



LOW MAINTENANCE - HIGH EFFICIENCY ROLLER CHAIN REPLACEMENT

ABSTRACT:

The traditional method of power transmission in the pulp and paper industry has been roller chain drives. This paper acknowledges the applications where roller chain drives continue to be the best alternative, identifies the six key problems associated with this type of drive, and analyzes the feature and benefits of Poly Chain® GT® belts as a positive alternative. It is concluded that while synchronous belts will not replace all chain applications, they are the most cost efficient form of power transmission in the industry.

1. 0 INTRODUCTION:

The chain drive is one of the oldest forms of power transmission known to man. There is evidence of chain driven water lifts as early as 225 B.C.. Leonardo da Vinci's sixteenth century sketches of a chain drive bore a strong resemblance to the modern silent chain. Real advancements in the use of chain drives in power transmission applications, however, began in earnest during the late 1800's. The cast iron detachable chain was developed. This was quickly followed by cast pintle chain, which was the forerunner of chain as we know it today.

The beginning of the twentieth century saw the expansion of chain into such applications as bicycle and automobile drives. They were both used for transmitting power to the drive axle and for synchronizing cam shafts. Industrial applications soon followed; by 1913 the roller chain industry was one of the first industries in the world to publish user standards.

The chain, the heart of all types of chain drives, comes in many variations. A wide range of accuracy's exist, extending from "precision" to "non precision". Some of the more popular types of power transmission chains are: roller chain - single or multiple strand, silent chain, HV chain, detachable chain and duplex chain. Chain applications can be grouped into two basic categories: power transmission and material handling. Our discussion will relate to power transmission application and in particular, the inherent weaknesses of chain drives under certain conditions. Particular attention will be paid to paper mill applications. The popularity of chain drives today stems from the ability of these drives to transmit high torque, at relatively low cost, while utilizing readily available stock components. Furthermore, it was until recently the only practical method of creating low speed, high torque applications which would work over a wide range of ratios with virtually unlimited centre distances.

Due to the lack of any other practical alternative, maintenance departments in today's mills have used chain drives for years and are very comfortable with the product. This reflex reaction has its down side though. Occasionally one will find chain drives on applications that are really beyond its capabilities. In addition, chain drives have inherent weaknesses - weaknesses which we have accepted for lack of any other alternative. Let us examine these weaknesses and then look at a very practical alternative.

2.0 WEAKNESS OF CHAIN DRIVES



A roller chain drive today is not really much different than it was 50 years ago. Sure, there have been slight re-rates to give higher capacities, and gains have been seen in increased operating life, greater reliability, and reduced maintenance. But these are the sort of things you might expect from a mature technology.

The real issue or problem associated with chain drives has not been dealt with. Chain drives are still a high maintenance drive system. This is something Mill Maintenance Departments have lived with from day one, and it is an accepted fact of life. Let's take a look at the six key reasons for the high maintenance associated with chain drives.

2.1 STRETCH

Chain drives require tensioning on a regular basis. Industry standards recommend chain replacement when the chain has "stretched" by approximately 3%. When the chain has "stretched" 3%, it is heavily worn. All the components of the chain: rollers, pins and bushings, have lost their case hardened surface, and failure is imminent. In every day terms, what does 3% "stretch" mean to you? It means that your maintenance crew will have to adjust the chain tension several times over the life of the drive. To be more specific, let's assume we have a chain drive 254 cm (100 inches) long. Over the life of the drive we will have to "take up" about 3.81 cm (1.5 inches) of centre distance which equates to 7.62 cm (3 inches) of apparent chain stretch.

2.2 LUBRICATION:

Lubrication is absolutely essential if one wishes to have reasonable chain and sprocket life expectancy. But here again, there is substantial maintenance cost involved with chain drives. When you select a chain drive for an application in your mill, the method of lubrication is every bit as important as any other drive design factors being considered.

Proper lubrication reduces the wear on all moving surfaces of the chain, and helps cushion the drive from the impact of shock loads. The loads and speeds under which the chain drive operates determine the lubrication system required. The higher the speed, the more sophisticated and costly the lubrication system. On high speed drives it is not uncommon to see the lubrication system costing considerably more than any other components. Even without a sophisticated lubrication system, it is essential that chain drives be enclosed in many areas of a mill, as contamination of the finished product by the lubricant can be a costly problem. For this reason, some mills choose not to lubricate certain chain drive applications, even though the chain industry estimates the unlubricated chain will wear up to 300 times faster than one properly lubricated.

