OPEN ACCESS

International
Journal
Of Modern Engineering Research (IJMER)

Study of Roller Conveyor Chain Strip under Tensile Loading

Jagtap M. D. [1], Gaikwad B. D.[2], Pawar P. M. [3]

1(PG Student ME Mechanical (CAD/CAM), SVERI's C.O.Engg, Pandharpur, Solapur University, India)

[2, 3] (Associate Professor, Department of Mechanical Engineering, C.O.Engg, Pandharpur, Solapur University, India)

Abstract: *Conveyor chain drives are one of the primary systems used in industry to transmit power and convey products. Conveyor chain that suffers from premature elongation due to wear and needs to be replaced on a frequent basis will negatively impact productivity and increase the cost of the operation. Roller conveyor chains are the critical component in sugar mills, paper mill, food processing, fertilizer industry, pharmaceutical industry, cement industry, foundry industry, heat treatment units, coal mines etc. The scope of this paper is to study the behavior of chain strip under tensile loading. In turn it will help in reducing down time and maintenance cost related chain assembly in various above said industries. Today, few literatures on the wear of conveyor chain are available. In this paper we study the analytical, experimental and numerical behavior of strip under tensile loading.*

Keywords: *Chain strip, Link plate, Roller conveyor chain, Tensile loading.*

I. Introduction

From a theoretical viewpoint chain is a continuous flexible rack engaging the teeth on a pair of gears. Cetrainly a sprocket being a toothed wheel whose teeth are shaped to mesh with a chain, is a form of gear. Based on its history and development, chian is a mechanical belt running over sprockets that can be used to transmit power or convey materials. Chain strips are machine elements that are subjected to extreme service conditions, such as high tensile loads, friction, and sometimes aggressive operating environment (e.g. presence of humidity, seawater, chemicals). Apart from tensile overload fracture, double shear is also an important failure mechanism which occurs under lower applied loads. Chain is the most important element of the industrial processes required for transmitting power and conveying of materials. As these chains operate under various forces, failure of chain assembly is the major problem. Causes of these failures are improper material selection, uncertainties in manufacturing, faulty manufacturing processes. It is important to study the influence of these parameters on the strength of the chain which governs the failure modes of the chain. The faulty manufacturing processes are another source of failure initiation.

Ledvina and Hummel [1] have developed a randomized sprocket for roller chain. A roller Chain and sprocket drive with a randomized sprocket which modulates the roller position on the sprocket by varying the radial seating position of the roller while maintaining a constant chordal dimension between the Seated rollers. Payet [2] has developed a process and conveyor device for feeding sugar cane in a Mill Train. Various known processes were used in sugar refineries for feeding sugar cane to mills or for conveying the bagasse from one mill to the next. The purpose of this invention was to produce a device enabling very high conveying speeds to be obtained and a regular feed to the three-roller crushing mills. White and Fraboni [3] have demonstrated roller chain sprockets oriented to minimize strand length variation. Numerous methods have been developed to reduce the radiated noise levels generated by the engagement of roller chains with sprockets.

A roller chain strip plate profile was developed by Moster et al., [4]. Material is added to the profile of the strip plates at the location on the strip plate where fatigue failure originates. The added material decreases the maximum stress levels effectively making the strip plate stronger, which provides for a stronger chain. A static stress analysis of strip plate of roller chain using finite element method and some design proposals for weight saving investigated by Noguchi et al., [5]. Roller chains have a long history as mechanical elements for transmission. Although they had clear advantages over belts in terms of performance and efficiency, but their larger weight has always been a disadvantage. Failure of engineering components due to presence of defects in the material was common issue. Sujata et al., [6] discovered a failure analysis of conveyor chain strips. These defects were either present in the material from the casting stage or get developed during subsequent hot working and thermal treatment operations.

Bhoite et al., [7] studied FEA based effect of radial variation of outer strip in a typical roller chain strip assembly. They summarized various design variables, such as wall thickness of strip, breaking area of strip and shape of the strip to formulate an idea of the system. Sapate and Didolkar [8] discovered metallurgical investigation of failure of coal mill drag chain pin. They done metallurgical investigation of fractured connecting pins of drag chain conveyors used for coal conveying from raw coal hopper to grave gate in coal mill of a cement plant.

