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FINITE ELEMENT ANALYSIS & DESIGN OPTIMIZATION OF TRICYCLE

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ABSTRACT

Less consumption of fuel, using cycle for basic transportation can be considered the best mode. The classic standard design do satisfy this need, but new concept of tricycle duly fulfills the basic need as well as being sporty design makes it stand out. The tricycle consist of foldable handlebar and curved frame, of which front wheel is supported with 20 inch tire whereas rear wheel is supported by two small 6 inch tires aligned with a pivot. As the driver's whole weight would be taken by curved frame, stress is induced when it is loaded with human. It can be achieved by performing structural analysis on frame with the help of FEA using suitable boundary conditions. Thus, paper consists of modeling & FEA of the tricycle frame to optimize the structure as well as the fatigue life is estimated and maximum stress area identified.

Keywords: tricycle, Finite Element Analysis, Design optimization.

I.INTRODUCTION

Design accordingly regular design is easier but to found new and optimized design and then try with design iteration is difficult job. It's not just giving accurate dimension but also shows the dimensions consideration was optimizing the structure. Variety in bicycle is not so important but nowadays people seeking towards the innovative designs. So developed model is innovative because of its aesthetics and ergonomics. The design tricycle model not includes seating comfort that is all comes in riding ways, it can only be enjoyed with standing. It provides a totally different riding experience which a tradition design bicycle can't provide and at the same time, it does not require any special skills. One have knowledge of balancing can easily drive it.

Suspension is driving comfort to absorb the shock due to path irregularities. For the tricycle suspension is providing easy turning mechanism too. This is one what adds the tricycle to more smooth with turning and driving. Generally bicycles having suspension prime purpose is driving comfort only.

Body of any bicycle is important that give look to it. Smooth curve are always called to be feature because that make look good and as an engineering point of view that is less stress concentration. In this tricycle model the body of used with smooth curve this starts at handle and accumulate all components easily on it. The material used for body is Aluminum alloy 6061.

II.LITERATURE SURVEY

There are already many bicycle are available in the market but still there are continuous work and study are going on in this sectors. There are lots of scope in this field. There are plenty of bicycle frame available [1]. Nowadays it's not just a way of transportation but it's a way to make ourselves healthy and fit. There are many product in the market to fulfil the requirement of make your journey more comfortable like electrical bicycles. There are charging & speed issues and many other factors which limited the use of this. But this work are dedicated to design such a product which give a sporty look and make ones journey comfortable as well as healthy. In this design where no seat which provides benefit of cycling and kick scooter. There are many researcher work with different material [2]. For light weight, composite material is used for manufacturing by some researcher. Liu and Wu [2] study the fiber orientation effect for manufacturing the bicycle frame using carbon/epoxy laminate. Al-6061 is easily available, cheap and easy to manufacture. In this paper, aluminum alloy is used for frame. Details about Al-6061 is adopted from ASM material sheet [3]. This design give the drive to front wheel because steering is work by springs. Its front wheel is large to provide a high torque. It will be very useful for near future where conventional energy fuel like petrol and diesel are limited and pollution is very big challenge for whole world.

Second area in which most of designer is interested is foldable bicycle. Nowadays it's a trend to make the thing which occupies less space and one can carry with self anywhere very easily. With the fulfilling of these requirements and don't compromise with its performance, this design is developed. It's foldable at near its front wheel and easily carry anywhere like lift. There are no unwanted folding are given to it because it may be reduce its strength and factor of safety. Safety is not just a slogan for a design. It is a field with one never want to compromise. Tube section are used form long time manufacturing. There are many fem analysis performed on this [4-6]. Covill et al. [4] perform the parametric FE analysis for getting the influence of tube section on frame stiffness. To provide this fold ability, there are rectangular cross section plate used for manufacturing. It also have very good stiffness in vertical loading because of high moment of inertia about horizontal axis. Dimensions are adopted from Half Bike [5]. Covill et al. [6] created a FE model to simulate the bicycle frame behavior on various load condition. In that there are some high stress region find out. Callens and bignonnet [7] study the fatigue design of welding joint of bicycle frame. Instead of frame analysis is performed on assembly. Fatigue life and high stress area is identified.

