Technical Overview

INNOVATIVE
CONVEYING SYSTEMS INTERNATIONAL

The Next Generation of Bulk Conveying Technology

Executive summary

1. The ICS is a unique, patented materials handling technology that offers unprecedented capabilities.

2. These capabilities include:
   - ♦ Mobility while in full operation.
   - ♦ Tight horizontal curves
   - ♦ Steep angle conveying
   - ♦ Wide variety of materials
   - ♦ High tonnage rate
   - ♦ Economic efficiency

3. The company is embarking on a strategy to apply the ICS to the Civil Industrial market, which is defined by non-mining activities involving materials up to 250 mm in size.

4. An ICS is an arrangement of distinct component assemblies, such as a feeder unit, a discharge unit, frame sections and so on. Each assembly has a variety of possible forms, ranging from the simple to the complex. Currently, these assemblies are available in their simpler forms, with more elaborate enhancements to be added over time. The currently available assemblies can be configured in many different ways to form systems suitable for a wide variety of circumstances.

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Overview

The Innovative Conveying System ("ICS") is a patented materials handling technology. It is applicable to many industries, including mining, civil engineering and ship-loading. The technology is currently entering its initial commercialisation stage, which will concentrate on situations where the material to be conveyed is no larger than 250 mm. This encompasses a wide range of products, from powders to crushed rock.

The ICS belongs to the class of enclosed conveyors, but it is unique in its architecture and capabilities.

The most distinctive components of the ICS are the belt edge section and the body of the belt, which forms a closed shape in the cross section. The corrugations are inherent in the geometry of the belt and grant it the ability to follow a complex path involving marked changes of direction in both the horizontal and vertical planes.

The patented suspension system, whereby the belt edges hang on a series of idlers, enables the ICS to cope with uneven ground and rough set-up. A series of in-line drive units liberates the system from the high tensile stresses of conventional systems, resulting in a relaxed system that can move while operating.

The ICS is modular in nature. This applies to the belt, which can be constructed in segments from six metres to thirty metres in length that can be easily joined by a non-expert to form a continuous loop. The result is that a system, including one of considerable length, can be transported to any location accessible by a standard truck. The modularity also enables trouble-free extension and contraction of a system.

The ICS is emerging from a decade of research and development into its initial stage of commercialisation. This stage is characterised by a concentration on particles that are no larger than 250 mm, and belongs to the market segment nominated by the company as the Civil & Industrial Sector. The three other sectors are Surface Mining, Underground Mining, and Long Distance Conveying.

This document is largely about the Civil & Industrial applications of the technology, but some references are made to other applications when the broader view is relevant.

Introduction

The ICS is an innovative, patented materials handling system. The original intention of the invention was to overcome the limitations of materials handling in the mining industry. In that industry the difference between the two main materials handling technologies is particularly evident. The two technologies are the truck and the belt conveyor (known as “conveyor” from hereon).

Trucks offer what conveyors cannot, namely the ability to cope with the rough and tumble of handling the large, abrasive rocks that are produced in the typical hard-rock mine. Trucks are also operationally flexible; they can be directed at will to any one of the active locations in a mine.

Belt conveyors, by contrast, generally offer the better material handling efficiency. They deal with the material in a continuous flow, in direct contrast to the “bucket” characteristics of trucks. However, conveyors are more demanding to install and are limited in the size of material they can carry as well as the incline at which they can operate.

The ICS is a continuous system, so it offers the fundamental advantage of conventional conveyors in this respect. But the ICS overcomes their traditional limitations to offer large rock capacity, undemanding installation, and steep angle capability. In this way the ICS goes some way to bridging the gap between the two traditional technologies. That is, to a large measure it combines the economic efficiencies of conveyors with the operational flexibility of trucks.

While originally designed to overcome material handling limitations in the mining industry, the ICS has emerged as a product that can be applied to an impressive range of non-mining situations. In fact, the initial market for commercialisation is not the mining industry but what has become known within the company as the Civil & Industrial sector. The nature of this market segment will become clear as the explanation progresses. This document focuses primarily on the Civil & Industrial area but includes comments throughout on other applications of the ICS.

