DESIGN & DEVELOPMENT OF CONVEYOR CHAIN OUTER LINK BY USING COMPOSITE MATERIAL

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ABSTRACT

In production or assembly lines roller conveyor chains are generally used 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. Motor capacity of conveyor depends on the weight of chain in chain conveyor system. It was determined that maximum amount of weight of chain conveyor is covered by outer link and inner link. In this paper, we concentrated on only outer link and weight optimization of link by using composite material (Glass Fiber & Carbon Fiber) to reduce the power requirement of conveyor.

KEYWORDS: Outer link design, Analysis by hand calculations & ANSYS, Alternate Composite Material for analysis.

INTRODUCTION

In agricultural as well as industrial sector roller conveyor chains are mostly used. In economy of state, Sugar factories play important role. About 60 % processes in these factories are based on roller chain conveyers. Apart from that, so many industries also use these chains frequently for process atomization. However, failure of this chain is continuous problem in these industries which causes huge losses to these industries along with its dependants and in turn economical growth of the state [1]. Because of that, roller chain is the most important element of the industrial processes. Chain drives had 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 low-priced components, the relatively high efficiency, the high reliability and durability, the flexibility in selecting shaft center position and distance, and the ability to drive more than one shaft.
A shape optimization process is used for the design of roller chain link for minimization of failure modes in this study. This process has various design variables, such as shape of the link, wall thickness of link and breaking area of link [2].

PROBLEM STATEMENT

In roller conveyor chain assembly the outer link is the most important part. The weight of the roller conveyor chain is major problem in industrial sector. The weight contribution in roller chain conveyor assembly is maximum by outer link. Weight of the outer link has significant weight contribution which makes the roller conveyor chain assembly heavier, hence increases the power required to run the roller chain conveyor. Most of the time chain is under tension which causes failure of chain assembly which is the problem for industrial sector. Improper design is one of the causes for failure. It is important to study the influence of these parameters. All these parameters can be considered concurrently and optimum design of chain link.

Fig.1. Failure of chain link

SIMULATION

Illustration for calculation and selection of conveyor chain

A appropriate type of chain has to be selected for horizontal slat conveyor:

Given values:
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

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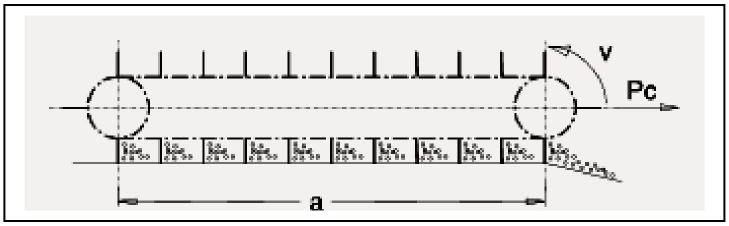

Fig.2. Horizontal conveyor

Corresponding type of chain according to DIN 8167 (ISO 1977) is MRC 80 x 125. [1]

Finding thickness of outer link:
Maximum force = 11679 N
Total length of the pin --- 55 mm (from the table of ISO Standard) [1].
Find out diameter of the roller pin.
Material of pin - Stainless Steel.

S= 200 N/ mm^2

$\sigma = \frac{200}{1.5} = 133.33$

Summation F = 0. Summation M = 0

$\sigma = \frac{P}{A}$ *Therefore,* $\sigma = \frac{P}{\frac{\pi}{4}d^2}$ $133.33 = \frac{11679\ X\ 4}{3.14\ X\ d^2}$

Therefore $d^2 = \frac{11679\ X\ 4}{3.14\ X\ 133.33}$ d^2=111.58 d=10.56

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 = $\frac{2\pi dt}{2}$ = πdt
Total Area = 50 t – π d t = (50 – π X 12) t = 12.32 t.

Also, $\sigma_{allow} = \frac{580}{3}$ =193.33 N/mm^2

$\sigma_{allow} = \frac{Force}{Area}$ Therefore 193.33=$\frac{11679}{12.32\ X\ t}$ t =$\frac{11679}{12.32\ X\ 193.33}$ t = 4.90

For safe design we take t= 5 mm.

