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The Innovative Conveying System (ICS)
An Overview of a New Bulk Conveying Technology

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Summary

The ICS is a new bulk conveying system developed over the past decade and recently commercialised. This paper begins with an explanation of the architecture of the pouch conveyors as we currently know them. It outlines the numerous inherent attributes of such a system as well as exploring the shortcomings. It then explains the reasons the ICS has categorized itself as belonging to this conveyor type by default. Traditional pouch conveyors are generally regarded suitable for conveying small tonnages of powders and aggregates. The ICS is substantially up-scalable and is capable of handling larger tonnages and a wide variety of materials. The paper will show how the ICS has been developed to perform tasks beyond the capability of current technology. These include very high angle conveying, high fill rates, large particle capability, mobility while operating and several other features. The paper then outlines some research and testing work both in-house and outsourced. This work was conducted to establish sustainable operational limits of various components, such as the load limits of the contact interface between the idler and J section of the ICS.

Introduction

The ICS is an innovative, patented bulk materials handling system. The original development of the invention was to overcome the limitations of materials handling in the mining industry. The development targets consisted of creating a system that can handle large rock particles. Other requirements included high angle capability; small radius horizontal and vertical curves; and various mobility, maintenance and environmental issues.

During the development it became obvious that in order to achieve all of the above a radical approach would have to be taken and conventional belt technology would simply not suffice. It became equally clear that the system would have to be enclosed and that the belt could not be supported by idlers which were underneath the material as the eventual target is for it to contain rocks approaching 1 cubic metre.

To this end, the belt would have to be suspended by idlers which were not in contact with the loaded part of the belt. By default, this architecture resembled the pouch conveyor as we currently know it, albeit it in a larger form.

Pouch conveyors possess numerous inherent capabilities as they do not suffer from tracking or alignment issues. Assisted by gravity, they will always hang vertically and do not tend to twist or rotate as can be the problem with pipe conveyors. By being enclosed they eliminate dust and prevent water intrusions. They also lend themselves to multiple drives and are able to negotiate small radius bends, at least in the horizontal plane, and convey at relatively high angles.

However, current pouch conveyors have some shortcomings including the essentially vertically orientated belt walls that are designed to contain a relatively small load volume. This in turn affects the high angle capability as the loaded material will tend to run back at angles approaching 35 degrees. The long vertical plane also requires a substantial radius for a transition from horizontal to vertical. The belt edges offer limited weight carrying capacity and are unable to induce substantial tractive force to motivate the belt. These issues have effectively rendered the pouch conveyors suitable for small tonnages of powders, granules and aggregates.

The ICS transcends the above limitations by employing specifically developed components and practices .

There are numerous innovations that collectively enable the ICS to perform unprecedented tasks. This paper deals with the key components including the unique corrugated enclosed belt, the modular frame assembly, and the in-line drive system.

Belt

When the ICS belt is viewed in cross section its outline forms a shape similar to an elliptical pipe or pear. The belt consists of two components which are mechanically joined.

The belt edges are termed J sections as they resemble an inverted J. These sections are multi functional and are constructed as a composite. They contain the main tensile reinforcing members as well as metal ribs.

The ribs stiffen the hoop strength of the J section enabling it to retain its shape while it is supported on the idlers and carries the weight of the loaded belt. The J section also serves as a means to motivate the belt by accepting the caterpillar drive belts in a manner that allows significant tractive forces to be generated. The radiused concave section is designed to swivel in a translational fashion about the idlers. This allows the belt to change its cross sectional shape when substantially filled without inducing a damaging crease.

The belt carcass is not subjected to tensile forces and is constructed with transverse corrugations along its entire length. These corrugations (resembling bellows) are also multi functional and enable the belt to comply with extreme directional changes by accommodating the required elongation of contraction of the belt wall in a geometrical rather than elastomeric fashion. The corrugations also greatly enhance the high angle capability by presenting the conveyed material with a profiled surface to avoid slide-back. As well the corrugations greatly stiffen the hoop strength of the belt and eliminate any tendencies to buckle while performing tight turns, as is the case in current enclosed conveyors.

An added benefit is that the unique design of the belt allows it to be filled to a point just below the apex. This gives the ICS an impressive advantage in terms of the amount of material. Unlike pouch conveyors, the ICS can be filled to 90% of its volume capacity.

One more feature should be mentioned here: namely, the modularity of the belt. The custom-designed joiners enable a section of belt to be added or removed in less than thirty minutes without the need for permanent splicing.

