Design and Mass Optimization of Fins of Chain Conveyor System

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Abstract: A conveyor system is mostly useful in the application involving the transportation of heavy and bulky materials. Now a days in industries use a drop forged mild steel chain conveyor system. In this conventional chain conveyor system the fins are welded with the chain conveyor links and because of mild steel material weight of the conveyor system is more. The main concept in this paper is to redesign the fins of chain conveyor system for easily intricate and disintricate the assembly and also changing the material with Aluminum Alloy for weight reduction and performance improvement. Design and Analysis is carried out with both materials viz Mild Steel and Aluminum Alloy. Impact of ribbing the flight with Aluminum Alloy material where stresses are found in conventional Mild Steel.

Keywords- Chain Conveyor System, Material Handling Equipments, Finite Element Analysis.

I. INTRODUCTION

In most of the industries used a conveyor system for the purpose of material handling. A conveyor system is a frequent piece of material handling equipment that transfers materials from one location to another location. Conveyor system is the commonly useful in the application involving the transportation of heavy or bulky materials. Generally in industries used a different types of conveyor systems like Belt Conveyor, Live Roller Conveyor, Chain Conveyor, Deep Pan Conveyor, Gravity Roller Conveyor and Screw Conveyor etc. Conveyor systems are basically used in various industries including Automobile, Aerospace, Agriculture, Cement industry, Chemical industry, Bottling and Canning, Coalmine, Limestone, Print finishing and Packaging etc. Drag Chain Conveyor system can convey the material in horizontal direction. The main concept of such type of material handling equipment is to transfer the material with high efficiency and less material transport time. The purpose of chain conveyor system is to save the time of material handling. In figure 1 shows a drag chain conveyor fin assembly of mild steel which is presently used in industries.

The important parts of chain conveyor systems are chain link and fins. In this paper work is focused on the fins of chain conveyor system.

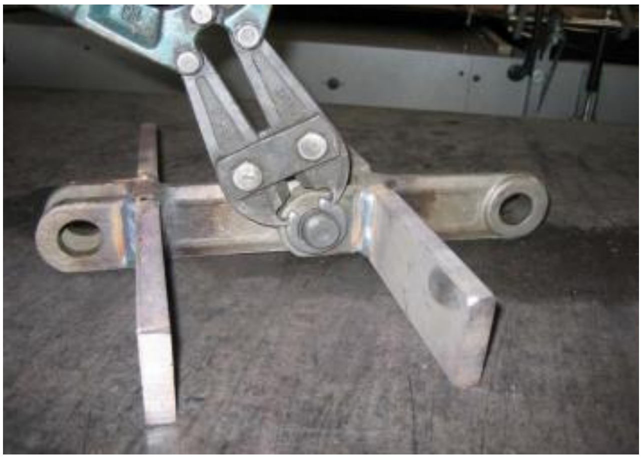

Figure:1 Fin Assembly

II. LITERATURE REVIEW

Kulkarni S. S. et.al. [1] have performed the work on chain link. They have increased the breaking strength of chain link from 40T to 70T. Currently Mahindra Tsubaki Conveyor system use 40T breaking strength of same pitch which is 216mm. In their paper they have used two methods for increasing the breaking strength. First method (a) Option I- Change the actual dimensions of chain link with existing material which is mild steel. Second Method (b) Option II- Change the material of chain links with actual dimensions of chain links. In option I they change the parameters including fork diameter, fork thickness and pinhole diameter. For these parameter changes there is necessary need of new die.

which is most disadvantages of option I. In option II there is no need of new die by only changing the material from 20MnCr5 to EN30B the target is achieved. Based on this study they found that the option II is best suitable as compared to option I. In option I there is increase the weight and cost of the product but in option II there is totally eliminate the cost of new die and the target is achieved only by changing the material.

4B Group Manual [2], This Company is the manufacturer of the chain conveyor systems.

Shinde S. M. et al [3] work has been carried out on roller conveyor system. They changed the some critical parts of existing roller conveyor system like C-channels, roller outer diameter and roller thickness for reducing the overall weight of assembly and save the material upto 30.93% due to new design.

Bosnjak S. M. et al [4]studied existing stacker crawler chain link and they found that the 30 chain links sustain fractured after only 1000 working hours. They research on present study and diagnose the cause of chain link breakdown occurrence. Find out the stresses which occurred in chain link by applying Finite Element Method and also done the Experimental investigation which defines the chemical composition, impact toughness and macro and micro hardness. By comparing the numerical and experimental results it concluded that the chain link breakdown is predominantly occurred by (a) Substantial deviation of mechanical properties of the material with respect to those prescribed by the standard and (b) The existence of macro and micro cracks in the material structure.