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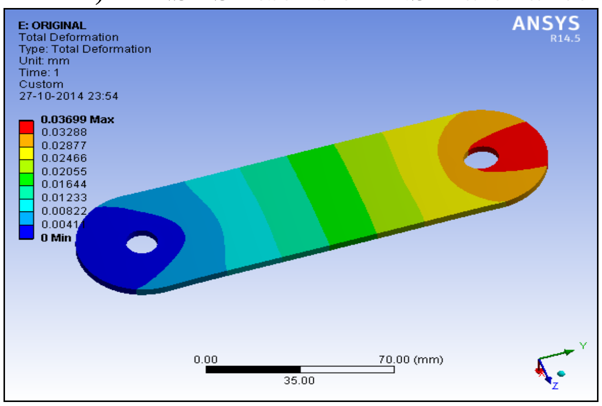
FEA RESULTS FOR MATERIALS

1) ANSYS results of M.S material outer link



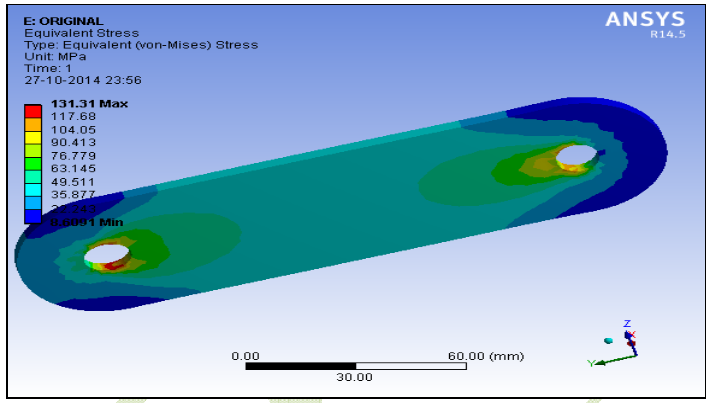
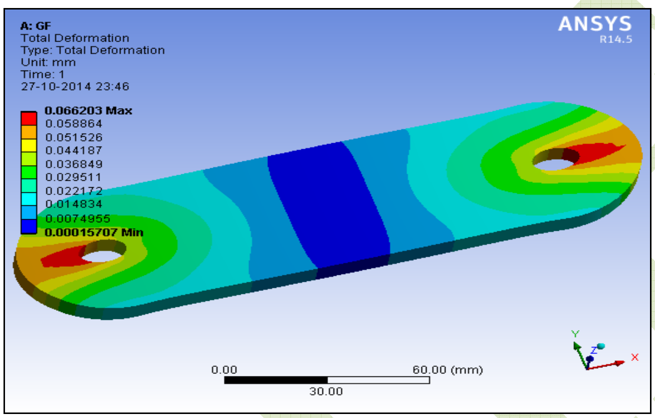


Fig.3.Total deformation is 0.03699 mm Fig.4. Equivalent stress is 131.31 MPa

2) ANSYS results of Glass fiber material 10mm outer link



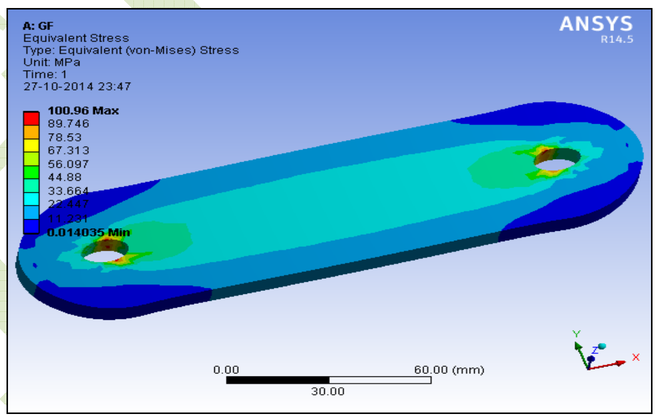
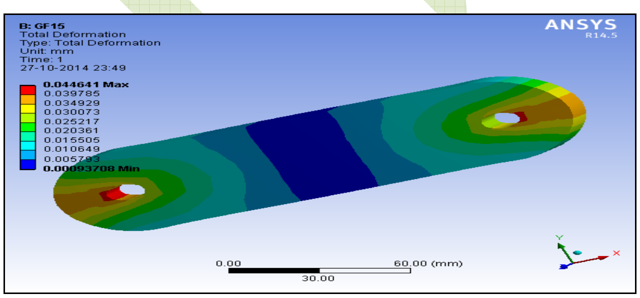


