Chain Tensioner Integrated with Differential Mounting Plate for Formula Student Vehicle

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Abstract - *The purpose of this project was to design a differential mounting along with effective chain tensioner for formula student vehicle. Main objective of this project is to reduce the weight as current system weighs a lot and it should adjust the chain tension effectively and easily. Also to have the chain under the right tension prevents the chain from excessive wear and from the possibility to hop of the sprockets during driving. This paper covers design considerations for the chain tensioner and finite element analysis of the mounting.*

Key Words: Chain Tensioner, Light Weight, Differential Mounting, Offset Disc, fsae

1. INTRODUCTION

In formula student competition, the event is divided into static part and dynamic part. Dynamic part covers more than a half points; hence good performance of vehicle is required to get maximum points out of these events. Since dynamic performance is solely depends upon engine and transmission, therefore good design of transmission system is necessary.

If the chain tension between the sprockets is not appropriate the wheels could not move with an expected performance. Presently team uses turn buckle system to adjust the chain tension. Limitation with this type of arrangement is that with excess in vibration turn buckle tends to loosen the chain, which directly reduces the performance of vehicle.

Before finalization of the design several different options were considered. Initially improvement in the current system was opted. Another was to induce spring loaded idler like used in the geared bicycle. The idler would take the slack with spring force and would always adjust the tension automatically. Problem with this arrangement was the positioning of an idler. It was requirement of this system to place idler in same plane of the other two sprockets. Since it was difficult to make this arrangement, team dropped this arrangement. Finally the eccentric chain tensioner was selected as it offers very easy and firm adjustment. Also it does not loosen the chain due to excess vibration like turn buckle system.

2. LITERAUTURE SURVEY

In Justin Lebowski Drivetrain Design, utilize similar titanium bolts for the lower engine mounting and a thru bolt 60 for the top mounts since a large amount of distance has to be covered to secure both mounting plates to the top mounts of the engine. This mount utilizes eccentric plates to adjust the tension in the chain. Two M8 bolts will be used on the top and bottom of each mounting plate to create clamping force to prevent rotation of the eccentric plates. The force necessary was calculated using a code that takes into account the forces normal to the left and right bearings and the friction properties of 7075 T6 aluminum. The top bolt will need to be loosened to adjust chain tension

In design of a drivetrain for a FS race car by Tom Bekker, the design of the chain tensioner consist of two eccentric disks witch each house one of the differential bearings. The disk can rotate in the differential mount. The centerline of the differential bearing has an offset of 1cm to the centerline of the chain tensioner disk. By rotating the chain tensioner disk 180 degrees the distance between engine and differential, or front and rear sprocket, vary by 2cm. if the top and bottom line of the chain runs parallel this means a difference in chain length of 4cm. This is a little more than the 31.75mm required to bridge two times the pitch.

3. DESIGN

As shown in figure, the assembly consists of two parts. The eccentric disc is housed in the differential mounting plate.

While designing eccentric disc the foremost consideration was the offset. It was decided to make disk offset by 20mm. Team uses KTM 390 engine which has a chain with a pitch of 15.87mm. When disc is rotated 90 degree towards front end or rear end it gives 20 mm adjustment at both ends which is slightly more than a pitch of chain. If the chain gets loose more than 20 mm then to adjust the tension one of the links can be removed. Hence this arrangement practically adjusts all possible tensions that can take place. Figure of an eccentric disc is as shown below;

Inner diameter of an eccentric disc is calculated by selecting the bearing. Outer diameter of the bearing is selected by calculating the load and other different parameter. This bearing is then housed in the eccentric disc and inner diameter of bearing resembles to the axle diameter.

Below figure shows the differential mounting plate. Mounting plate is held at two points as shown. Upper point is secured on rear bulk head and lower point is fixed at the upper portion of jacking bar as SAE rulebook prohibits mounting anything in bottom 180 degree of jacking bar.

There are series of holes made on internally extruded periphery as shown. This amount of holes gives higher flexibility of adjusting the eccentric disc. Similarly there are also holes on eccentric disc. After adjusting the tension 4 or 5 bolts can be used to hold the setting.

