

Selection, Design & Analysis of Transmission Drives of Formula Student Vehicle Transmission System

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Abstract - Generally, "Transmission" is associated in a system or action of transmitting something, moreover how the process takes place also refers to the same. Forthwith, "Transmission system" is the process or mechanism of transmitting the power developed in the engine (if combustion vehicle) to the wheels, this power created in the engine needs a medium to deliver to the wheels which is nothing but the "transmission drive". Every automotive industry object to deliver maximum output from the engine to the wheels with minimum losses. This research paper gives a limelight to how and why a type of drive is effective in a specific way.

Key Words: Transmission Drive, Gear Drive, Shaft Drive, Belt Drive, Chain Drive, Efficiency.

1. INTRODUCTION

There were diversified types of drives introduced according to the user's requirements in order to enhance the effectiveness of power transmission. Gear drive, shaft drive, belt drive, chain drive are the types of drive which infers to the medium used like gears (type of gear) depending on the user's requirement, belts (open belts, cross belts etc.) and chain drive (ex. chain and sprocket). Every drive has their pros and cons, they even change according to the setups of the drives. Hereafter, the factors to be considered while selecting a type of drive, their setups, their specifications, analysis of the suited feasible drive for formula student prototype vehicle is explained further.

1.1 METHOD APPROCHED

The study of each type of transmission drives are done from various articles & reference books. The transmission drives are classified into different categories as per there applications, and select one type of transmission drive according to our requirement for design and analysis. The Designing of selected drive was done in SolidWorks software. The Factor of Safety and Equivalent stress concentration analysis of each component of selected transmission drive was done in Ansys software.

All our obtained results are cross checked with all the calculations and software's. While deciding the durability & performance of the component we used the manual available with each material and components.

1.2 FACTOR CONSIDERED FOR TRANSMISSION DRIVES.

1. Power transfer with high efficiency
2. Minimum losses
3. Minimum weight
4. Less maintenance
5. Cost efficient

2. SELECTION OF TYPES OF TRANSMISSION DRIVES

2.1 GEAR DRIVE

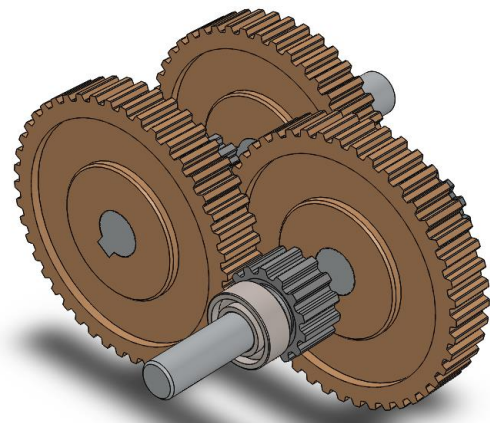


Fig -1: Gear Drive

Gear drives, are also mention as gear trains, are system containing an assembly of gears and other machine components for mounting the rotating elements. They made a mechanical mechanism used for transmitting power from driving component such as motor or engine to a driven part of system. Gear drives can change the transmitted power with the help of different types of gears.

It can increase or decrease the rotational speed of the output gear (shaft). A basic use of gear drives is to reduce the speed of engine or motor that generally runs at hundreds or thousands of revolutions per minute (rpm). These are also called as speed reducers. By reducing the rpm or speed, torque is increased. This force magnification property is one of the main concerns of speed reducers.

Table-1: Gear Drive Specifications

Efficiency	98%-99%
Losses	1%-2%
Weight	More
Maintenance	More
Cost	More

2.2 SHAFT DRIVE

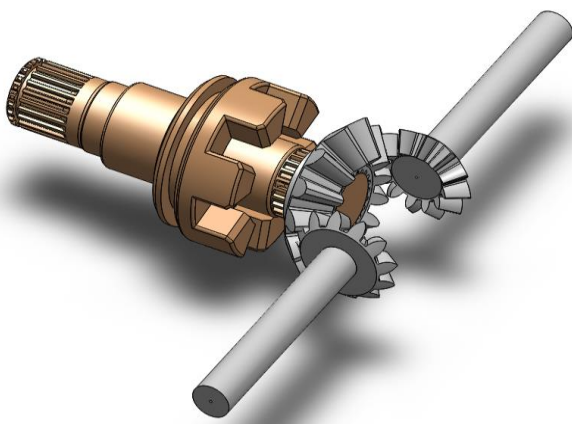


Fig -2: Shaft Drive

In a shaft drive, a shaft connected to gear inside the gearbox using bevel gear for transferring 90-degree power & drive the rear wheel with the help of transmission shafts. When the motor start running (in EV), power is transmitted along the shaft to the rear wheel, and the vehicle moves forward.

Shaft drive having very high efficiency, long service life, transfer large power & torque, less operating noise. But a shaft drive has high initial manufacturing cost, less economical, heaviest type of transmission drive, difficult & expensive to repair.