Architecture

The following comments represent an introduction to the architecture of the system for the purpose of explaining how the technological and operational breakthroughs of the ICS are achieved.

There are three key components that combine to offer a materials handling system with unprecedented capabilities. These are; the unique corrugated enclosed belt, the modular frame system, and the in-line drive system.

Belt

Two properties of the ICS belt in particular explain the extraordinary capacity of the ICS system. The first is that the belt encloses the material. Simply put, rather than the material sitting on the belt (as with conventional conveyors) the material sits in the belt.

When the ICS belt is viewed in cross section its outline forms a shape similar to an elliptical pipe or pear. The conveying industry would categorise this as belonging to the pouch or enclosed conveyor type. But this class of belt, as deployed to date, suffers from the disadvantages associated with forming a pouch from a flat belt (albeit that these belts are customised to some degree). While such a belt can cope with horizontal directional changes (though in a strictly limited manner) it requires a substantially larger radius to change in the vertical direction.

The ICS belt transcends this limitation by employing a unique design. This is the second property of the two mentioned earlier. The design involves outward pointing hook-shaped edge sections and a series of corrugations running across the line of belt. The latter are inherent in the structure of the belt and are designed to permit it to change direction in the horizontal or vertical planes without distress to the belt material. 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 it can carry as well as a substantially enhanced high-angle capability.

One more feature should be mentioned here: namely, the modularity of the belt. That is, the belt is composed of segments typically six metres in length (for the Civil & Industrial applications).

The custom-designed joiners enable a section of belt to be added or removed in less than thirty minutes.

This has been made possible by eliminating the need for high tension in the belt. As subsequent comments will explain, the in-line drive system avoids the need to stretch the belt around two end pulleys (characteristic of conventional conveyors). Indeed, a remarkable feature of the ICS is that it operates as a “relaxed” or “loose” system. This low level of tension produces relatively low stress on each join, enabling the process of joining to be executed by a customised coupling arrangement that is simple and quick.

The modularity of the belt makes it easy to transport. The segments are able to be stacked on a standard truck tray and connected upon arriving at the site of the ICS installation.

The size of the ICS belt expressed in terms of cross section. The belt cross section is the internal diameter of the belt when in its closed form and in the shape of a pipe.

Modular Frame System

The ICS belt forms an enclosed cross section (roughly approximating the profile of a teardrop) when in its carrying position. It is suspended from a series of idlers that are attached to a frame. When viewed in cross section the edges of the belt take the form of an upside-down “J” (hence it is known as the “J Section”). This continuous hook portion of this profile sits over the idler wheel on each side. The effect is that of the belt “hanging” from the frame.

A valuable consequence of this architecture is that there is great flexibility in the design of the frame. Its function is simply to provide a structure on which to suspend the belt. 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, for 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 infrastructure.

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. For example, the conveyor path may begin within a pit from which crushed rock is being evacuated. The first section of the system may be composed of mobile frame to allow the ICS to synchronise with the excavator as it shifts along the working face. The mobile section may then be followed with static frame sections that extend the system out of the pit at a 45 degree angle, being anchored to the batters. This may be further followed by another section of static frames (of a simpler design than those used for the incline portion) that take the system to the top edge of the waste dump. The final section may be composed of mobile frames that allow the system to move while it discharges the material progressively back and forth along the stockpile face.

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. In cases where the in-pit portion of the system must be removed to enable a blast to proceed, it can be quickly disconnected at the bottom edge of the incline section, moved away, and then reconnected when the all-clear is given.

In-line Drive System

The ICS is driven by a system of intermediate drive units. These are positioned such that the driving force on the belt is evenly distributed over the set of drive units. 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 350KW 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.

The caterpillar drive can use positive or friction mating. The former refers to an arrangement (mostly for high load systems) where a series of teeth on the caterpillar drive mate with a corresponding series of apertures in the J Section. The arrangement is such that the driving load is distributed over a number of teeth, lessening the stresses on both sides of the arrangement. A friction drive, as the phrase suggests, relies on the friction provided by the mating of the outside surface of the caterpillar drive and the inside surface of the J Section. It is designed to be employed in systems that do not present a high inertia.