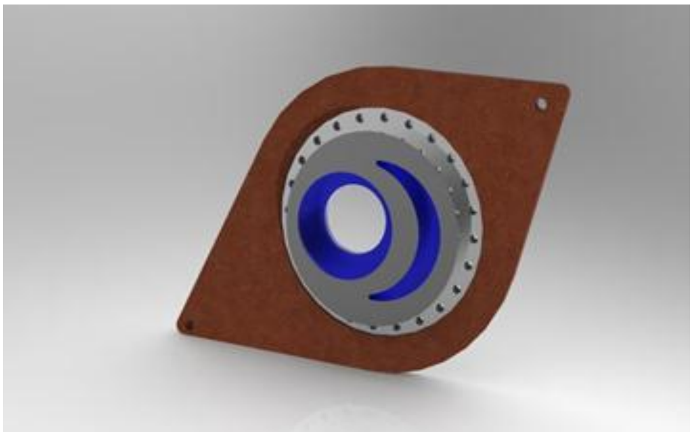

Fig-1: Assembly of chain tensioner system

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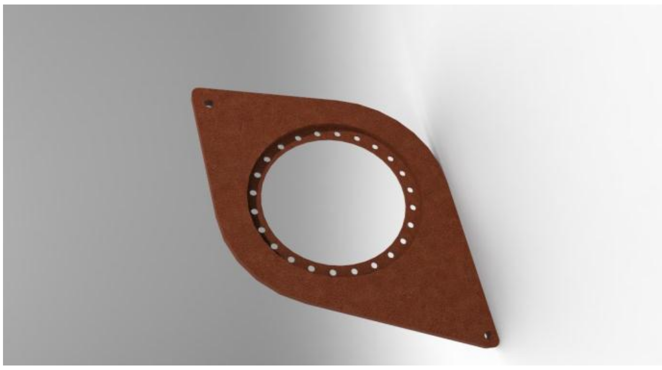

Fig-2: Differential mounting plate

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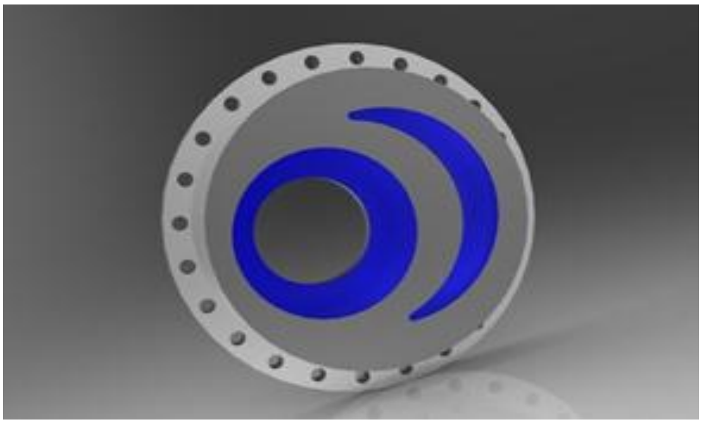

Fig-3: Offset Disc

4. MATERIAL SELECTION

Previous year's assembly of chain tensioning and differential mounting plate was made from mild steel which was the main reason of its more weight. As one of the main objective of this project focusses on to reduce the substantial weight, aluminium 6061 T6 was selected as a material for new differential mounting – chain tensioner assembly. Since aluminium has higher strength to the weight ratio compare to mild steel. Hence alumimium 6th series material were finalized as maaterial for this assembly.

5. FINITE ELEMENT ANALYSIS

For analysis of an eccentric disc four points where bolts are going to be are made fixed. A bearing moment is applied on the inner surface of the disc. Bearing moment is calculated by multiplying the highest torque that engine produces with gear ratio at first gear provided by the manufacturer and finally to the sprocket ratio of primary to the secondary sprocket.

Secondly vertically downward load is applied on the bottom half of the inner circle. Load can be calculated by weighing the axles and differential plate.

For both eccentric disc and differential plate Aluminium 6061 T6 is used, because it is easily available in market and has low weight for required strength than mild steel.

