Hex Shaft Upgrade Kit

VRC TEAM: 7682S

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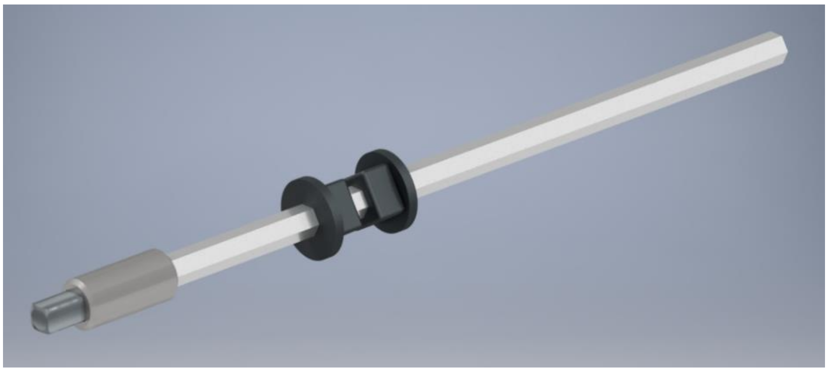


INTRODUCTION

Many VRC teams have problems with VEX 1/8" Drive Shafts in high-torque/high-impact applications due to them having a relatively low resistance to twisting and bending fatigue. To counter this problem, VEX designed 1/4" High Strength Shaft hardware for teams to use. However, the HS Shaft also has some issues.

The current High Strength Shafts are only compatible with 1/4" hardware, so new bearing flats, spacers, and clamping collars need to be bought instead of reusing ordinary Drive Shaft hardware. Larger holes must also be drilled in metal structure pieces where HS Shafts pass through, which has a negative effect on reusability of VEX structural pieces.

These reusability issues could be solved by using a shaft stronger than the square Drive Shafts that could still fit through an ordinary Bearing Flat. There are 2 potential ways of creating such a shaft: changing the material of the Drive Shaft, or changing the shape of the shaft.

I decided on the latter option and explored the possibility of using a Hex Shaft with the VEX EDR system. A hex shape is closer to circular than a square shape, so the cross-sectional area of the new Hex-Shaft could be larger than the square Drive Shaft. Hex Shafts are also readily available as off-the-shelf components. In fact, VEX sells Hex Shafts as part of their VEX Pro product range (although they are too large for this application).

This project was completed using Autodesk Inventor Professional 2017

REQUIREMENTS

Requirements for Hex Shaft:

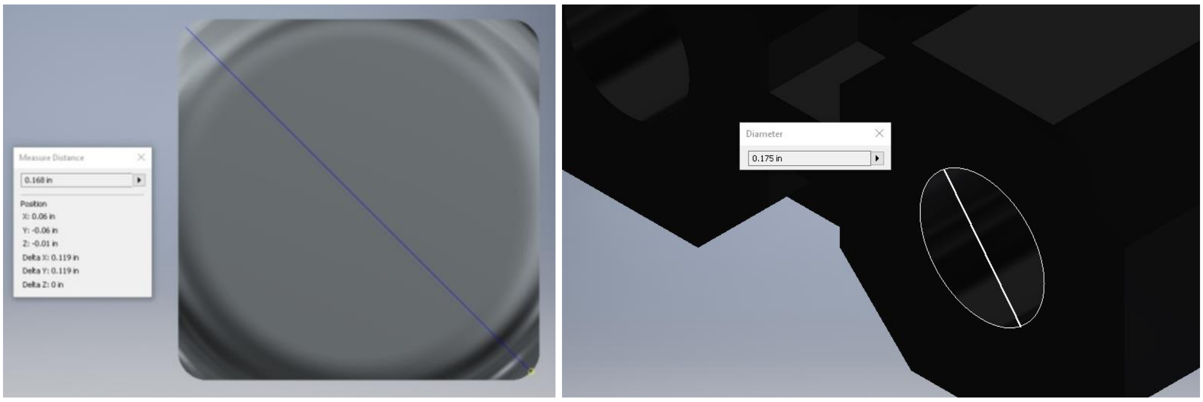
1. More resistant to twisting and bending fatigue than ordinary Drive Shafts
2. Spins freely in a standard Bearing Flat

Requirements for Hex Shaft Upgrade Kit:

3. Compatible with most existing Drive Shaft hardware (i.e. Bearing Flats, Spacers, Shaft Collars), and Gears (i.e. have a Hex Shaft Insert)
4. Easy conversion between square Drive Shafts and Hex Shaft

The kit will be made up of 2 components: A Hex Gear-Insert, and a Hex Coupler.

