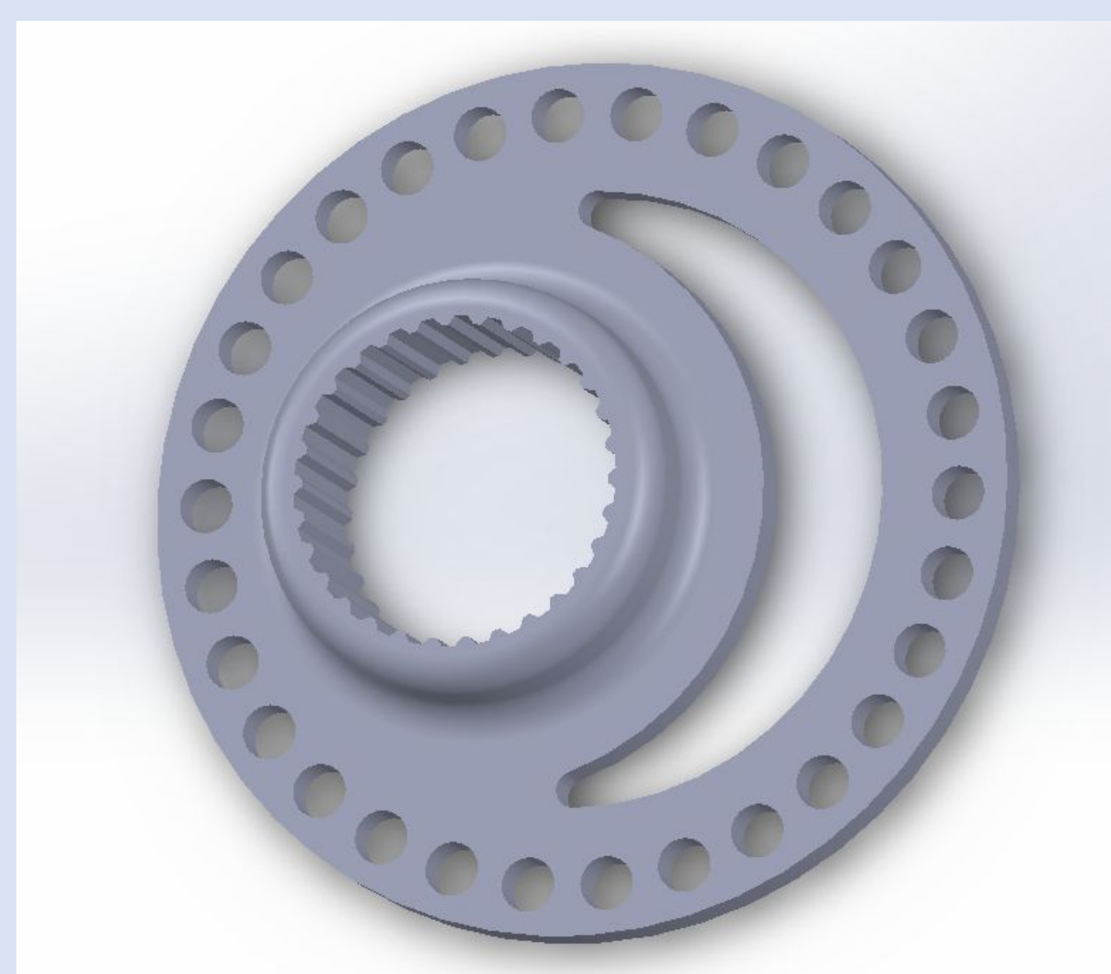
Design Goals

- Reliable system of tensioning the chain connecting the two sprockets between the electric motor and the differential
- Maintain or increase efficiency of the system

Results



Threaded Rod Design Example by Justin Lebrowsky, BS. Oregon State University
Image 1



Eccentric Mount modeled on Solidworks by Mohamed Wagiealla, BE. The City College of New York
Image 2

Example of an Idler mentioned in Design 1, Product designed by MONSTERCRAFTSMAN
Image 3

Discussion

- The first design may be simple to implement, but it reduces the efficiency of the drivetrain system as it introduces a new part that is forced to spin.
- The major benefit that the idler design has over the other two is that it doesn't require any adjustment. The spring applies a certain amount of force and as the chain loosen over time, it will automatically adjust its position to maintain a constant amount of tension.
- The second design eliminates this issue as it removes this part and only uses the two sprockets on the system.
- The problem introduced with the eccentric mounting system is that there are set points for how much tension can be applied. If the desired amount of tension is between two points, the team would be unable to achieve the desired tension.
- The third design overcomes this issue as it allows for an infinite amount of adjustment points.
- Although the second and third designs improve efficiency greatly by reducing the amount of the moving parts, they also will slightly reduce efficiency as the change in orientation of the drivetrain will also change the angle that the half-shafts (from the differential to the drive wheels) are mounted in.

Conclusions

- For both performance and efficiency reasons, a chain tensioner is essential to the operation of a chain and sprocket drivetrain system.
- There are numerous ways of accomplishing this task and as one way makes an advantage out of another's weakness, it creates its own disadvantages.
- Through analysis of each disadvantages, we found that a system using threaded rods allows us to achieve our current design goals of maintaining great overall efficiency will providing tension to the chain despite being the most difficult to implement.
- It is possible to use any of the other designs, but that largely depends on which system is being used and the layout as some designs only work with certain systems.

References

1. Lebrowsky, Justin. Drivetrain Design for the 2016 Global Formula Racing Combustion Car. Mechanical Engineering
2. MONSTERCRAFTSMAN, Manufacturer, www.monstercraftsman.com

Acknowledgements

The authors gratefully acknowledge support by the Fu Foundation School of Engineering and Applied Science at Columbia University and awards granted by Amazon. This work was performed in part with Columbia University Formula Racing (CUFR) team.

Contact

Mohamed Wagiealla, BE
The City College of New York
mwagiea000@citymail.cuny.edu

Design Descriptions

- In the threaded rod design shown in the Image 1, it can be shown how the threaded rods (in blue) can rotate the differential mounting plates about the fixed point where the plates are mounted below. Using this layout, the tension in the chain is increased as the rods are extended and lessons when they are retracted.
- The holes shown in eccentric mount presented in the Image 2 are the mounting points that can be selected from. The differential mounting hole is off-centered to the left to allow for the differential rotate away about the center of the mount when different holes are selected. The cutout on the right serves a primary purpose of weight reduction.
- The idler design shown in the Image 3 demonstrates the use of a spring and sprocket system to apply a force on the chain resulting in an increase of tension.

Differential Used In the Drivetrain System