Research in Economics and Management
ISSN 2470-4407 (Print) ISSN 2470-4393 (Online)
Vol. 3, No. 3, 2018
www.scholink.org/ojs/index.php/rem

Original Papers

Lightweight Design of Large and Small Chain Wheels of University Formula Racing Car Transmission System Based on CAD Technology

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Received: July 28, 2018 Accepted: August 18, 2018 Online Published: August 20, 2018

doi:10.22158/rem.v3n3p256 URL: http://dx.doi.org/10.22158/rem.v3n3p256

Abstract

The achievements of the Chinese college students' equation competition have already represented the strength of a college automobile field, and more and more auto related colleges and universities have paid more and more attention to this event. The vehicle drive system has a great influence on the power of the car, and the research of the light quantization in the power transmission system has become a hot spot of concern in the world. This paper will design and study the light weight of the large and small sprockets, and hope to draw lessons from the design of the other university students' equation racing car.

Keywords

Student formula contest of China University, transmission system, sprocket, lightweight

1. Introduction

The Chinese University equation competition is an automobile design and manufacturing event of a National College of automotive engineering or automobile related majors. The competition is designed and manufactured in accordance with the rules of the events and the standard of racing car, and it has higher requirements for the students' professional knowledge, team work, and emergency response. The performance of the car determines the final result directly. The dynamic performance of the car is determined by the transmission system. It can be said that the good or bad of the transmission system will determine the success or failure of the race.

In 2010, the China Automobile Engineering Society and Yi Che network jointly launched the first university formula racing competition in China (FSC). At present, China has successfully held 7 events, of which the electric equation competition (FSEC) has been held since 2013, and has been 5 years. The referees come from auto plants such as FAW, Dongfeng, SAIC, Changan and Beiqi, as well as professionals from research institutions such as China Automotive Technology Research Center and Shanghai motor vehicle testing center.

In this paper, we design and study the lightweight problem in the large and small chain wheels in the transmission system, and finally design the large and small sprocket conforming to the requirements of the competition, the requirement of strength and the good performance.

2. Basic Size of Design

According to the requirements and actual situation of the formula racing events for college students, the engine type CBR600F4I is selected. The parameters are as follows:

Table 1. Engine Parameters

Performance index of engine	Related parameters
Engine displacement	599cc
Engine compression ratio	12:1
Speed extremum (r/min)	13000
Cylinder diameter x stroke (mm)	67x42.5
Maximum torque of engine	6.3kg-m/10500 rpm
Engine horsepower extremum	110ps/12500 rpm
The highest power in unrestricted flow (kw)	80
Engine maximum power after limiting air flow	47kw/11000 r/min

At the speed of 110 km/h, the transmission ratio of the final drive for the FSC racing car on the traight road is calculated.

The engine speed is faster than 1.955, the third gear speed is 1.556, and the outer diameter D is 510 mm Hoosier racing tire

$$n_t = \frac{1000v}{60\times 2\pi r} = \frac{1000\times 110}{60\times 510\times \pi} = 1144.25 \quad (1)$$

$$i_f = \frac{n}{n_t i_g i_0} = \frac{11000}{1.955\times 1.556\times 1144.25} = 3.16 \quad (2)$$

The transmission ratio of the main drive system of the University formula racing car transmission system is 3.16.

The mechanical design manual shows that the number of small sprocket teeth should be at least 9. Considering the rationality of the design and the superiority of the chain wheel and the use of the chain wheel, and in order to control the wear between the sprockets, the number of teeth of the small sprocket is 11 teeth, and the number of the teeth of the large sprocket can be calculated in the previous calculation of the transmission ratio of 3.16 to the number of 34.

2.1 Selection of Materials

The design of the concept is mainly lightweight, after a comparison of the final determination of the size of the material for the selection of 7075 aluminum alloy, material is not only high in strength, tight structure, good wear resistance, good corrosion resistance, the most important is the low density of aluminum alloy, the design of the sprocket more portable. Moreover, 7075 aluminum alloy can be treated by heat treatment to achieve a higher strength. Physical properties of materials such as Table 2:

Table 2. Mechanical Properties of Materials

Material name	Poisson ratio	density	Young's modulus	hardness	Yield strength
7075-T6	0.33	2.81g/cm^3	72GPa	150HB	503

2.2 Design of Large Sprocket

The main function of the large sprocket is to change the torque and transmit the power from the small sprocket to the other differential. Large sprocket and differential are connected in two ways:

(1) connect the large sprocket to the differential by using the original spline and bolts.

