MULTIPLE TAKE-UP CONVEYOR SYSTEMS

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SUMMARY

Increasing capabilities in the manufacturing of high strength steel cord conveyor belting is leading to longer conveying lengths. As conveyor system lengths increase, the problem of maintaining belt tensions throughout the system becomes more pronounced. One option available to conveyor system engineers is the installation of take-up systems at multiple locations along the conveyor. Take-up units perform two fundamental tasks, maintain sufficient tension at the drive to prevent slip between the belt and the drive pulley, and control tension to prevent excessive belt sag or high belt stress. Occasionally, the best location for the take-up to perform one of these tasks may not be the best location to perform the other. In such a situation, there is the option of using a separate take-up for each task. This paper examines applications suitable for multiple take-up systems and uses dynamic simulation to evaluate how this concept can improve performance and reduce capital and operating costs.

1.0 INTRODUCTION

The take-up system for a belt conveyor performs two basic functions. The first is to maintain the belt tension on the output side of the drive to ensure the drive pulley doesn't slip. The second is to set the background tension of the system to maintain the minimum allowable belt sag under all operating conditions. Is not unusual for the best location to perform these two functions to be at different locations in the system. To overcome this problem the take-up tension must be selected to cover all requirements. The result can be a high take-up tension, selected due to transient or dynamic effects which may not be encountered during normal operation. If secondary take-up units designed to handle specific conditions can be located along the conveyor a lower overall belt tension may result. A lower overall operating tension leads to lower belt rating and savings in the capital cost of the system. Lower tensions also reduce stress on the belt and support structure resulting in a more reliable system.

For an uphill conveyor system, the best place for a take-up to maintain belt sag is often at the tail of the system. This is where the lowest belt tension occurs. If the take-up is located at this position, however, there may be a long distance between the take-up and the drive. For the take-up to effectively maintain the tension on the output of side of the drive the take-up has to move the entire return strand of the belt in order to pull belt out of the drive area. For this configuration to be reliable the starting time must be very long, or the take-up needs to set to a high value to ensure the drive does not slip on starting. A better option would be to have a take-up system designed to maintain belt sag, with another system designed to prevent drive slip.

2.0 DESIGN CONSIDERATIONS

Secondary take-up units are generally not functional during normal operating conditions. The primary take-up sets the background tension for steady state operation, the secondary take-up(s) will be used to cope with a transient or dynamic effect encountered during starting or stopping, or under certain load conditions. To achieve this one of the take-up units must be selected as the primary unit and the selected take-up tensions distributed such that this unit remains dominant throughout system operation. Multiple take-ups should not be allowed to "compete" for belt.

Mechanically this is achieved by restricting the motion of the secondary take-up. For a gravity take-up this can be achieved using a mechanical stop such as a buffer or a cable. For a winch type take-up this can be achieved using the winch control mechanism. In either case, two functions must be performed. The secondary take-up must have an non-functional position where it is held stationary unless the belt tension reaches certain limits. The speed of movement of the take-up must be restricted to ensure the impact forces of the take-up coming against the limit of its travel does not cause structural damage. Figure 1 shows two methods of restricting the motion of a gravity type secondary take-up. This arrangement allows the take-up mass to drop and pull in belt if the belt tension drops below the value. The design would be such that under normal operation, the belt tension is larger than the force generated by the take-up mass and therefore the mass would rest against the mechanical stop. In this position, the take-up remains stationary providing the belt tension stays above a certain level effectively making the take-up non-operational.

It is important that the normal operating tension in the area of this type of secondary take-up are sufficiently high to pull the take-up mass back to its standby position under normal operation. If the force generated by the take-up mass is close to the belts operating tension level then the secondary take-up may try to pull belt out of the primary take-up located elsewhere in the system. In this situation the performance of the conveyor is unpredictable. Extensive steady state and dynamic analysis of the system operation is required to ensure the selected mass of the take-up is correct.