Table-2: Shaft Drive Specifications

Efficiency	92%
Losses	8%
Weight	Moderate
Maintenance	Less
Cost	More

2.3 BELT DRIVE

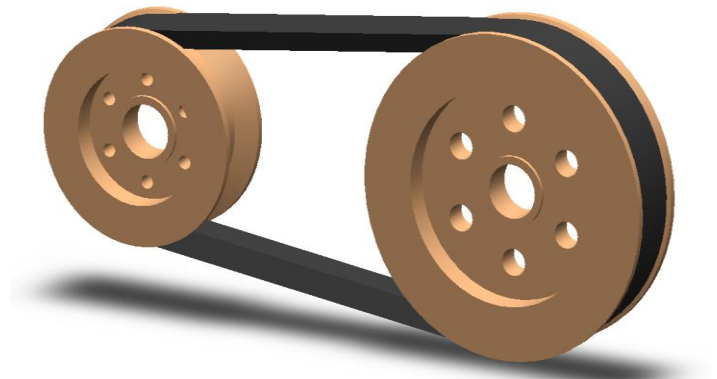


Fig -3: Belt Drive

A belt is a flexible component used to connect two or more rotating shafts mechanically, most frequently parallel shafts. Belts is used as cause of motion, to transmit torque & power efficiently. Belts are the moderate utility for torque transmission between the shafts which is not axially oriented. Torque transmission is done by well-designed belts and pulleys.

Belt drives run smoothly with less noise & vibrations, having long life up to 1,00,000 KMs, and less transmission losses. A drawback to belt drives is that it required more space, and can operate only up to certain speed, due to low coefficient of friction between belt & pulley they tend to slip more.

Table-3: Belt Drive Specifications

Efficiency	95%-98%
Losses	2%-5%
Weight	Moderate
Maintenance	Moderate
Cost	Moderate

2.4 CHAIN DRIVE

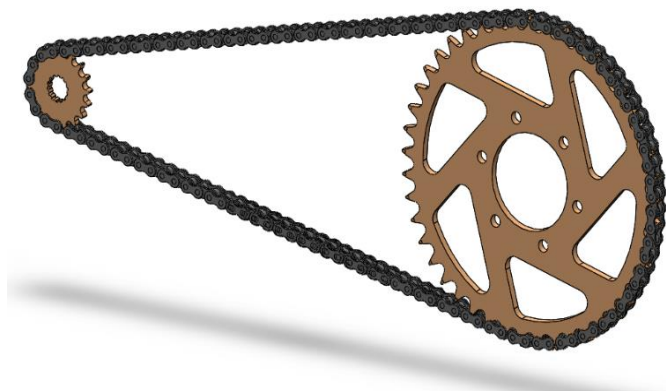


Fig -4: Chain Drive

A chain drive is a Mechanically working mechanism where we can use different types of chains for torque transfer. Normally, the chain drive is used where the distance between the motor and differential is less. Chain drive is frequently used to transmit torque to the wheels of a vehicle. Most frequently, the torque is transmitted by a roller chain, called as the chain drive, loop over a both sprocket with the teeth of the sprocket engage with the slots in the links of the chain.

Chain drive is cheaper to manufacture, having high efficiency of torque transfer, can operate in any condition, easy & cheap to repair. But a chain drive requires frequently lubrication.

Table-4: Chain Drive Specifications

Efficiency	98%
Losses	2%
Weight	Less
Maintenance	Less
Cost	Less

Considering all pros & cons of each type of transmission drive, we decided to design & analysis the Chain Drive for our Electric Formula Student Vehicle.

3. DESIGN AND ANALYSIS OF CHAIN DRIVE

Following are the components that we have to design and analysis of Chain Drive.

1. Front Sprocket
2. Rear Sprocket
3. Chain

3.1 FRONT SPROCKET

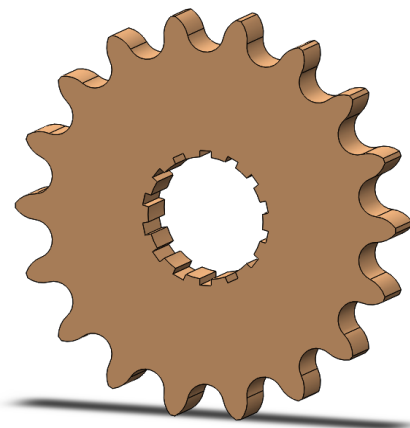


Fig -5: Front Sprocket

For speed reduction transmission system, we have to design one small sprocket (Front Sprocket) and one big sprocket (Rear Sprocket). Small sprocket having a smaller number of teeth compare to big sprocket. Due to small size the force acting on Front sprocket is too high; therefore, we have to design strong Front sprocket. So, we select En19 material for Front sprocket manufacturing. The Front sprocket is mounted on motor shaft with the help of splines. The analysis of Front sprocket done on ANSYS software.

