Design and Analysis of conveyor chain link using composite material: a Review

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Abstract

The basic aim of this review has been conducted on the most of the time conveyor chain is under tension which causes failure of chain assembly which is the major problem for industrial sector. Causes of this failure are improper design. It is important to study the influence of these parameters. All these parameters can be considered simultaneously and chain link design optimally. Optimization is the process of obtaining the best result under given circumstances in design of system. In optimization process we can find the conditions that give the maximum and minimum value of function. In this study a shape optimization process is used for the design of roller chain link for minimization of failure modes. This process various design variables, such as wall thickness of link, breaking area of link and shape of the link. While deciding the shape optimization of roller chain link raw material plays important role, so it is necessary to decide raw material. [1]

Introduction

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. However, failure of this chain is perennial problem in these industries which causes huge losses to these industries along with its dependants and in turn economical growth of the state. So, roller chain is the most important element of the industrial processes. Roller conveyor chains are common used to transport goods in production lines or assembly lines, such as pallets, cars or steel coils. They are sometimes used in severe environments, soiled with water, foreign particles, chemicals or other contaminants. Normal use will result in wear of the components of the chain which can lead to unexpected failure and costly production downtime. [2]

Today, little literature on the wear of conveyor chain is available and there are almost no reliable test-rigs to generate and measure chain wear in a reproducible manner. In this research the different components of conveyor chains and the loading conditions are described. Additionally, the applications and (dis)advantages of chains with polymer rollers are discussed. The chain wear mechanisms found in literature are listed. Abrasive and adhesive wear between pin, bushing, roller and track are discussed. 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.
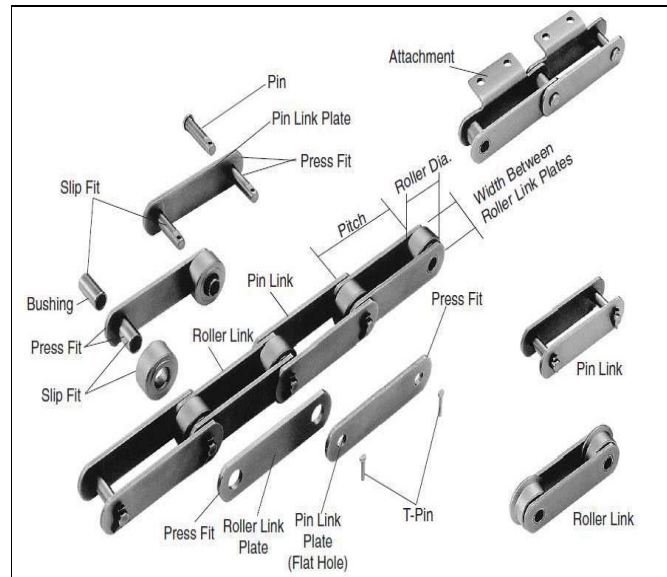
Fig.1 Details of Conveyor chain

A typical conveyor chain is constructed with two different types of shackles: the roller link (or inner link) and the pin link (or outer link), see Figure 1. The roller link consists of two steel bushings that are press-fitted inside the roller link plates, while the pin link consists out of two steel pins press-fitted inside the pin link plates. To prevent disengaging of plates and pins, riveted pins or t-pins (as shown) are used.

Finite Element Analysis

Finite Element Method is a numerical method used for obtaining the approximate solution of engineering problem. In this method, the complex region or body defining a continuum is discredited into simple geometric shapes called element. The properties and motion relationship are assumed over these elements & expressed mathematically in terms of unknown values at specific points in the element called nodes. An assembly process is used to link the individual element to the given system. When the effect of load's and boundary conditions are considered, a set of linear or nonlinear algebraic equations is usually obtained. Solution of these equations gives approximate behavior of the continuum or system. The continuum has infinite number of degree of freedom. While discredited model has finite number of degree of freedom.

Literature Survey

Finite element method calculates the stress concentration and different parameters of failures of chain link; like the base of literature review is the radial variation in chain outer link, wear of conveyor chain with polymer roller and forces acting at the time of articulation.