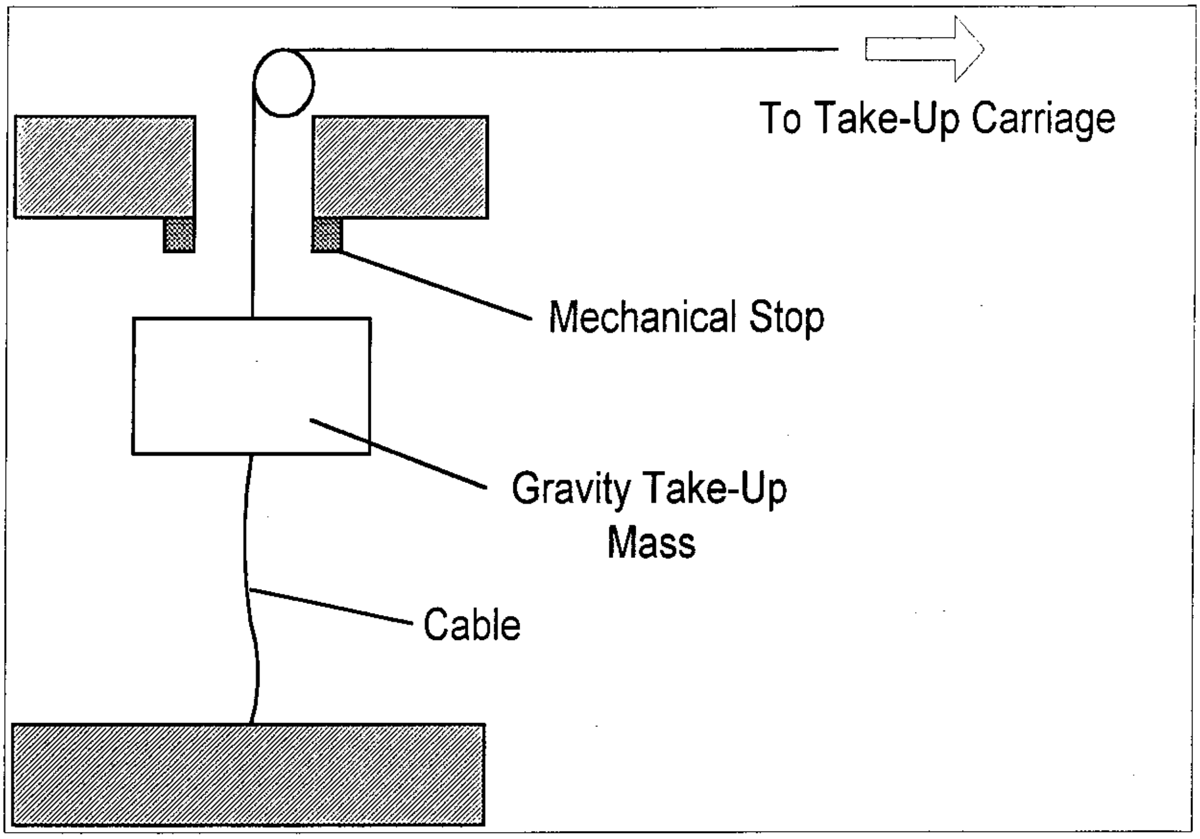


Figure 1 : Secondary Take-Up with Mechanical Stops

3.0 APPLICATIONS FOR MULTIPLE TAKE-UP SYSTEMS

A multiple take-up conveyor system is by no means a standard configuration. The conditions which combine to make a multiple take-up system a viable option consist of conveyor length, profile, operation and dynamic characteristics. A number of situations where a multiple take-up could be of benefit are outlined below.

In these cases, the main advantage of the multiple take-up arrangement is to reduce the required pretension in the belt and thereby reduce the required belt rating.

3.1 Long, Low Lift Conveyor Systems

Long, low lift conveyor systems present a specific design problem for conveyor design engineers. The low tension point on the conveyor is at the tail, this is the best location for a take-up to maintain belt sag. The distance from the head end of the conveyor means that there is a large time lag during start-up between when the belt starts moving at the head and when the belt starts moving at the tail. The possibility of drive slip under these circumstances is very high. If the take-up is located at the head, the problem with drive slip is eliminated but the take-up tension must be set very high to ensure the tension at the tail does not drop below required levels. The reason this problem is less prevalent in high lift systems is that the slope of the belt allows the return strand to move easily away from the drive during start-up. A low lift system will generate much lower tensions at the output side of the drive if a take-up is not located in this position.