II. Basic structure of roller conveyor chain.

Chains are used in a variety of applications in engineering practice. In general, there are three basic types of system; hoisting and securing chains, conveying and elevating chains and power transmission chains. Conveyors chains are used when material are to be moved frequently between specific points. Depending on the materials to be handled and the move to be performed, a variety of conveyors can be used. All roller chains are constructed so that the rollers are evenly spaced throughout the chain. Several types of roller chains are used in conveyors, many of single-pitch or double-pitch conveyors chain but here below Fig.1 shows the basic structure of roller conveyor chain.

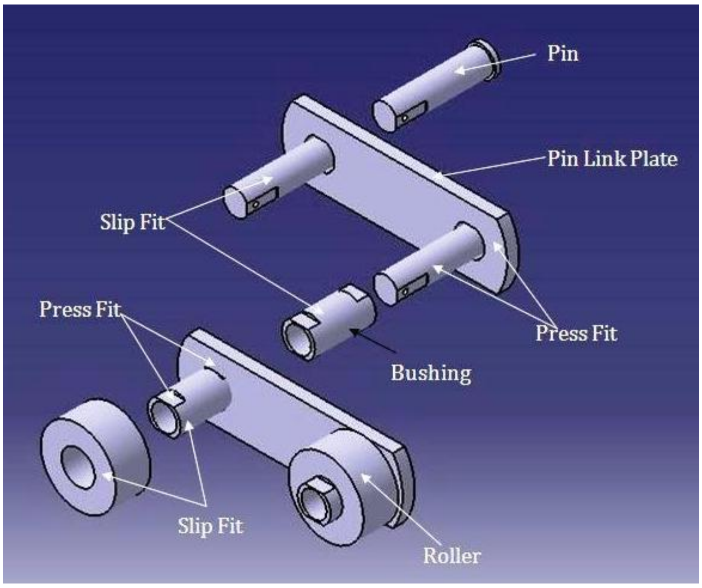

Fig.1 Basic structure of roller conveyor chain

Above Fig.1 shows the basic structure and components of roller conveyor chain and the different types of fits assembled under working conditions. Main components of roller conveyor chain are pin, link plate (strip), bushing and roller. The pin link plate i.e. strip is the assemblies of two pins that are press fitted into the holes of two pin link plates. The press fit between pin and the pin link plate prevents the pin from rotating. Usually there is a repeated loading, sometimes accompanied by shock. The pin is subject to shearing and bending forces transmitted by the plate. There is slip fit between bushing and pin.

The bushing is subject to shearing and bending stresses transmitted by the plate and roller, and also gets shock loads when the chain engages the sprocket. In addition, when the chain articulates, the inner surface forms a load-bearing part together with the pin. The outer surface also forms a load-bearing part with the roller's inner surface when the roller rotates on the rail or engages the sprocket. There is slip fit between the bushing and the roller. The roller is subject to impact load as it strikes the sprocket teeth during the chain engagement with the sprocket. After engagement, the roller changes its point of contact and balance. It is held between the sprocket teeth and bushing, and moves on the tooth face while receiving a compression load. A major advantages of roller chian is that the rollers rotate when contacting the teeth of the sprocket.

III. Analytical Study of Chain Strip

Roller conveyor chain or bush roller conveyor 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, wire and tube drawing machines, printing presses, cars, motorcycles, and bicycles. It consists of a series of short cylindrical rollers held together by side strips i.e. link plates as we had seen the basic structure in Fig.1. It is driven by a toothed wheel called a sprocket. It is a simple, reliable, and efficient means of power transmission.