FAE Based Study of Effect of Radial Variation of Outer Link in A Typical Roller Chain Link Assembly [1], 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
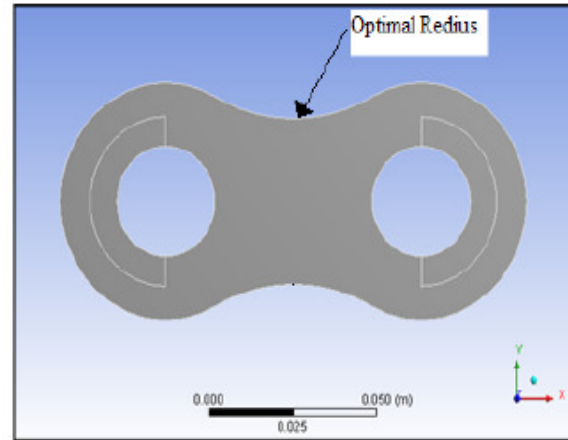
Fig.2. Optimizing radial distance

Wear of conveyor chain with polymer roller [2], conveyor chains with polymer rollers are widely used. Mostly because of they are capable of working without any lubrication and have good corrosion resistance. From the study of the contact mechanics in a chain, the sliding contact between roller/bushing and rolling contact between roller and track were found to be the most wear critical areas. The wear mechanisms occurring with conveyor chain were listed. For conveyor chains with polymer rollers, the expected wear mechanisms are adhesive wear, abrasive wear, impact with sprocket and softening of the polymer due to heat generation.
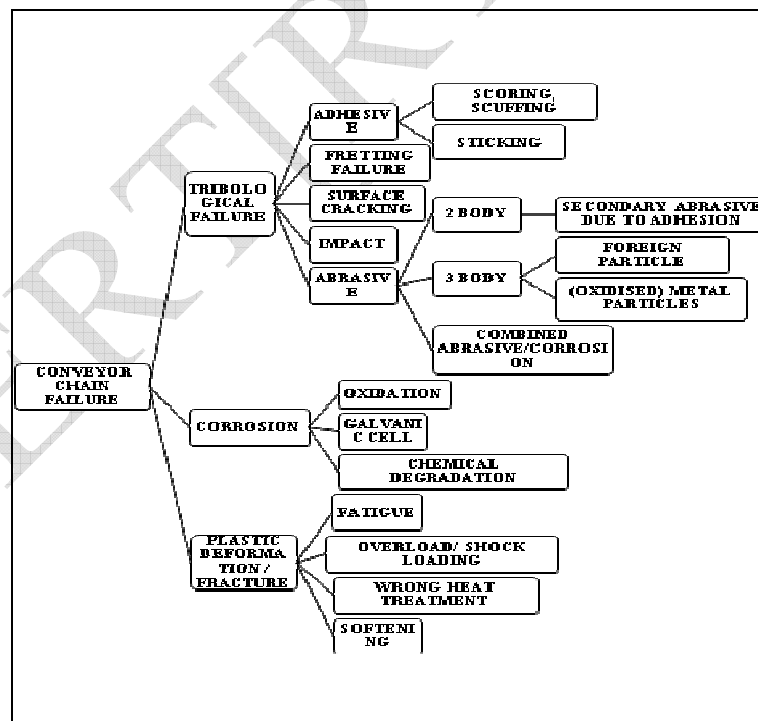

Fig.3. Wear mechanism occuring in steel and polymer conveyor steel

Forces in Heavy-duty drive chain during articulation [3], some innovations were devoted on improving chain components and articulation of the chain. Hollingsworth and Hills worked on forces in a heavy-duty

drive chain during articulation. 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. This difference is due to presence of coulomb friction forces at the sliding joints and their geometry during articulation. Experimental verification of the chain link tension is good.

Failure analysis of the stacker crawler chain link [4], the aim of this paper is to find out the cause of the chain link breakdown occurrence. Its superstructure leans on three crawlers of the same length, width and the height. During the stackers travels from the erection site to the open pit mine, three crawler chain link fractured. Working stresses in the chain link are defined by applying FEM. Experimental investigations define the chemical composition, the tensile properties, the impact toughness, the macro and micro hardness.

