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# Advancements in Mechanical Belt Fastener Technology

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## Introduction

The improvements made to the designs of conveyor belt fastening systems have been directly related to changes in both conveyor belt design and construction, as well as the need to meet new requirements of industry. This paper is intended to briefly review past conveyor belt fastener designs and applications, and also to review the improvements made to these products over the years

The importance that mechanical belt fasteners has played to the global heavy duty and light duty industries that use belt conveyors must not be overlooked. The advantages offered by mechanical belt fasteners has allowed industry to operate more efficiently, allowing for the conveyor lines to be repaired quickly and economically, with minimal downtime. I believe that most will agree that mechanical fasteners have provided numerous benefits to industry and continue to be suitable for use in the majority of belt applications today.

## A Brief History

One day in the 11$^{th}$ century, someone looped a cord around two wheels in order to turn a device for winding a thread on a bobbin. This gave history the first recorded forerunner of belt power transmission.

For the next few hundred years, this invention saw little use other than spinning wheels, then gradually found its way into harnessing water wheel power for the milling of grain.

About the year 1500, Leonardo Da Vinci noted the advantages of transmitting power with a flat belt instead of a cord. But like so many of Da Vinci's proposals, this concept was ahead of its time. Up into the early 1800s, power transmission usually relied on crude gears of wood or iron with rope drives occasionally used for low power applications.

Then, as the industrial revolution gained momentum, powered machinery began leading the way to large scale production. Steam engines began replacing water wheels as the main power source. Their higher speeds and additional horsepower obsoleted the crude gears of that time. Instead, power was transmitted to production machinery by long overhead drive shafts powered by multiple rope drives. From pulleys along these shafts, loops of rope descended to turn the drive pulley of each machine.

Finally, Da Vinci's vision prevailed. Flat belt proved itself more efficient at higher speeds and began replacing rope drives. By the 1870s, transmission systems typically used flat belts made either of leather or of closely woven cotton duck built up in layers and impregnated with balata, a form of rubber with low elasticity.

Both leather and balata belts could be reliably spliced into continuos loops necessary for line shaft power systems. But installing either type of belt properly called for the skill of an experienced craftsman. The belt was slung over the line shaft and joined into an endless loop by one of several methods.

Leather belts were commonly joined by a process in which belt ends were shaved or skived into matching bevels, glued together, then dried eight hours. Balata belts were joined using a similar method which involved vulcanization with heated clamps. An alternative method for leather belts, faster but not considered as good, was to lace the belt ends together with leather or gut thongs.

Slide showing belt and thongs

It was said to take 60 to 90 minutes to lace 12 inches of belt by this method.

As industrial production grew larger and better organized, manufactures increasingly sought ways to improve production, make maintenance simpler, and reduce the time lost in repair and replacement functions. It was this search for new and better ways to do things, focused on the need for faster, simpler methods of installing and maintaining transmission belts, that gave birth to mechanical belt fastening.

## The First Mechanical Belt Fasteners

Many inventors took up the challenge to create a mechanical belt fastener that would meet the needs of a growing industrial boom. The first patent awarded for a rigid mechanical fastener in the U. S. was given in 1859.

Slide of rigid fastener patent

The first patent for a hinged belt fastener dates to 1866.

Slide of hinged fastener patent

Both of these designs pioneered the concept of metal devices attached to the belt ends by rivets, staples, and bolts. Towards the end of the 19th century, as the demand for workable fasteners grew, these basic concepts were refined into several distinct designs. Drive on plates and strips appeared almost simultaneously in 1889.

Slide of drive on plate patent

These plates were table shaped, each with four leg-like prongs that were driven through and clinched against the underside of the belt. The strip design involved a zigzag pattern stamped out of strip metal, made long enough to span the width of the belt, with one continuous fastener that crossed back and forth across the belt joint. Outer points of the zigzag pattern were bent down to form teeth that were driven through the belt and clinched.

Bent wire hooks appeared on the scene in the late 1890s.

Slide of wire hook patent

These fasteners were individual wire hooks with each end bent for insertion through holes punched in the belt. The middle of the hook was formed into a circular loop. The belt ends with hooks inserted into them were brought together so that the loops were meshed in alignment. Then, a piece of wire as wide as the belt was pushed through the loops, uniting them into a single hinged joint.

A few years later, at the turn of the century, belt studs were developed.

Slide of belt stud patent

These fasteners were curved pins with flanges on both ends and were inserted through slots cut in belt ends, the same way cuff links are put into place on a shirtsleeve.