(2) the sprocket hole is directly processed into the internal spline and the chain wheel is mounted on the outer spline of the differential.

By comparison, the second ways can increase the web area of the sprocket, which is more beneficial to the optimization of the sprocket structure. When designing large sprockets, we should try to reduce the quality while ensuring its strength. Therefore, we need to design weight reduction holes in the web position of the sprocket, and the weight reduction holes should have the advantages of easy processing. After some study and research, the final design of the large sprocket is shown in Figure 1. Finally, the large sprocket is designed with beautiful appearance, weight reducing holes, and the quality of the whole sprocket is greatly reduced.

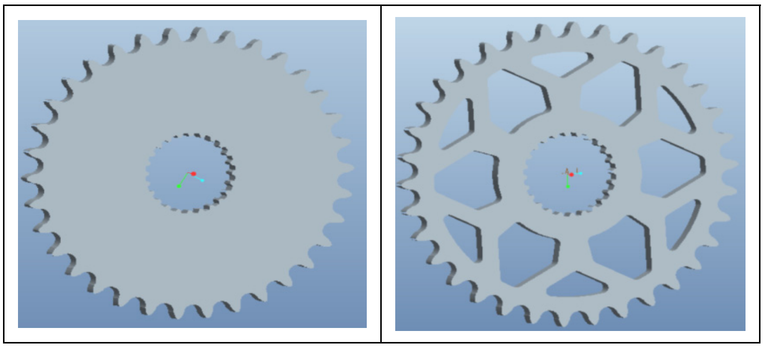

Figure 1. The Design Process of the Dalian Wheel

2.3 Design of Small Sprocket

Because the small sprocket is smaller, only 60mm. Its weight is not too large, so it is not necessary to make small sprockets hollow to reduce weight. The shape of the small sprocket is shown in Figure 2.

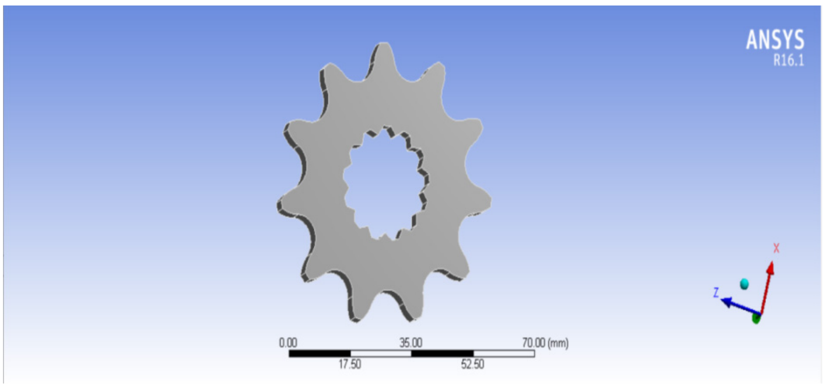

Figure 2. Small Sprocket

2.4 Checking of Parts

After completing the design of parts, parts need to be checked to ensure that parts can be used normally during use. The main check is the surface pressure stress of the parts. If the pressure stress can be less than the yield strength of the part material, then the part is safe, and in the process of use, the failure will not occur. Calculating the surface compressive stress of parts can be done by formula 3.

$$\sigma = \frac{W}{A} \qquad (3)$$

(1) stress calculation of small sprocket

The main source of the pressure of the small sprocket is the single side of the tooth 41.92mm2, the maximum torque of the engine is 63N m, the one gear ratio is 2.833, the drive ratio of the engine internal decelerator is 1.955, the small sprocket radius is 30mm, and the transmission coefficient is 0.95. Therefore, the force on the small chain wheel can be calculated to be 11050N. From the above, it is known that the angle of the small sprocket is 157 degrees, so there are 5 teeth in the meshing chain per unit time, and the force of the single tooth is about 2210N. The formula can be used to calculate the stress on the small chain wheel is 52.72Mpa, much smaller than its yield strength, and the design strength is qualified.