Fig.5.Total deformation is 0.066203mm Fig.6. Equivalent stress is 100.96 MPa

3) ANSYS results of Glass fiber material 15 mm outer link



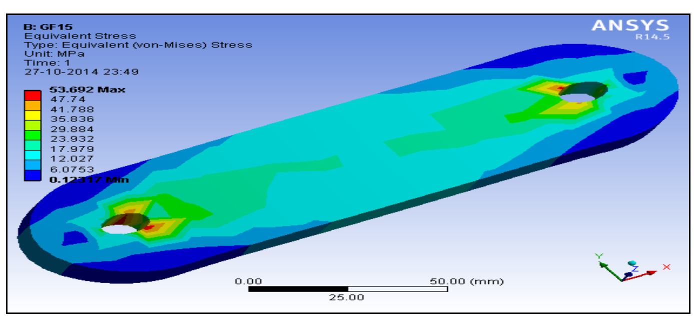


Fig.7 Total deformation is 0.044641mm Fig.8 Equivalent stress is 53.692 MPa

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4) ANSYS results of Glass fiber material 5 mm outer link

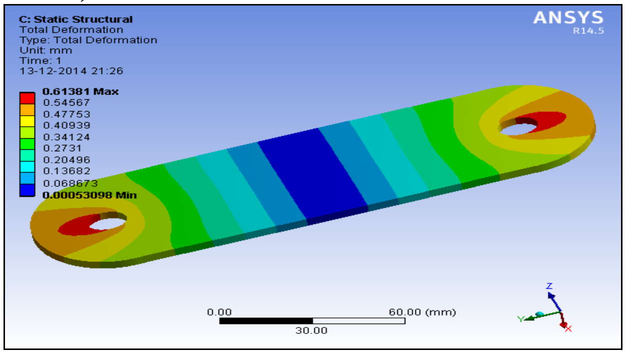

Fig.9 Total deformation is 0.61381 mm

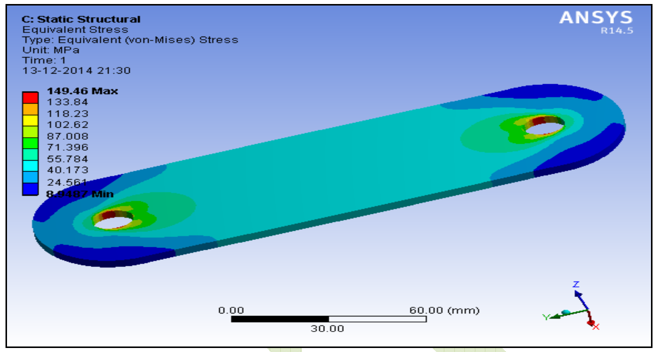

Fig.10 Equivalent stress is 149.46 MPa

5) ANSYS results of Carbon fiber material 5 mm outer link

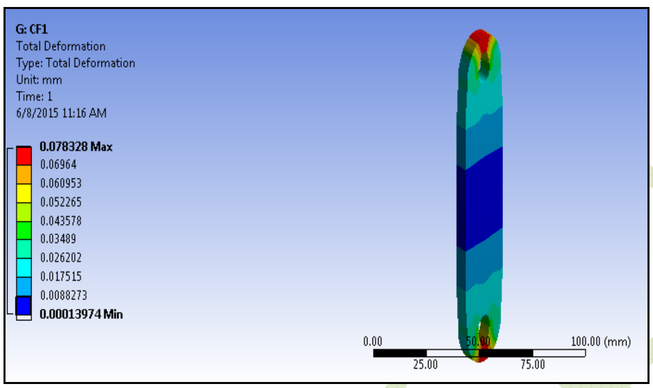

Fig.11.Max deformation is 0.078328 mm

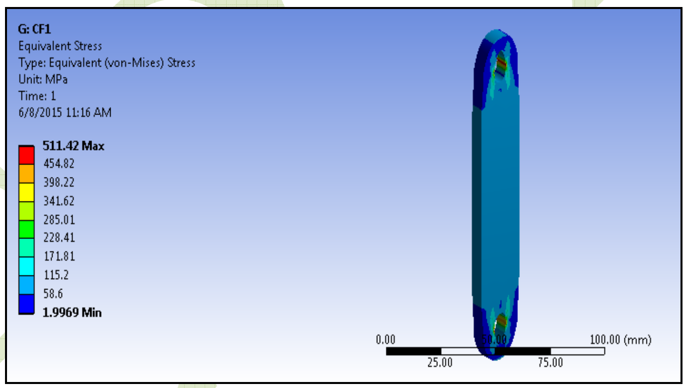

Fig.12.Equivalent stress is 511.42 MPa

6) ANSYS results of Carbon fiber material 8 mm outer link

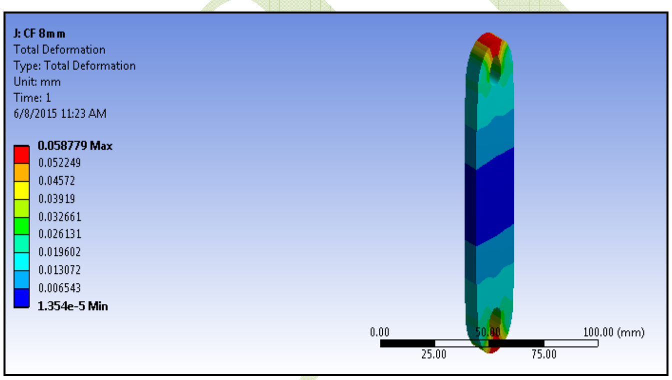

Fig.13.Max deformation is 0.058779 mm

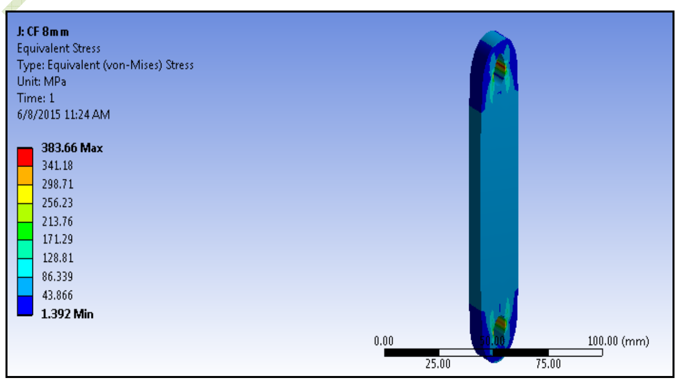

