BELTCON 1997

INTRODUCTION

This paper attempts to clarify the considerations to be taken into account when designing a conveyor with an automatic winch take-up / tensioning system.

Over the years enormous improvements in conveyor design have simplified the requirements of the take-up system resulting in a lack of development in winch take-up technology.

No startling revelations will be made but situations have changed sufficiently for note to be taken as costs do come into the equation as simpler winch systems are now able to handle the starting requirements.

THE FUTURE OF FIXED SPEED TAKE-UP WINCHES IS BRIGHT

Traditionally there are four basic methods used to control the tensions in a conveyor belt and to overcome the problems encountered during starting and running. Namely :

1) LOCKED take-up's , using mechanical means like screw take up or hand winches to apply a fixed force to the belt prior to start up. This creates a condition with high tensions in the stationery belt and lower tensions during running as no adjustment is made for the belt stretch caused by the power on the belt. This is a practical system for short belts only.

2) GRAVITY take-up's , using large mass counter weights to apply a constant tensioning force to the belt at all times . The size of the mass is generally a compromise between ideal running tension and best starting tension which means higher than necessary tensions in the running belt . This can be overcome by using a pair of gravity masses, connected by means of a flexible connection. During start up the upper mass and the lower mass are used, whereas during normal running the pair of masses are lowered until the lower mass rests on the ground. These systems are extensively used in surface installations but have problems with space and height when installed underground.

3) AUTOMATIC WINCH take-up's which use tension sensing devices. These systems continuously monitor belt tension and operate the winch to control the belt to the preset starting and running levels. In order to adjust without hunting back and forth these winches must have a slow rope take-up speed even though it may cause problems during start up as they generally will not be able to handle the slack belt coming through from the drives. The starting tension levels are set considerably higher than the running levels to assist in accommodating the rapid rate of belt stretch.

4) SLIP-DRIVE take-up's using fast winches with tension and or winch torque sensing devices to adjust to ideal belt tensions. There are two methods employed in this type of take-up, mechanical and electrical. The mechanical methods using hydraulics , pneumatics or slip clutches generally have high maintenance costs, while the electrical units using continuously slipping eddy current couplings would appear to have high running costs. The eddy current coupling winches possibly provide the closest simulation of gravity .

That background highlights some of the problems in take-up areas and we can now look specifically at slow fixed speed winches.

The future of fixed speed take-up winches for tensioning long conveyor belts in the bulk conveying industry improves with every advance made in the starting techniques used for the modern long, high speed conveyor belts as found in our coal mines.

First a bit about winch take-up philosophy
It must always be remembered that belt tensions change slowly as it takes time for the belt tension to dissipate through the length of the belt. The best analogy which can be applied to this is the pouring of water into one end of a long trough to raise the level. It takes time for the raised level to move through the length of a trough and settle at the new height. If the water is poured slowly there is little or no disturbance and the new level is attained as quickly as possible. Pouring the water quickly creates waves which move up and down and until these have settled the new level cannot be measured.
The starting and acceleration of long conveyor belts has been the subject of enormous discussion, research and development over the last decade. The improvements in drive technology have dramatically changed the requirements and simplified the problems encountered in maintaining proper tension during starting and running. The biggest factor here is that they have extended the acceleration time period and in so doing reduced the rate of belt stretch to a level which can be accommodated by a slow winch, even though the same sources of high dynamic loads still exist. These are, 1) high starting torque's, 2) long take-up loops, and 3) rapid belt deceleration.
High starting torque's have been reasonably well controlled by the delay fill type fluid couplings but still cannot differentiate between full belts and empty belts with the result that empty belts are still accelerated too quickly with the consequent dynamic disturbance.
The use of variable frequency AC drives brings a new and precisely controlled belt acceleration curve into focus as it is now possible to program an exact acceleration curve for the belt which will apply whether the belt is full or empty. The ideal curve being a sinusoidal curve with half speed at half time. (fig 1)Take-up technology and performance could become a more exact science with AC variable drives to accelerate the belt at precisely determined rates. Currently on site tuning is carried out and this is based mainly on past experiences and assumptions.

