STRUCTURAL ANALYSIS OF MOTORCYCLE CHAIN BY USING C.A.E. SOFTWARE

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ABSTRACT

Any catastrophic failure in the chain used in power transmission of a motorcycle could lead to a safety hazard. Determining safe load for the chain and the ability of the same to withstand the using Finite Element Modeling would be the core objective of this work. An existing chain link would be used for benchmarking the research work. Finite Element Analysis tools like HyperMesh and ANSYS are suitable to find the performance of the link under tensile loads. Recommendation over the best suited geometry or material would be presented to conclude the work.

Keyword: Chain, Chain link, Finite Element Analysis, HyperMesh, Tensile loads.

I. INTRODUCTION

A chain is a reliable machine component, which transmits power by means of tensile forces, and it used primarily for power transmission. The function and uses of chain are similar to a belt, Roller chain or bush roller chain is the type of chain drive most commonly used for transmission of mechanical power on many kinds of domestic, industrial and agricultural machinery, including conveyors, cars, motorcycles, and bicycles. It consists of a series of short cylindrical rollers held together by side links. It is driven by a toothed wheel called a sprocket. It is a simple, reliable, and efficient means of power transmission. Two different sizes of roller chain, showing construction. There are actually two types of links alternating in the bush roller chain. The first type is inner links, having two inner plates held together by two sleeves or bushings upon which rotate two rollers. Inner links alternate with the second type, the outer links, consisting of two outer plates held together by pins passing through the bushings of the inner links. The "bushing less" roller chain is similar in operation though not in construction; instead of separate bushings or sleeves holding the inner plates together, the plate has a tube stamped into it protruding from the hole which serves the same purpose. This has the advantage of removing one step in assembly of the chain [1].The roller chain design reduces friction compared to simpler designs, resulting in higher efficiency and less wear. The original power transmission chain varieties lacked rollers and bushings, with both the inner and outer plates held by pins which directly contacts with the sprocket teeth; however this configuration exhibited extremely rapid wear of both the sprocket teeth, and the plates where they pivoted on the pins. This problem was partially solved by the development of bushed chains, with the pins holding the outer plates passing through bushings or sleeves connecting the inner plates [2]. The addition of rollers surrounding the bushing sleeves of the chain and provided rolling contact with the teeth of the sprockets resulting in excellent resistance to wear of both sprockets and chain. Roller chains are of primary importance for efficient operation as well as correct tensioning [2].

II. DESIGN CONSIDERATIONS

Roller chains are used in a wide variety of applications, but most roller chain is used in drives. The shaft speeds of the drives range from less than 50 rpm to nearly 10,000 rpm, and the amount of power transmitted ranges from a 1 kW to 1000 kW. The main design considerations for a roller chain to be used on a drive are the various tensile loads [3].

2.1 Ultimate Tensile Strength

The ultimate tensile strength of a chain is the highest load that the chain can withstand in a single application before breaking. It is not a major consideration in designing roller chains. It is only important because yield strength and fatigue strength depend on ultimate tensile strength. Minimum ultimate tensile strength (MUTS) is a requirement in the ASME standards that govern roller chains. A well-made roller chain almost always meets the standard [3].

2.2 Yield Strength

The yield strength of a chain is the maximum load from which the chain will return to its original state (length). For many standard chains, the yield strength is approximately 40% to 60% of the minimum ultimate tensile strength [3].

III. MATHEMATICAL TREATMEAT

Table 1 Inputs Data for TVS 250CC Motorcycle.

Specifications of TVS 250CC	
Engine Type	Single Cylinder, 4 Stroke
Engine Displacement (CC)	250CC
Maximum Power	22kW
Speed of smaller sprocket, n1	5000 rpm
No. of Teeth on smaller sprocket, Z1	15
No. of Teeth on smaller sprocket, Z2	44
Chain Pitch, p	12.7 mm
Roller diameter, d	8.51 mm
Mass of chain per meter length, m	0.7 Kg
Breaking strength of chain, WB	22 kN

Velocity of chain,

$$V = (Z1 \times p \times n1)/60$$
$$= (15 \times 0.0127 \times 5000)/60$$
$$V = 15.88 \text{ m/s}$$

Design Power = Rated Power × $f_1 \times f_2 \times f_3 \times f_4$.

