Stress Analysis and Shape Optimization of Block type of Chain

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ABSTRACT

Over the years a lot of work has been done and is still continuing with great effort to save weight and cost of applications. The current trend is to provide weight/cost effective products which meet the stringent requirements.
The aim of this paper is to study existing conveyor system and optimize the shape of the chain link by using stress analysis. And to reduce the entire weight of the Block Forged chin used in sugar factory. And hence reduce the power consumption to drive the chain.
This paper documents the brief literature survey of stress analysis and failure criteria. It also describes the detailed methodology weight reduction of forged chain link.

Keyword: -*Block type chain, Shape optimization, stress analysis, and conveyor system*

1. INTRODUCTION

A chain is a reliable machine component, which transmits power by means of tensile forces, and is used primarily for power transmission and conveyance systems. The function and uses of chain are similar to a belt. There are many kinds of chain. It is convenient to sort types of chain by either material of composition or method of construction.

We can sort chains into five types:

1. Cast iron chain.
2. Cast steel chain.
3. Forged chain.
4. Steel chain.
5. Plastic chain.

Demand for the first three chain types is now decreasing; they are only used in some special situations. For example, cast iron chain is part of water-treatment equipment; forged chain is used in overhead conveyors for automobile factories. We will sort chains according to their uses, which can be broadly divided into six types:

1. Power transmission chain.

2. Small pitch conveyor chain.

3. Precision conveyor chain.

4. Top chain.

5. Free flow chain.

6. Large pitch conveyor chain.

The first one is used for power transmission; the other five are used for conveyance. In the Applications Section of this book, we will describe the uses and features of each chain type by following the above classification.

1.1 Early developments in chain

Chain is one of the oldest power transmission and material transport devices known to man. In 225 B.C., Philo described a chain-driven water lift as shown in Fig. 1.1.

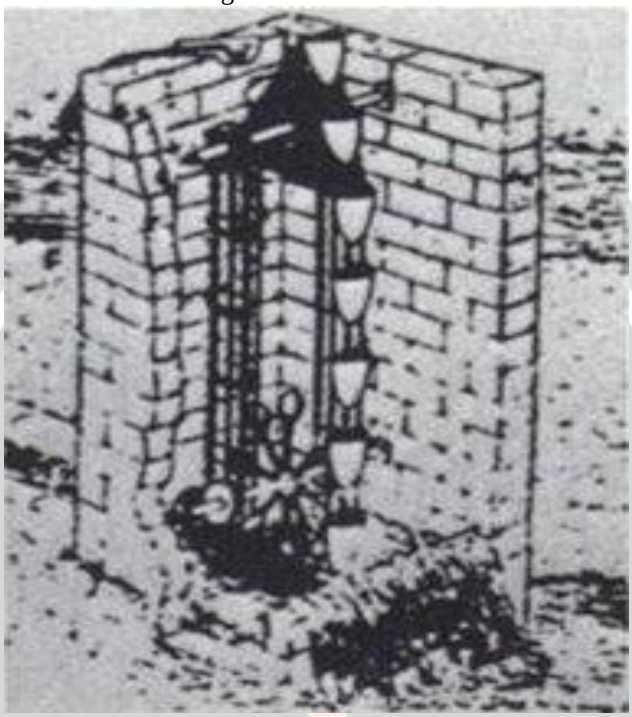

Fig. 1.1 Philo's Chain Driven Water Lift [2]

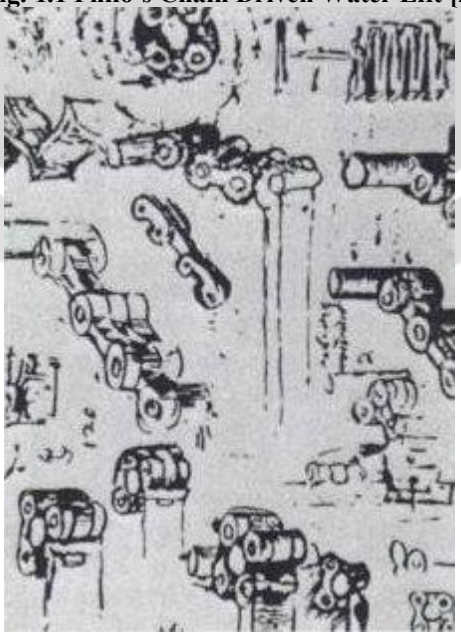

Fig. 1.2 Leonardo da Vinci's sketches [2]