(2) stress calculation of large sprocket

The single side 42.43 mm2 of the large chain gear is not changed by the force of the small chain wheel to the big chain wheel in the chain transmission process, so the check big sprocket is also the force of 11050N, the angle of the big sprocket is 203 degrees, the tooth of the meshing chain is 19 in unit time, and the single tooth is about 581.58N. The formula can be used to calculate the stress of 13.71 Mpa, far less than its yield strength, and the design strength is qualified.

3. Strength Checking

3.1 Statics Analysis of Small Sprocket

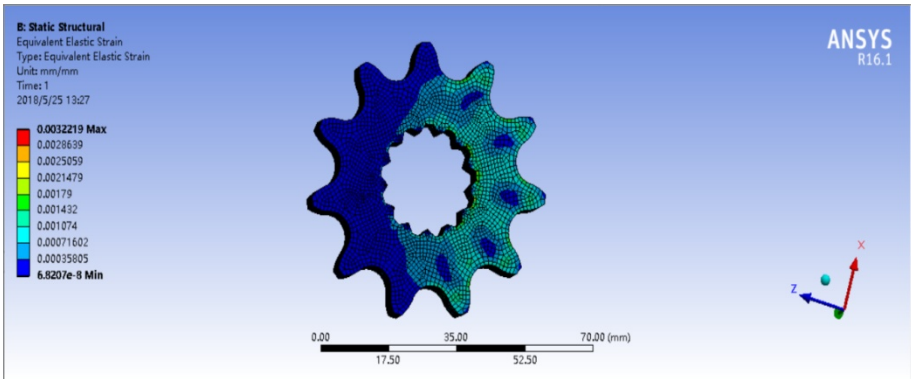

Figure 3. Small Chain Wheel Strain Cloud Map

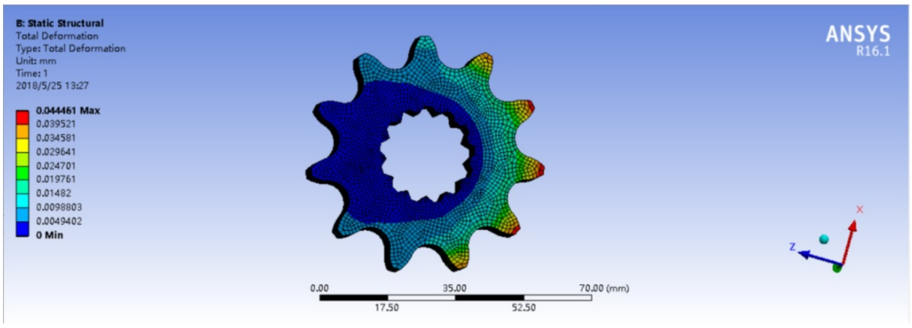

Figure 4. Small Chain Wheel Deformed Cloud Chart

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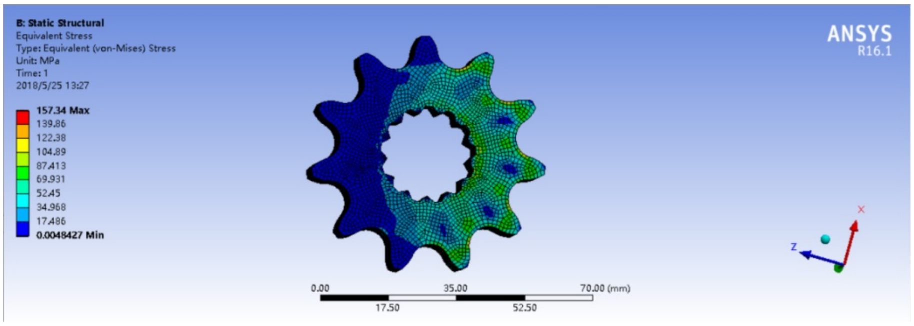

Figure 5. Small Chain Wheel Stress Cloud Map

From the analysis results, the strain and deformation of the small sprocket are very small. And the maximum stress of the small sprocket is 157.34Mpa, far less than its yield strength, so the small sprocket of this design is reasonable in strength, and the tooth of the sprocket is the most deformed place in the whole chain wheel, so the chain wheel can be heat treated for the service life and safety of the sprocket, in order to increase the sprocket. The hardness of the sprocket ensures the safety in use.