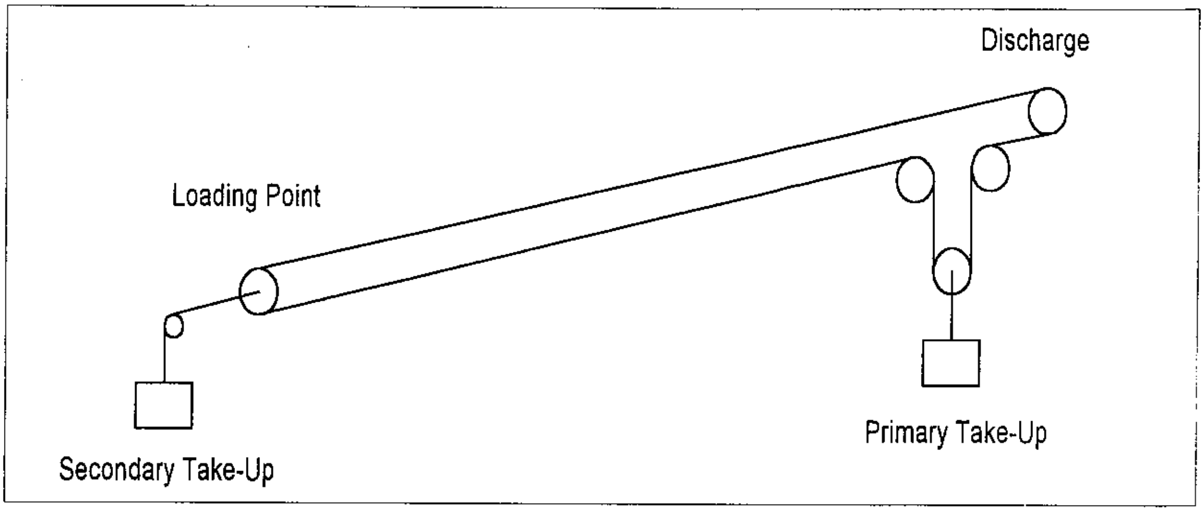


Figure 2 : Long, Low Lift Conveyor System

Figure 2 shows the layout of a long, low lift conveyor system. Figure 3 shows the running tension for this system with a single take-up unit at the head, and with a dual take-up system, primary take-up at the head and secondary take-up at the tail. In both cases the selection of the belts background tension is governed by the low tensions generated at the tail of the conveyor during a power off stop. This condition can be dealt with during a normal stop by powering down the drive over a long period of time. This minimizes the dynamic tensions at the tail.

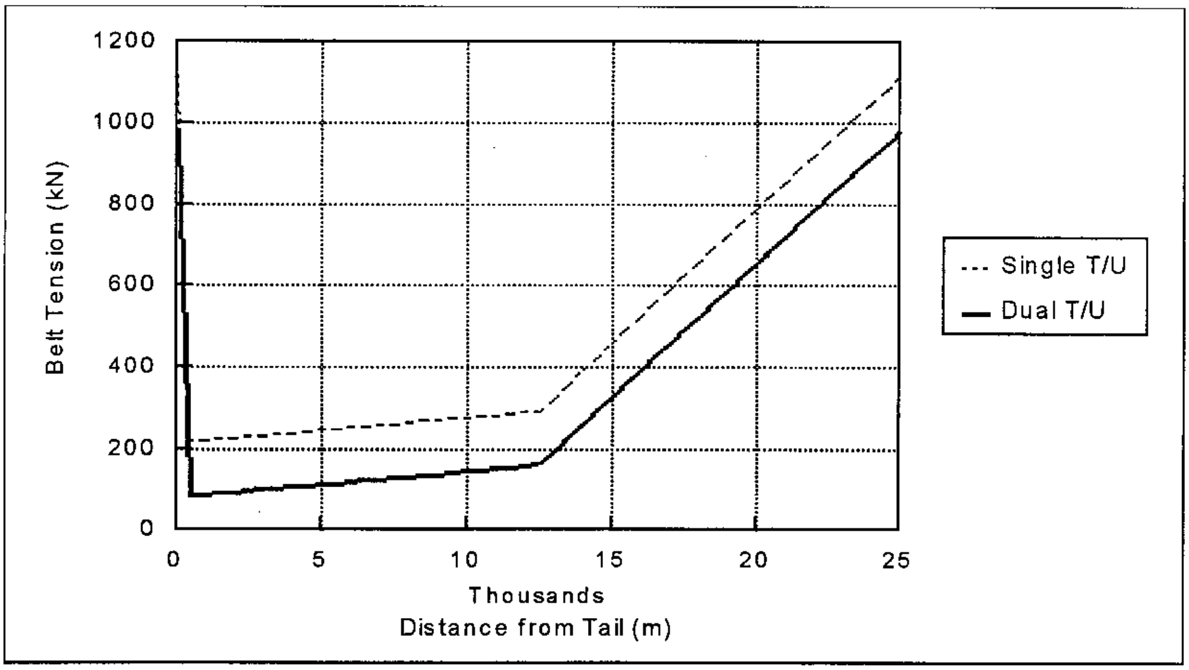


Figure 3 : Comparison of Running Tension for a Long, Low Lift Conveyor with Single and Dual Take-Ups

