Tech-Notes

Technical Notes from the Technical Committee, NIBA – The Belting Association

#7   MINIMUM   BELT   TENSION

WHAT IS PROPER MINIMUM BELT TENSION?

Proper minimum belt tension is the tension required so that a given belt conveyor or belt elevator system will operate properly in its environment.

This means minimum belt tension is great enough so that the belt conforms to the crown on any crowned pulley or pulleys. After all, how can the crown do its job if the belt is not in contact with it? **It also means** that minimum belt tension is great enough so that the **belt does not slip** relative to the drive pulley under the most demanding conditions which can be expected.

HOW CAN I ACHIEVE PROPER MINIMUM BELT TENSION?

Start by shutting off the conveyor and tensioning the belt until there is no "play" between the edge of the belt and the crowned pulley. Push (with your finger) against the belt to find out if there is any play. If more than one pulley has a crown, check the edge of the belt on each of the pulleys. If there is any play, tighten the belt until play is eliminated. At this point, you are very close to a proper minimum tension, as the belt is conforming to the crown on the pulley (or pulleys) and, therefore, will respond to them.

Now operate the belt conveyor or belt elevator system under the most adverse conditions it will encounter, and observe closely to see if there is any slippage between the drive pulley and the belt. If there is, **more tension is required.**

SUPPOSING ONE OR MORE OF THE BEARINGS OR PULLEY SHAFTS FAIL?

Simply replace them. Either they have failed or the system was improperly designed or built.

HOW CAN I TELL HOW TIGHT THE BELT REALLY IS?

Trying to determine belt tension by subjective evaluation is extremely difficult. Even the most experienced development and maintenance engineers can not do it, except by accident. If you feel you really need to know the exact tension of your belt, use the belt as a stress/strain gauge. Start with the belt in a totally relaxed condition. Draw a line perpendicular to the belt center line; then draw another, perpendicular to the belt center line, exactly 100" away. At this point, you should contact your belt manufacturer. He will be happy to tell you the stress/strain characteristics of the specific belt you are working with.

Suppose now, you are working with a given belt and Sales/Service has told you that the belt will stretch 1% at full rated load. You then go through the above procedure so as to arrive at proper minimum belt tension. Now that you are satisfied that you will not encounter any slippage at worst conditions, stop the conveyor and measure the two base lines again. You will find that your 100" dimension has grown. If it has grown to perhaps 100.25" this means the belt has been stretched .25% which is 1/4 of the 1% figure given you by Sales/Service. (Since we are operating so low on the stress/strain curve, we can assume a straight line relationship and be fairly accurate.)

Therefore, .25% means that you have achieved 1/4 of the rated belt tension. Careful: you will notice that your two lines are no longer parallel to one another. They will assume a "parenthesis-like" shape, reflecting the kind of pulley crown or crowns employed in the system. If positive crowns are used, you will note that the center of the belt has been stretched a good bit more than the edges of the belt. To arrive at an **average** belt tension, you need to **choose** the points at which you make your measurement.

At this point, you have determined average **"belt at rest"** tension. **This is not identical to "slack side" tension** -- it is usually greater.

IS THIS ALL THERE IS TO PROPERLY TENSIONING A CONVEYOR OR ELEVATOR BELT?

Essentially, all you have to do is make sure the belt is **conforming to the crowns** on the pulleys and that you have tensioned the belt until **slippage stops** under the most adverse conditions this system will experience.

The force required to drive a belt conveyor or belt elevator usually is transmitted from the drive pulley to the belt by means of friction between the pulley surface and the belt surface. The force required to restrain a down-hill regenerative conveyor is transmitted in exactly the same manner. In order to transmit the right amount of power to drive the conveyor or elevator system at rated speed and under **full load**, there will be a difference in the tension in the belt as it approaches and leaves the drive pulley. This difference in tension is supplied by the driving power source and is known as effective tension (TE).

For convenience of discussion, let us call the **tight side** tension at the pulley T_1, and the **slack side** tension at the pulley T_2. Therefore: TE = TO - TS.

It can be shown that the slack side tension, T_2, is equal to kT_e where this so-called "k" factor is equal to the following expression:

$$k = \frac{1}{e^{f\Theta} - 1} \qquad (e = \text{base of naperian logarithm} = 2.718)$$

(When computing belt tensions, you would typically refer to a "k" factor table such as can be found in most major belting product line brochures.) To determine the "k" factor, you would need to know the following:

a. Belt wrap at drive
b. Bare steel pulley or lagged pulley, and
c. "Screw" take-up or "gravity" take-up.

The 'k' factor, as can be seen from the expression

$$k = \frac{1}{e^{f\Theta} - 1}$$

is dependent upon the coefficient of friction (f) between the pulley surface and the belt surface and the wrap (Θ) of the belt around the pulley with Θ measured in radians.

With the conveyor/elevator system designed and built, the installation or maintenance man is faced with the problem of making the entire system function correctly. Essentially, the only variables over which he has some control are the coefficient of friction and belt tension. He can "control" coefficient of friction by making sure that the pulley face or pulley lagging and the belt surface are both clean. If a contaminant is introduced between those surfaces, the belt can slip relative to the drive pulley unless they are cleaned or belt tension is increased.

DO I EVER HAVE TO RE-TENSION THE BELT?

Possibly. When you originally tensioned the belt, you were working with a clean belt and clean pulley lagging. This gave you a relative coefficient of friction such that, when coupled with the minimum belt tension you provided, any tendency to slip was overcome. Now, however, if a contaminant has been interjected between the conveyor belt surface and the pulley lagging or pulley surface, that relative coefficient of friction may change. Should this occur, it is important that you clean both surfaces in order to re-establish the original relative coefficient of friction. If, on the other hand, it is impractical to do this because of environmental factors, you may need to compensate with increased tension.

Further, you will encounter **belt stretch**. Know what to expect and how to handle it.

WHAT CAN I DO ABOUT BELT STRETCH?

Discuss your specific belt with your belting manufacturer. He is knowledgeable and will be able to tell you what you can expect. If the particular belt you are working with has a polyester warp system, you can expect to achieve maximum stretch within the first **24 hours that the belt is operating under full load**. At this point, the belt will usually stabilize. Make your final installation tension adjustment and any tracking adjustments indicated.

Maintenance, from this point forward, will usually be minimal. Although "good maintenance practices" dictate frequent, periodic inspections.

If, on the other hand, your belt construction employs a nylon or a cotton warp system (lengthwise yarns), you will encounter two to three times as much stretch in that first 24 hour period (and even more). You should now re-tension the belt as above.

Unfortunately, however, nylon will creep. Cotton and nylon will absorb and/or lose moisture and **change dimension**. This means that they will not stabilize after the initial 24 hour "break-in" period, but will continue to stretch and/or contract. Accordingly, belt retensioning must be a routine maintenance procedure in these cases.

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