2.3 SPEED & RATIO LIMITATIONS:

Roller chain is predominantly used for low speed, high torque applications. Capacity starts to decline between 610 to 914 meters/minute (2,000 to 3,000 feet per minute). For higher speed applications silent chain and HV chain are used. Silent chain capacity will peak about 1524 m/min. (5,000 FPM), while HV chain has a peak of approximately 1981 m/min. (6,500 RPM). As we all know, there is a price to pay for this higher speed. Silent chain drives will be 4 to 5 times more costly than roller chain, and HV is 30 to 35% more expensive than silent chain. In addition, both require sophisticated lubrication systems as well as proper chain cases, seals etc.. Another problem arises in the servicing of these drives. Because there are so many variations of silent chains, some with centre guides, double



centre guides, side guides, or various combinations of all of the above, the sprockets for silent chain are very rarely stock items. As we all know, made to order products are very costly and have long lead times. All of this makes these drives rather undesirable, unless there are no other options.

2.4 CHORDAL ACTION

Another major problem with roller chain drives is the variation in speed or surging caused by the acceleration and deceleration of the chain as it goes around the sprocket link by link. This variation of speed is called "Chordal Action" or "Pitch Line Rise and Fall". It starts as soon as the pitch line of the chain contacts the first tooth of the sprocket. This contact occurs at a point below the pitch circle of the sprocket. As the sprocket rotates, the chain is raised up to the pitch circle and is then dropped down again as sprocket rotation continues. Because of the fixed pitch length, the pitch line of the link cuts across the chord between two pitch points on the sprocket, remaining in this position relative to the sprocket until the link exits the sprocket. This rising and falling of the pitch line is what causes chordal effect or speed variation.

Chordal action is inversely proportionate to the number of teeth on the sprocket. Drive configurations which have 25 or more teeth on the sprocket exhibit minimal chordal action - about 1/2 of 1% in the variation of the speed of the chain. However, as the number of teeth in the sprocket decline, the variation in the chain speed increases dramatically.

Using a 17 tooth sprocket, the speed variation is about 1.5%. A 10 tooth sprocket produces a variation of about 5%. This pitch line rising and falling which results in speed variation at low speed, will produce vibration as the chain speed is increased. To further compound the problem, this chordal effect will be transmitted through the entire drive system, affecting the chain, the sprockets and bearings and seals, as well as the driven component. A perfect example is the concern for roll grinders.

2.5 SHOCK LOADING & BACKLASH

Chain drives do not handle shock loading well. This is not a major issue in pulp mills as it is in other areas of the forest industry. Shock loading can cause substantial damage to all components of the chain. Further adding to the destruction of the chain caused by shock loading, is backlash. As the chain and sprockets wear the combined impact of shock loading and backlash will result in higher maintenance. This problem becomes even more complex because, contrary to manufacturers recommendations to replace sprockets when replacing chain, few maintenance departments do replace the sprockets until they are noticeably worn. This will dramatically shorten the life of the replacement chain.

2.6 COST OF MAINTAINING

While initial costs of roller chain drives can be quite low, the cost of maintaining these drives can be substantial. Labor costs are a major portion of maintenance department budgets. With chain drives little can be done to reduce this component of ones budget. In order to keep equipment running, it is absolutely essential that the maintenance crew be on the floor - lubricating and tensioning chain drives on a regular basis. In addition, there is a further cost - the associated down time in a paper mill for this "regular" maintenance. In other words, reduced productivity. This



cost can be in excess of thousands of dollars per hour. A much more significant cost than the actual maintenance costs themselves.

The high costs of maintaining chain drives are widely accepted.

They are accepted only because this has always been the case with chain drives. One is reminded of the famous conversation where one asks "Why?" and the response "Because, it's always been like that", flows without any second thought.

3.0 AN ALTERNATIVE TO CHAIN DRIVES:

Unlike the past however, alternatives do exist today. The answer is an offshoot of the traditional timing belt. The engineers who developed the original timing belt, which was a light duty rubber synchronous belt for the sewing machine industry, had no idea that their original concept would someday have the capacity to meet and exceed the ratings for chain drives as well as heavy duty V-belts.