Figure 1: *Belt displaying typical corrugations patterns*

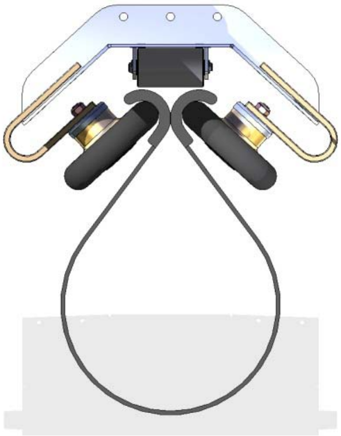

Figure 2: *Cross section of belt and idler assembly*

Modular Frame System

A valuable consequence of this architecture is that there is great flexibility in the design of the frame. The frame of an ICS has three key functions. The first is to suspend the belt. The second is to create the path along which the material will travel. The third function is to provide the system with the required mobility.

In terms of its suspension function, the frame enjoys considerable design flexibility. In long distance, fixed-path applications the frame can be constructed of long, stationary sections that are attached to pylons sunk into the ground. In short mobile applications (such as in tunnelling or ship loading) the frame can be mounted on wheels. In industrial applications, such as those where material must be moved around existing infrastructure (as in a processing plant, for instance) the frame can be attached to that structure.

If the conveying path must traverse a waterway the frame can be attached to a bridge structure for that section of the path. Furthermore, different frame designs can be combined in one conveying path. Whatever the combination of frames and regardless of the curves and angles composing the path of the system, the ICS completely eliminates the need for any transfer points.

Frame segments are designed to be quickly coupled and uncoupled. Where a mobile section needs lengthening, the system can be decoupled at the desired point (including disconnection of the belt using the joiners mentioned earlier) and the new section or sections can be inserted.

Figure 3: *Example of wall mounted frame*

Figure 4: *Example of fixed frame*

In-line Drive System

The ICS is driven by a system of intermediate drive units Variable speed drives interfaced with a plc are utilised to promote load and speed sharing to synchronise the multiple drive stations The number of drive units dedicated to a system is at the discretion of the system designer. Systems that involve a significant lift from the origin to the destination will call for more drive units than systems that are designed to move material in a mainly horizontal fashion. The chief constraints are the tensile rating of the belt and the sustainable tensile forces possible by the caterpillar drives. That is, in rough terms, the total duty (energy required to move the belt) divided by the number of drive units must not exceed the safe working rating of the belt. The power rating of each drive unit can vary considerably from system to system.

A system built around a 250 mm cross-section belt will call for drive stations about 10 to 15 KW capacity each while a system employing a 1300mm belt will require drive stations around 150KW each. These can vary, depending on material properties and system path.

While the system of motivating the belt is unique, the components are fairly standard. A typical drive unit is composed of a caterpillar drive and an electric motor (coupled with a gearbox) mounted at the desired point on the frame.

Drive units are designed to be installed in pairs, each pair forming a drive station. Drive stations are mainly installed along the loaded section of belt, but can also be installed along the return section in longer distance applications.

A caterpillar drive is a loop of customised belt that fits neatly into the J Section (the hook shaped edge section of the belt). The contact (under compression) between the caterpillar drive and the inside wall of the J Section provides the means by which energy is transferred to the belt to induce motion. This contact is achieved for the length of the caterpillar drive belt, with the effect of distributing the force such that high pressure, single point contact is avoided.

Drive units can be added as a system extends in length or as the duty rises. This is important, because it means that an ICS can extend to a great length without imposing appreciably more stress on the belt than is the case with a short system.

The distribution of stress also means that an ICS can be brought to a halt (if necessary) and subsequently re-started while fully loaded. Furthermore, there is sufficient buffer built into the design where an ailing drive is induced into a coasting mode by the plc and compensated for by the other drives, meaning the system can operate until a replacement unit is ready for an exchange with the under-performing unit.