During the sixteenth century, Leonardo da Vinci sketched a number of chain designs, many being similar to modern chain as shown in Fig. 1.2. One of da Vinci's chain sketches bore a strong resemblance to modern silent chain. By the early 1800's, development of chain began to gather momentum. The early designs had frequent breakage problems and were difficult to repair. These problems were addressed in 1873 with the introduction of cast detachable chain. The development of cast detachable chain greatly assisted the growing mechanization of farm machinery in the late 1800's. The cast pintle chain shown in Fig. 1.3, developed in the late 1800's, was the forerunner of chain as we know it today.

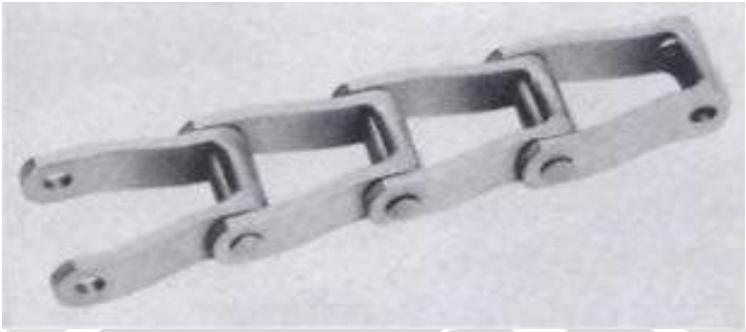

Fig. 1.3 PintleChain[2]

The beginning of the twentieth century saw the expansion of chain into such applications as bicycle and automobile drives. Chain was used on automobiles to transmit power from the transmission to the driving axle, as well as application on camshaft drives. A chain drive was used for the propeller drives on the Wright Brother's first successful airplane. The roller chainindustry was the first industry in the world to publish user standards when they did so in 1913.
Now days there are a large demand of chain for bicycle, and soon for motorcycle, automobiles and trucks. That sparked organized methods of manufacturing that led to the modern chain industry.

1.2 Standards of Chain

Mainly there are few organizations agreed for standard development of chain–
1. American National Standard (ANSI)
2. International Standard (ISO)
3. European Standard (ES or DIN)
4. Japanese Chain Association Standard (JCAC or JIS)
For further study ISO standard power transmission roller chain is considered.

1.3 Types of chain

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1.3 Conveyor chain

The most significant development made in the industrial world is conveyors (Singh & Singh, 2012). Conveyor is one types of material handling that existed for over 100 years. By referring to Material Handling Equipment Distributors Association or commonly known as MHEDA. (2001), since 1795 people already used belt conveyor as a transport of bulk material from one location to another. In the 20th century, conveyors become popular with more tough and versatile. In 1902, steel conveyor belt had been manufactured by Swedish company, Sandvik. Then, around 1908, first pattern of roller conveyor received from a man named Hymle Goddard of the Logan Company. In 1910 pioneered by Henry Ford, he developed an assembly line that consist conveyor to carry the product with mass production in automotive industries (Allen, 2010). The industrial revolution in process then becomes shines when most of automotive companies began using conveyors in 1919 due to the successes of Henry Ford's innovation in assembly line.

Conveyors provide lots of benefit that cannot be undisputed. Imagine that how many times will be wasted if the workers need to walk by holding the item from one location to another location. This situation can be handled by using conveyor to bring the item to the desired location throughout a plant. Furthermore, conveyor can be used to transport the object for a long distance such as the longest belt conveyor in the world is in Western Sahara with 100 km long to transport the phosphate from the Bu Craa mine to the coast at El Aaiun (Lewis, 2011).

