TRANSMISSION DESIGN REPORT

OVERVIEW

The Car's transmission consists of a chain drive in order to achieve the optimal total reduction which turns A locked differential (spool) which is further connected to half-shafts using Tripod(Constant Velocity) joints.

FORCE CONSIDERATION:

All drivetrain components (i.e Sprockets, Spool Mounts, Spool, Tripods) are designed by taking into consideration the maximum torque output of the motor multiplied by the total reduction.Also taking into consideration the load cases of maximum acceleration and braking. Components are designed with a minimum factor of safety of 2.

Forces considered for the designing of components were ;

Motor Peak Torque – 135 Nm

a. Chain Force (Hand Calculated) = 9905 N

b. Spool Mount Bearing Force = 8kN

c. Tractive Force = 2.4kN

Total Reduction = 5.46

WORKING PRINCIPLE:

The drivetrain is a vital link between a car's motor and the wheels. It helps us to amplify the torque and transmit power which allows us to maximize traction utilization.

The motor's torque is amplified by a chain drive consisting of a much larger driven sprocket which has a Final Drive Ratio(FDR) of 5.46 and is fastened to the locked differential that rotates both half shafts at the same speed, regardless of the conditions. This design enables the wheels to produce maximum tractive force even if there is less traction on either of the wheels.

DESIGN CONSIDERATIONS:

1. Torque vs RPM data was collected from the motor which is used to calculate drive ratio using OptimumLap software. Based on this data the software calculates lap times and torque on wheels.

2. OptimumLap is used to finalize the total reduction and is an iterative process to achieve minimum lap times in acceleration run as the drivetrain was designed keeping in mind faster acceleration and the 100 points available for the acceleration event without compromising other events' lap times.

3. After the Total Reduction is finalized, the spool and spool mounts are designed considering the torque transmitted after the reduction.

4. To keep the weight to a minimum with higher FOS of the components, aluminum 6061 T6 is selected due to its high yield strengths and machinability.

5. OEM Tata Nano driveshafts are selected as they are compatible with our system and readily available.

6. Fixtures are designed to minimize the manufacturing errors like welding contractions, placement of components according to the CAD, regular maintenance of the components are a few engineering practices that are kept in mind while designing and manufacturing the components.

7. The driveline is designed such that the unsprung mass could be as low as possible to reduce the negative effects of higher unsprung mass. This is again, an iterative process. The rear spindles are made as light as possible from the previous iteration.

8. The design of three element bolted spool is such that it can not be bolted on unless and until the tripods and the middle elements are concentric, hence reducing the concentric manufacturing of the spool.

9. Proper fits while assembly, alignment of bolting holes, and checking for abnormal rotating noises are a few ways to ensure the quality of the machined and assembled components.

COMPONENT SELECTION:

MOTOR MOUNT

To ensure a simply supported setup, the motor is equipped with two mounts made up of Aluminum 6061 T6 to provide ample strength and rigidity to prevent motor movement, all while prioritizing lightweight design.

This configuration allows for a balanced and stable arrangement, effectively distributing the load.

The mount is complemented by an external bearing seat. This addition facilitates a stable and balanced setup for the motor shaft, promoting smoother operation and minimizing any potential shaft deflection or misalignment.

DRIVE

For our purpose, chain drive was selected as the efficiency of chain drive is near to 98% and no slip condition can be achieved. Also, chain drives can be easily maintained.

We used an OEM 428H chain. Custom sprockets were manufactured.

Driving Sprocket: 13 teeth (Thickness- 7mm)

Material: C45

Manufacturing Processes: VMC

Driven Sprocket: 71 teeth (Thickness- 7mm)

Material: C45

Manufacturing Processes: Surface grinding, Laser cutting

DIFFERENTIAL

Locked Differential: It has a simple construction. A locked differential causes both the left and right wheels on the same axle to rotate at the same speed under all conditions, As a result, each wheel can apply as much tractive force as the grip allows, and the torques on each side-shaft are unequal. (Equal rotational speeds, unequal torque).

Material Selection: The whole Spool is made up of aluminum 6061 T6. This is one of the stronger aluminum alloys available, allowing us to design the lightest component possible to withstand the loads. T6 temper 6061 has been treated to provide the highest precipitation hardening (and thus yield strength).