A system may have one drive or it may have many. The number required is dictated by the length of the system and the material handling load. The in-line feature means that the ICS belt does not have to operate in tension. That is, it is not stretched over two pulleys (head and tail as in conventional configurations).

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 full. Furthermore, there is sufficient buffer built into the design where an ailing drive is 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.

Capabilities

Material Variety

The normal carrying geometry of the ICS when viewed in cross section is that of a closed shape, roughly approximating the form of an elliptical pipe. The belt can be filled to approximately ninety percent of its interior volume and can carry any solid material that can fit into the cavity. The size of the belt is matched to the task at hand. A typical surface mining belt will be approximately 1.3 metres in cross section, enabling it to carry large rocks around 1 metre in any of the dimensions. At the other end of the scale, a Civil & Industrial application may require a belt of 250 mm in the cross section.

In mining applications, or those involving a large particle size, the cross section of the belt is largely determined by the size of the material to be carried. For instance, an application involving some particles that are 400 mm in any dimension will require a belt of approximately 650 mm cross section. Civil & Industrial applications are defined as those involving particles not exceeding 250 mm in size. The company is offering a maximum belt size of 500 mm (and a minimum of 250 mm), which covers the whole of the Civil & Industrial sector.

Another critical determinant of the belt size to be used in a particular application is the required tonnage per hour of material movement. The amount of material that can be transported per unit time is a function of belt cross section and belt speed.

The ICS belt can be filled almost to its apex, leaving very little wasted space. This means that even the smaller belt sizes can convey at an impressive rate. For instance, a system employing a 250 mm belt and travelling at 1.5 metres a second (a leisurely pace in the conveying world) can move approximately 300 tonnes per hour.

This varies somewhat, depending on the type of material. In the case of material with a high specific gravity the tonnage rate will be higher. The examples provided here are based on a bulk density of 1.5 tonnes per cubic metre.

As mentioned previously, the tonnage rate is also directly dependent on belt speed. The reference speed in the above example is 1.5 metres per second. A speed of 2.5 metres per second is sustainable in most applications. This would enable a 250 mm belt (a relatively small belt size) to transport material at a rate of approximately 480 tonnes per hour.

The larger belt sizes, as will be applied to surface mining, have considerable tonnage rate potential. At 1.5 metres per second, a 1.3 m belt can transport around 10,000 tonnes of material per hour.

But the main point of this section is that the ICS can handle a wide variety of materials. For instance, the fully enclosed characteristic of the belt renders it highly suitable for transporting very fine powders. Being fully contained within the belt prevents such materials from the effects of adverse weather conditions.

The same profile makes the system ideal for transporting material at the opposite end of the size scale. Consider the 1.3 m surface-mining belt, currently in the planning stage. It is being designed to accommodate run of mine material at minus 1 metre. That is, it is being designed to carry single rock particles weighing between 2 and 3 tonne each. Being fully enclosed, these large particles cannot escape the belt.

Clearly, the ICS can handle all materials that lie between these two extremes. The range includes fine sands, salt, grains, woodchips, aggregate, and coal. This capacity to handle a wide variety of materials is a key feature of the ICS.

Tight Curves

The ICS has the impressive capacity to follow a path composed of tight curves in both directions while fully loaded. The most important aspect of design permitting this is that the ICS is not end driven. That is, it is not stretched tightly between the head and tail pullies. Instead, the in-line drives allow it to operate free of the high tensile forces associated with an end-driven system. The result is that the ICS operates in a relaxed manner, allowing it to change direction and move while operating.

Supporting this is the ability of the belt to bend tightly. 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 pucker 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.

This feature could be useful in many situations. For instance, there are often obstacles between the origin and destination of material. That is, a straight line may not be possible or practicable. An example might be that of unanticipated material handling requirements in a processing plant whereby existing infrastructure lies on the implied path of the material. In such a circumstance, the curving capability of the ICS can be useful for forming a path around such obstacles.