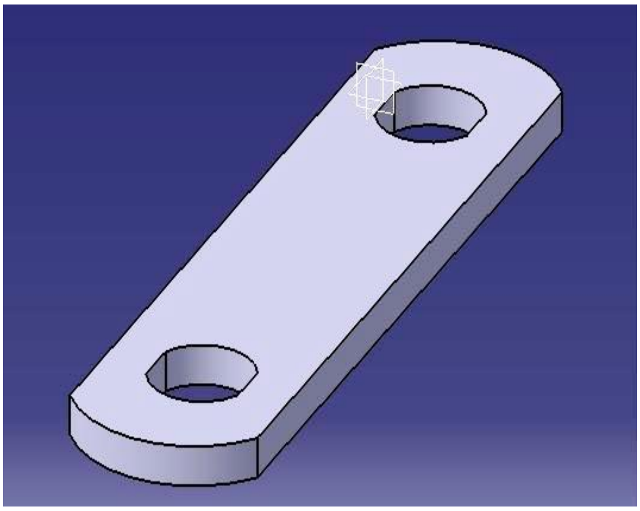

Fig.2 Strip dimensions (55mm x 150mm (Pitch) x 10mm)

Fig.2 shows the Strip of dimensions 55mm x 150mm (Pitch) x 10mm. Now by using the analytical formulae we find out the value of maximum stress i.e. ultimate tensile strength for

Values from design data book
Tensile strength = 67-71kgf = 630 N/mm^2 to 710 N/mm^2
Modulus of elasticity = 2.05*10^5 N/mm^2
Poisson's ratio = 0.3

$$\text{Working stress} = \frac{Maximumstress}{Factorofsafety}$$

$$\text{Working stress} = \frac{710}{1.5}$$

$$\text{Working stress} = 473.33 N / mm^2$$

So as per the above analytical calculations we got working stress of 473.33 N/mm^2, now by using that working stress value we calculate the working load the strip can carry by using the following formulae.

$$\text{Working stress} = \frac{WorkingLoad}{\mathrm{Re}\,sistingArea}$$

$$473.33 = \frac{WorkingLoad}{27 \times 10}$$

$$\text{Working Load} = 473.33 \times 270$$

$$\text{Working Load} = 1,27,799 N$$

So as per the above analytical calculations we got working load of 1, 27,799 N. Now we can check these values with experimental and numerical results.

IV. Experimental Study of Chain Strip

For Experimental testing of chain strip of dimensions 55mm x 150mm x 10mm of EN353 material were taken to study the working stress of the strip. For this testing we are using a Universal Testing Machine of 40tonne capacity. The Experimental test setup for this experiment is shown in Figure 2.

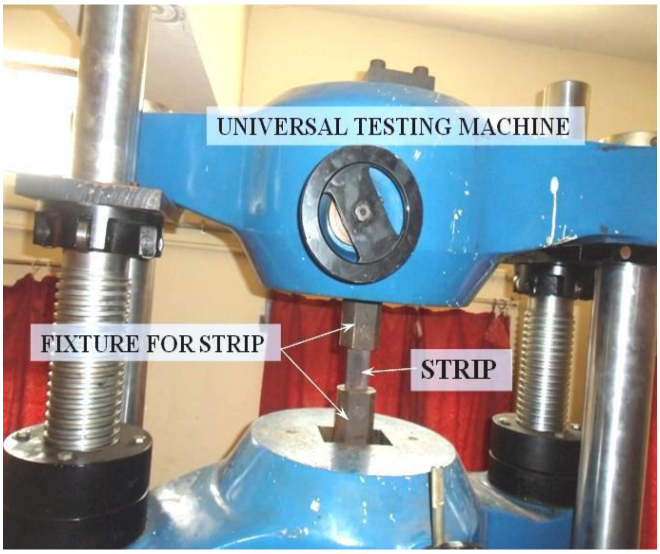

Fig.3 Testing of Chain strip

As shown in above Fig.3 the strip of dimensions 55mm x 150mm x 10mm was clamped on the Universal Testing Machine with the help of two fixtures. The load was given by the application of the hydraulic pressure.