The trade name of this product is Poly Chain® GT®. Substantial development has occurred in synchronous belt design since the 1940's. We can describe each evolution as being a new generation - Poly Chain GT belts being the third generation of synchronous belts. Much of this development has been centered on displacing the chain drive. While the original timing belt could not handle the torque at slow RPMs, the second generation belt, know as HTD, was initially directed in the 1970's at the chain market. It was soon found that it was not a practical alternative in most low speed high torque chain applications. You ended up with a belt that was 4 to 5 times wider than the chain, and significantly more costly. It took another 15 years for the materials and technology to evolve to a stage where they could compete with chain drives - the Poly Chain GT belt is the first of this new generation of synchronous belts.

The curvilinear tooth profile of Poly Chain GT belts was developed on the basis of the Tratrix Mathematical Function, which is recognized as a "frictionless" system in the world of Gear Design. This results in minimal meshing interference, while decreasing backlash by 45 to 50% when compared to HTD, and an even more substantial increase over roller chain. The polyurethane compounds, combined with aramid fiber tensile cords, merge to provide a truly suitable replacement to many problem chain drives in your mills. This new technology allows us to exceed roller chain capacities while maintaining the same dimensional characteristics. The cost of Poly Chain GT is still 2 to 3 times higher than many roller chain drives, but will provide up to 5 times longer life. This is the kind of return on investment today's successful mill operations are striving to achieve. While the initial cost of Poly Chain GT is higher than roller chain, this is not the case when comparing to silent chain applications. Here Poly Chain GT drives will be as much as 40 to 60% lower in price than comparable silent chain drives. Additionally, Poly Chain GT in the vast majority of conversions is an off the shelf item, compared to the lengthy lead times associated with made to order silent chain components.

3.1 COST BENEFITS OF NON CHAIN DRIVES:

Replacing chain drives with Poly Chain GT will provide many hidden benefits to mill maintenance departments, both in the reduction of maintenance costs, as well as time. And as we all know, time is money.



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For instance, the need to tension the drive on a regular basis is virtually eliminated. As previously mentioned, the 254 cm (100 inch) chain required about 3.81 cm (1.5 inches) of centre distance takeup, while the takeup required for a similar length Poly Chain GT belt required 1.016 mm (0.04 inches).

Maintenance departments are advising us of applications running for over a year, without having to make any adjustments on the belt. With the opportunity to reduce labor and down time from several times a year to less than once, the payback can be dramatic.

Poly Chain GT belts will work well over a wide speed range. From the slowest speeds associated with roller chain, to the high speed applications common to silent chain and V-belt drives. It does this without the need of lubrication and/or expensive lubrication systems. The savings in lubricant and lubrications systems, as well as the ongoing problems associated with leaking seals and contaminated finished product will result in a sizable annual saving.

The speed limitations of the stock Poly Chain GT belt product line is 981 M/Min (6500 FPM). This is the limit for the cast iron sprockets. However with made to order sprockets, speeds as high as 3048 - 3658 M/Min (10 -12,000 RPM) can be achieved with stock belts. Stock ratios available with off the shelf components go as high as 10:1.

Having a constant angular velocity, Poly Chain GT belt drives are much smoother running than roller chain. The result is the elimination of speed variation and vibration as the pitch line of the belt moves around the sprocket relative to the pitch line of the sprocket. This single benefit will improve the performance of bearings and seals, as well as all associated equipment. In addition, it will eliminate the transfer of related shock and vibration to the finished product.

Shock loading is handled exceptionally well with Poly Chain GT belts as it is manufactured in a one piece construction, without an assortment of pins, rollers and bushings common to every link of a chain drive.

What becomes increasingly noticeable when comparing Poly Chain GT belts to roller chain is the fact that maintenance is virtually eliminated with this new technology. By replacing chain drives, Poly Chain GT belts will provide a payback of less than a year in most cases.

4.0 CONCLUSIONS:

Poly Chain GT belt is certainly a viable alternative to both roller chain and silent chain drives in most cases. To suggest that Poly Chain GT belts can replace all chain drives, would be a foolish statement.

There is now, and always will be, a very large market for chain drives. For example - there are areas in mills subject to extreme heat where chain is the only solution, as well as applications with maximum centre distances that would be physically impossible to do with belting. Or if a chain drive is lasting in excess of 12 to 18 months or longer, why change it?

Poly Chain GT belts as we know them today will eventually replace about 15% - 20% of chain applications. Not that chain drives can't do the job, but because the benefits of Poly Chain GT belts provide a higher return on investment.



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