In 1906, Olaf N. Tevender, a plant superintendent with American Can Company in Toledo, Ohio, had a belt fastener patent that caught the interest of three gentlemen from Chicago, Illinois,: Mr. George Purple, Mr. A. B. Beach, and Mr. Philip S. Rinaldo Sr.

Show slide of Flexco founders

These gentlemen teamed up to buy the Tevender patent, and formed the beginnings of what is now Flexible Steel Lacing Company, or Flexco as we are commonly know by today.

Show slide of Tevender patent

Many refinements were added to this patent until the final design was concluded which resulted in the familiar product still known 90 years later as Alligator® Belt Lacing. Because the product replaced the leather gut thongs used previously, it became commonly referred to as "flexible steel lacing"; hence the name for our company.

Slides of early products produced

## Heavy Duty Fasteners Developed

As mentioned previously, these early fastener designs were intended to be used on flat power transmission belts, made of leather or balata. The idea that belts could be expanded for use in conveying materials occurred around the late 1800s when the American belt maker, Thomas Robbins, proved that belt could be used for the transportation of heavy materials such as coal, ore and rock. This development triggered a broad expansion of belt conveyor design and application in the U. S. between the years 1895 and 1910.

Drawing of the Oliver Evans grain handling conveyor designed about 1785.

First drawing of a belt conveyor.

Up until 1919, Flexible Steel Lacing Company's efforts had been concentrated on the mechanical joining of light duty belts, both power transmission and conveyor belts. At this time, Flex was approached by the U. S. rubber make BF Goodrich Company, and requested to develop a heavy duty belt fastener for a two inch thick belt they were manufacturing for an open pit copper mine in Chile. Vulcanizing services would not be available in this remote mining area, so the need for a mechanical means of connection was very important.

Slide of George Purple's HD solid plate fastener

Mr. George Purple, one of the founders of Flexible, conceived the idea of using a pair of metal plates with teeth and high strength bolts as a means of connection. Although, by this time, belt conveyors were commonly being used in open pit mining applications, the Chilean project proved that heavy belt applications need not depend on the costly and time consuming process of vulcanization. Industry wide recognition of this development helped accelerate the spread of both belt conveying and mechanical splicing of belts.

## Further Developments

The post WWII U. S. economy in the late 1940s accelerated the need for improved industrial products, especially those that added speed and efficiency of handling to production. At this time, the U. S. government began the development of the U. S. interstate highway system. Road construction for this huge project required tremendous amounts of sand and crushed stone, with an increasing number of conveyors needed for processing these materials. This significant surge in demand for material caused Flexco to refine many of the types of solid plate and hinged bolt fasteners that are still in the product offering today.

Slide of Flexco Solid Plate
Slide of Flexco Hinged Bolt

Another significant development occurred in 1958 when Raybestos-Manhattan, a U. S. manufacturer at the time of heavy duty mining belts, requested assistance in developing a mechanical splice that would hold in high tension belts, which at that time, required vulcanization. The collaborative effort of technical people at both companies resulted in the development of the Wedlok® splice pattern ...

Slide if Wedlok

a V shaped splice that works like a Chinese finger puzzle ... the more force applied on the belt, the stronger the splice becomes. This is due to the fact that the No. 2 Flexco plates mounted at 15 degree angles cause the belt ends to push against one another, resulting in exceptional holding ability. Flexco paid royalties to Raybestos-Manhattan for 17 years, until the expiration of the patent. The Wedlok splice is still used in many high tension applications today, usually in applications where the belt, due to its design and construction, needs to be vulcanized. It is known today throughout the world as the "mechanical splice for fabric belts intended for vulcanization".

In the 1940s the U. S. underground coal industry underwent major changes that were intended to improve productivity. The mining methods changed from conventional blasting and loading to continuos mining with machines that scrape the material off the mine face. The continuous method caused mine output to increase substantially. Because of this, mine management needed to investigate new haulage techniques which would replace the train car/track system used in the industry. Belt conveyors soon proved their worthiness in the coal industry, as main haulage belts were installed as the primary means of removing the coal from the mine. These main belts were fed by panel or extendible belts, that hauled the coal directly away from the coal face. When the industry first made the change to belts in the late 1940s early 1950s, the fastener most commonly used in the American mines was the British made Hayden wire hook fastener.

Slide of Hayden fastener

As tonnage increased, the need for a more substantial joint was evident. The 250X/500X fastener was developed by Flexco as the company's first belt splice for coal mining.

Slide of 250X/500X

This product was developed further into the 550X product that is still being manufactured today, but not commonly sold to the coal industry.

Slide of 550X

Today, the industry standard in the coal industry are two designs, both hinged style fasteners, one with narrow loops and heavy duty staples and the other with wider plates and staggered rivets.