DIFFERENTIAL MOUNT

To make the spool mounts, we used aluminum 6061-T6. The left mount holds the brake caliper. We installed SKF 61819 bearings in the mounts. The spool is press fitted in the bearing inner races by contracting it with dry ice and then returning it to room temperature to achieve a perfect fit. The mounts were designed with chain tension, torque transmission through the spool, and impact force cases in mind. This design was improved by connecting the spool mount to the box sections, resulting in a lower part count and complexity

Material Selection: The spool mounts are made of aluminum 6061-T6. This enabled us to design a light and simple spool mount that makes it possible to handle the loads we anticipate in the spool mount.

DRIVESHAFT

Driveshafts play a vital role while transmitting power through the driveline. We are using OEM Tata Nano driveshafts since it is compatible with our driveline and readily available.

IMAGES:

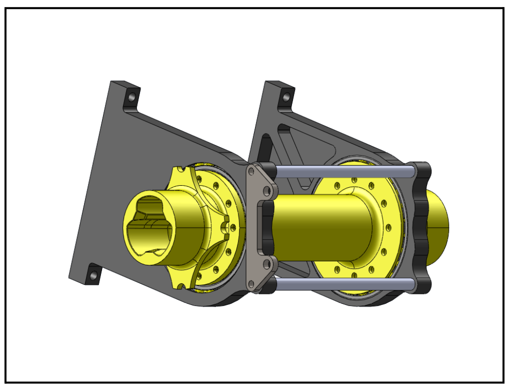

Figure 1.1: Differential Assembly

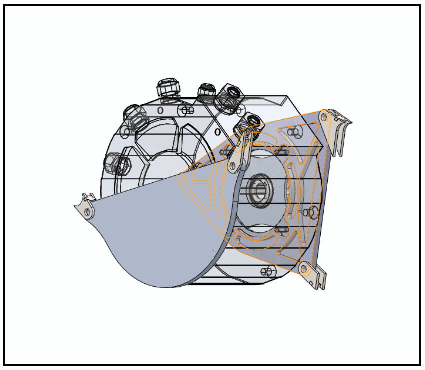

Figure 1.2: Motor Mounts

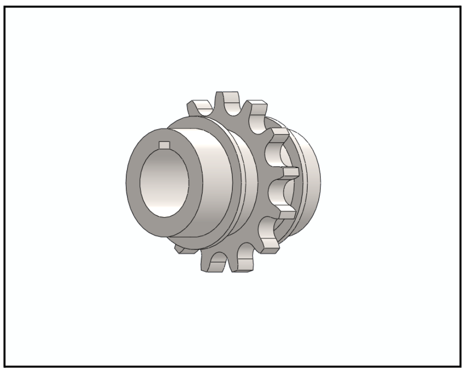

Figure 1.3: Driving Sprocket (13T)

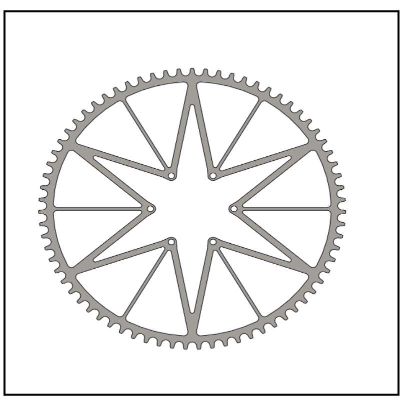

Figure 1.4: Driven Sprocket(71T)

STRUCTURAL ANALYSIS OF COMPONENTS:

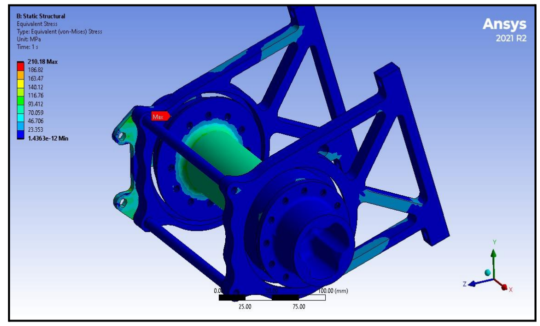

Figure 2.1 Spool Assembly

Max Stress = 210MPa

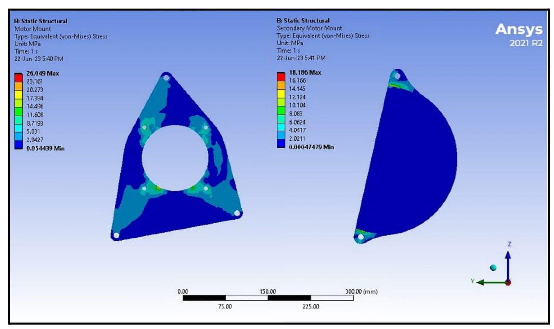

Figure 2.2 Motor Mount, Primary Motor Mount

Max Stress = 26MPa, 18MPa respectively

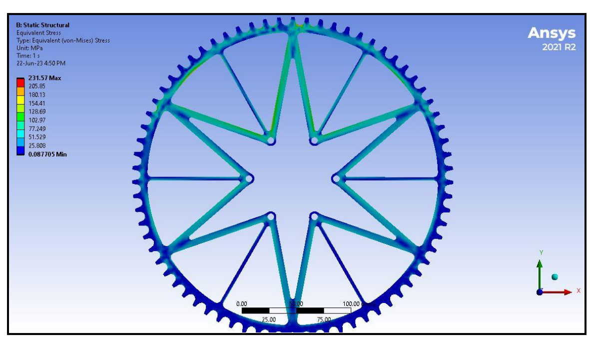

Figure 2.3 Driven Sprocket

Max Stress = 230MPa

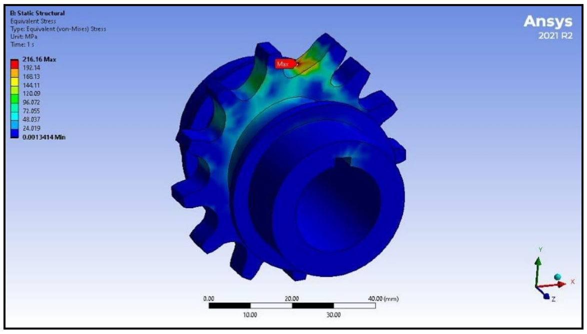

Figure 2.4 Driving Sprocket

Max Stress = 216MPa

RESULTS:

Performance figures via OptimumLap Software

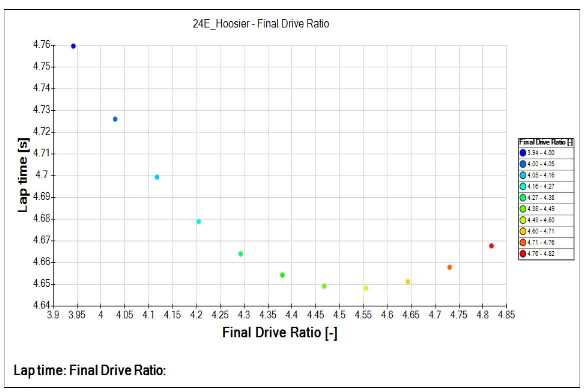

Figure 3.1 FDR Selection

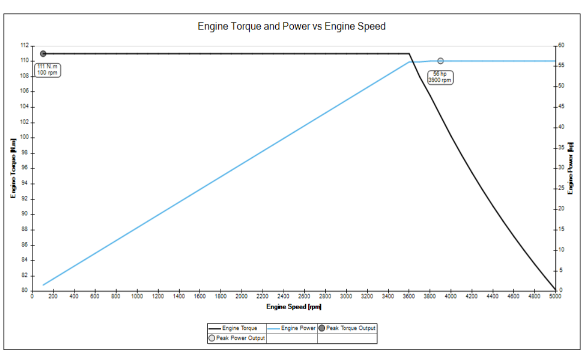

Figure 3.2 Motor Speed vs Torque

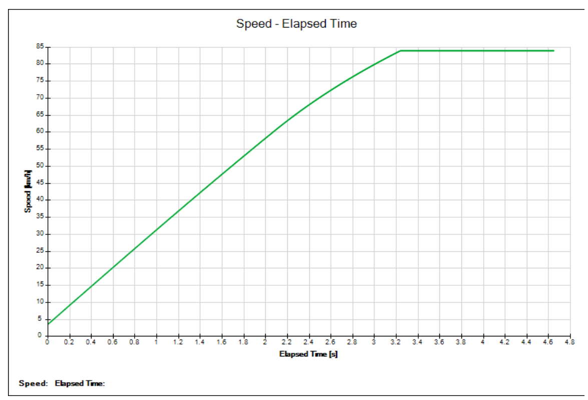

Figure 3.3 Speed vs Elapsed Time