However, the possibility of power loss during operation must be allowed for. With the standard configuration of a single take-up unit at the head end of the conveyor the belt tension at the take-up must be set to approximately 220 kN to ensure sag limits at the tail are maintained during a power off stop.

With a secondary take-up located at the tail, the belt tension in the primary take-up can be reduced to 90 kN as the secondary take-up assists in maintaining belt tension at the tail during a power off stop. This potentially reduces the required belt rating from approximately ST6000 to ST5200. For a 15 km conveyor the resulting savings is substantial.

The dynamics during stopping of this type of system is examined in more detail in later in this paper.

3.2 DIFFICULT OVERLAND PROFILES

Conveyor installations can have specific load conditions which generate extreme tensions. Figure 4 shows an overland conveyor profile which will produce very low tensions in the valley before the drive during stopping. Typically the take-up located at the head end of the conveyor would be sized to ensure the tensions in the valley did not drop below a certain level. In this case, the result is high belt pre-tension and the associated high belt strength.

A secondary take-up located in the valley would assist in maintaining belt tension during a loaded stop. The disadvantage with this system is that it adds a transfer point. The transfer point would, however, be in-line and the reduction in the required belt strength could outweigh the extra maintenance.

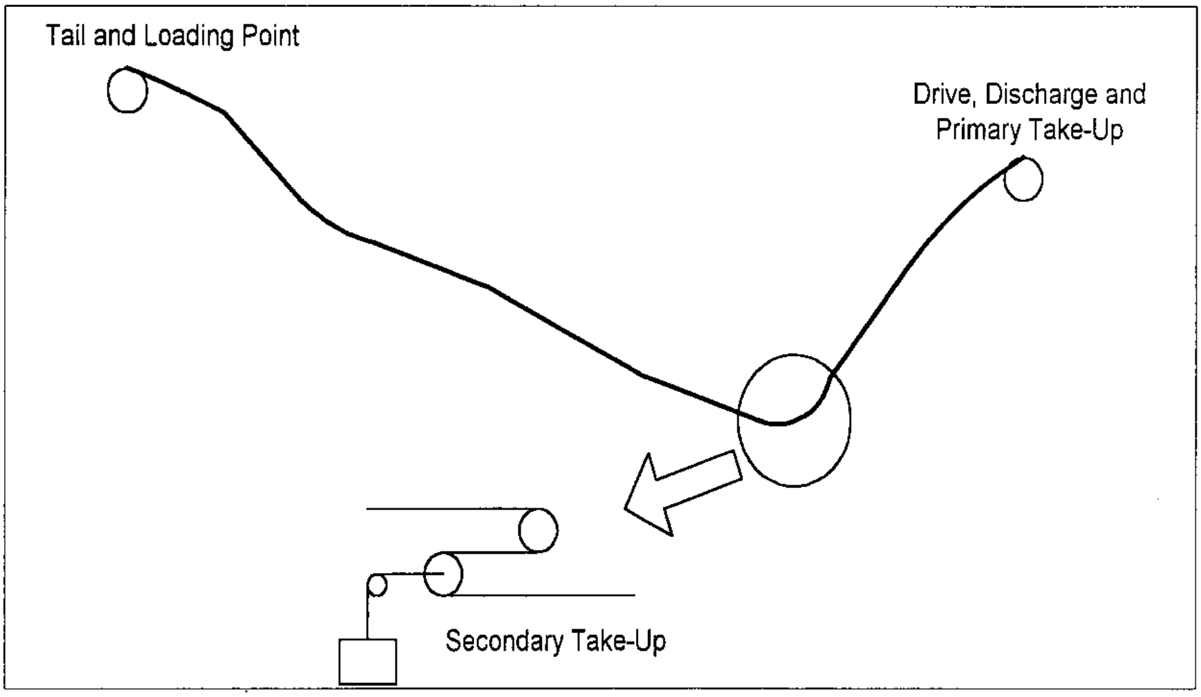


Figure 4 : Difficult Overland Profile with Possible Secondary Take-Up Location

4.0 DYNAMIC ANALYSIS OF A LONG, LOW LIFT CONVEYOR

Figure 5 shows the simulated belt tensions at the head, tail and take-up for a full load stop of the system described in Figure 2. The 220 kN belt tension in the take-up for the single take-up system is barely sufficient to keep the belt tension at the tail above 0 kN during a full load power off stop.