Another example of how this feature could be advantageous is where the optimum path of the material is not straight. High wall coal mining represents such a scenario. It is a means of mining a coal seam laterally from within a large trench that has been cut to the depth of the coal seam. Currently the most widely used methodology is to auger horizontally (or at a shallow angle) into the seam. This method suffers from poor yields, restricted depth capabilities and difficulties in following undulating seams. However, the better way is using a remote guided mining machine for advancing into the seam, provided the coal can be evacuated from behind it. Several such systems are being and have been developed with limited success due to technical and cost issues.

The ICS could fulfil this role. Its mobility (the subject of a later section) would allow it to follow the mining machine as it penetrates deeper into the seam. Its curving ability could enable it to form a sharp turn at the mouth of the entry so that the coal is transported along the line of the trench to a place convenient for stockpiling. Or, in some circumstances the ICS would be utilised to evacuate the material completely out of the trench to the desired destination.

The curving ability of the ICS extends to curves that change over time. This would be the case where the system is coordinating with an excavator as it moves along a face or where the system emits material progressively along the edge of a waste dump. In those cases the curve of the system changes as the position changes.

A further example is that of salt harvesting. To prevent the stress (on the truck) of slowly moving while being loaded, the path flexibility of the ICS can be used to good effect. That is, the system can be induced into a curve. The feeder system can then travel along with the salt harvester and the discharge unit can form a central stockpile somewhat removed while the curve gradually straightens as the feeder moves further from the discharge. In between loading trucks the discharge can be shifted to re-create the curve while a hopper mounted on the unit absorbs the flow of material produced during the move.

Steep Angle

The ICS is able to transport materials at very steep angles (up to 80 degrees). Two features in particular allow it do this. The first is that the belt can form a tight vertical curve without imposing excessive stress on the belt material. The second feature is that the ICS belt promotes bridging of material at steep angles, eliminating any tendency for the material to slide or roll back down the belt in obedience to gravity.

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 cohesion and bridging. The latter is a well known phenomenon in material handling. Normally it is 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.

Belt corrugations and bridging combine to invest the ICS with the capability to transport materials at steep angles. This is useful in any situation where the loading point is substantially either lower or higher than the discharge point.

Mining provides the most obvious examples. In a typical open-cut mine, the material commences its journey at the pit floor and completes it on the waste dump or the ore stockpile. The extent of the lift can be in the hundreds of metres. The incline conveying capability of the ICS would allow it to effect this in one continuous path, eliminating the need for problematic transfer points. The system would be able to exit the pit directly up the wall (usually an angle of approximately 45 degrees). Similarly, the material could be transported to the top of the waste dump from where it proceeds to be discharged at the end as the system slowly sweeps along the top edge of the waste dump, distributing the material in a pattern that extends the waste dump as required.

But there are applications for this capability in areas other than mining. Examples include loading wheat or woodchips into ships, creating plateau or tabletop stockpiles (in contrast to cone or dune stockpiles), or negotiating a natural obstacle such as a hill. The feature is also critical in negotiating infrastructure obstacles such as roads or rail tracks, where the material is elevated temporarily. That is, the system could form a bridge over a road or similar obstacle.

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. The latter should be applied only where it is justified. But the choice of mobile or fixed frame is entirely at the discretion of the system designer and the client.

Transport

There are several aspects to mobility. First there is the matter of transport. Equipment used in industrial and particularly in mining is often large and difficult to transport. Simply transporting a tyre for a large haul truck becomes a complicated exercise due to it being over-size. Fortunately, the modular nature of the ICS avoids this problem. All sizes of ICS can be disassembled into components that can be transported on standard trucks without the need for special permission or escorts.

Fully assembled relocation

Another aspect of mobility is that relating to movement of the entire system when fully assembled. An example of this is the Shortbridge, a particular configuration of the ICS customised to the needs of the tunnelling industry. It is designed to be approximately seventy metres in length and to be composed entirely of mobile frame sections. The feeder and discharge units are equipped with motorised wheels, enabling the system to relocate as a whole unit. This might involve manoeuvring to a new location on the face or it might entail a complete exit (or entry).

