Finite Element Based Stress Analysis of Plastic Conveyor Slat Belt

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***Abstract*— McCain Foods, an MNC, manufacturer and supplier of FMCG products located in Gujarat, India was experiencing frequent breakdown in operations. During inspection, the plastic conveyor belt and gear mechanism were suspected. Stress analysis of a standard plastic modular link is done using finite element methods. The mechanical behavior of a standard Slat chain which is loaded by the maximum allowed load are considered. The Finite Element analysis has been proved appropriate tool as compared to theoretical computations.**

Keywords—Slat Conveyor belt, Fininte Element method, Shear Stress, Structural Stress

I. INTRODUCTION

Slat conveyor as shown in the fig.1.1 uses discretely spaced Slats connected to a chain. Material (unit) being transported retains its position. These types of conveyors are used for heavy loads or loads that might damage a belt. Food processing industries, Bottling and Canning plants use flat chain or Slat conveyors because of wet conditions, high temperature, and cleanliness criteria.

Fig. 1.1, Slat Conveyor belt

The Tensile Forces acting on conveyor belt can be expressed for two different types of Slat chain belt as follow;

For Straight Flex Slat Chain-

$$F = (mp+2\times mc)\times L1\times \mu1\times C\times SF \quad (1)$$

(Without accumulation)

$$F = [(mp+2\times mc)\times L1\times \mu1+(mp\times \mu2\times L1)]\times C\times SF \quad (2)$$

(With accumulation)

For Side Flex Slat Chain –

$$F=(mp+2\times mc)\times S\times \mu1\times C\times KCW\times SF \quad (3)$$

(Without accumulation)

$$F = [[(mp+2\times mc)\times S\times \mu1]\times KCW+(mp\times S\times \mu2\times KCP)]\times C\times SF \quad (4)$$

(With accumulation)

F = Tensile force, N
mp = Product weight, kg/m
mc = Chain weight, kg/m
L1 = Horizontal length of belt section, m
µ1= Friction coefficient, chain-wear strip
µ2= Friction coefficient, chain-product
KCP= Curve factor, chain-product
KCW = Curve factor, chain-wear strip
C = Force conversion factor
SF = Service factor

To find out stress σPP, following equation is used.

$$F = (d\times t \times \sigma PP) \quad N \quad (5)$$

where F is Tensile Force in Newton, d is the diameter of pulley in mm and t is the thickness of Slat Belt in mm.

The shear stress, τ can be computed from the expression;

$$F = 2x(\Pi/4)xd^2x\tau \quad N \quad (6)$$

A finite element method is well-known and one of the frequently used methods of continuum mechanics. The theoretical differences and the superiorities of the technique over experimental results are widely investigated in literature survey. Plastic Modular Conveyor belt which is used as pulling and driving member of material handling mechanism is inspected. Stress analysis of a standard plastic modular link is performed using Finite Element method.

Typical conveyor belt, also used for washing application has been shown in Fig. 1.2. It separates heavy and light density parts due to their floating and sinking phenomena.

Fig. 1.2, Washer

II. MODELING OF PLASTIC SLAT BELT CHAIN

A. Modeling of Plastic Slat Belt

After performing the simple calculations, the model has been prepared on the Solid works, version 2009 and the analysis has been carried out on ANSYS, version 12.1.

B. Schematic Diagram of Slat Belt

Following Fig. 1.3 explains schematic diagram of Slat Belt.

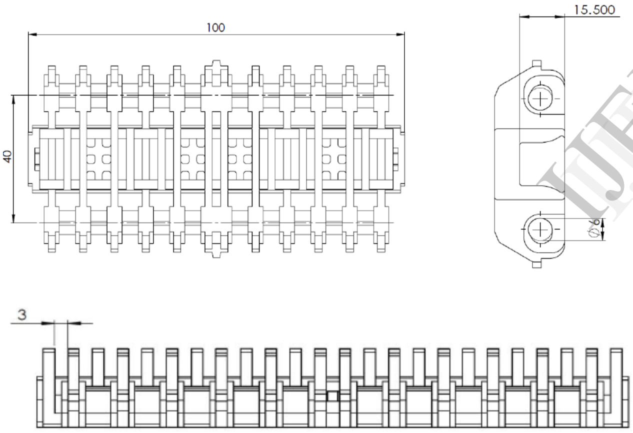

Fig. 1.3, Schematic diagram of Slat Belt

III. FE ANALYSIS OF PLASTIC SLAT BELT

The 3-D model of Slat belt for performing FE analysis has been shown in Fig. 1.4.