DETERMINING SHAFT SIZE



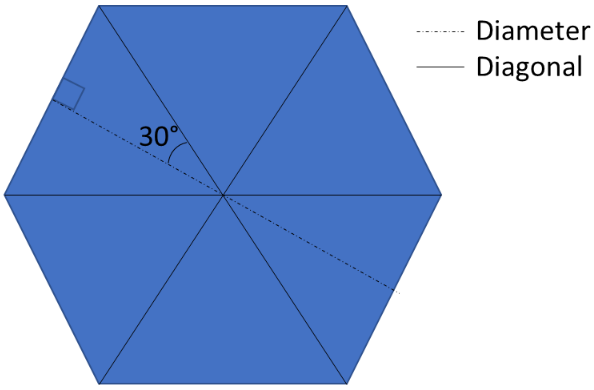
Finding clearance of shaft in hole with the Measure Distance tool

A certain amount of clearance between the shaft and bearing hole is required for the shaft to spin freely in the bearing flat. The clearance amount is dictated by the widest point of the shaft (i.e. diagonal).

Shaft Diagonal (rounded edges) = 0.168”

Hole Diameter = 0.175”

Clearance = 0.175 – 0.168 = 0.007”



The longest diagonals of the Hex Shaft should be equal to the square shaft diagonal.

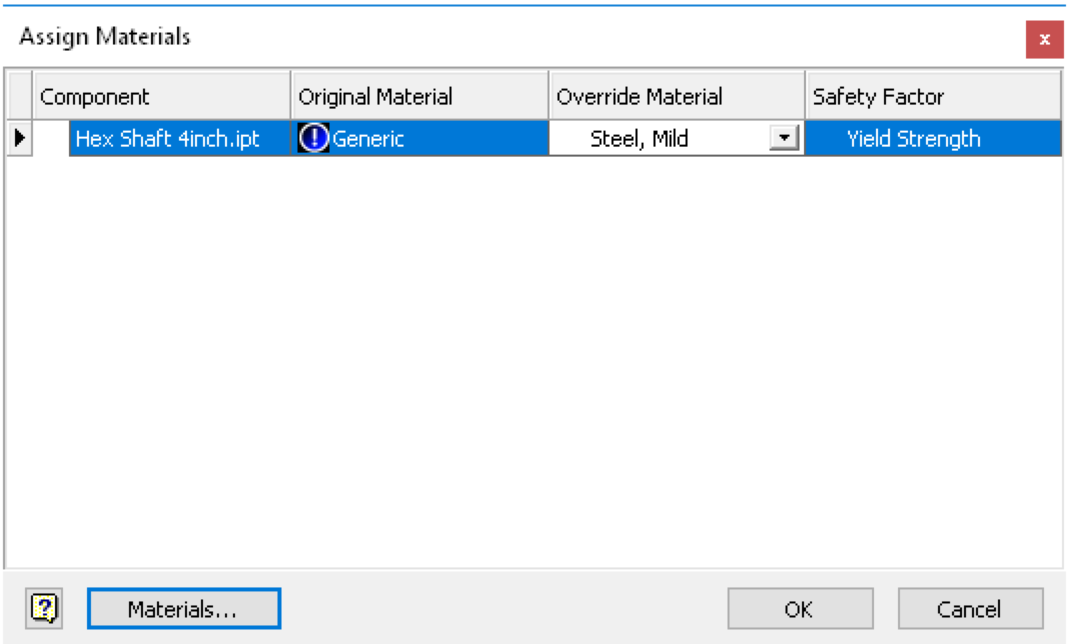
Hexagon Diagonal = Diameter/cos 30°

Hex Shaft Diameter = cos 30° * 0.168” = 0.145” = 3.696mm

3.5mm diameter Hex Shaft is close to the desired size and is readily available, so it will be used as the shaft diameter.

