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Design And Analysis Of Chain Outer Link By Using Composite Material

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Abstract: *Chain Link assembly is extensively used in the industry, the scope of this paper is to review the applications in the industry and explore the design considerations that go into the design of the assembly. The paper delves into various application aspects and manufacturing aspects to formulate an idea of the system. Finally Finite Element Analysis (FEA) has been used to conduct shape optimization. Since lot of work has already been done in other components, in this paper the focus has been narrowed down to specific component of outer link [1]. We have to use of composite material for chain out link to minimize the weight of link.*
Keywords: *Roller chain, link plate, FEM analysis, stress analysis, shape optimization*

I. Introduction

Chain drives have been established as one of the most effective forms of power transmission in mechanical systems. The major advantages of using chain drives are the relatively cheap components, the high reliability and durability, the relatively high efficiency, the flexibility in selecting shaft center position and distance, and the ability to drive more than one shaft. However, chain drives introduce some problems such as noise and vibrations. Although the chain drive has been used for a long time, most of the published research on it has been concentrated to the latter half of the 20th century. This is caused by the development of powerful computers, which have made it possible to numerically solve some of equations given by the chain drives' complicated mechanisms [2]

Roller conveyor chains are generally used in production or assembly lines where individual large objects need to be conveyed. Typical applications of roller conveyors are carrier conveyors for the transport of steel coils in a steel plant or slat conveyors that carry objects. A slat conveyor consists of two or more endless strands of chain with attached non interlocking slats or metal flights to carry the material. Other examples are conveying pallets, tree-stumps or even whole cars. Wheeled cars, for example, can be carried by the chain but can also be pulled by the chain [3]. Applications can be divided in two basic conveying modes:

- The material is supported and carried entirely by the chain and attachments.
- The chain does not support the material, but it is pushed, pulled or scraped.

Roller chains are widely used as pulling and driving members of chain mechanisms in escalators, passenger conveyors and especially in conveyors[4].Roller conveyor chains differ from transmission roller chains such as a bicycle chain, which is used to transfer torque instead of conveying goods. Conveyor chains have a large pitch which is efficient in bridging large distances with fewer shackles, they generally have thicker side plates and rollers with large diameter. Therefore they can withstand higher tensile and shock loads than transmission chains. Furthermore they can bear large amounts of wear before breakage occurs. On the other hand, roller conveyor chains have a necessary clearance that easily becomes contaminated with particles from the conveyed material.A rigid-body analysis is presented of the forces which occur in chain bearing in an articulation. The analysis differentiates between the two types of chain bearing open end leading or open end trailing and the results show that the force characteristics in each are significantly different[5] Chain is the most important element of the industrial processes required for transmitting power and conveying of materials[6].

Chain strips are machine elements that are subjected to extreme service conditions, such as high tensile loads, friction, and sometimes aggressive operating environment. As these chains operate under various forces, failure of chain assembly is the major problem.The faulty manufacturing processes are another source of failure initiation. Main parts of roller conveyor chain are rollers, bushings, bins and chain strip also known as link plate. In roller conveyor chain there are two chain strips outer and inner respectively.

As the chain revolves on the sprocket continuous repetitive loads are acting on the strips. The tensile forces are applied by pins which are assembled through holes in the strips. The holes in the strips are significant stress risers. The chain strips are primarily tension members, and they also are subjected to substantial bending and stress concentrations around the holes. The chain strips must have enough strength to withstand the tensile forces without deforming or breaking, and they must have enough ductility to withstand substantial bending and to resist fatigue[7].

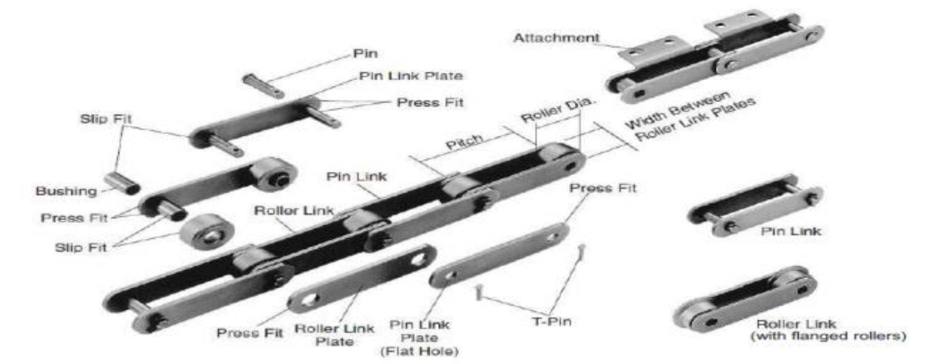

Figure 1: Basic structure of a conveyor chain [3]