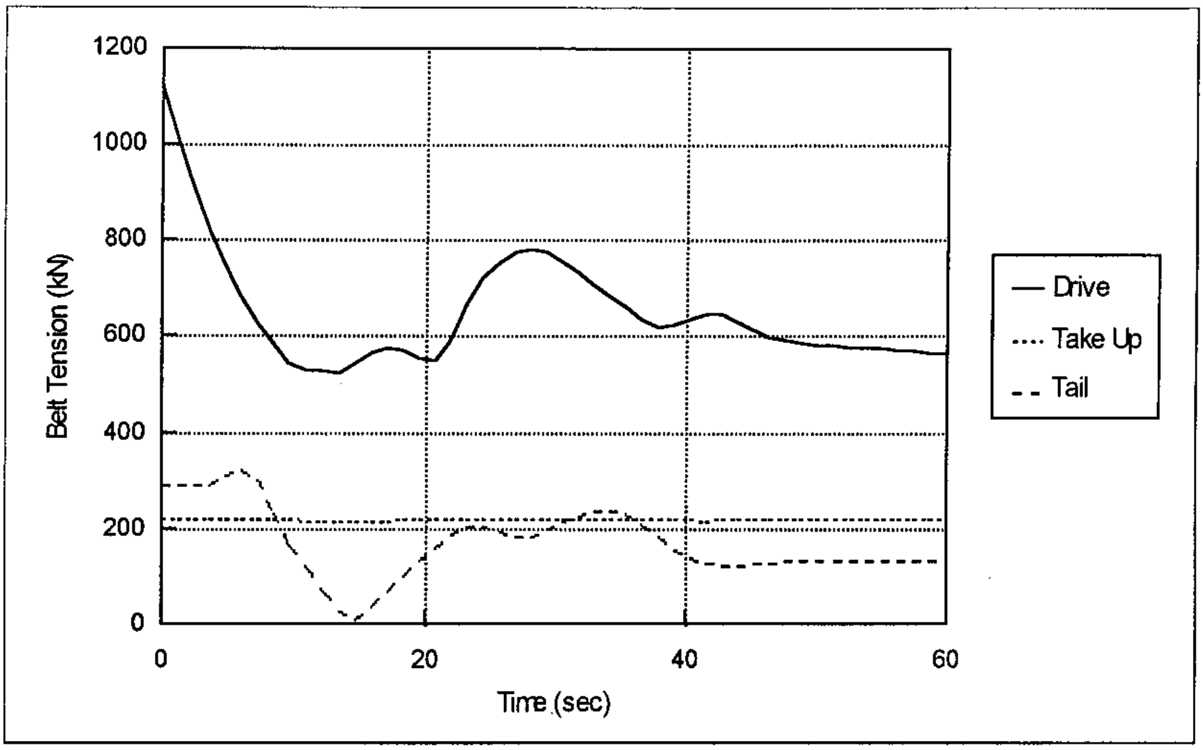


Figure 5 : Stopping Tensions for a Long, Low Lift Conveyor with Single Head End Take-Up

Figure 6 shows the same tensions for the system with a secondary take-up at the tail. The lower belt tension in the head end take-up (90 kN) would result in the belt tension at the tail dropping below 0 kN except for the operation of the secondary take-up. The secondary take-up keeps the belt tension at the tail above 15 kN, sufficient to maintain adequate belt sag limits for a power off stop.

Figure 7 shows the take-up movement with a single head end take-up. Figure 8 shows the take-up movement of the dual take-up system. The single take-up system shows the take-up at the head feeding in belt with approximately 5 m of movement. With the dual take-up system the movement of the primary take-up is similar to the single take-up system. The secondary take-up pulls in belt for approximately 15 seconds and then pays out again as the low tension wave passes the tail area. Note that the selection of take-up masses results in the secondary take-up being pulled back to its stationary or "non-operational" position as the belt approaches a stop. If the selected take-up masses are not correct, take-up movement as shown in Figure 9 could result. The movement of both take-ups is larger due to the fact that the primary take-up at the head is releasing belt into the secondary take-up. This means the selected take-up mass for the secondary take-up is too close to the belts operating tension. It is important to accurately model this type of system to ensure the take-ups interact correctly.