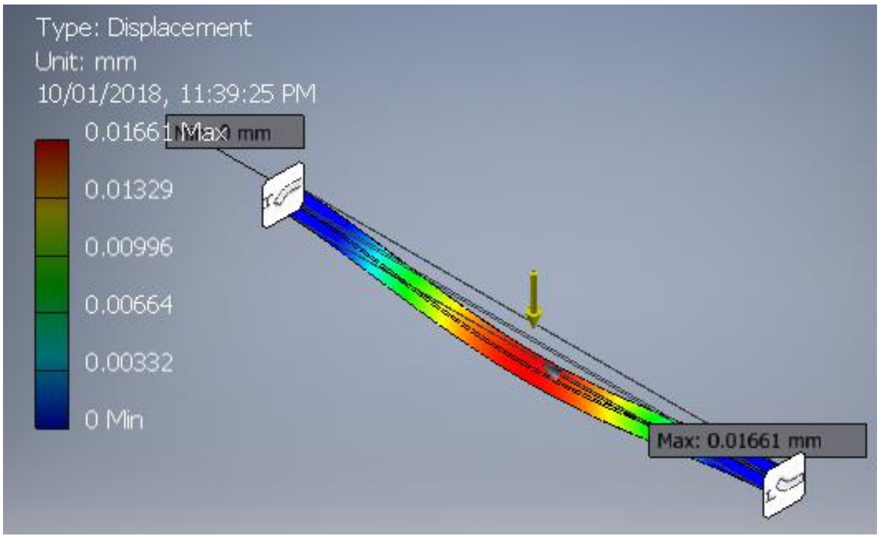
SHAFT TESTING

Before going any further with the design of the Hex Shaft Upgrade Kit, testing whether the Hex Shaft meets the requirement of being stronger than ordinary Drive Shafts needs to occur. Inventor’s Stress Analysis tool was used for this purpose.

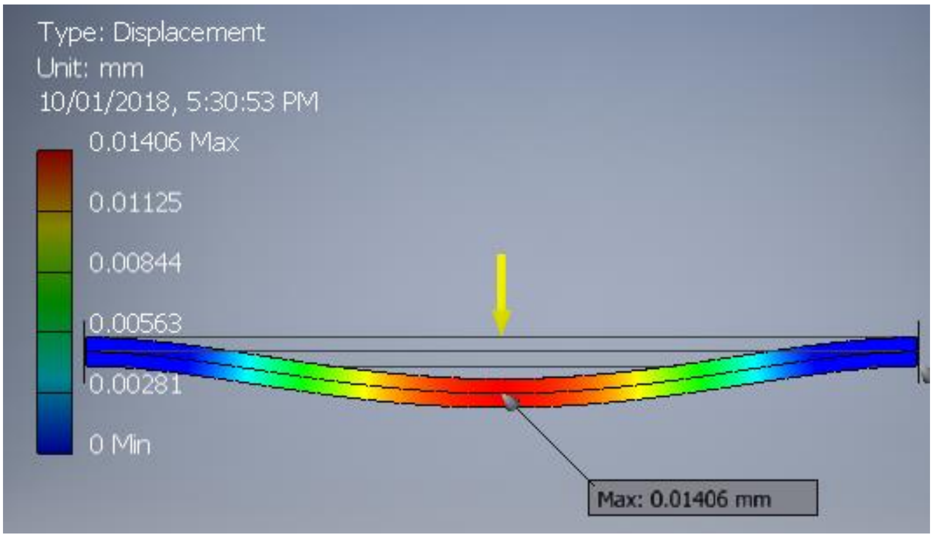


Setting shaft material for the simulation

The vexrobotics.com website states that High Strength Axles are made from 1018 Steel (mild/low carbon). I made the assumption that 1/8” Drive Shafts would be made of the same material, and that the Hex Shafts would be as well.



Bending resistance test for square shaft



Bending resistance test for hex shaft

I simulated a 10N load on 4" long axles, with the ends of the axles being fixed in position. The material, length of axle and load were all constant, meaning the only variable in this test was the cross-sectional shape of the axle (i.e. square or hex).