II. Design

A. Hand Calculation

Transported material	brown coal
Conveyor length	30 m
Flow	30 T/h
Conveyor conduit width	350 mm
Conveyor conduit height	250 mm
Number of chains	1
Number of teeth of the sprocket	9 (pre-selected)
Load distribution	even

Corresponding type of chain according to DIN 8167 (ISO 1977) is MRC 80 x 125
Maximum force = 11679 N
Total length of the pin 55 mm from the table of ISO Standard .
Find out diameter of the roller pin .
Material of pin - Stainless Steel.
$S = 200\ N/mm^2$.

$$6 = \frac{200}{1.5} = 133.33\ N/mm^2.$$

Summation F = 0.
Summation M = 0 .

$$6 = \frac{P}{A}$$

$$6 = \frac{P}{\frac{\Pi}{4}.d^2}$$

$$133.33 = \frac{11679 \text{ X } 4}{3.14 X d^2}$$

$$d^2 = \frac{11679 \text{ X } 4}{3.14 \text{ X} 133.33}$$

$d^2 = 111.58$
$d = 10.56$ mm
Therefore d= 11 mm
Diameter of pin of roller = 11 mm
Force = 11679 N.
Material of link – Carbon steel C40 ,Hardness 44 HRC.
$6 = 580$ MPa.
Total Area of Cross Section ,
Ac = H X t = 50 X t.

Cross section area of hole = $\frac{2\,\pi\, d\, t}{2} = \pi\, d\, t$.

Total Area
= $50\, t - \pi\, d\, t$
= $(50 - \pi \text{ X } 12)\, t$
= 12.32 t.

Now 6allow = $\frac{580}{3}$ = 199.99 N/ mm^2

Also,

6allow = $\frac{\text{Force}}{\text{Area}}$

193.33 = $\frac{11679}{12.32\ t}$

Therefore t = 3 mm.

For safe design take t= 4 mm.

B. Material properties

Table.1

Sr.no	Properties	E-Glass/ Epoxy	Original material
1	EX(MPa)	43000	20000
2	EY(MPa)	6500	
3	EZ(MPa)	6500	
4	PRXY	.27	0.3
5	PRYZ	.06	
6	PRZX	.06	

III. Ansys Results

In ANSYS,in order to calculate the maximum stress and deformation for both the original outer link selected and the glass fiber link,statistical structural analysis is done and from the hand calculation ,the maximum force of 11679 N is applied at both the flat hole in outward direction.The ANSYS results formulated for both the links are as below:

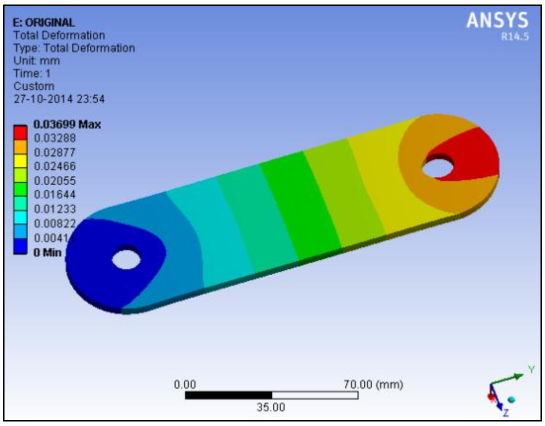

Fig.2 Original chain link deformation From above figure, the original chain link maximum deformation from structural analysis=0.03699mm.