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.

Coordination with loading equipment

In many material handling applications the source of material is spread in a manner such that the loading equipment must progressively move along the material to bring it within its grasp. This is the case, for instance, when an excavator is mining a working face in an open-cut mine or when a salt harvester moves along the salt pan.

The ability of the ICS to move as a whole lends it particularly well to such situations. The relaxed nature of the system and its ability to tolerate significant deviations in angle and path along its length enables it to move while operating. That is, the system can coordinate precisely with the respective loading equipment without any interference to production.

Sweeping Discharge

Many material handling applications require that the material be distributed in a particular fashion at its destination. Waste dumps in the mining industry are a good example. For both economic and compliance purposes these must be formed according to height restrictions. Often they resemble an artificial plateau.

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 the waste dump or stockpile. In that sense it operates as a stacker.

This capability offers considerable cost savings. It alleviates the need for expensive machinery to manage the material at the discharge point. The conventional approach is to either use a dedicated stacker (which can be extraordinarily expensive) or to use heavy machinery to arrange the material.

Variable Length

At the broadest level the ICS can be depicted as being composed of three main sections. At the origin there is the feed section, which is composed of the feeder module and sometimes a length of mobile frame (if the location of the origin is dynamic). At the destination is the discharge section. This includes the discharge module and, if the destination location varies, a length of mobile framework. In between these two is the body of the system.

This middle section may be composed of one type of framework or it may be composed of many. The point here is that it can be extended or contracted at will. Some of the frame sections may be fixed to infrastructure and therefore may be a continuous construction extending over a considerable distance.

But in many cases the framework, whether mobile or fixed, will be in sections of 6 to 12 metres long.

Each of these frame segments is self contained in that it hosts the running gear (from which the belt is suspended) and the linkage mechanism at each end. Frame sections are connected to each other using a single point linking mechanism that can be swiftly engaged or disengaged. A chain placed between each two frames prevents them forming sharp angles relative to each other.

Not only is the framework modular, but the belt is also manufactured in segments. These segments are typically 6 metres long, but can be in excess of 30 metres in the case of long distance applications. However, the emphasis of this document is the civil & industrial sector, in which the typical length of belt section is 6 metres.

The belt segments are joined to make a continuous length. The joins are very strong, although they do not have to contend with anywhere near the tension of a conventional conveyor of similar length. As explained previously in this document, the ICS employs multiple in-line drive units to motivate the belt. The result is a system that operates at much lower tension than conventional conveyors, meaning that joining sections of belt is a much simpler proposition than is typical for conveying.

In each case the procedure follows the same basic format. In the case of extending the system, the process begins with loading a length of frame with belt (whether a single segment or multiple segments) that corresponds to the length by which the system is to be lengthened. For the purpose of explanation this shall be referred to as the “new section”. The insertion point is selected and the belt is then moved such that a connector corresponds to the selected point. The belt and frames are parted to split the system into two sections. These are then drawn or driven apart to enable the new section to be placed in between the two sections of the existing system.

Shortening a system involves the reverse of extension as described in the previous paragraph.

State of the Technology

Civil & Industrial Applications

The ICS is an emerging technology with substantial scope for applications in different industries. This range of capabilities means that the diffusion of the technology into the relevant industries is best managed in stages. The stages roughly correspond to the four application areas each of which defines a market sector. These application sectors are: Civil & Industrial, underground mining, surface mining and long distance conveying. This overview is predominantly based on the first of these, the Civil & Industrial segment, although it includes examples and references relating to some of the other segments.

The Civil & Industrial sector covers all those applications that are not directly related to mining and do not involve distances exceeding 2 km. Materials covered within this definition include powders, sands, grains, rock aggregate, woodchips, and tunnelling spoils (produced by roadheaders or tunnel boring machines). Industries that intersect with the Civil & Industrial segment include ship loading, salt harvesting, grain handling, mineral processing, and tunnelling.

