International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 7 July 2021, pp: 1667-1673 www.ijaem.net ISSN: 2395-5252

Design and Analysis of Reverse E-Trike

Rakesh Jose[1], Arjun T P[2], Arun Sabu[3], Joel George Kalampukattu[4]

[2, 3, 4]*Student, Department of Mechanical Engineering, Viswajyothi College of Engineering and Technology Vazhakulam, Kerala.*

[1]*Assistant Professor, Department of Mechanical Engineering, Viswajyothi College of Engineering and Technology Vazhakulam, Kerala*

Submitted: 01-07-2021 Revised: 10-07-2021 Accepted: 13-07-2021

ABSTRACT: Designing a small object with functionality is no easy task. Any object we use with functionality had undergone a lot of designing processes before taking its final form. It starts off as an idea to bring about a solution to an existing problem or bringing about some new features to an existing solution. This idea then changes into a concept , which then evolves to take the final form as a solution to the problem. This process of a concept to the final reality undergoes through many changes which is done during the designing process. Thus designing is an important part for the idea to into reality as a solution to the problem. In our project we have designed a Reverse Tilting E-trike with the aim of improving the design based on other existing designs. The functionalities remain the same but with improved performance and is more reliable. Each part was designed considering many factors such as strength, availability of the materials during fabrication, cost of the material, design constraints and considerations, machinability etc. After designing the entire reverse E-trike we have also analysed the components and the chassis for deformation, stress, safety, factor and modal analysis. Finally, the results of the design and analysis are summarised and concluded.

KEYWORDS: Trike, designing, analysis

I. INTRODUCTION

Reverse trike is not a not a new concept and has been around quite some time. It is an automobile with two wheels in the front and one wheel at the back. The reverse tilting trike is the same concept with an added feature for tilting much like a motor bike. There are different designs for the reverse tilting E-trike . The main concept of the E-trike is to providing balance to the rider, improving traction, braking performance, better control and having better cornering ability around tight corners. The safety of the passenger is the first and most important thing to be considered, but the normal trike is highly unstable during cornering, which results in an increase in rate of accidents due to slippage and roll over of the vehicle. The use of a tilting mechanism in three wheel vehicles will reduce the rate of accidents caused due to slippage and rollover. The tilting mechanism provides directional as well as dynamic stability and also increases the ride comfort and braking performance.

The main requirement of this project is suitable 3D designing software to design the components within given parameters and easily available materials for manufacturing and also the manufacturing process. It also requires the software to assemble all the parts and should be transferrable across other devices for any changes, as and when required during fabrication. The 3D software used in this project is SOLIDWORKS after considering the ease in designing the components, assembling the final model and also transferring the design to an analysis software to test for structural integrity of the design.

The second part of the project, which is analyzing the individual components,after designing the models, is to apply the maximum and minimum values of constraints such as stresses to evaluate the compatibility and strength of the components to withstand the different conditions that it may get exposed to, during its lifetime. Also the final product after assembly should also be analysed during different riding conditions this is done using analysis software ANSYS: Mechanical.

II. METHODOLOGY

• Designing of individual components with consideration of materials to used.
• Analyzing the individual componenets at different conditions.
• Making required changes to the individual components if needed after analysis.
• Making required changes to the structure if needed after analysis.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 7 July 2021, pp: 1667-1673 www.ijaem.net ISSN: 2395-5252

• Assembling the individual component models to get the final product.

III. DESIGNOF COMPONENTS

3.1 CONTROL ARMS

A control arm is a hinged suspension link between the chassis and the suspension upright or hub that carries the wheel. It is used to hold the suspension load and to transmit them to the shock absorber. A double wishbone suspension is a design using two wishbone shaped arms to place the wheel. It has two mounting points to the chassis and one joint at the knuckle.

Figure 1-Lower control arm

Figure 2- Upper control arm

The thick hollow pipe of outer diameter 50 mm and internal diameter 15 mm is used as it provide more structural strength to the portion where the arm connects the frame and hub. Next part is a solid pipe with outer diameter of 25mm. The reason on giving it a solid instead of hollow is also to give more structural strength to the arm. A solid block is given at the solid pipe to give more aesthetic looks. However, as this design was life and other provided, the stiffness and life of the component is reduced. So in order to minimize these values the ends of the solid parts is slightly redesigned to increase the life and other factors.

3.2 STEERING KNUCKLE

Designed steering knuckle is shown below. This part is used for the wheel hub for wheel connection, and connects the suspension and the steering mechanism.