III. METHODOLOGY

This project commences with the creation of new & better design of bicycle compared to its counterpart classical design of bicycle. The curved beam material property consists of Aluminum alloy 6061. Material properties are taken from the ASM data sheet. Modulus of elasticity of Al-6061 is 68.9 GPa and Poisson's ratio is 0.33. The suitable thickness and width of frame is found out after performing stress analysis on the cycle frame taking suitable average human loads into consideration. The Life of cycle as well factor of safety has been found out by performing fatigue analysis due to reversible loads acting on the frame. Maximum stress area also

find out. After finalizing the dimensions, the design of tricycle is carried out and after that it will assembled. FE analysis is performed on the whole assembly.

The design of cycle was carried out in following steps:

3.1 Modeling

The assembly of tricycle is shown in the Fig. 1 below. The software used for Modelling of cycle is Solidworks 2014 version by Dassault Systems. Cross section of the frame is 6×50 mm^2. Distance between the wheels is 72cm. Front wheel and rear wheels diameter is 500cm and 200cm respectively. Size of the tricycle is 100×34×110cm and folded size of tricycle is 100×34×52cm.Total weight of the tricycle is approximate 8.5 kg which can be carry anywhere easily. In tricycle, front wheel contains 20 inch pneumatic tire and rear wheel contains 6 inch pneumatic tires.

Fig. 1: Assembly of tricycle

The stages involved in modeling of cycle are:

a) Sketcher
b) Part modelling (part design)
c) Assembly Design

Major parts of this design is frame, handlebar, handle, crank set, pedals, integrated truck and wheels. Using sketch parts are designed and after that assembly is done by assigned the proper mating.

3.2 Analysis of cycle assembly

To analyze the tricycle with loading conditions two major loads it carries that is one on bicycle frame and other on handle in working condition. Following analysis shows the static and fatigue analysis for 90 kg weight person. 80 kg load is equally divided on pedals. There are 10 kg load is applied on handle equally divided on

both ends. Structural Analysis is carried out on whole assembly of cycle. The software used for structural analysis is Ansys 16.0 .The steps involved in analysis of cycle are as follows:

3.1.1 Importing geometry

The assembly geometry file of cycle was imported into Ansys in parasolid format (.x_t) and material properties and element types are assigned.

3.1.2 Meshing

The first in Finite element method is discretization, that is, to divide the part into countable number of smaller standard elements. The figure shown below shows the meshed model of cycle. There are total 76746 number of elements & 171001 number of nodes.

Table 1

Statistics	
Nodes	171001
Elements	76746
Mesh Metric	Aspect Ratio
Min	1.1375
Max	4319.8
Average	3.4098
Standard Deviation	12.964

Table 1 contains the detail about nodes and elements during the FE analysis.

3.1.3 Boundary Conditions

The next step in Finite Element method is applying boundary conditions. One support is applied at the front end of wheel axis & two supports are applied at rear end at pivot.

3.1.4 Loading

After assign the boundary conditions, Loads are applied on handle and frame. There are concentrated load is applied on handles and distributed load is applied on pedals.

3.1.5 Post Processing

Next step in finite element analysis is post processing. In this appropriate solvers are used to solve the problems. Output are available after post processing.

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IV. RESULTS & DISCUSSION

As shown in the figure is design are safe and most of the area are have factor of safety upto 15 which is remarkable. This shows that this design have very good durability and long life in operation. Frame have deformation below the 0.5 mm and maximum deformation at pedal corner which is because of soft material used. Maximum stress on the integrated truck which is as per expected. On the basis of this, this design is safe and provides a long lasting product.