2. Basic Structure of Large Pitch Forged Block Type Conveyor Chain

Large pitch conveyor chain has a headed pin, and usually does not use a riveted pin. Large pitch conveyor chain is also called engineering class chain.

2.1 Functions of Chain Parts

- **Chain Plate/Link**

Fig. 1.4 Chain Link

The plate is the component that bears the tension placed on the chain. Usually this is a repeated loading, sometimes accompanied by shock. Therefore, the plate must have not only great static tensile strength, but also must hold up to the dynamic forces of load and shock. Furthermore, the plate must meet environmental resistance requirements (for example, corrosion, abrasion, etc.).

- **Chain Pin**

The pin is subject to shearing and bending forces transmitted by the plate.

Fig. 1.5 Chain Pin

At the same time, it forms a load-bearing part, together with the bushing, when the chain flexes during sprocket engagement. Therefore, the pin needs high tensile and shear strength, resistance to bending, and also must have sufficient endurance against shock and wear.

- **Chain Bush**

Fig. 1.6 Chain Bush

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. Therefore, it must have great tensile strength against shearing and be resistant to dynamic and shock wear.

- **Cotter Pin, Spring Clip, T-Pin**

These are the parts that prevent the outer plate from falling off the pin at the point of connection. They may wear out during high-speed operation, therefore, for this application, these parts require heat treatment.

3. LITERATURE SURVEY

Suhas M. Shindeet. al.[1]In this paper study existing conveyor system and optimize the critical parts like roller, shafts, C-channels for chassis and support, to minimize the overall weight of assembly and material saving. In that

he is worked on redesign existing gravity roller conveyor system by designing the critical parts (Roller, Shaft, Bearing and Frame), to minimize the overall weight of the assembly and to save considerable amount of material. Geometric modeling of existing roller conveyor. He has generate parametric model using ANSYS Parametric Design Language (APDL) program to carry out linear static, modal, transient and optimization analysis of existing roller conveyor. Then create Modification of critical conveyor parts for weight optimization and carry out Analysis of Modified design for same loading condition. Recommendation of new solution for weight optimization.

Jagtapet. al. [2] This paper is about the behavior of chain strip under tensile loading. In turn it will help in reducing down time and maintenance cost related to chain assembly in various industries. In this paper he study the analytical, experimental and numerical behavior of strip under tensile loading.

Bhoiteet. al. [3]This paper 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.

M. Sujataet. al. [4]This paper studied failure of engineering components due to presence of defects in the material. These defects are either present in the material from the casting stage or get developed during subsequent hot working and thermal treatment operations. Identification of the origins of defects is an important task while analyzing failures where pre-existing defects in the material are the causative factors. A case study on failure of conveyor chain links is presented in this paper. It was determined that the failure was caused by defects related to the metal processing. These defects were identified as surface defects in the billet, which got translated into lap or fold like defects in the final products. It was recommended that the billet be properly dressed and the surface defects are removed prior to forging operations.

M. Pietrzyket. al.[5] Complex approach to the design of manufacturing processes based on considering the whole Life Cycle (LC) of material, including processing and exploitation stages, is presented in the paper. Modelling of the Life Cycle provides possibility to control the final product properties at the stage of manufacturing. It means that required properties and specific behavior of product under exploitation conditions can be obtained by optimization at the stage of material processing. The concept of the design of the entire manufacturing chain is presented in the paper and the application to manufacturing of the connecting part made of modern biotitic steels is proposed.

V. Velkovaet. al.[6] This paper presents a novel process chain for fabrication of replication masters for serial manufacture. The proposed process chain is validated for serial fabrication of (large area) organic electronic devices on flexible substrates. The advantages and limitations of the component technologies in the proposed manufacturing route are discussed and their process chain for producing both 2.5D and 3D Nano- and micro-structures are analyzed.