Slides of SR and F series

## Changes In Belt Design and Construction

As stated previously, the early designs of conveyor belts ranged from the use of leather and cotton/balata in the early 1900s to more widespread use of cotton and rayon, both natural fabrics in the 1920s through the 1950s. These belts with natural fabrics for plys were multi plied and manufactured with capped rubber edges, to prevent mildew and rot of the fabric. Around the 1960s the American belt manufactures began to introduce synthetic fabrics to the market. These fabrics, nylons and polyesters, provided more strength than natural fabrics and allowed the use of reduced plies in belting manufacture. This change allowed belt to be handled easier at the job sight, made it easier to ship more belt on a single roll, made the belt more flexible for smaller diameter pulleys, as well as eliminated the need for belt to be made with capped edges. The synthetic fabrics were resistant to water, which allowed the belt to be made in wide widths, which could then easily be slit down to narrower sizes by a distributor near to the customer. In addition to this, these changes in belt carcass design affected the mechanical fastening holding ability and caused belt fastener manufacturers to review fastener designs and ensure that mechanical fasteners were compatible with modern belts. This caused the birth of several new designs of fasteners that we will talk about now.

## Modern Fasteners Used on Today's Belts

The conveyor belt market can be broken down into two general parts: light duty and heavy duty. Light duty is defined usually as food processing, agricultural harvesting, package handling, etc. It uses belts that are generally under 7mm in thickness. Belts are usually either rubber plied, PVC solid woven, or the new type of oriented nylon belts from Europe.

On the other hand, the heavy duty belt market is defined as mining applications, construction, aggregate processing, grain handling, ship loading, etc. Belts used in these industries are either rubber plied, solid woven PVC, or steel cord rubber for high tension. The plies range from 1 ply up to as many as 5 or 6 plies, and up to 30 - 35 mm in thickness.

The common types of fasteners used in light duty are:

Slides of Alligator lacing, wire hooks, staple, plastic fasteners, etc. Describe advantages and limitations of each

The common types of fasteners used in heavy duty are:

Slides of Flexco solid plate, hinged Flexco, SR and BR, and F series. Describe advantages and limitations of each

Important Considerations When Fasteners Are Used

Proper selection is vital in order to gain the maximum benefit available from a mechanical belt fastener. It is important to be sure that the fastener style that is chosen is appropriate for the mechanical strength of the belt. Also, the installer must pay attention to the belt thickness and the recommended minimum pulley diameter of the fastener. Also, ensure that the fastener installation method will be the most practical method for the application and will offer the best benefit for the installer. Fasteners are available in many alloys; make sure that you choose the proper alloy that will give the best service life. If a hinged splice is to be used, choose the pin that is most suitable for the application.

Finally, it is paramount to remember proper installation. Fasteners are designed to be installed by anyone, with no need for special skills. However, care needs to be taken to ensure that the fasteners are installed correctly. It is very important that the belt be properly squared and cut with a belt cutter before fastener installation.

Show slides of squaring the belt and 820 cutter.

A belt that has been squared properly off a center line, rather than the edge of the belt, will track straighter and run longer. There is a danger in squaring off the edge of the belt, due to the fact that most belt edges are edge worn, which means that it will be impossible to get a square cut in this case. Additionally, an improperly squared belt means that the tension is not distributed evenly across the splice, which means that the splice will usually not last as long as one installed correctly.

Show slide of FSK tool

If the splice will not be countersunk, ensure that the bolt heads and/or rivets are peened down properly. It is important to do this in order for the splice to work well with other conveyor components.

The proper installation of any type of a mechanical belt splice, regardless of the brand or design, is important to maximize productivity and reduce maintenance costs. I recommend that the installer thoroughly investigate and follow the manufactures recommendations. If there are any doubts as to the answers to any questions about the proper and safe use of mechanical splices, consult with the belt fastener manufacturers. The fastener manufacturers are good resources and are waiting to help you solve your belt maintenance problems.

## Conclusion

While there have been many improvements over the years in conveyor and conveyor component design, it is important to note that most industrial and mining operations operate with substantially fewer people in maintenance capacities. In order to gain the benefits that conveyors offer for increased production, it is vital that the conveyor system be properly maintained. Mechanical belt fasteners are part of the total conveyor system and will perform to their maximum potential only when the total system is properly maintained. Issues such as housekeeping (ensuring that fugitive material does not bury the conveyor) maintaining trough and return idlers, proper material loading, etc. all affect the conveyor ability to operate to its ultimate potential.

## References

*Flexco - Mechanical Belt Fastening - A Brief History*