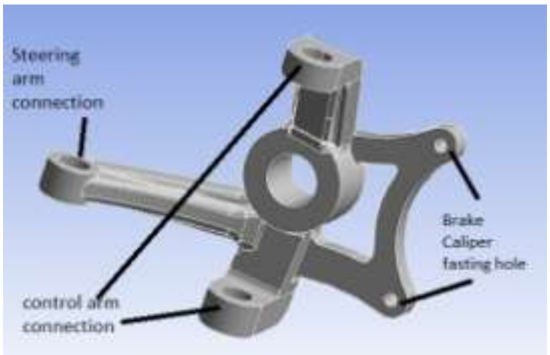

Figure 3 – Steering Knuckle

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 7 July 2021, pp: 1667-1673 www.ijaem.net ISSN: 2395-5252

Above figure, figure 3 shows the designed cad model of steering knuckle. The hub is connected to the steering knuckle is through a stub axle. Above design is perfect for connecting the designed control arm and steering connection for turning and tilting stage. Control arm is connected through a small connector, which helps to rotate the wheel and to tilt the trike on our desired way.

3.3 WHEEL HUB

The wheel hub is an automotive part that used to connect the wheel to the vehicle. It is connected to the suspension of the vehicle with the help from stub axle.Figure 4 shows the wheel hub designed for the reverse E-trike. The designed part is a 4-bolt wheel hub. Reason for designing a 4-bolt wheel hub to hold the wheel while in motionwhile keeping the weight reduced. Hub is fixed to the steering knuckle by stub axle. It passed thorough the center of both hub and steering knuckle.From the figure 4, both surface A & B is used to hold the disc for brake and the wheel. Wheel is attached at the backside of surface B. A heavy-duty bearing is used at the center of hub for avoiding friction while in the running conditions. The holes used for internal threading have a major diameter of 10mm, minor diameter of 8 mm with a pitch of 2mm. After the designing of hub, analysis of the component taken, adjusted to get the maximum efficient value.

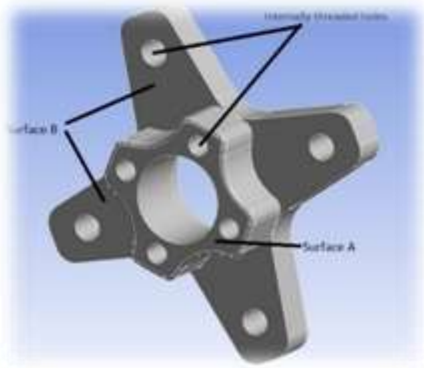

Figure 4 – Steering Knuckle

3.4 CHASSIS

Chassis, sometimes called as Skelton is a supporting frame of a structure. Each components are fixed to chassis. They can be made of different material (from structural steel to carbon fiber reinforced plastic), to provide less weight maximum stability, depends on the use of chassis on vehicle.

On our designed structure of chassis, the center and rear side of the chassis is similar to normal bike chassis. However, from the front section additional structure designed to fix the control arm and other suspension components. From the front section between the two large pipes where the control arm is connected, a small part is designed to hold both the front suspension. In the final design the front suspension is connected together to get the tilting effect.

Figure 5 – Side view of chassis

From the design on Figure 5 and Figure 6, the front section where the control arm is connected is been lowered, because when the pipe is gone straight line, entire trike chassis would get a slopping effect at the front section. As this, because the weight of components to lean in a foreword direction, the

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 7 July 2021, pp: 1667-1673 www.ijaem.net ISSN: 2395-5252

welds create in front section may get break or cause the material to damage. Therefore, to prevent this from happening, the front section is slightly lowered to get a raised position. By giving such increased at the steering column (Pipe 02) from the ground level, the rider gets a more comfortable riding position.

Figure 6 – Isometric view of trike chassis

Most of the chassis pipes are of same diameter and are mostly on the front and middle section of trike chassis. This is because; they need to hold more amount of weight, from control arm, suspension, steering, electric motor, and other miscellaneous parts. Rear portion hold the weight of person, and rear suspension and other small parts. The over-all length of the trike be 1422.45mm. After clearing all the errors and interference joints in the design, the model is further proceed to analysis section.

IV. ANALYSIS OF COMPONENTS

4.1 CONTROL ARM

Figure 7 gives the total deformation of the part at the point of application of force. The maximum deformation is 5.6508 x 10^{-4} m when a force of 1650 N is applied.