Figure 6 : Stopping Tensions for a Long, Low Lift Conveyor with Dual Take-Ups

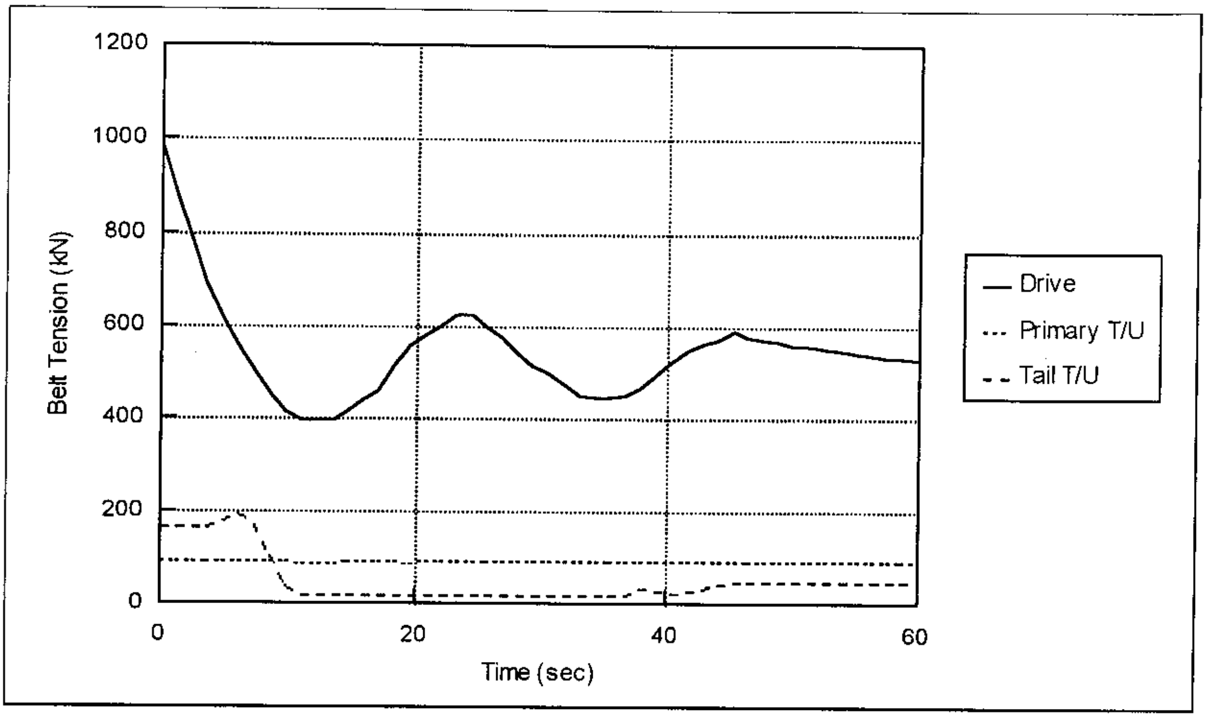
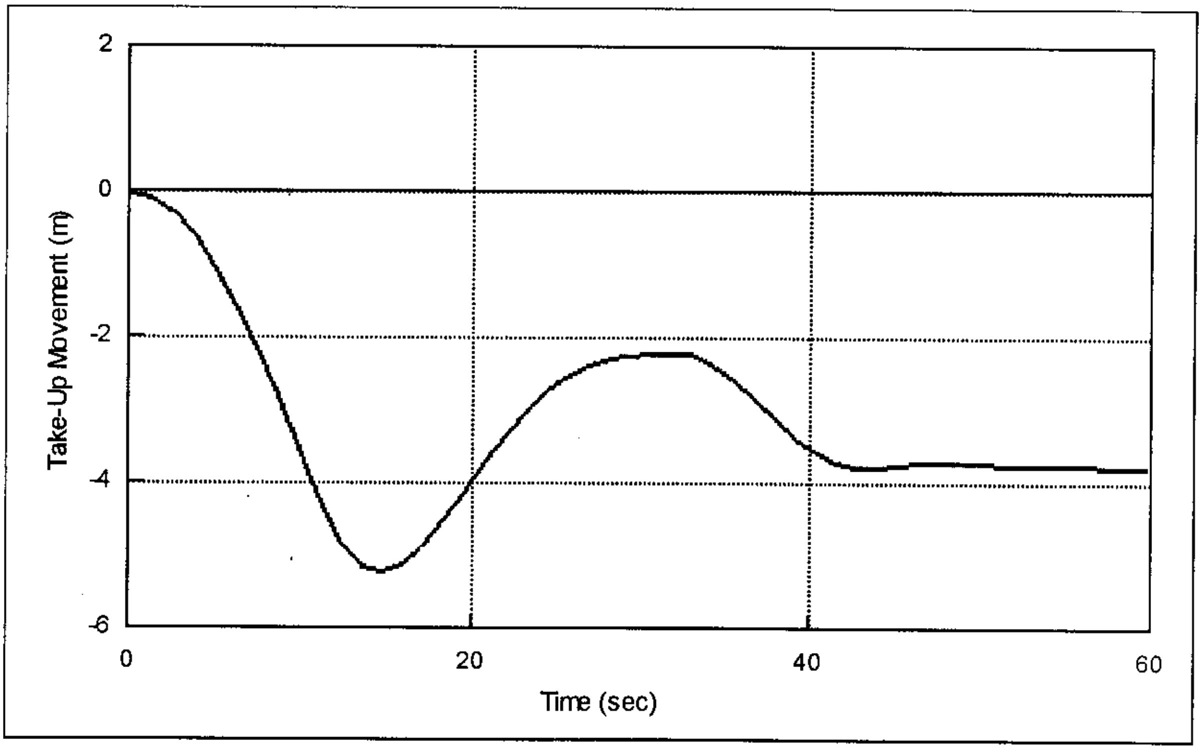