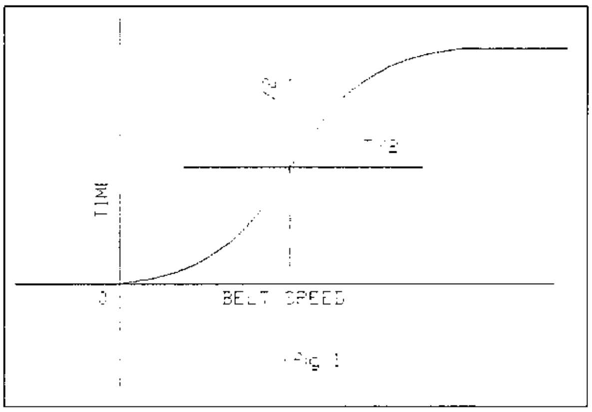
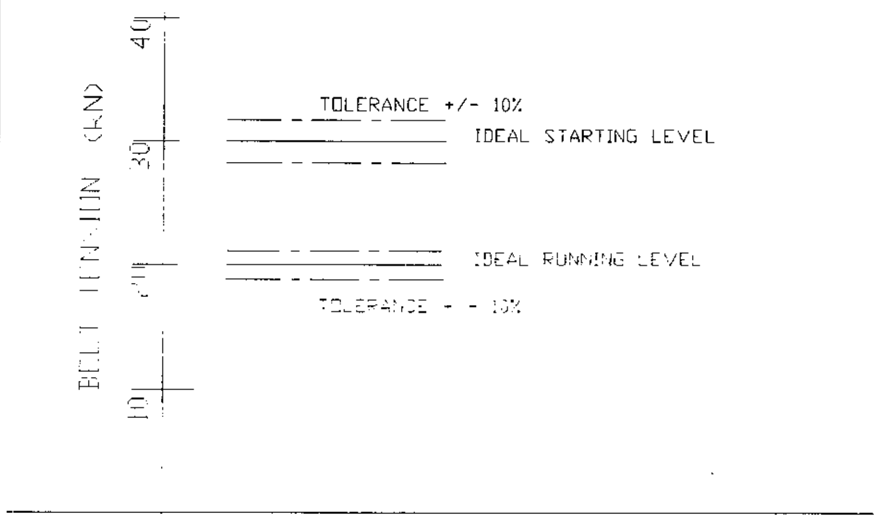


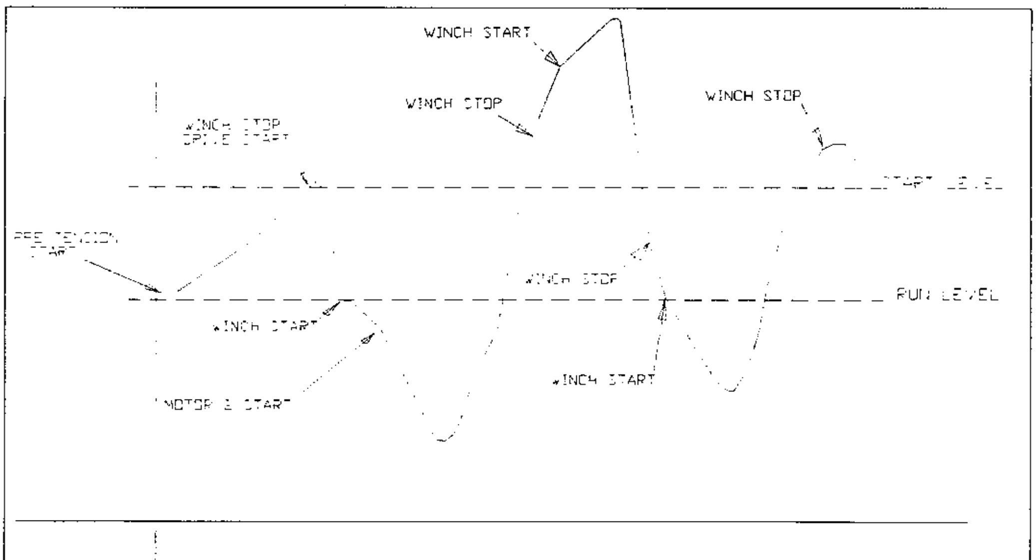
Fig 1

Long take-up loops in the pre tensioning system cause problems during starting and stopping due to the inrush of belting into the return of the conveyor, however fixed or slow winch pre-tensioning behind the drives can help prevent the inrush of extra belting towards the tail of the conveyor.
High deceleration is a problem to which new solutions are still being sought but could be assisted by using winches with overload slip devices to bypass the fail safe brake on the winch systems and allow belt to be pulled back into the conveyor system at a pre determined force.