NurIsmalina[7]This paper study to investigate the causes of failure of chain system through characterization on the failure component. The failures that occur are relate to welding because this dipping latex industry use customized chain that have to be welded at joining with outer chain links. The analysis revealed that the weld defect such as crater leads the crack propagation and added with cyclic loading that cause the fatigue failure. The fatigue failure occurs due to this inherited crack at the outer circumference of the weld within chain attachment and outer chain link plate. This type of defect also can be categories as designing-in defect. Fatigue crack propagation was evident by progressive beach marks and the scanning electron microscopy (SEM) analysis revealed the types of microstructure that resulting at heat affected zone (HAZ). Hardness testing by using Rockwell Tester found the different hardness profile at three areas that are weld metal, base metal and heat affected zone. The maximum hardness values were found at heat affected zone and weld metal. Finite element method (FEM) that is Ansys Workbench was used to review the different size of outer link plate thickness that affected to the stress distribution. It was found that stress can be minimized with increasing the plate thickness.

S. R. Kale[8]In resent work he had studied the different failures of roller conveyor chain links under different loadingconditions using Mild Steel. In chain conveyor system motor capacity of conveyor depends on the weight of chain. It wasdetermined that maximum amount of weight of chain conveyor is covered by outer link and inner link. He concentrated onboth link and weight reduction of link by using composite material (Glass Fiber & Carbon Fiber) to reduces the powerrequirement of conveyor.

3.1PROBLEM DEFINITION

It has been observed that in previous researches they are working on existing conveyor system and optimize the critical parts like roller, shafts, C-channels for chassis and support, to minimize the overall weight of assembly and material saving [1]. About the behavior of chain strip under tensile loading [2]. FEA based effect of radial variation of outer strip in a typical roller chain strip assembly [3]. Studied failure of engineering components due to presence

of defects in the material [4]. Complex approach to the design of manufacturing processes based on considering the whole Life Cycle (LC) of material, including processing and exploitation stages [5].

I did the survey of sugar industry and found that, there is scope to reduce the power consumption by reducing the weight of chain link. Hence I am studying, on stress analyses of Block forged type chin and to reduce the weight of the chain link, which will help to reduce the power consumption. In sugar industry large amount of power is required to drive the mill and conveyor. Hence I am research over entire design of chain link to reduce the weight of chain link i.e. to reduce power.

3.2 METHODOLOGY AND WORKING STEPS:

- **Step 1:To do survey of sugar factory.**
  - Study the application of Block chain.
  - Study the weight of can which carry by chain.
  - Study working condition and working load of chain.

- **Step 2:To check the chemical composition of material used for Block chain elements.**
  - The chemical composition of the Block chain materials is determined by spectroscopy chemical analysis.

- **Step 3: To study mechanical properties of Block Chain material.**
  - Study mechanical properties of Block chain material such as tensile strength; yield strength, elongation and reduction area.
  - Preparation of specimen to study above mechanical properties.
  - Perform the test with the help of Universal Testing Machine.

- **Step 4:Parametric study of existing Block Chain.**
  - Study all dimensions of cane carrier Block type chain.
  - Draw the detailed drawing of all components of Block chain with the help of CAD software.
  - Checking the hardness of chain material by Rockwell hardness test machine.

- **Step 5: FEA analysis of Block Chain Link.**
  - Study the stress distribution in Block chain link to find out minimum stress area.

- **Step 6: Redesign of Block Chain Link.**
  - Redesign the Block chain link without affecting breaking load of it.
  - Redesigning the Block chain link to reduce the weight.

- **Step 8: Comparison of existing and redesigned chain Link.**
  - Compare the weight, cost and power consumption of existing chain with redesigned chain.

4. CONCLUSIONS

This paper helps to understand the failure criteria of block type forged chain which is used in conveyer system of sugar factory, which used to convey the sugar cane. It also describe the brief methodology about weight reduction of the block forged chain link.

5. REFERENCES

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