The meshing of Slat conveyor belt depends upon the type of type of material of chain (Poly Propylene in this case) and type of element (Tetrahedral). The meshing of Slat belt is done on ANSYS workbench as shown in Fig. 1.5.

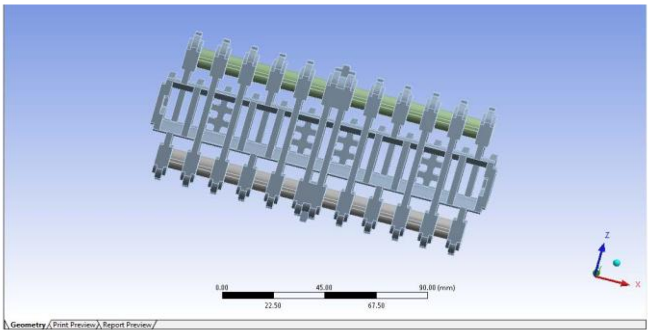

Fig. 1.4, 3 D Model of Plastic Slat Belt

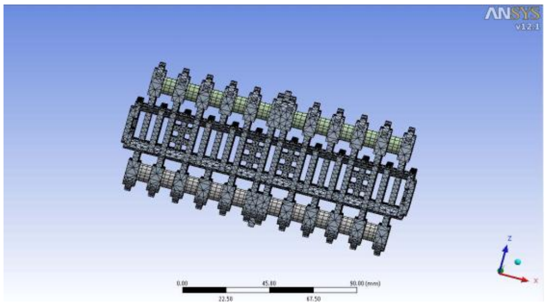

Fig. 1.5, Meshing in ANSYS

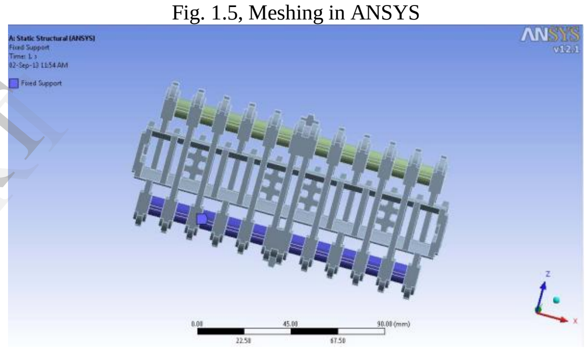

Fig. 1.6, Applying fixed support

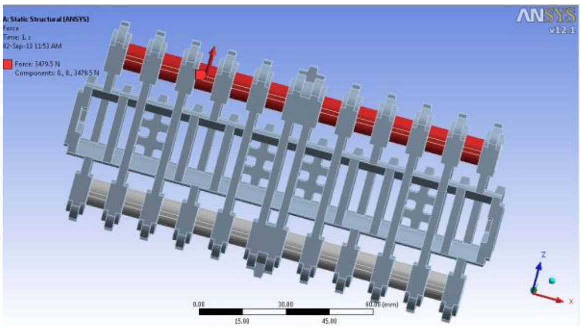

Fig. 1.7, Application of Force

The number of Nodes considered were 105622 and elements were 51978. Fig. 1.6 shows the fixed support applied to the Slat pin highlighted by blue color. Fig. 1.7 depicts the application of axial force according to weight of work piece and belt dead weight.

With above criteria, the FE analysis was carried out for structural and shear stresses. The FE analysis has been carried out in ANSYS.

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Fig. 1.8, and 1.9 show the structural and shear stresses respectively experienced by the Slat belt during simulations. The structural stress measured was 2.95 MPa (Mega Pascal) and shear stress was equal to 1.86 MPa. These stresses are within the allowable limit of Poly Propylene material.
Thermo Structural analysis of Slat conveyor belt has been carried by applying heat as shown in Fig. 1.10.