Shirong Zhang et al [5] describe the model based optimization by taking all parameters in four coefficients. The main objective of

PROPERTIES	VALUES
Elastic modulus, e	68.9 GPa
Poisons ratio, µ	0.33
Yield stress	214 MPa
Ultimate tensile stress	241 MPa
Density, ρ	2700 Kg/m^3

this paper is to improve the efficiency of belt conveyor at the operational level.

Wankhede V. et al [6] describes to change the design of Nut, Spilt dowel pin with circlip for decreasing the total cost and also enhancing the performance of drag chain conveyor system. From this changes it can be save the material up to 4.5%.

Tramco Manual [7] This company is manufacturer of conveyor system. They manufactured wide variety of conveyor systems like horizontal to inclined, L-path, S-path and loop design.

III. OBJECTIVES

- To study the conventional chain conveyor system.
- Design fins for easily intricate and disintricate assembly.
- To carry out FEA analysis on conventional material as well as aluminum alloy.
- Replacing existing Mild Steel material with Aluminum Alloy for mass optimization and performance improvement.

IV. EXPERIMENTAL SET UP

Break load test of fins of drag chain conveyor system will be carried out on Universal testing machine which is shown in figure below

PROPERTIES	VALUES
Elastic modulus, e	$2.1X 10^5$ MPa
Poisons ratio, µ	0.3
Yield stress	250 MPa
Ultimate tensile stress	390 MPa
Density, ρ	7850 Kg/m^3

Figure:2 Experimental Set Up (Universal Testing Machine)

Tensile test will be done on the fins of chain conveyor system. The fins are placed at the bottom of the Universal Testing Machine and its fixed with clamp and chain link is pull up during testing.

MATERIAL PROPERTIES

A. Mild Steel

Table 1: Material Properties For Mild Steel

B. Aluminum Alloy

Table 2:Material Properties For Aluminum Alloy

ANALYTICAL ANALYSIS

Consider conveying material as cast iron borings.
Density of cast iron borings = 3200 kg/m3
Flight to flight distance = 200 mm
Volume of flight can be found by its dimensions as
= 0.2 X 0.5 X 0.2= 0.02 m^3
Load On Flight :
We know,
Mass = density X volume
Mass = 3200 X 0.02
= 64 Kg
Load= 64 X 9.81= 630 N/m= 0.63 N/mm
Analytical Analysis of Flight :
Taking Moment About Point B,
$-M + (0.63 \times 500 \times 250) = 0$
$M = 78.75 \times 10^3$ N.mm ……………………… (1)
Taking Moment About Point B,
$+(78.75 \times 10^3) - R_H \times 57.5 = 0$
$R_H = 1370$ N …………………………… (2)
$R_V = 0.63 \times 500$
$R_V = 315$ N …………………………… (3)

Analysis of Mild Steel Flight:
According Von mises stress analysis
Max. Bending Stress $\sigma_b = \frac{My}{I}$
$I_{xx} = \frac{bd^3}{12} = \frac{60 \times 20^3}{12} = 40 \times 10^3$ N.mm
Y = d/2 = 10 mm

$$\sigma_b = \frac{My}{I}$$

$\sigma_b = \frac{(78.75 \times 10^3)}{40 \times 10^3} \times 10$
$\boxed{\sigma_b = 19.68 \text{ MPa}}$
Max. Displacement/ Deflection Of Mild Steel Flight Under Loading:

$$\delta max = \frac{Wl^4}{8EI}$$

$$\delta max = \frac{0.63 \text{ X } 500^4}{8 \text{ X } 210 \text{ X } 10^3 \text{ X} 40 \text{ X } 10^3}$$

$$\boxed{\delta max = 0.58 \text{ mm}}$$

Analysis of Al. Alloy 6063 Flight :
According Von mises stress analysis
Max. Bending Stress $\sigma_b = \frac{My}{I}$
$I_{xx} = \frac{bd^3}{12} = \frac{60 \times 20^3}{12} = 40 \times 10^3$ N.mm
Y = d/2 = 10 mm

$$\sigma_b = \frac{My}{I}$$

$\sigma_b = \frac{(78.75 \times 10^3)}{40 \times 10^3} \times 10$
$\boxed{\sigma_b = 19.68 \text{ MPa}}$

Max. Displacement/ Deflection Of Al. Alloy 6063 Flight Under Loading:

$$\delta max = \frac{Wl^4}{8EI}$$

$$\delta max = \frac{0.63 \ X \ 500^{\ 4}}{8 \ X \ 68.9 \ X \ 10^3 \ X 40 \ X \ 10^{\ 3}}$$

$$\boxed{\delta max = \ 1.78 \text{ mm}}$$

Stress Produced in Bolted Joint:
From Equation (2)
R_H= 1370 N is Axial Force in nut which Causes to produce Tensile stress in nut.

$$\sigma t = \frac{P(\text{Axial Force})}{A(\text{Area})}$$

$$A = \pi r^2 = \pi \ X \ 7.5^2 = 177 \text{ mm}^2$$

$$\sigma t = \frac{1370}{177} = 7.74 \text{ MPa}$$

$$\boxed{\sigma t = 7.74 \text{ MPa}}$$

From Equation (3)
R_V = 315 N is force Cause to produce Shear stress in Nut.

$$\tau = \frac{P(\text{Shear Force})}{A(\text{ Shear Area})}$$

$$\tau = \frac{315}{177}$$

$$\underline{\tau = 1.77 \text{ MPa}}$$

Above Value of Tensile Stress and Shear stress are within Safety Limit of Nut and Bolt.