Design and analysis of chain outer link by using composite material [5], using FEA software package ANSYS and by hand calculations comparing the weight optimization of chain outer link. The goal of this paper is to optimize the weight of chain. According to the ANSYS result and hand calculation there is little difference in result. These are the theoretical results, not actual test model. For the original chain link compare to the glass fiber, weight is more, nodes and elements required more. And the stress is decreases as the thickness of chain link increase in composite material

Study of roller conveyor chain strip under tensile loading [6], For the testing purpose, EN353 material model is used with size 55x150x10 mm. The review of this paper shows that the sample model tested for tensile strength on universal testing machine. The fatigue initially nucleated at external crack of the chain link and later propagated to the inside of the link until sudden fracture occurred. Comparing the analytical, experimental and numerical result there is +/- 10% difference in result. It shows that, strip is safe under the maximum working load condition. A roller chain drive may be subjected to all of the tensile loads, thus the roller chain must have several tensile load properties to withstand the wide range of tensile load that may be imposed on it.

Fig.4. Failure of strip
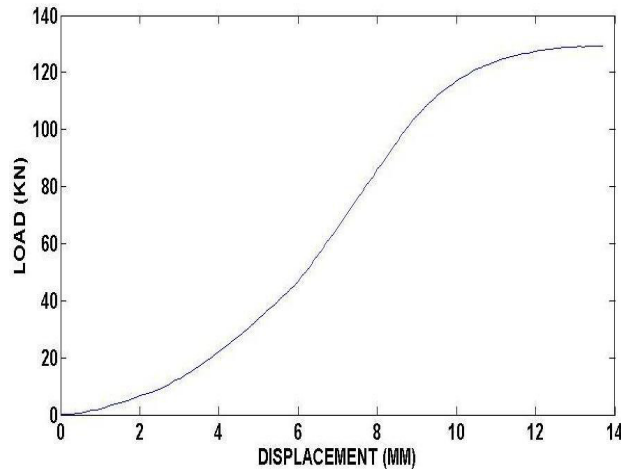
Fig.5. Graph of load v/s displacement

The graphical representation of load (kg) verses displacement (mm) of chain strip for the tensile strength of strip, the experiment done on universal tensile machine.

Static stress analysis of link plate of roller chain using finite element method and some design proposals for the weight saving [7], stress on the commercially available standard chains are analyzed .When the form of the link plate changed, the analyzed stress was compared with that of the standard chain. To simplify the analysis of link plate stress, the roller was not regarded because the roller did not support the generated force when the chain was pulled independently. To determine the standard stress for weight saving design, FEM analysis was applied for the static tensile load of 500 N. The result shows that stress concentrate around the pin or bush. Moreover, the stress at the constricted part of the link plate is large. In Some design proposals, **i) link plate with centrally located hole;** the different holes sizes are considered for the weight reduction and for stress analysis. It is possible that a 10% maximum weight saving is realized without a change a change in maximum stress at centre hole. **ii) Changing thickness of link plate,** if the thickness were changed, the other dimensions would remain constant. Therefore, effective weight saving would be realized. Thus he stress was analyzed with the change in the thickness of inner and outer link plate for the standard roller chain. Different sizes of thickness of link plate analyzed, the tensile stress increases when thickness of the plate decrease. Particularly, if the thickness becomes less than 1.25 mm, the stress increases. However, in the thickness range larger than 1.50 mm, weight saving ratio is similar to rate of increase in tensile stress. Consequently, weight saving with decrease in the thickness of link plate can be realized using higher strength material. **iii) Chamfering edges of link plate circumferences,** stress does not get cantered at the circumference of link plate. Three types of models tested, model 1 with chamfer at one side of plate does not markedly affected the stress, model 2 with chamfer at both side of plate- weight is reduced by 14% but tensile stress also increased and model 3 with centre hole with one side chamfer- the state of stress is similar to model1 and weight is reduced by 3%.

CONCLUSION

The literature review presents that design optimization of link, wear mechanism, stress analysis is widely done by FEA & FEM and failure of link plate. Chain link consider different design parameters and behaviour of failure. FEA apply in mechanical element and link, we find in which the parameters are affect to its failure. FEA based simulated model gives approximation of simulated parameters and generate the mesh FEA model gives the result respect number of nodes and elements. Also the review presents that for weight reduction and effectiveness of chain operation, the focus will be on using alternate polymer material & design parameters.

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