Fig.14.Equivalent stress is 383.66 MPa

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7) ANSYS results of Carbon fiber material 10 mm outer link

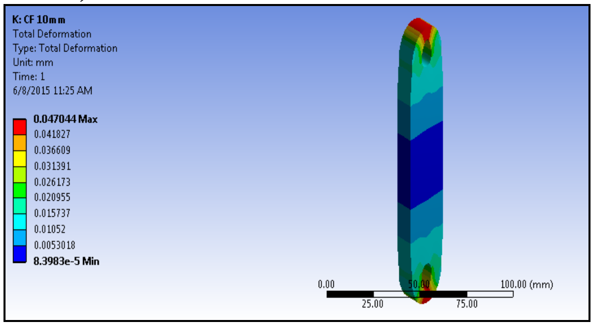

Fig.15.Max deformation is 0.047044 mm

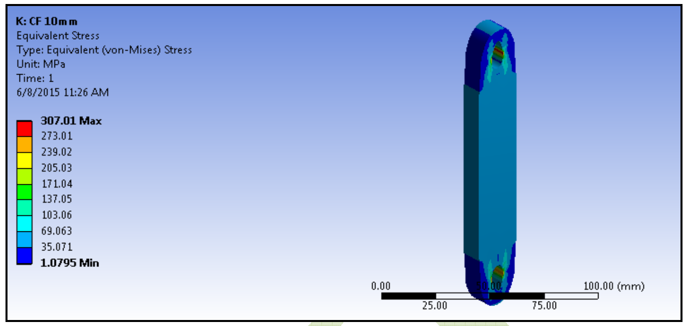

Fig.16 Equivalent stress is 307.01 MPa

EXPERIMENTAL RESULTS

As per the result of Finite Element Analysis it is detected that the roller conveyor chain link made of glass fiber is having minimum stresses. For the justification purpose, test of glass fiber link is carried out on Universal Testing Machine. With the help of locking tools, the specimen is fixed in universal testing machine. Both the ends are fixed in the universal testing machine & testing done [4].

Fig.16. Testing on UTM

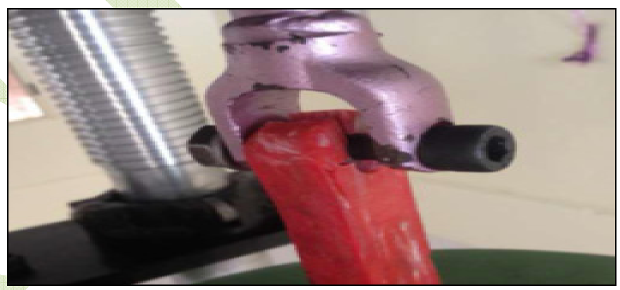

Fig.17. Failure of glass fiber sample at top

Comparison of Load V_s Deformation graph:

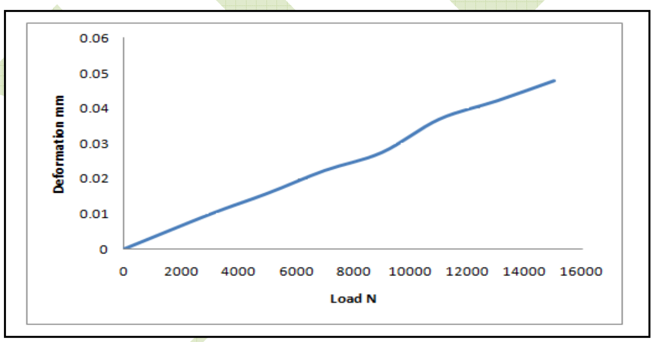

Fig.18 Load V^s Deformation graph for G.F link

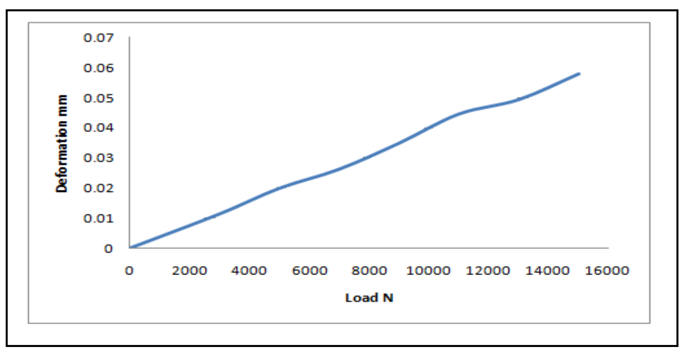

Fig.19. Load Vs Deformation graph for M.S

The graph shows, there is no deformation in the glass fiber link up to a load of 7000 N. deformation starts increasing from 10000 N up to a maximum load of 16000 N. With slightly increasing the load, glass fiber link breaks. The maximum deformation in the glass fiber link is 0.05 mm. The link is required to take a maximum load of 11600 N which well below the maximum load carrying capacity of glass fiber link.

RESULT & DISCUSSION

Type of Outer link	Volume (mm^3)	Mass (kg)	Total deformation (mm)	Equivalent stress (MPa)
M.S 5mm link	39937	0.3135	0.03699	131.31
Glass fiber10mm link	80234	0.16047	0.066203	100.96
Glass fiber 15 mm link	120350	0.2407	0.044641	53.692
Glass fiber 5 mm link	40117	0.080234	0.61381	149.46
Carbon fiber with 5 mm link	20555	0.032888	0.078328	511.42
Carbon fiber with 8 mm link	27406	0.04385	0.058779	383.66
Carbon fiber with 10 mm link	34258	0.05481	0.047044	307.01

The equivalent stress induced in M.S link is 131.31 MPa and weight is 0.3135 kg. Finite Element Analysis is carried of material glass fiber and carbon fiber with different conditions and thickness. The better results are found with glass fiber having thickness 15 mm with 24% weight optimized. The maximum stress induced in glass fiber having 15 mm thickness is 53.692 MPa and maximum deformation is 0.044641 mm. The carbon fiber link with 10 mm also optimized the weight up to 57%. But availability of glass fiber material and cost of material which makes itself a good alternative material for mild steel .As per the UTM test result, the maximum load carrying capacity of roller conveyor chain link made of glass fiber is 16000 N. The force acting on roller chain link is about 11600 N. hence the load carrying capacity is better as compare to define the load.

CONCLUSION

Finite Element analysis was performed to achieve the stresses and deformations and in results, it is found that, there is a maximum deformation of 0.03699mm in the mild steel link and in glass fiber with 15 mm thickness is 0.044641mm. From the static analysis results, we see that the von-misses stress in the mild steel is 131.31MPa. And the von-misses stress in glass fiber is 53.692MPa. Glass fiber link plate can be suggested for alternative for the steel link plate from stress and stiffness point of view. A virtual study has been made between steel and composite link with respect to strength and weight. Fatigue life of both glass fiber link and carbon fiber link is higher than the mild steel link. As per the UTM test performed, the maximum load carrying capacity of the glass fiber link is 16000 N which is well above the defined load. Weight optimization is achieved 24 % with glass fiber, the weight of the glass fiber link is 0.2407 kg and that of mild steel link is 0.3135 kg. It must be noted that, in typical industrial application thousands of such link will be needed. Thus, the weight optimization will have significant impact on cost of the chain and power consumption by motor.

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