V. NUMERICAL ANALYSIS

A. CAD Model

Dimensions offinsassembly are taken from the company catalogue and model is created in CATIA V5 R20 software.
A - 60 mm, B -500, C-114.5mm, D-15mm
Bolt Size: ISO M16X150

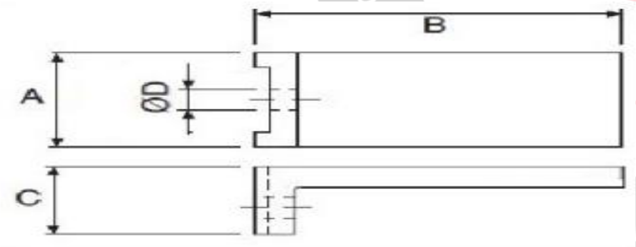

Figure: 3 "L" shape with one fixing hole

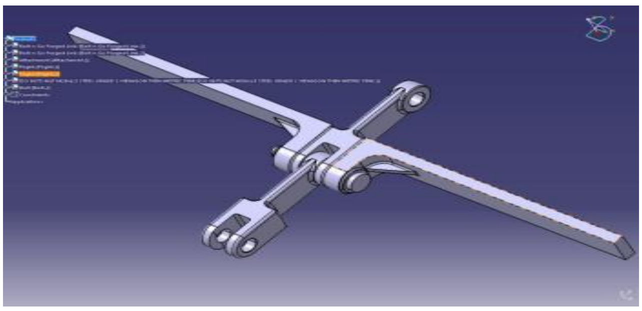

Figure: 4 CATIA model of Fins Assembly

B. Meshing Model

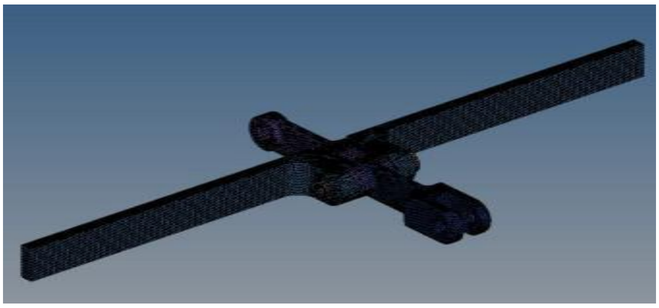

Figure: 5Meshed model of fins of chain conveyor system

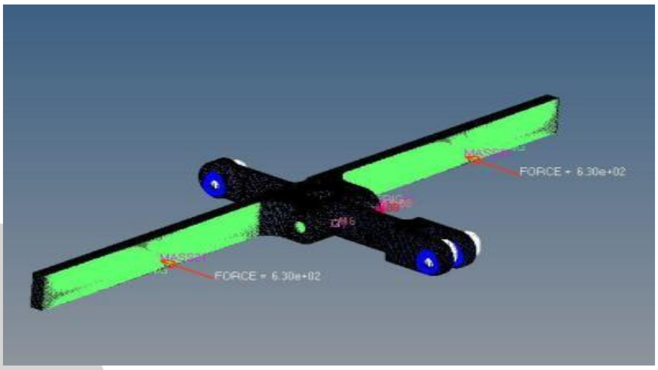

Figure: 6 Constraints and forces applied on model in Hypermesh

C. Stress and Deformation Results for Mild Steel (MS)

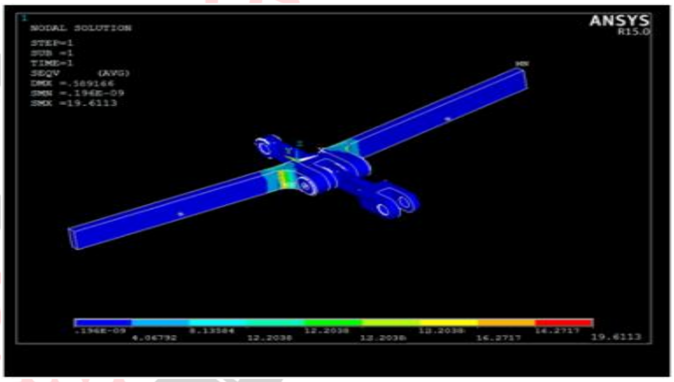

Fig. 7 Von-mises stress for Drop Forged Chain Fins Assembly

Maximum Stress Value for Drop Forged Chain Fins Assembly is 19.61 N/mm^2 which is less than their respective permissible yield stress value. Hence our design is safe.