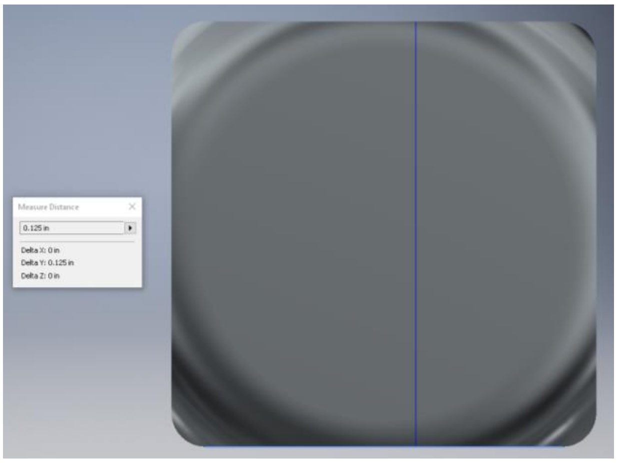
Displacement (Square Shaft) = 0.01661mm

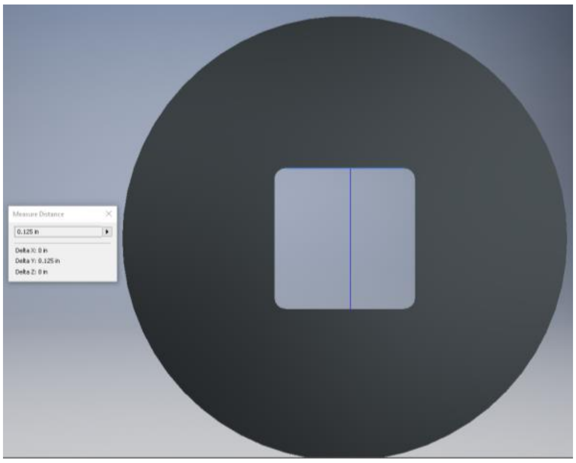
Displacement (Hex Shaft) = 0.01406mm

Improvement (Bending resistance) = (0.01661 – 0.01406) / 0.01406 = 18.2%

The results of this test show that the Hex Shaft would be slightly stronger than the original square shaft. This improvement could potentially be increased by changing the material of the Hex Shaft.

HEX GEAR INSERT

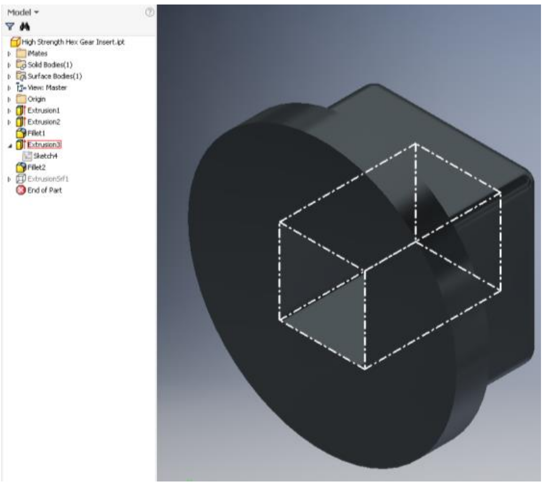


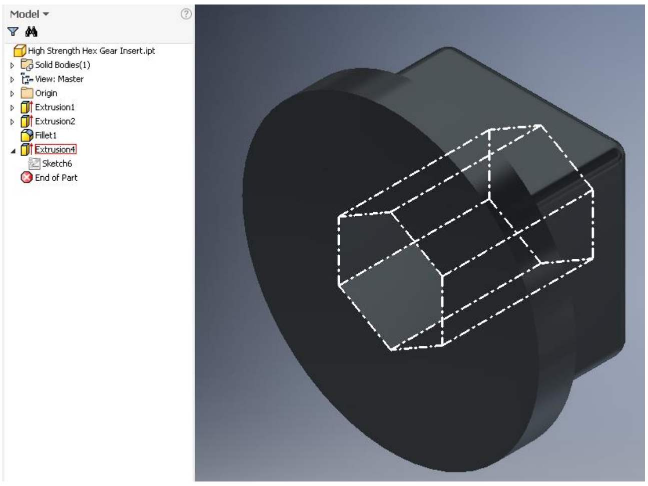


Finding clearance of shaft in insert with the Measure Distance tool

Square Shaft Length = Square Hole Length = 0.125"

The gear insert has no clearance space for the axle.