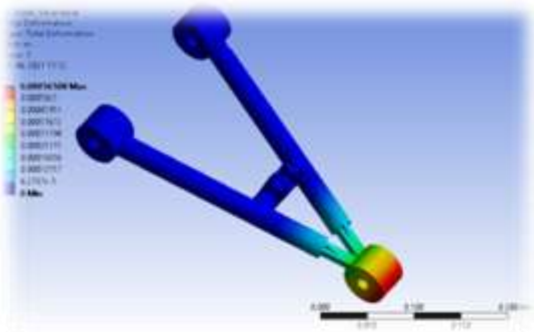

Figure 7–Total deformation of control arm

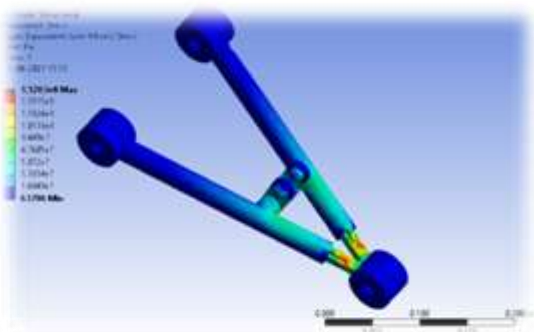

Figure 8 – Equivalent stress of control arm

International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 7 July 2021, pp: 1667-1673 www.ijaem.net ISSN: 2395-5252

Figure 8 gives the equivalent (von- Mises) stress that it experiences when a force of 1650 N is applied at the joint where it connects to the steering knuckle. The maximum stress experienced is 1.5203 x 10^8 Pa and the minimum stress experienced is 63796 Pa.

4.2 STEERING KNUCKLE

Figure 9 gives the total deformation of the steering knuckle during the steering condition i.e. when the force of 500 N is applied during the steering condition. The colored region gives the range of maximum to minimum deformation that occurs during steering condition. In the above case we can observe that only part where the steering knuckle connects to the steering rod undergoes total deformation unlike the following case. The maximum deformation is 7.3065 x 10^{-5}.

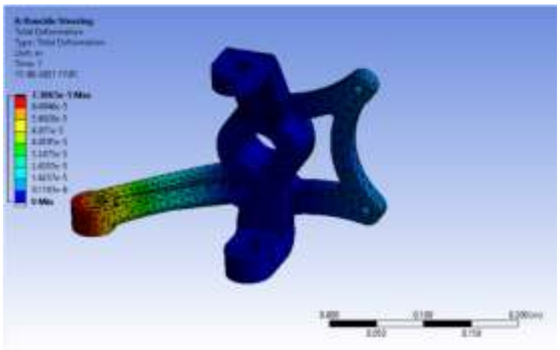

Figure 9 – Total deformation of steering knuckle

Figure 10 represents the equivalent stress that the steering knuckle experiences during steering condition. The maximum value of the equivalent stress is 1.6033 x 10^7 Pa and the minimum value of the equivalent stress is 46.842 Pa. The maximum stress occurs at the lower region of the part and towards the corner near where the control arm is to be bolted.

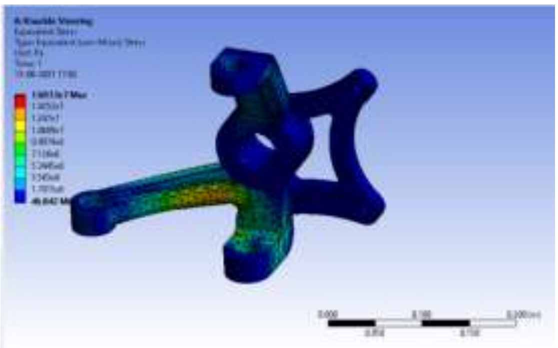

Figure 10 – Equivalent stress of steering knuckle

4.3 WHEEL HUB

Figure 11 gives the total deformation that occurs when a force of 5000 N is applied at the bolted region .The maximum deformation is 1.6671 x 10^{-5} m. The maximum deformation occurs at the red region as the force is applied at the hole where the bolts are to be inserted to connect to the wheels of the E-trike.

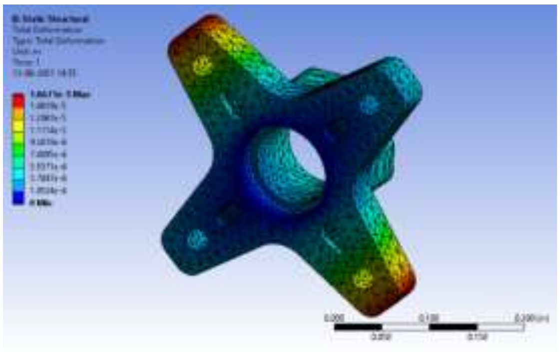

Figure 11– Total deformation of wheel hub

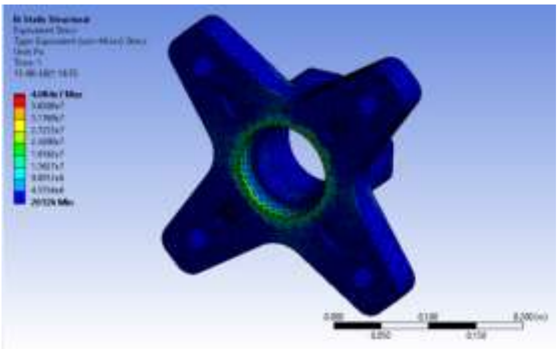

Figure 12 – Equivalent stress of wheel hub

Figure 12 gives the equivalent stress that is experienced by the wheel hub when the force is applied at the bolted region. The maximum stress is 4.08 x 10^{-7} Pa and it is experienced at the hole where the stub axle is joined to the wheel hub. The minimum stress experienced by the wheel hub is 20126 Pa.