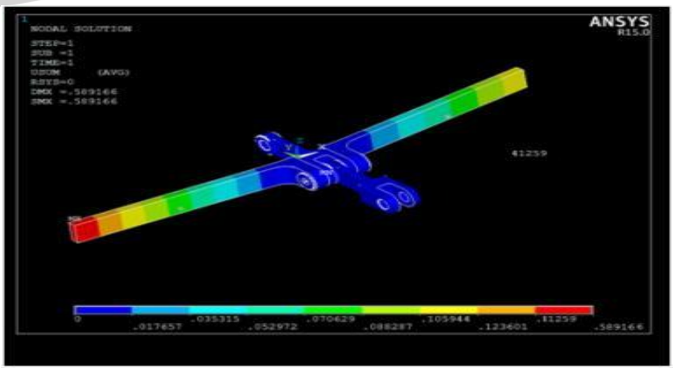

Fig. 8 Displacement result for Drop Forged Chain Fins Assembly.

From fig. deformation for Drop Forged Chain Fins Assembly is 0.58 mm.

D. Stress and Deformation Results for Aluminum Alloy

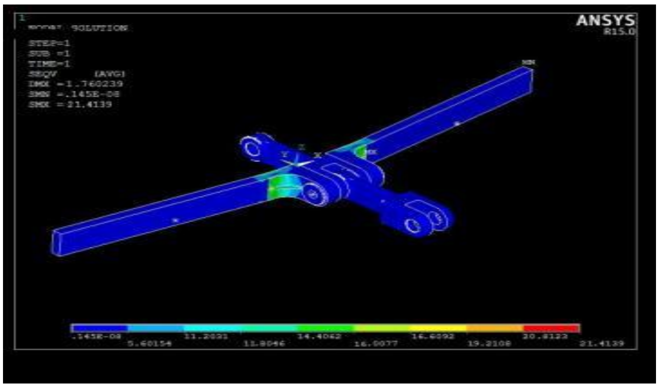

Fig. 9 von-mises stress for Drop Forged Chain Fins Assembly (Aluminum Alloy).

Maximum Stress value for Drop Forged Chain Fins Assembly is 21.41 N/mm2 which is well below the critical value. Hence, design is safe.

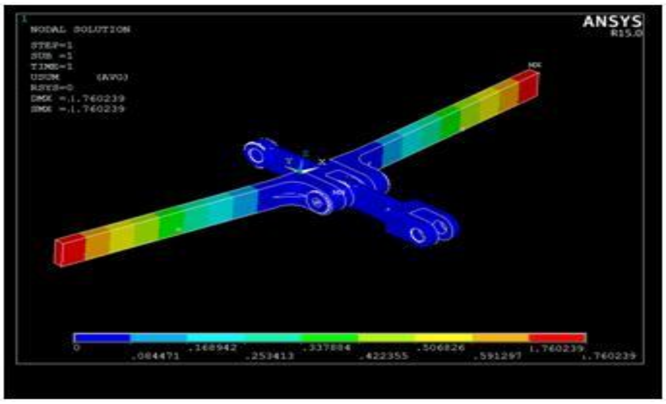

Fig. 10 Displacement result for Drop Forged Chain Fins Assembly (Aluminum Alloy).

From fig. deformation for Drop Forged Chain Fins Assembly is 1.76 mm.

VI. RESULT VALIDATION

Table 3:Comparison of FEA and Analytical Result For Stress

Sr. No.	Material	FEA Max. Stress	Analyticcal Stress
1	Existing Mild Steel	19.61 MPa	19.68 MPa
2	Aluminum Alloy 6063	21.60 MPa	19.68 MPa

Table 3:Comparison of FEA and Analytical Result For Dispalcement

Sr. No.	Material	FEA Displacement	Analyticcal Displacement
1	Existing Mild Steel	0.58 mm	0.58 mm
2	Aluminum Alloy 6063	1.76 mm	1.78 mm

By comparison of analytical calculations and results obtained from FEA for conventional mild steel and aluminum alloy 6063, maximum stress and the displacement of aluminum alloy 6063 is found within safe limit.

VII. CONCLUSION

The density of Aluminum alloy is less as compared to other material used for in fins chain conveyor systems, also Aluminum alloy has high strength than mild steel materials.

FEA analysis on the existing component is performed and the material is replaced with Aluminum Alloy. Results for von mises stress with rib for Aluminum Alloy material is under safe limit.

The aluminum alloy Flight is best suited with the replacement of existing Flight in terms of cost, weight and performance.

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