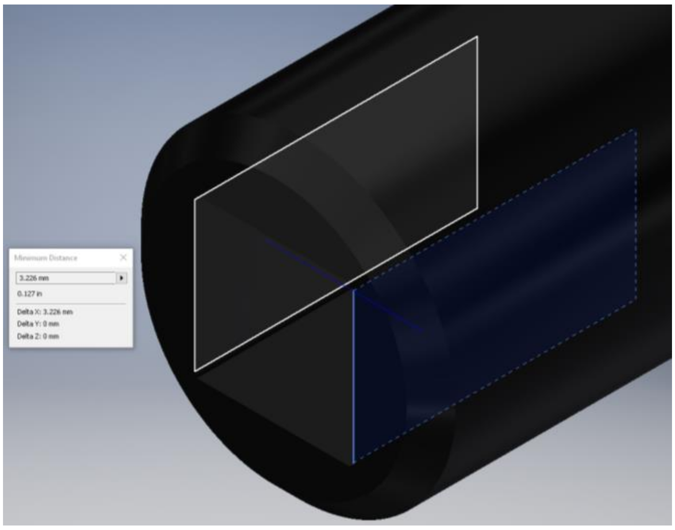




To create the Hex Gear-Insert part, I simply modified the sketch for the extruded square hole of the original High Strength Square Gear Insert part. I used the parallel constraint tool to align the rotation of the hex-shaped hole.

HEX COUPLER

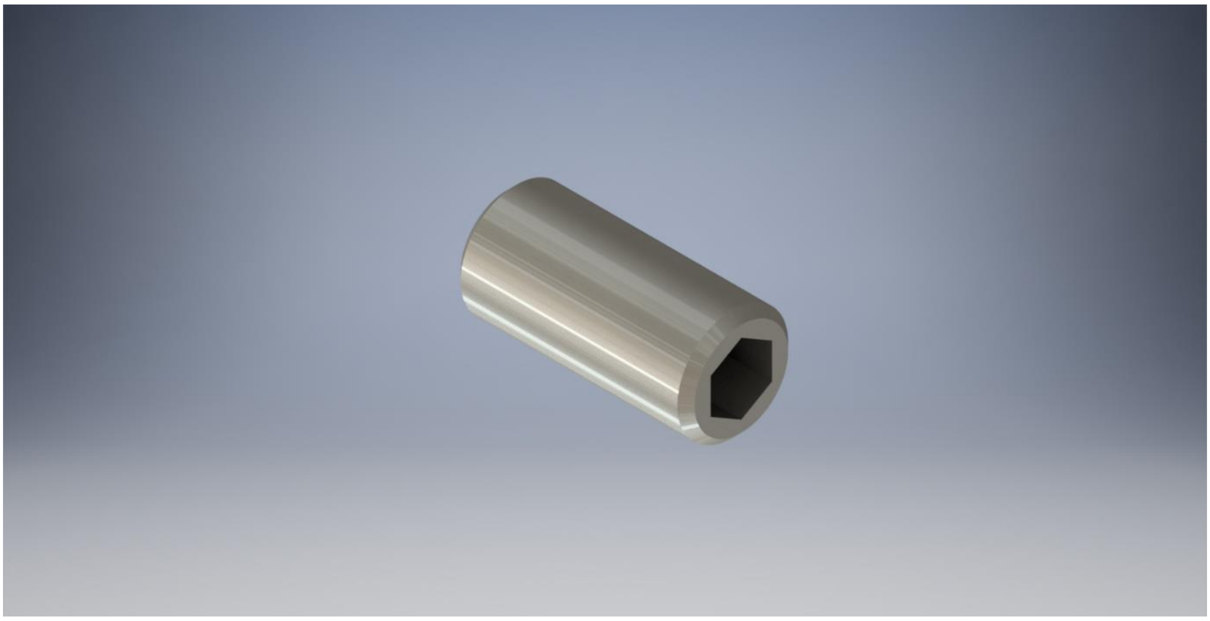
The Hex Coupler part is based on the existing Shaft Coupler part. It provides a means of converting from a Hex Shaft to Square Shaft (e.g. to drive a hex shaft directly from a motor).