Current Configuration

Introduction

The ICS is a modular system that is composed of components arranged in many different configurations to suit particular circumstances. As explained in the section dealing with the architecture of the system, the key components are the frame, belt and drives as well as the end units. The latter refers to the Feeder System and the Discharge System. These five components can be built in different sizes and with different characteristics.

An ICS is an assembly of components. The combined characteristics of these components are called a configuration. Some configurations are standard and can be given a product name. An example is the Shortbridge System (developed for the tunnelling industry), which is composed of a mobile feed system, approximately seventy metres of mobile frame, a 350 mm cross section belt, and a mobile discharge system.

Other configurations can be quite unique. The distinctiveness can be derived from the overall characteristics of the system (such as length and terrain) and the specific characteristics of the components. For example, a particular configuration may involve a section of the system resting on pontoons in calm water. Another example would be where the feeder system may be stationary and the discharge system mobile, or perhaps the reverse. A third example would be where the belt size is 500 mm to accept larger particles yet the drive system may be geared to produce a slow belt speed of 0.5 metres per second to match the required tonnage capacity.

This modularity and extensive range of possible configurations suggest that the ICS cannot be adequately described in terms of defined products. Rather, the most accurate indication of what the technology can do at any particular stage is a description of the components. The comments to follow describe each of the major components in order to indicate how each currently contributes to the overall capabilities of the system. Concentrating on the components is also a good way of establishing what the technology is not yet designed for.

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. Provided that the structure can bear the attendant load, a frame can be constructed in the shape and pattern best suited to the task at hand. In a processing plant the frame skeleton may be a series of pre-shaped metal elements that are attached to a succession of existing structures (such as tanks or buildings) along the path. Alternatively, in a tunnel the skeleton will be composed of a series of carriage structures mounted on wheels and connected to each other.

In relation to path formation, the responsibility of the frame is to conduct the belt from the material origin to the material destination.

In many cases the origin and destination points move over time, such as in the case of a mining application where the feeder unit must coordinate with the excavator as it moves along the working face, and where the unloading unit moves in order to deposit the material so as to form the waste dump. The ICS caters for this with mobility. Both the feeder and unloading units can be mounted on tracks or wheels. The frame sections comprising the body of the system can also be mounted on wheels.

However, not all applications require mobility. The frame sections can be designed to be fixed in a predetermined path, one that may be straight or may involve multiple horizontal curves and vertical curves.

Construction of the frame sections (whatever their particular design) employs the well tested methods of metal fabrication. Frames can be designed and built to meet the specific requirements of almost any application. That is, the frame component does not place any practical restrictions on what can currently be offered.

Belt

The ICS belt is produced by applying elastomeric polyurethane to specialised plugs and moulds. There are three key characteristics of the belt that can be adjusted through modifying mould and plug design. These are the corrugation pattern, belt cross section, and belt strength. For the Civil & Industrial sector the corrugation pattern and the belt strength are held constant, having been designed to cope with all Civil & Industrial requirements. The one characteristic where variation is offered is in the belt size.

Belt size is measured in the cross section. The size of the belt is dictated by two overriding considerations. First, the cross section of the belt represents the upper constraint on particle size. Clearly, a 250 mm cross section belt cannot sustainably convey material that includes particles larger than the belt size. The rule of thumb for enclosed belts (such as the pipe conveyor) is that the maximum particle size should not exceed one third of the cross section. The ICS is not restricted by this constraint and can comfortably handle particles that are considerably more than half the cross section. The particle size that can be reliably handled by the belt is also dependant on the construction of the feed unit.

This dependence is based on the question of particle geometry. For instance, a simple feed system that ignores particle orientation must not be allowed to present particles that are larger than the belt size in any dimension (length, width, or height). This is because of the probability (the extent of which varies considerably with the particle size distribution of the material) that such a particle could lay in such a way as to prevent the belt from forming into its closed shape. On the other hand, a feed system that attends to the orientation of the particles could allow entry of material that is larger than the cross section in one dimension by ensuring that the largest dimension is in line with the belt. As later comments suggest, this orientation capability is not central to the requirements of the Civil Industrial segment, but will be a vital feature for the mining industry.