As winches and their control systems are slow to react, an initial tension or pre start tension (fig 2) is required before starting the belt. This will help absorb some of the initial and dramatic (fig 3) loss in belt tension as the power is applied from causing belt slip. The pre-start tension is higher than the running level and is required to take care of the initial belt stretch and the higher torque encountered during belt acceleration. When the belt is up to speed the system must adjust to the ideal running tension which is required to maintain the smooth running of the belt. This is usually the lowest possible tension for minimum stress levels while still insuring that no belt slip is allowed during normal running .



(fig 2)



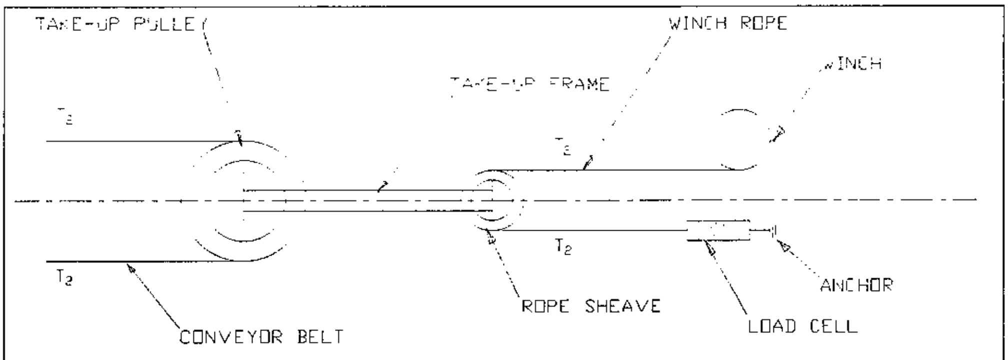
(fig 3)

TYPICAL EVENTS EXPECTED FROM WINCH & BELT DURING START

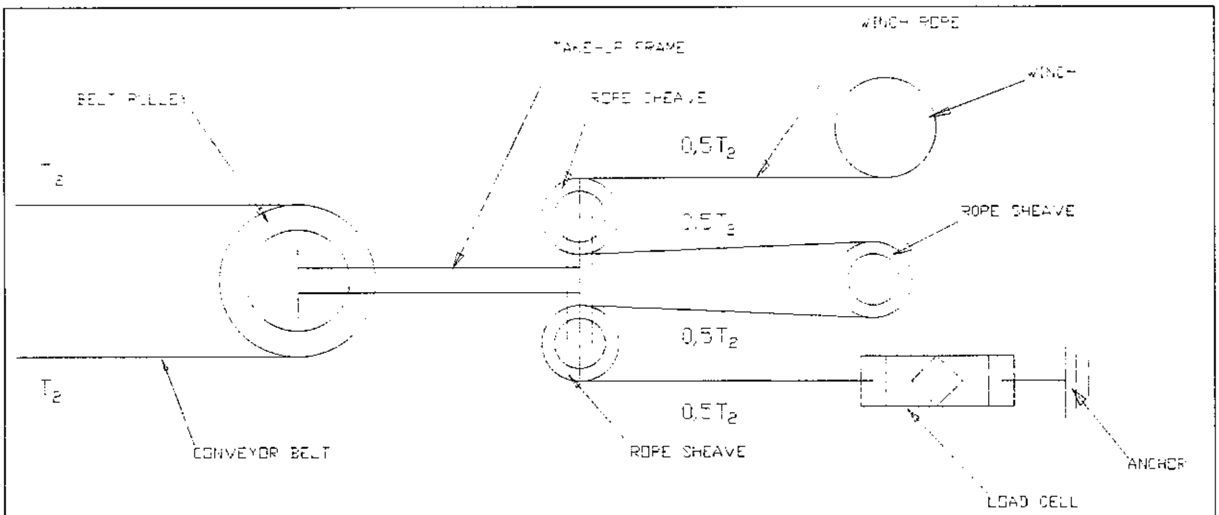
During belt start and acceleration the winch should react to all tension changes and take in and pay out as necessary. This must be done as quickly after the event as possible even though the winch reactions are very slow and late in relation to the events in the belt. These reactions must include paying out to over tension measurement as this prevents the belt from reaching higher tension levels than necessary. This payout helps reduce the intensity of the dynamic forces created in the belt during acceleration.