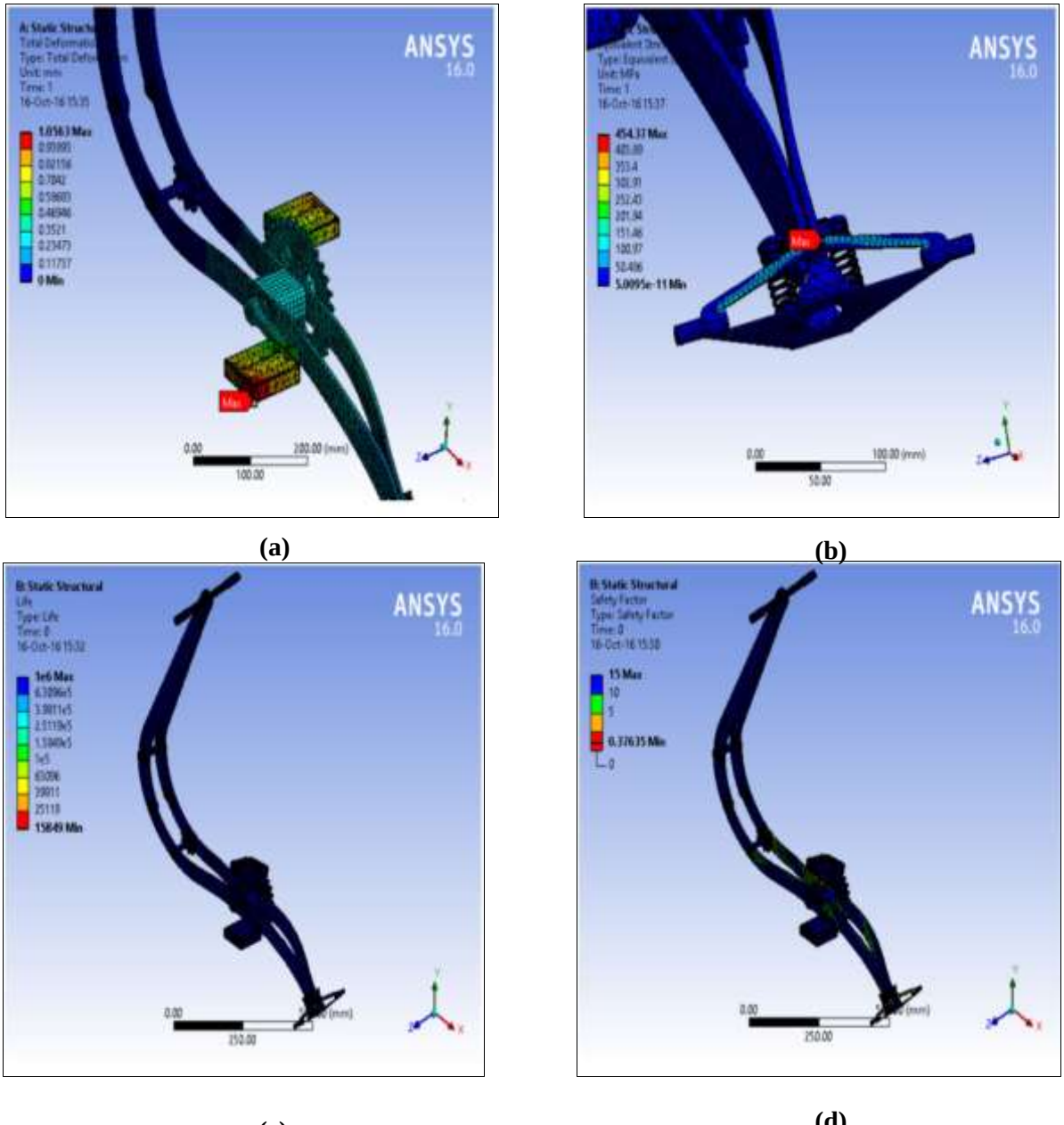

Fig.2: (a) Max deformation on pedal (b) Max stress location (c) Fatigue life of tricycle frame (d) Factor of safety for bicycle frame

V.AESTHETICS & ERGONOMICS

Ergonomics plays a key role in the designing of cycle. It provides the comfort as well as maintains the aesthetic look of cycle. Proper steering and comfort the handle height is important because human height is very with person to person. For this purpose the height is divided into three categories. In first category include the height between 150-170cm similarly second and third category includes 170-185cm and 185-195cm respectively. This dimensions don't have significant effect on analysis parts. Design Cycle is for second category.

The notable points where ergonomics play a role are

- Two curvy beams support all the mechanism without complicating the design.
- The handles are kept at such height so that controlling the steering operation is easy.
- Three wheel base gives more balancing than classic two wheel cycle.

VI.CONCLUSION

After design & analysis of tricycle, it can be concluded that the tricycle is feasible & safe to operate since it passes all the acceptance criteria & standards. The further scope of this tricycle is moving toward electrical transmission, power manipulation and more fold ability. It is better as compare to traditional cycle design in aesthetics and ergonomics point of view. It provides healthy and ecofriendly ride with fun.

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