Figure 7 : Take-Up Movement for a Single Take-Up Unit



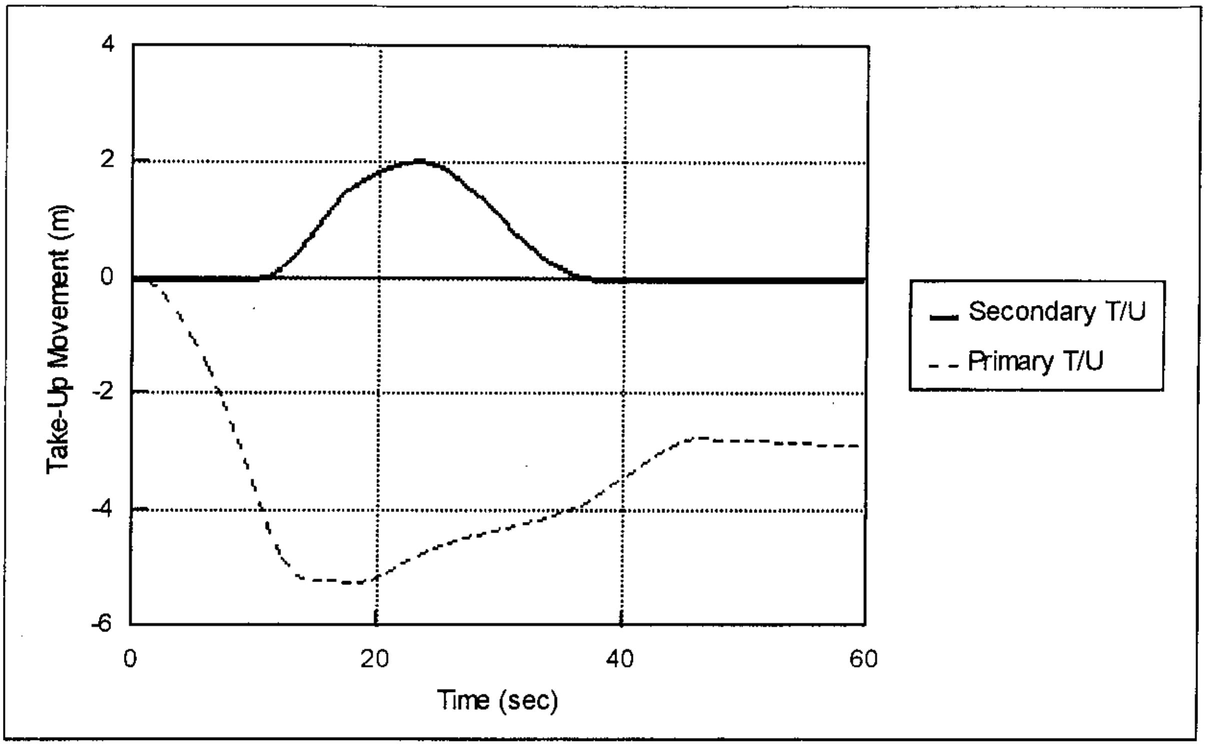


Figure 8 : Take-Up Movement for a Dual Take-Up System

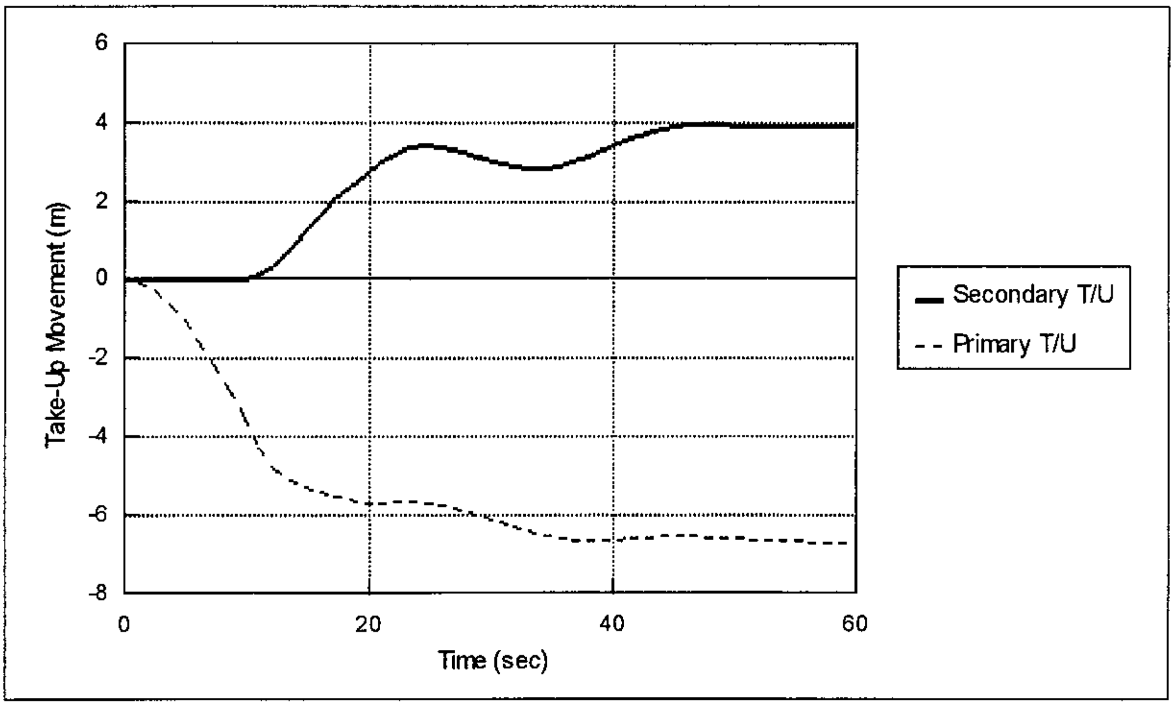


Figure 9 : Take-Up Movement for a Dual Take-Up System with Incorrect Belt Tension Selections

5.0 CONCLUSION

The ability to control belt tensions at multiple locations may well find applications in many areas not discussed in this paper. Multiple drive conveyor systems which are becoming common in the underground coal industry may find applications with overland and high lift systems. In such cases, certain load conditions may require the ability to control belt tension in more than one location along the conveyor in order to utilize the full installed power of the system. Reversible conveyors are another application well suited to dual take-up arrangements. A system whereby the take-up maintains a minimum belt tension but becomes stationary when the belt tension increases as the direction of the conveyor is reversed is a cost effective solution to the problems unique to reversible conveyors.

Multiple take-up systems can be a viable solution to certain unique conveyor configurations. As conveyor systems increase in size and complexity, these types of applications will certainly increase in number. Computer simulation of the dynamic characteristics of multiple take-up conveyor systems will play a crucial role in creating successful multiple take-up designs.

6.0 REFERENCES

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