4.4 CHASSIS

Figure 13 shows the total deformation that takes place at the rod in the front part of the chassis during an impact with a force of 14500 N from the opposite direction. The colored regions shows the areas where the deformations occurs with red being the region of maximum deformation of the rod and dark blue being the region with the least deformation. The value of maximum total deformation is 0.00020066 m and the value of minimum total deformation is 4.3031 x 10^{-5} m. As shown in the above figure the maximum deformation occurs at the center of the rod while the minimum deformation occurs at the ends of the rod.

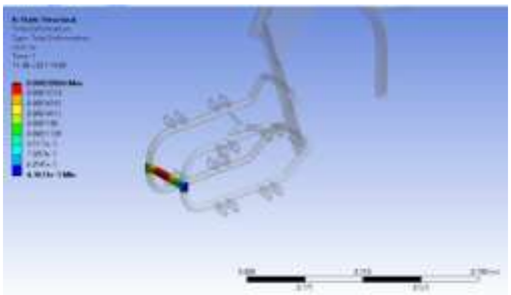

Figure 13 – Total deformation of the chassis

Figure 14 shows the equivalent stress that the rod experiences during the impact with the force of 14500 N at its center. From the figure above we can observe that the maximum stress occurs at the end of the rod. We can also infer from the above figure that the impact is also absorbed by the nearby hollow bend pipes which the rod joins with. Thus there is also a stress experienced by the hollow bend pipes. The maximum stress experienced by the rod is 1.7584 x 10^{8}Pa at the ends and the minimum stress experienced is 1.6751 x 10^{-9} Pa.

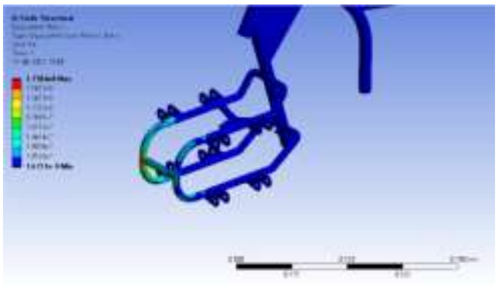

Figure 14 – Equivalent stress of the chassis

V. RESULTS

1. CONTROL ARM
   Total deformation = 5.6508×10^{-4} m
   Equivalent stress = 105203×10^{8} Pa
2. STEERING KNUCKLE
   Total deformation = 7.3065×10^{-5} Pa
   Equivalent stress = 1.6033×10^{7} Pa
3. WHEEL HUB
   Total deformation = 1.6671×10^{-5} m
   Equivalent stress = 4.08×10^{-7} Pa
4. CHASSIS
   Total deformation = 2.0066×10^{-4} m
   Equivalent stress = 1.7584×10^{8} Pa

VI. CONCLUSIONS

The design of the trike model is based on the rider's comfort, flexibility of the joints and suspension in the framework structural strength of the individual components and the structure as a whole. It is aimed at providing the rider with a three wheeled vehicle with more control and traction on the road especially while cornering. It provides stability and above all provides more safety than a two wheeler with better breaking efficiency. All the components were designed and analysed for verification of the final structure through design and analysis softwares before finalizing the product design and found to be quite satisfactory.

REFERENCES

[1]. Wheel Steering System by Md. Danish Akhtar. Global Academy of Technology, Bangalore Vishveshvarya Technological University
[2]. Stability Of Three-Wheeled Vehicles With And Without Control SystembySAEEDI M.A., KAZEMI R.
[3]. Atheender A, Gautam M, ArshathGani A, Veneeth T S " Tilt Suspension System for Three Wheelers and Reverse Trikes"International Journal of Engineering Research in Mechanical and Civil Engineering
[4]. Subhash N, ThejasUrs, Jeevan K Athreya"DESIGN OF LEANING ATTACHMENT"International Journal of Mechanical And Production EngineeringDesign of Leaning Attachment; Subhash N, ThejasUrs, Jeevan K Athreya International Journal of Mechanical And Production Engineering, ISSN: 2320-2092,
[5]. KaustubhDilipPatil, Prashant S. Mulmule, Vikrant S. Satalkar and Ramesh S. Thorat, "Design and Manufacturing of Tilting Trike Tiltra Msx-1" International Journal of Innovative Research in Science, Engineering and Technology
[6]. LawayneMatthiesMark D. SiegelJohn D. Nickles Mystery Designs patent