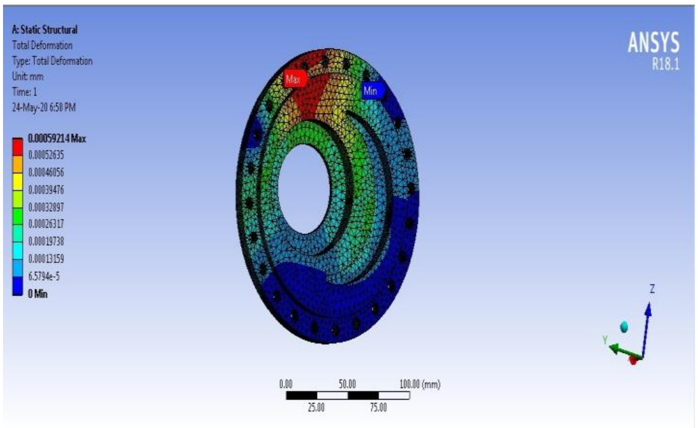

Fig-4: Total deformation of offset disc

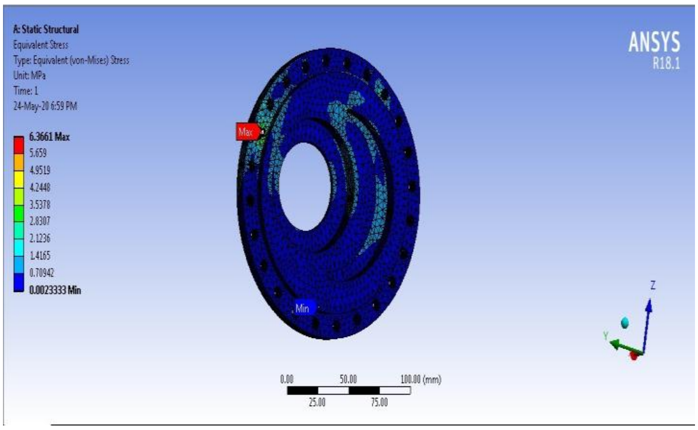

Fig-5: Equivalent stress analysis of offset disc

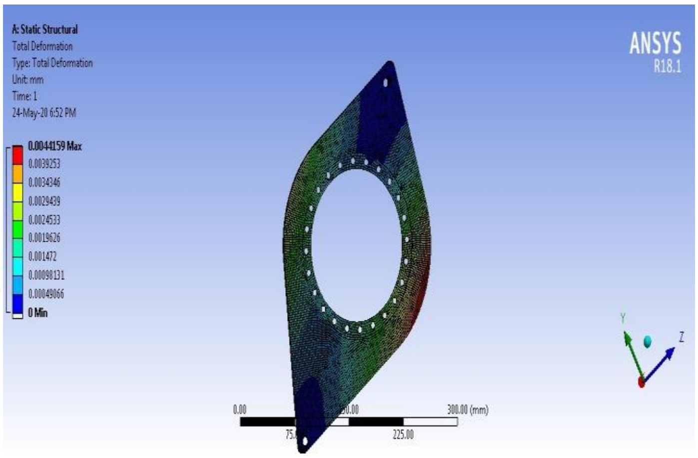

Fig-6: Total deformation of differential plate

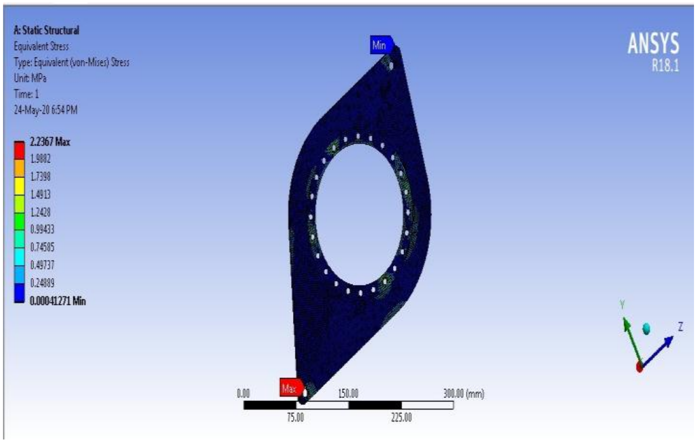

Fig-7: Equivalent stress analysis of differential plate

6. RESULT AND DISCUSSION

This arrangement offers great flexibility in adjusting the tensions as there are 24 holes to adjust 20 mm offset. Adjusting of chain tension can be done very easily by removing and reassembling nut bolts. As seen from finite element analysis both the eccentric disc and differential plate are safe from the potential failure. Following table shows failure analysis of both differential mounting plate and chain tensioning offset disc.

Table -1: Failure analysis result

Object	Max. deformation	Max stress generated
Plate	0.0044mm	2.2367MPa
disc	0.0005mm	6.3661MPa

7. CONCLUSION

As the main objective of the project was to make system light weight, the differential plate weighs only 600 grams which is very less as compared to previous. Eccentric disc chain tensioner is also reliable as it does not change the tension because of vehicles vibrations after setting as in case of turn buckle.

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