3.2 Statics Analysis of Large Sprocket

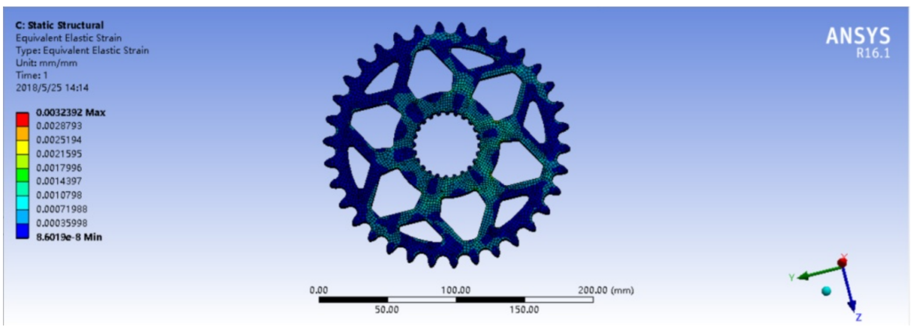

Figure 6. Large Sprocket Strain Cloud Map

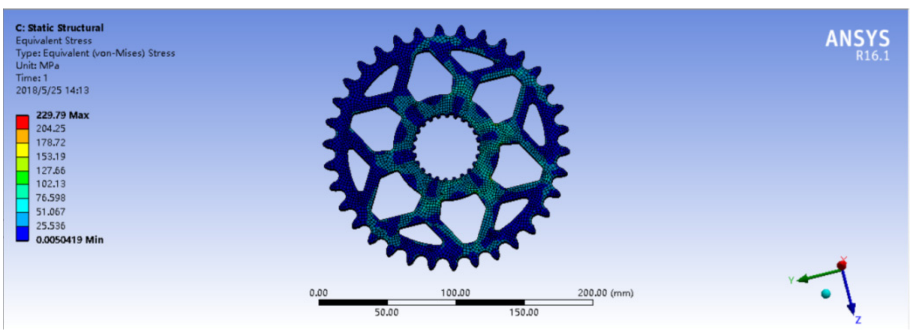

Figure 7. Large Sprocket Stress Cloud Map

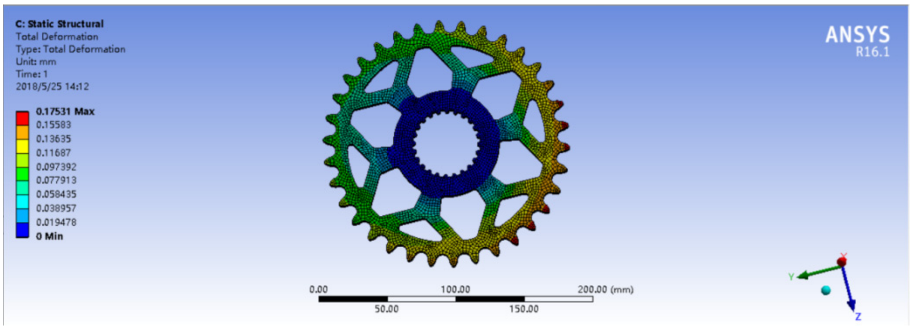

Figure 8. Large Sprocket Deformed Cloud Chart

From the analysis results, the strain and deformation of the large sprocket are very small. And the maximum stress of the big sprocket is 241.3Mpa, far less than its yield strength, so the large sprocket of this design is reasonable in strength, and the tooth of the sprocket is the most deformed place in the whole chain wheel, so the chain wheel can be heat treated for the service life and safety of the sprocket, in order to increase the chain. The hardness of the wheel ensures the safety of the use.

4. Result

After the size calculation of the large sprocket is completed, the web position of the sprocket is optimized. After optimization, the quality can be greatly reduced while the strength is guaranteed. The optimized sprocket volume is 117975mm^3 and the mass is 331.501g. Compared with other papers of similar design, the parts designed in this paper are lighter, less fuel consumption and improve the dynamic performance of formula racing car.

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