Service Factors:

Effect of the number of teeth of the small chain wheel (f_1) z = 15, f_1 = 1.27

Effect of ratio (f_2) i = 2.93,f_2 = 1

Effect of Shock factor (f_3) = 1.59

Effect of ratio of Centre distance (f_4) = 1

$$P = 22 \times 1.27 \times 1 \times 1.59 \times 1$$

$$P = 44.42 \text{ kW}$$

Tangential drive force on chain,

$$F_T = P/V$$

$$= 44420/15.88$$

$$F_T = 2797.23 \text{ N}$$

Centrifugal tension in chain,

$$F_C = m \times V$$

$$= 0.7 \times 15.882$$

$$F_C = 176.52 \text{ N}$$

Total tension in chain,

$$W = F_T + F_C$$

$$= 2797.23 + 176.52$$

$$W = 2973.75 \text{ N} = 3000 \text{ N (Approx.)}$$

IV. CHAIN LINK SPECIFICATIONS

Table 2 Dimensions of Chain Parts

Sr. No	Parameter	Length (mm)
1	Chain Pitch	12.7
2	Width of Inner Plate	7.75
3	Pin Height	17
4	Pin Diameter	4.45
5	Roller Outer Diameter	8.51

V. THREE DIMENSIOAL CAD MODEL

Fig. 1 shows structure of roller chain as per chain specification of chain part.

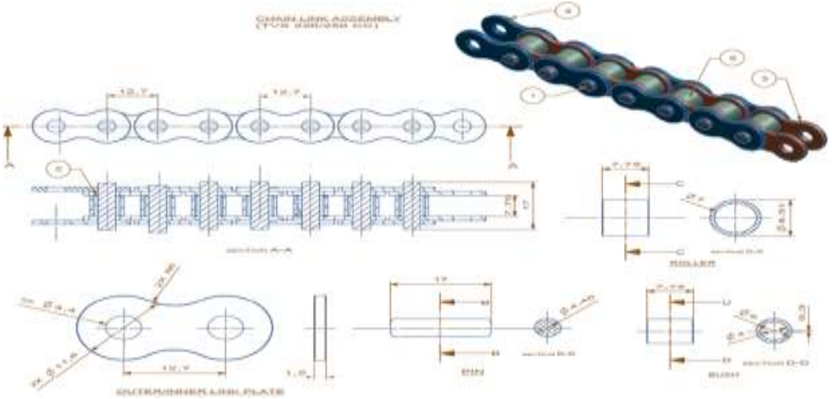

Fig. 1 Three Dimensional Model

VI. FINITE ELEMENT ANALYSIS

Numerical techniques consist of three basic steps: “pre-processor, processor and post-processor”. The pre-processing stage consists of the procedures as constituting creating the model as per dimension. In ANSYS the Cad Model of Chain link is developed. After that for analysis the Finite element model is generated In engineering data define defining material properties. In that entering the physical and material properties of the model to the software, defining the element type meshing criteria, Mesh body consisting of total solid body is created. After modeling the chain link meshing is done in ANSYS Workbench. Meshing involves converting of geometry into nodes and elements.3D Hex Dominant mesh type is used for meshing. It has compatible displacement shapes and well suited to model curved boundaries. Chain links is done by giving element size 0.5 mm for better results. Here the number of time meshing was done i.e. at 2 mm element size, 1.5 mm element size, 1mm element size, 0.8 mm element size, 0.6 mm element size but at 0.4 mm and 0.5 mm element size the result that is stresses are does not change. Therefore element size taken as 0.5 mm for better results. At the point of application of load the fine meshing is done. After meshing total 305600 No. of Nodes and 159126 No. of Elements are obtained for chain link having inner and outer link plate thickness is 1.5 mm.

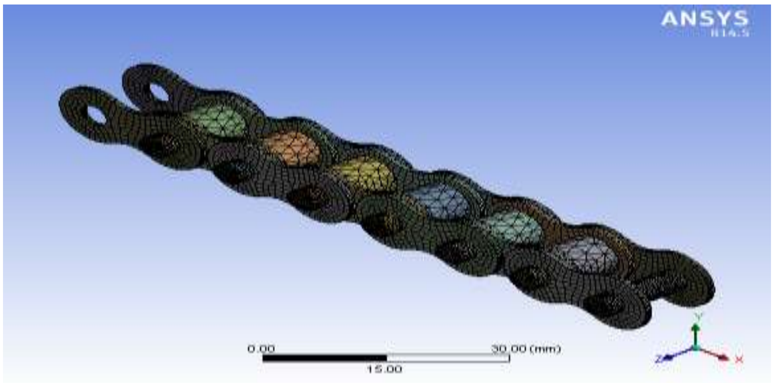

Fig. 2 Meshing of Model

After modeling of chain links then give the actual supporting boundary conditions are applied i.e. fixed support and horizontal support. In fixed support there is no any degree of freedom i.e. there is no displacement at any direction. But in horizontal support only horizontal motion is present and vertical motion is restricted.While modeling link, imprint faces are created which are useful for selecting particular faces at the time of applying boundary condition. As shown in Fig. 3 the blue face indicates the fixed support and tensile force of 3000 N is applied to red face in X direction.