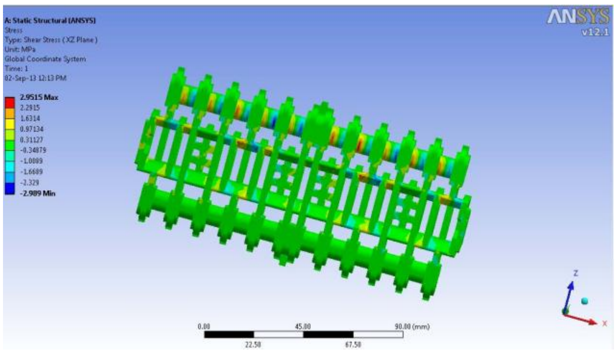

Fig. 1.8, Structural stress

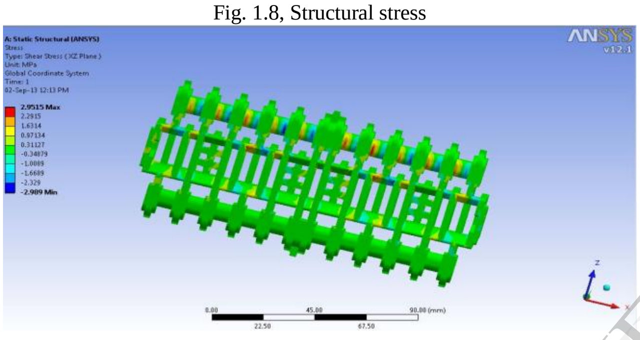

Fig. 1.9, Shear Stress

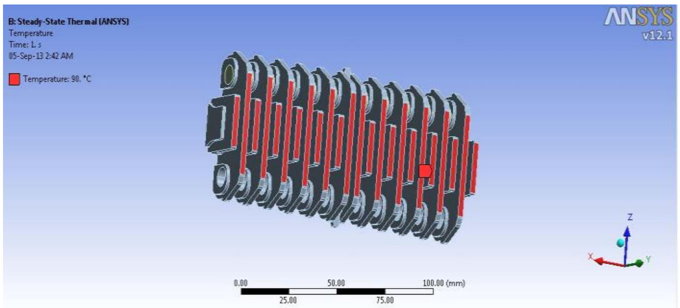

Fig. 1.10, Heat application

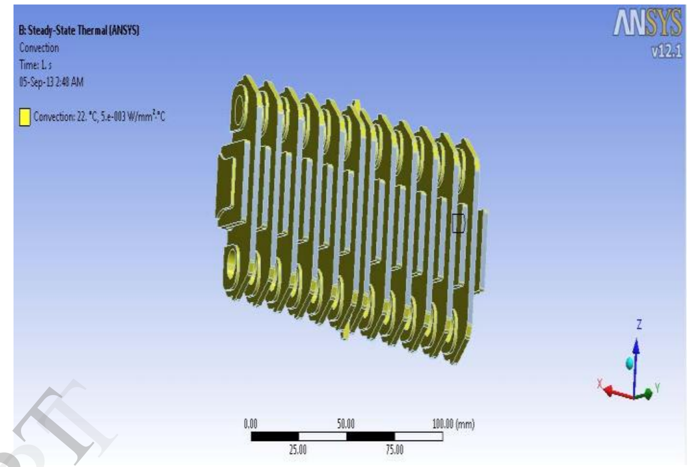

Fig. 1. 11, Heat Convection

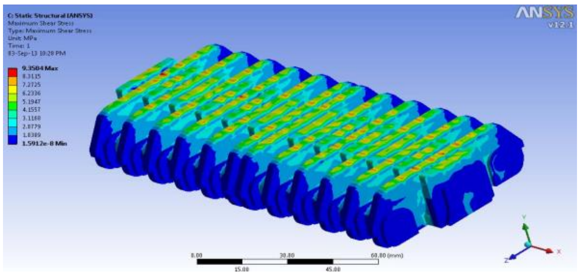

Fig. 1.12, Maximum Shear Stress

Table 1 Thermo Structural Analysis results

Belt Height in mm	Measured Thermo Structural Stress in Mpa	Yield Stress of the Material in Mpa	Color Indication
12.50	28.837	25.00	Not Safe
13.50	24.055	25.00	Safe and Recommended
14.50	21.664	25.00	Safe
15.50	16.882	25.00	Presently in Use (In McCain Plant)

As shown in Fig. 1.11 the convection takes place on the other surface except top surface with a value of $5x10^{-3}$ W/mm^2 ^0C. The Fig. 1.12 shows maximum shear stress 9.35 MPa, appearing on Slat Conveyor Belt.
Table 1 shows the stress analysis for different belt heights. For thinner belts, the safety margins are violated.

CONCLUSION

From the above FE analysis results, it is understood that the maximum stresses are within the allowable limit of Poly Propylene material, both for mechanical & thermo structural configuration. An optimized weight of Slat belt may reflect on the power requirement.

Abbreviations and Acronyms

FE- Finite Element

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