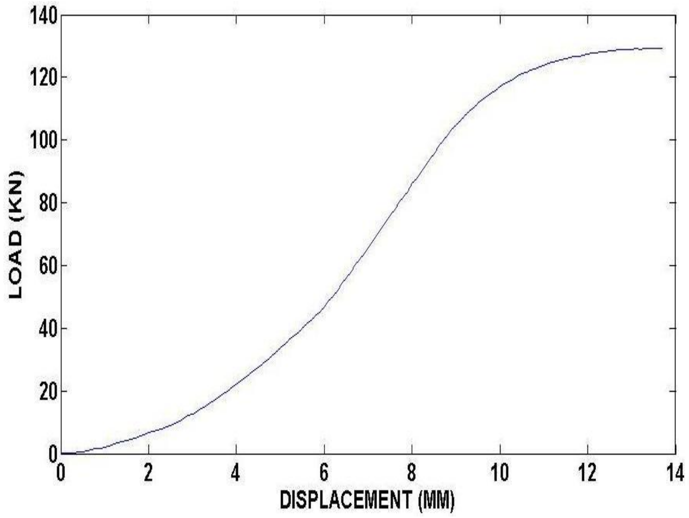

Fig.4 Graph of Load v/s Displacement

As shown in the above Fig.4 displacement in MM is shown on x-axis and load in KN is shown on Y-axis. The max load of 129.2KN is taken by the strip and then it fails elliptical hole. The maximum tensile strength of 490 N/mm^2 was gained by the strip.
Tensile strength = 490 N/mm^2
Maximum load = 129.2KN

V. Numerical Results of Chain Strip

In the assembly of roller conveyor chain on the outer sidebars i.e. on strips tensile forces are applied by pins that are assembled through holes in the sidebars. The holes in the sidebars are significant stress risers. The outer sidebars are primarily tension members, and they also are subjected to substantial bending and stress concentrations around the holes. The outer sidebars 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.

Table.1 Input parameters for the simulation.

INPUT PARAMETERS	
Young's Modulus	2.05e+005 N/mm^2
Poisson's Ratio	0.3
Define By	Components
Coordinate System	Global Coordinate System
X Component	0. N
Y Component	0. N
Z Component	128000N

The strip is first modeled in CATIA V-5 and then exported to ANSYS where it is further meshed, constrained and loaded and simulated further. As far as loading and geometry of strip is concerned, it is necessary to carry out three dimensional analysis .Therefore; Strip is fine meshed. Material properties of EN353 are entered as an input. The above Table.1 shows the input parameters required for the simulation.

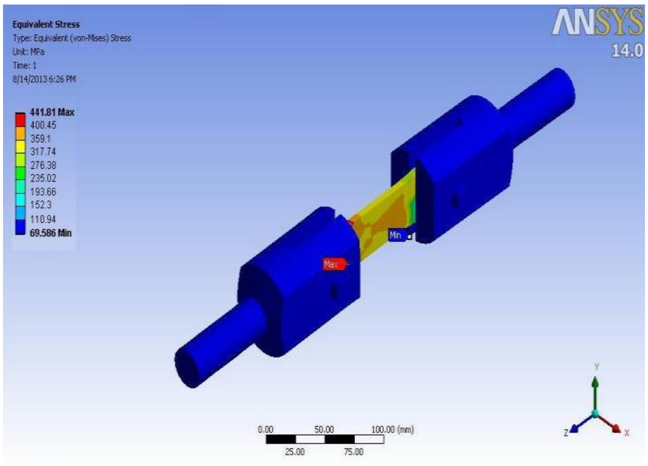

Fig.5 FEA set up with fixture

Finite element analysis (FEA) of strip has been carried out as shown in above Fig.5. As far as boundary conditions are concerned, total 128000N static load is applied in positive Z at one end of strip i.e.at fixture. Red colored arrows show reaction of applied forces. Maximum stress developed in strip has been found out. Also, region of failure for strip was observed after simulation.