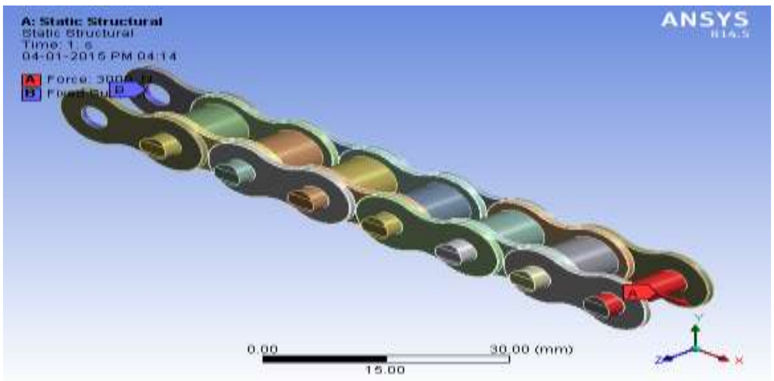

Fig. 3 Applying Boundary Condition

The FEA results of Chain link for Direction deformation, Equivalent Elastic Strain and Equivalent (von-Mises) Stress as calculated by using C.A.E. In Fig. 4 red face indicate maximum deformation occurs on pin which is 0.053343 mm and blue face indicate minimum deformation.

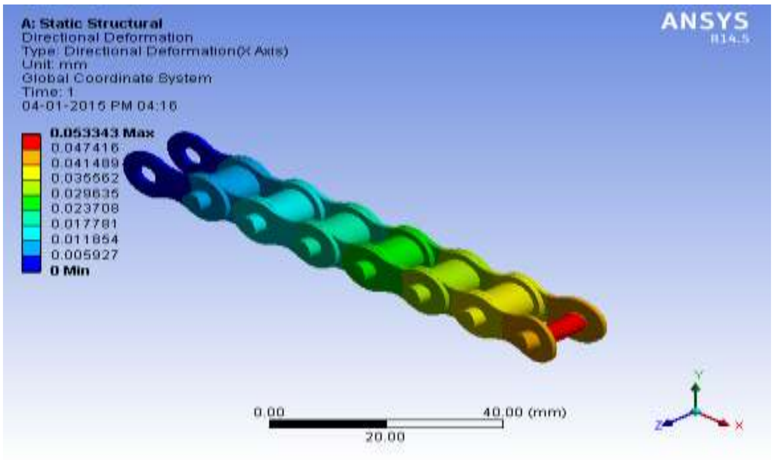

Fig. 4 Deformation in Model

The FEA results of Chain link for Equivalent Elastic Strain is maximum at roller which is 3.2184e-003 mm/mm and minimum at pin 2.6212e-006 mm/mm this result as shown in Fig. 5.

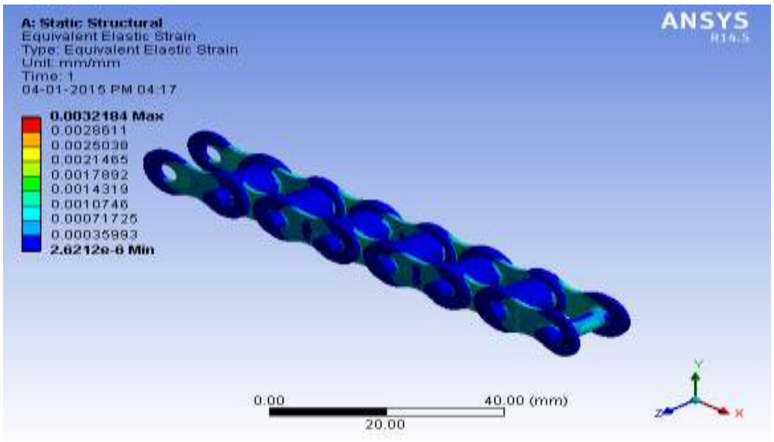

Fig. 5 Equivalent Elastic Strain in Model

The stress distribution in chain link having maximum value of stress that is 643.1 MPa at Roller and minimum value of stress that is 0.2913 MPa at Pin.