Finding clearance of shaft in coupler

The shaft coupler has a clearance of 0.002” for the square shaft. I used the same clearance for the hex shaft hole as the square shaft hole.

Due to some dependency issues I was unable to resolve, I drew up a new part using the original for reference instead of modifying the original part. I made use of the parallel constrain tool to align the rotation of the hex-shaped hole with the square hole, as well as the chamfer tool to bevel the edges of the coupler.

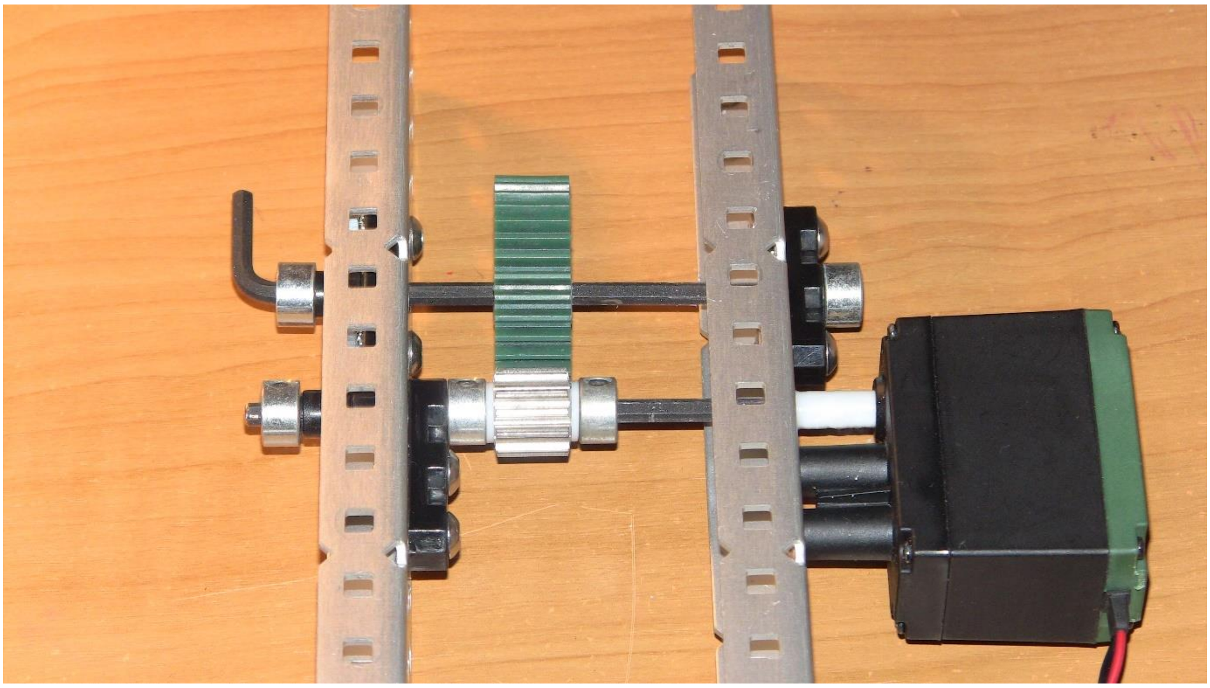


Hex Coupler render

3D-PRINTED PROTOTYPE

Failed first attempt. Hole was too small and blocked off by excess plastic.

The 3D printer used for the parts did not have a very high level of precision, so the holes weren’t exactly as specified in the part files. After a failed first batch of printing, I slightly increased the size of the holes on the printing files to compensate.



I was able to successfully construct a simple gear ratio using hex shafts (cut up Allen keys…), hex gear inserts and a hex coupler.

CONCLUSION

Through this project I have learnt new ways 3D-design software can be used: For verifying the feasibility of design ideas through simulation, and as a reference tool by viewing existing models.

Feasibility analysis and reference models are both very useful tools for a competitive robotics team as well as professional engineers.