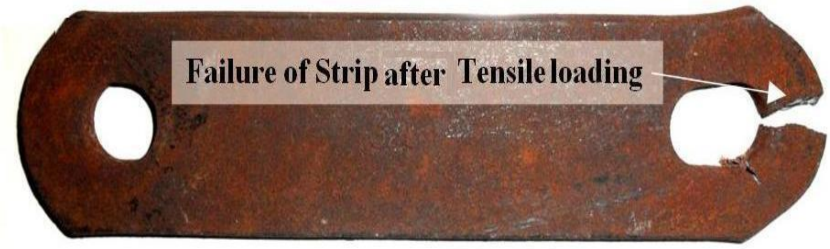

Fig.6 Failure of Strip

The above Fig.6 shows the actual failure of strip under tensile loading. It is observed that the round hole of strip becomes elliptical under tensile loading. Further while gradually increasing of load it fails near to elliptical hole.

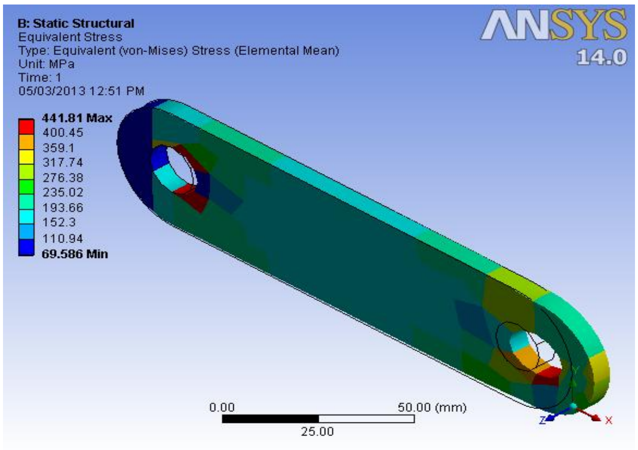

Fig.7 Finite element model of strip

From above Fig.7 it is observed that there is stress concentration near to elliptical hole in the strip, so the strip will fail in that region. It can sustain maximum stress of 441.81 N/mm^2. If stress value at any point in strip crosses 441.81 N/mm^2 strip starts yielding and it will fail.

VI. Conclusion

We studied the analytical, experimental and numerical behavior of strip under tensile loading. The fatigue initially nucleated at the external cracks of the link, and later propagated to the inside of the links until sudden fracture occurred. Below table shows the comparison results.

Table.2 Comparison of results

Tests	Analytical result	Experimental result	Numerical result
Tensile Stress(N/mm^2)	473.33	490	441.81

As above table shows all the results are within +/- 10% of the calculated working stress, so the strip is safe under the maximum working load of 1,28,000 N. A roller chain drives may be subjected to all of the tensile loads, thus the roller chain must have several tensile strength properties to withstand the wide range of tensile loads that may be imposed on it.

REFERENCES

[1] Ledvina T. J. and Hummel J. A. (2002) Randomized Sprocket for Roller Chain, European Patent # EP0907041
[2] Payet P. R. (1964) Process and Conveyor Device for Feeding Sugar Cane in a Mill Train, U. S. Patent # 3,120,173.
[3] White D. C. and Fraboni H. J. (2001) Roller Chain Sprockets Oriented to Minimize Strand Length Variation, United States Patent # 6213905.
[4] Moster A. and Ledvina T. J. (2003) Roller Chain Link Plate Profile, European Patent # EP0833078
[5] Noguchi S, Nagasaki K., Nakayama S., Kanada T., Nishino T., Ohtani T., "Static Stress Analysis of Link Plate of Roller Chain Using Finite Element Method and Some Design Proposals for Weight Saving", Journal of Advanced Mechanical Design, Systems, and Manufacturing, (2009), Vol. 3, No. 2.
[6] Sujata M., Venkataswamy M., Parameswara M., Bhaumik S., "Failure Analysis of Conveyor Chain Links", Engineering Failure Analysis, (2006), 13(6), 914-924.
[7] Bhoite T., Pawar P., Gaikwad B., "FEA Based Study of Effect of Radial Variation of Outer Link in A Typical Roller Chain Link Assembly", International Journal of Mechanical and Industrial Engineering (IJMIE), (2012), ISSN No. 2231 –6477, Vol-1, Issue-4.
[8] Sapate S., Didolkar V., "Metallurgical Investigation of Failure of Coal Mill Drag Chain Pin", Materials and Design, (2009), 30(7) 2623-2629.