Spur Gear Designing and Weight Optimization

Mr. Naveen Kumar¹, Mr. Vaibhav Chittoria², Mr. Utkarsh Upadhyay²  
¹Assistant Professor, ²Student,  
Department of Mechanical Engineering, ABES Engineering College,  
Ghaziabad, U.P., India.

Abstract: In this paper, we are designing and optimizing of gear for event SAE BAJA Transmission. The given values of forces, torque and factor of safety of gear are calculated in accordance to custom vehicle. The gear is designed using SOLIDWORKS Toolbox. Gear weight is optimized by material removal from specific region. After it, simulation on SOLIDWORKS and ANSYS is done giving input values from calculation. The result shows the difference in weight and factor of safety between optimized and un-optimized gear models.

INTRODUCTION:

Gear is used to gain mechanical advantage in power transmission. Gears of different types: Spur Gear, Helical Gear, Bevel Gear, Worm and Wheel Gear. Gears are commonly used in Transmission of Automobiles via Gearbox. Transmission assembly are stated: Simple Gear train, Compound Gear train, Planetary, etc. Weight of gears in gearbox becomes a constant factor of vehicle weight as whole. In college projects like SAE BAJA, SUPERA, etc. the basic knowledge of transmission is seen by an engineer skill to design a gearbox of required strength and maintain lightweight. The vehicle this gear is designed for uses a Engine power source with CVT.

OBJECTIVE:

• To choose material of high strength.
• To calculate the theoretical forces on spur gear by conventional formulas.
• To model the spur gears on SOLIDWORKS using toolbox spur gear.
• To remove material and optimize weight of spur gear.
• To simulate gear on SOLIDWORKS and ANSYS.

ANALYSIS:

THEORETICAL ANALYSIS

Gear Material

Material for Gear is chosen based on yield strength of material. Materials commonly used are AISI 4340, EN 353, etc. We have taken AISI 4340 for its high strength. The properties are as in Table 1.

Table 1

<table>
<thead>
<tr>
<th>AISI 4340 Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density</td>
</tr>
<tr>
<td>Hardness(BH)</td>
</tr>
<tr>
<td>Young’s modulus</td>
</tr>
<tr>
<td>Poisson’s ratio</td>
</tr>
<tr>
<td>Yield strength</td>
</tr>
<tr>
<td>Ultimate tensile strength</td>
</tr>
</tbody>
</table>

Engine

Engine used here is Briggs and Stratton engine, Model 19(Fig. 1). Its specifications are given in Table 2.

Fig. 1 B&S Power Graph
Continuous Variable Transmission (CVT) is used as constant reduction between engine output and gearbox input. Specifications are given in Table 3.

### Calculation

**Torque on Gear**
Torque is transferred from engine to gearbox after reduction from CVT. The final torque on gear is:

\[
M_t = \text{max. torque input at gear} \\
M_t = \text{max. torque of engine} \times \text{max. CVT ratio} \times \text{Gear reduction ratio}
\]

\[
M_t = 19.6 \times 3 \times 7.54 = 443 \approx 450 \text{ Nm}
\]

**Spur Gear nomenclature**
Basic dimensions of Gear are given:
- Module(m)=2.5
- Number of Teeth(z)=59
- Pitch Circle Diameter(d)= m*z = 147.5mm
- Width of Gear(b)=20mm
- Output Shaft Diameter=36mm

**Calculation of Tangential Force**
The two components of net force on gear tooth are: Radial force(F_r), Tangential force(F_t). The only force responsible of gear rotation is F_t, calculated below:

\[
F_t = \frac{2 \times M_t}{d} \\
F_t = \frac{2 \times 450 \times 1000}{147.5} = \frac{6101.6949}{N}
\]

**Calculation of Beam Strength of Gear Teeth**
The resistive force offered by gear tooth is calculated below:

\[
F_{en} = \frac{\sigma_{en}}{3} \times b \times Y \times m \\
F_{en} = \frac{1110}{3} \times 20 \times (0.175 - 0.95 / 59) \times 2.5 = 9235.0843 \text{ N}
\]

**Calculated Factor of Safety (FOS)**
Factor of Safety is calculated:

\[
\text{FOS} = \frac{F_{en}}{F_t} = \frac{9235.0843}{6101.6949} \approx 1.51
\]

### GEAR DESIGNING
For Gear model, we take a standard spur gear from SOLIDWORKS Toolbox. Assign the Module and Teeth number. The software will generate a gear using Global Equations. We optimize it according to design using Static Simulation. For simulation the center hub is fixed fixture and tangential force is applied on teeth for worst condition possible. Simulation of Gear on SOLIDWORKS Fig. 2, 3.
Fig. 2 Stress

![Stress Diagram]

Fig. 3 Factor of Safety

![Factor of Safety Diagram]
Simulation of Gear on ANSYS Fig. 4, 5.

RESULT :

After simulations, we got the following results give in Table 4.

Table 4
Comparison Result

<table>
<thead>
<tr>
<th></th>
<th>Normal Gear</th>
<th>Optimized Gear</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOS</td>
<td>2.24</td>
<td>2.01</td>
</tr>
<tr>
<td>Mass</td>
<td>2505.51gm</td>
<td>888.86gm</td>
</tr>
</tbody>
</table>
REFERENCES