Pre start tensions are generally set between 140 % and 180 % of running tension. These levels are normally determined from observations during commissioning.

All winch style belt take-ups use either mechanical or electronic tension sensing in the winch rope system. This is normally done at the dead end of the rope (fig. 4 & 5) which is brought back to a fixed & stationary point by using two or four falls of rope. This also obviates the need for any cable carrying catenary`s.
By using an equal number of falls of rope to laps of belt rope tension can equal belt tension but this is not a requirement. For very short belts extremely low take-up speeds are required to stop hunting. This is very easily obtained by using extra falls of rope as shown in fig. 5. This not only decreases the speed it also increases the pulling power which means that a smaller winch may be used.



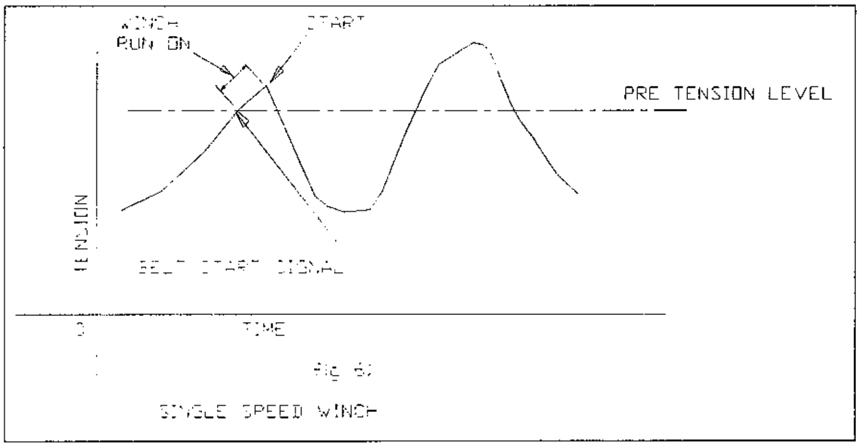
(fig 4)

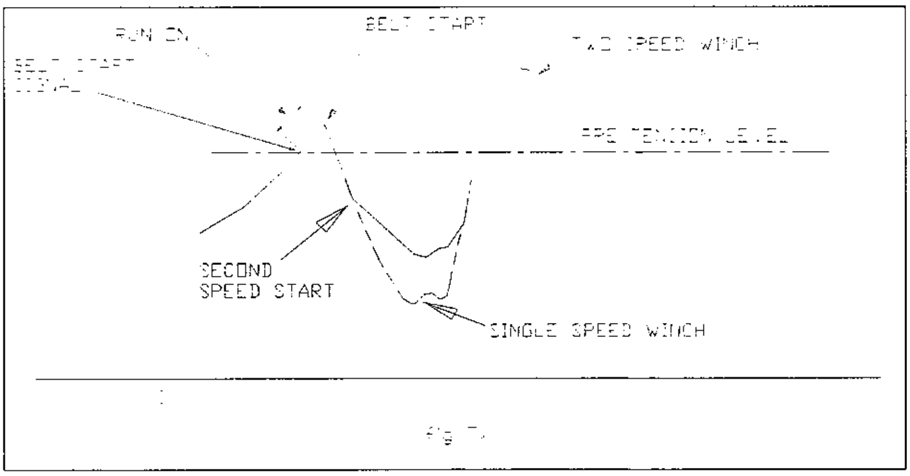


(fig 5)

Mechanical tension sensing has a very limited range and is generally not considered an option particularly as the two set point method which is used with mechanical dynamometers causes hunting in the system. This will lead to winch motor burn outs with consequent down time and maintenance costs.
Electronic tension sensing on the other hand can be adapted to suit almost any requirement or philosophy required for maintaining proper belt tension. Whilst electronic tension sensing is a continuous process reaction delays can be built into the system. This prevents the system reacting to short out of tension spikes during normal running and thus eliminates unnecessary motor starts.