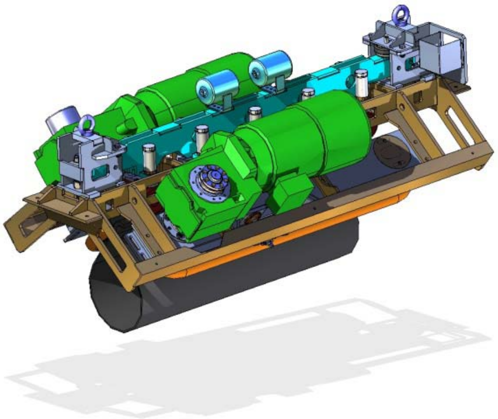

***Figure 5**: Illustration of complete drive station*

***Figure 6:** Caterpillar drive belt*

Capabilities

Material Variety

The ICS is designed to convey a wide variety of materials. At one end of the spectrum, it is well suited to carrying powders or fine particles. At the other end of the spectrum, the architecture of the ICS provides for the conveying of very large rocks. Currently, the ICS is capable of handling material up to 400mm in size.

Tight Curves

The inherent corrugations, or ripples, provide a flexibility that is based on geometry rather than elasticity. When a tight curve is formed there is a substantial difference in length between the outer and inner edges of the belt.

If there were no corrugations the only way to accommodate this length differential would be for the belt material to stretch on the outer edge and buckle on the inside edge. This would elevate the stress on the belt. Instead, the unique design of the ICS belt means that the corrugations adjust in shape so as to compensate for the differential, with the result that the belt negotiates path curves in a comfortable manner. The belt can bend both horizontally and vertically fully loaded within a radius of 15 times closed belt diameter ie a 3 metre radius for a 200mm belt and 6 metre for a 400mm belt.

Figure 7: *ICS test unit utilising 300mm belt negotiating a 5 metre radius*

Steep Angle

The ICS is able to transport materials at very steep angles (up to 80 degrees). It is the corrugations in the ICS belt that allow it to curve upwards. A tight-radius vertical curve produces a substantial difference in the length of the top and bottom of the belt over the length of the curve. No practical belt material can stretch or compress sufficiently to accommodate this difference without causing damage.

The corrugations overcome this barrier by adjusting their shape so as to effectively redistribute the belt material in accordance with the length differential between top and bottom. This enables the ICS belt to negotiate vertical curves without creating undue stress within the belt material.

The belt holds material in such a way that it remains captive at steep angles. Two features underwrite this capability. The first is that the belt is designed to be filled well above its centre line, with the material occupying up to 90% of its interior volume.

The second is that the influence of gravity causes the belt carcass to compress the enclosed load, which, in conjunction with the inherent corrugations, induces compression and bridging. The latter is a well known phenomenon in material handling. Normally it is a blight on production because it prevents material from flowing through chutes. But in the case of high angle conveying it works in favour of the ICS.

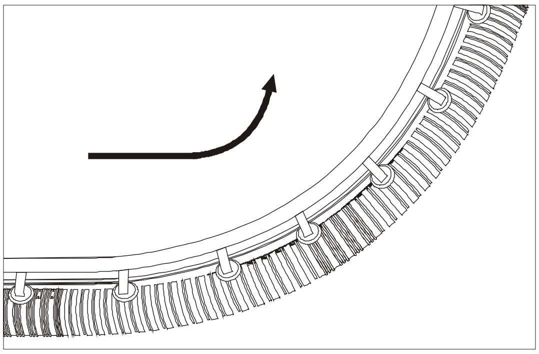

Figure 8: *Corrugation design allowing for steep angle conveying of materials*

Figure 9: *Transition from horizontal to vertical within a 4m radius for 300mm diameter belt*

Mobility

The ICS can be constructed to be highly mobile. In some circumstances it is most sensible for the frame to be fixed, not necessarily for the whole of the conveying path, but at least for part of it. This is because a fixed frame costs less than a mobile frame.

Another aspect of mobility is that relating to movement of the entire system when fully assembled. The feeder and discharge units can be self propelled enabling the system to relocate as a whole assembly.

This capability offers great operational flexibility. In addition to those cases just mentioned, there are two special cases of whole-unit mobility; namely, coordination with loading equipment, and sweeping discharge.

Figure 10: *A completely mobile ICS that can be moved as an entire unit via remote control*

Sweeping Discharge

Many material handling applications require that the material be distributed in a particular fashion at its destination.

The discharge unit of the ICS can be configured to be mobile, mounted on wheels or tracks as circumstances require. The unit can be controlled manually or remotely to travel as the material is being discharged. That is, to move while the system is in full operation. Consequently, the material can be placed in the pattern required for building a waste dump or stockpile. In that sense it operates as a stacker.

The system utilises the articulated frame assembly to house a continuous belt from the load to the discharge point without the requirement for transfer points.