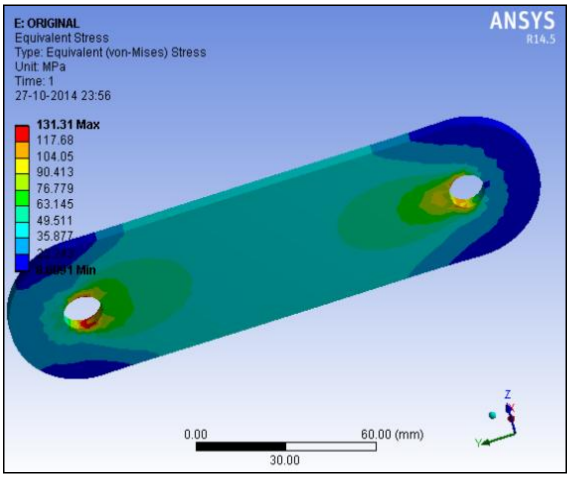

Fig.3 Original Chain Link Stress From above figure, the original chain link maximum stress from structural analysis=131.31 mpa

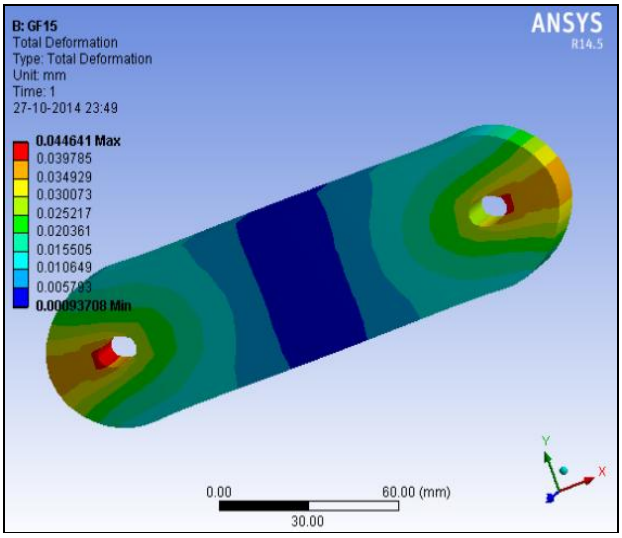

Fig.4 Glass Fiber Chain Link Deformation From above figure, the glass fiber chain link maximum deformation from structural analysis=0.044641mm.

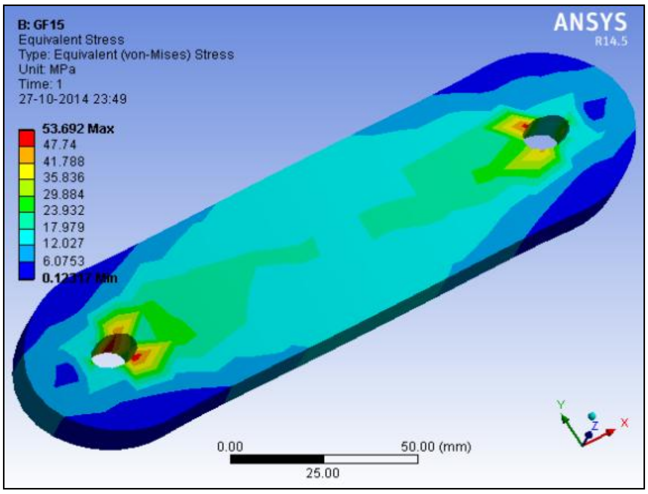

Fig.5 Glass Fiber Chain Link Stress From above figure, the glass fiber chain link Maximum stress from structural analysis=53.692 mpa.

IV. Results And Discussion

A. Hand Calculation

Sr.No.	Part	Stress
1	Original	133.33 mpa
2	Glass fiber	108.81 mpa

Table.2

B. Ansys

Sr.No.	Part	Stress	Deformation
1	Original	131.31mpa	0.03699mm
2	GlassFiber	53.692mpa	0.04464mm

Table.3

V. Conclusion

For original chain outer link, the weight of the link is 0.3135 kg alongwith 7805 nodes and 3963 elements on meshing. For glass fiber chain outer link, the weight of the link is 0.2407 kg with 1276 nodes and 629 elements on meshing.

By using glass fiber link, there is reduction in weight of the outer link material. Also comparing the hand calculations and the ANSYS results tabulated in Table 2 and Table 3, there is a slight difference in the hand calculation and ANSYS values for original outer link stress but there is a variation in glass fiber stress .With increase in glass fiber link thickness, the stress is reduced to a great extent.The reduction in weight and maximum stress is obtained by using glass fiber as compared to original outer chain link.

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