In this field there are two main methods of control, one using a standard off the shelf PLC and the other using purpose built hard wired logic controllers with micro processors for the different control situations. Using a PLC has the advantage that the same PLC can be used to start the conveyor drives. The disadvantage is that the programs usually have to be proved during commissioning which creates delays in start up due to misunderstandings between the end user and the programmer. This reprogramming is normally done on site and is very time consuming. Another disadvantage of using a PLC is that the system status monitoring is not as extensive. The purpose built logic controllers however have a series of proven programs which can be switched on and off to suit the users requirement. This facility greatly shortens commissioning and start up time for a new system. Reinventing the wheel is not required.
All electro-mechanical tensioning systems react to history and start adjusting after the event has begun. As a result the reaction time of the electronics and the electrics must be as fast as possible. The only event which can be anticipated is the start and the immediate drop in tension as the drive pulleys start to rotate (fig. 6 / 7), for this reason it is imperative that the winch be allowed to run on when the pre start tension level is reached and the drive start signal is given. Alternatively it must start taking in again on the same signal that starts the conveyor drive in order to anticipate the tension drop at start.





The main advantages of automatically controlled winch take-up's are:-
1) Compact installation, which has enormous underground benefits.
2) Adaptable to any take-up length
3) Cost effective
4) Adjustable starting tensions
5) Conveyor belt status monitoring
6) Adjustable to suit various belt conditions & lengths
7) Adaptable to belt storage systems for extendible or retractable conveyors.

The main disadvantages of automatically controlled winch take-up's are:-
1) The locked up situation on power failure or power trip
2) Slow reaction to events
3) Necessity for high pretensions on start up to cater for belt stretch.

THE WINCH OF THE FUTURE

The change towards longer more complex conveyor belts is going to demand better and more reliable winches with bigger diameter drums for better rope life. This particularly as a winch or rope failure is expensive down time for a high turnover / high production conveyor. The drums should have rope rollers and other devices for preventing slack coils of rope forming on the drum when the rope and belt are slacked off for belt maintenance. Rope in horizontal winching situations is most often destroyed when rope is pulled tight over loose coils. By improving the rope diameter to drum diameter ratios and preventing slack rope on the drum damage by crushing will be minimized and this will allow lower factors of safety for the rope. Rope laying devices could also be considered but these are traditionally high maintenance devices which could reduce reliability and cause extra down time for the belt. However with some research these could be improved and would be a definite asset. The take-up winch of the future must have a reliable torque overload device which can release rope into the system on demand and not require extensive maintenance to maintain accuracy and reliability. This overload system must bypass the fail safe brakes normally fitted to take-up winches as the greatest need for rope to be rapidly paid out into the belt system is in the event of a power failure, particularly during start up when the belt tensions are at their highest. The conventional high speed overload clutch between the motor and the gearbox has a habit of disappearing in a puff of smoke when a tension spike accelerates through the gear system to the clutch position and becomes a very high maintenance item. Ideally the overload device should be on the low speed side of the winch. As brakes are often badly adjusted the use of inefficient gearing with poor back driving properties should be considered as this could help to prevent a disastrous runaway caused by brake failure. The extra cost of improved take-up winches will be minor in the overall concept.

CONCLUSION

If money is correctly spent on the starting and acceleration of conveyor belts the take-up requirements become less arduous and downtime caused by failure of the take-up system can be greatly reduced. If this is looked at in conjunction with purpose designed take-up winches and electronic sensing systems great reliability can be built into the take-up systems and the cost savings in maintenance and downtimes will be substantial.