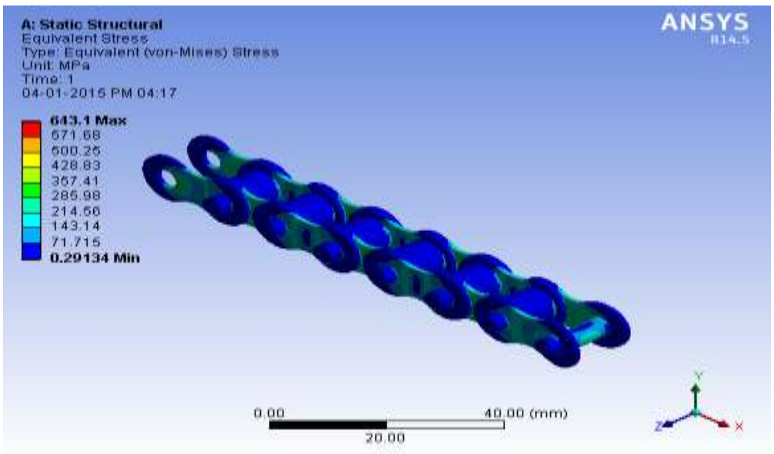

Fig. 6 Stress Distribution in Model

If the thickness were changed, other dimension would remain constant .Therefore effective weight saving would be realized. Thus stress analyzed with change in thickness of 1mm for inner and outer link plate. The Model for thickness of 1mm to be analyzed . Calculate result for maximum deformation occurs on pin which is 0.1162 mm and -1.1038e-002 mm minimum deformation**.**

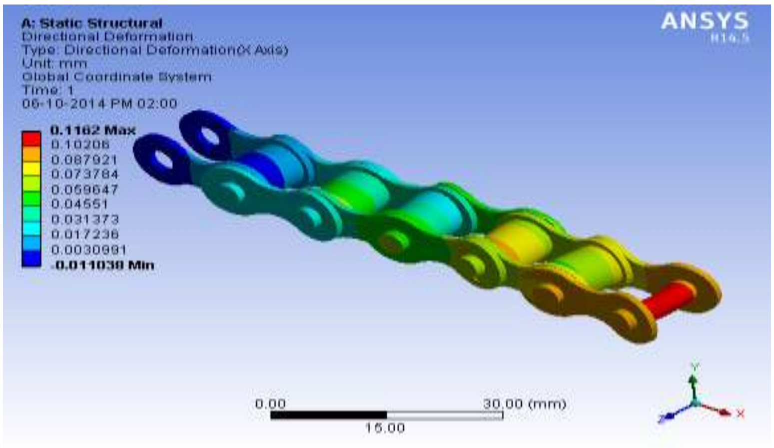

Fig. 7 Deformation in Model

The stress distribution in chain links shown in Fig. 8. Position of stress concentration is the same and maximum value of stress that is 777.25 MPa at Roller and minimum value of stress that is 1.9722e-003 MPa at Pin. The FEA results of Chain link for Equivalent Elastic Strain is maximum at Roller which is 4.0484e-003 mm/mm and minimum at Pin 9.8611e-009 mm/mm .

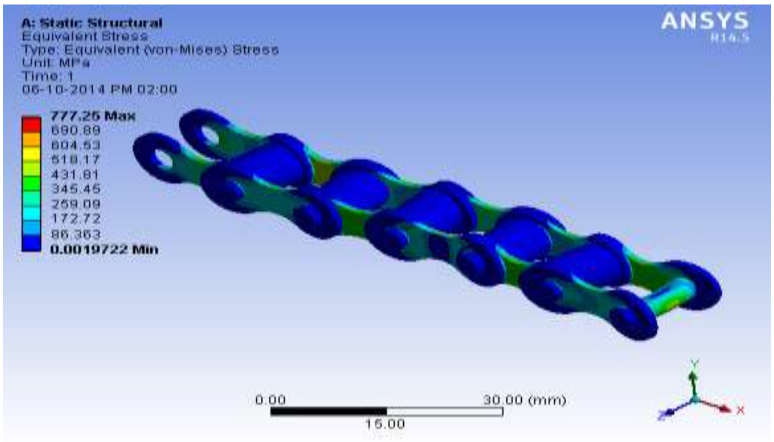

Fig. 8 Stress Distribution in Model

Table 3 Results of F.E Analysis

Thickness of Plate, mm	Maximum Tensile stress, MPa	Maximum compressive Stress, MPa	Maximum deformation	Maximum Equivalent Elastic Strain mm/mm	Minimum Equivalent Elastic Strain mm/mm
1.5	643.1	291.3e-003	0.053343	3.2184e-003	2.6212e-006
1	777.25	1.9722e-003	0.1162	4.0484e-003	9.8611e-009

VII. CONCLUSION

The design for the chain would be subjected to F.E Analysis to find the effect of loads (tension) on the link. The proposed method utilizes software in the FEA domain for analyzing the effects of the variation in the values of the design parameters influencing the performance criterion. As the thickness decreases, other dimension would remain constant. Therefore effective weight saving would be realized. If the thickness of link plate decreases to the rate of increase in tensile stress. Consequently weight saving with a decrease in the thickness of the link plate can be realized using a higher strength of material. The FEM method is used to analyze the stress state of an elastic body with a given geometry, such as chain link.

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