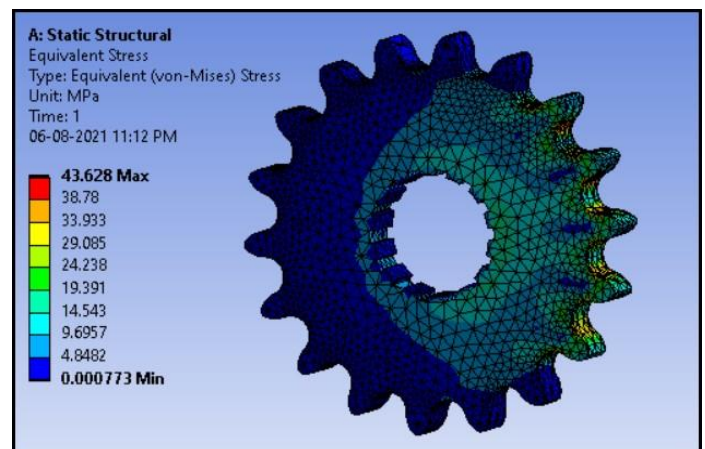


Fig -6: Front Sprocket Equivalent Stress

Table -5: FEA Results

Description	Maximum Stress (MPa)	Maximum Deformation(mm)	Meshing
Front sprocket	43.628	0.004	Triangular

Table -6: FEA Results

Description	Maximum Stress (MPa)	Maximum Deformation(mm)	Meshing
Rear sprocket	153.7	0.06	Triangular

3.2 REAR SPROCKET

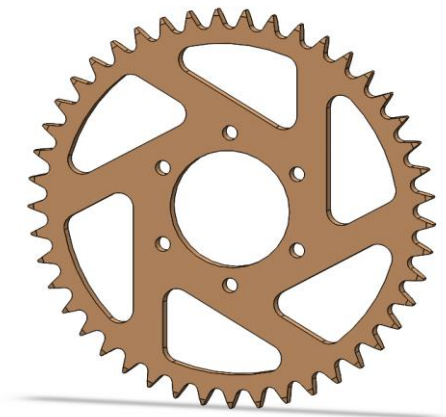


Fig -7: Rear Sprocket

Rear sprocket having larger number of teeth's as compare to Front sprocket, due to that rear sprocket has greater pitch circle diameter. So, we can remove the extra material by weight reduction. The rear sprocket mounted on differential box of transmission with the help of 6 bolting points. The Rear sprocket has large surface area due to that stress get distributed. Therefore, we can use Al7075 material with hard anodize for Rear sprocket manufacturing.

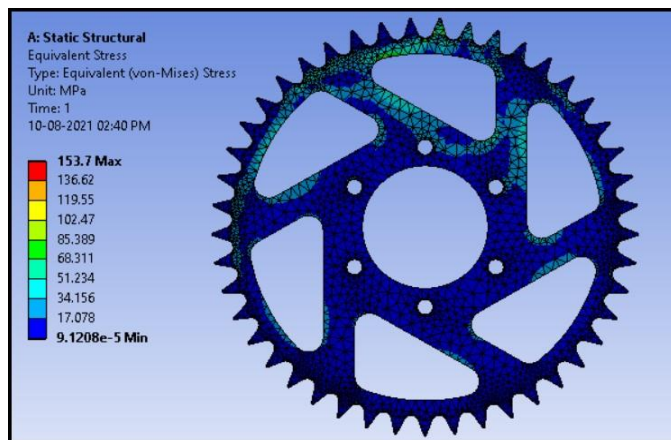


Fig -8: Rear Sprocket Equivalent Stress

3.3 CHAIN

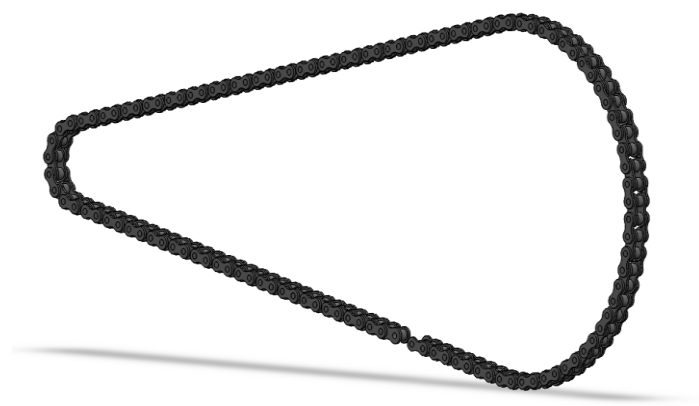


Fig -9: Chain

The chain is the key component of chain sprocket assembly. Therefore, chain should be strong and can be able to sustain the high tensile force. That's why we will directly procure OEM chain from manufacture. The OEM chain is enough stronger to sustain the large amount of force. We can manufacture the chain by our own, but the drawback is manufacturing cost of self-manufactured chain is much higher than OEM chain. The vehicles chain is available in various categories like 420, 428, 520, 525, etc. According to requirement we can choose anyone of the above.

We select, design & analysis the Chain Drive. Maximum stress is within permissible limit. Our design is safe.

4. CONCLUSION

We study the different type of transmission drives for a Formula Student vehicle. We compare each type of Transmission drive for selection. And selected Chain Drive, which satisfy our all needs which is required a formula student vehicle for good power transmission by chain drive, without compromising reliability of vehicle.

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