The second consideration with belt size is the flow capacity. The cross section shape of the belt remains roughly similar across all belt sizes. Therefore, the volume per metre of belt is a direct function of cross section. The larger the cross section, the greater the volume (in an exponential relationship). As an example, consider that a 250 mm belt could convey around 300 tonnes per hour while a 500 mm belt could convey 1,200 tonnes per hour (both assume a bulk density of 1.5 and a belt speed of 1.5 metres per second).

Currently, belt is available in sizes up to 500 mm cross section.

Drives

The ICS is motivated by in-line drives. The location of these drives is at the discretion of the designer, although the primary guiding principle is that the burden is shared as equally as practicable by each drive.

A drive is introduced to a system by a single frame segment on which a drive station is mounted. A drive station is composed of two drive units. A drive unit involves two synchronised drive arrangements; one for each side of the belt edge section.

A drive can be powered either hydraulically or electrically, depending on the specific task requirements and the surrounding circumstances.

Drive units range from 5 KW in power to 150 KW. There is a mathematical relationship between the peak energy required by the system, the working tensile load rating of the belt, and the power rating of each drive. The number of drives is calculated by dividing the tensile load rating of the belt into the peak system load (that includes rolling resistance as well as vertical lift and allows for the inertia of the system fully loaded). The power rating of each drive is roughly determined by dividing the peak system load by the number of drives derived from the previous calculation. The positioning of the drive stations is determined by the system path and the topography of the host location.

There is little practical limitation on the number of drives that can be installed on a system and their distribution (leaving aside economic factors). Therefore, the company can supply the drive system to suit any ICS applied to the Civil & Industrial sector.

Feed Unit

The feed unit has the responsibility of introducing material into the belt. For most of the length of an ICS (that is, between the feed and discharge points) the material is enclosed within the approximate pipe-like profile of the ICS belt. However, at the feed point, specifically the position where the feed chute discharges its material, the idlers on either side of the belt are separated to part the two edges of the belt in order to offer an opening for the material to enter. As the material enters the belt in this manner an oscillating unit shakes the section of belt that is accepting the material. This has the effect of encouraging the particles to flow or fluidise (rather like a coarse liquid) into the belt cavity. The result is that the belt fills with a minimum of cavities to a level just below its apex and encounters no resistance to closing as it moves away from the feed point. Closing the belt is achieved by bringing the two idler paths (one for each of the top edges of the belt) back together over a short travel.

The process allocates two important responsibilities to the feedbin. The first is to ensure that the rate of material discharged through the chute is matched with the capacity of the belt. This is achieved by altering the aperture of the feed chute.

The second responsibility is to prevent oversize material from entering the belt. Powders and particles present no problems by virtue of their small size relative to the size of the belt. However, rock particles that are not already sized require a grizzly of appropriate aperture to be placed over the feedbin.

Currently, the system is organised to accept only particles that are smaller than approximately 60% of the belt cross-section in all their measurements (meaning length, width and height). However, later refinements will allow particles that are larger than the cross section in one of their dimensions to be placed safely. This would involve orientating such a particle with its longest dimension in line with the belt. The resultant capability will be valuable for application in the mining industry by enabling run of mine material to be loaded into the system. However, the nature of the Civil & Industrial sector is such that it is not a critical consideration.

A Feeder Unit may be stationary or mobile. The latter is achieved through four wheels, two of which are powered by independent motors, or by tracks. This arrangement invests the unit with impressive manoeuvrability. Control of the unit may be a simple manual system or one that is operated remotely. An example of the latter is an excavator operator remotely adjusting the position of the feeder unit from within his machine, or a system operator standing in a safe area and directing the feeder unit into an area of a tunnel that is not yet cleared for personnel.

Currently, feeder units are available for applications where the material is introduced to the feed bin using conventional equipment, such as an excavator, front-end loader or another conveyor. Future development is planned for a specialised feeder unit that is able to operate within the hold of a ship.

Discharge Unit

The discharge unit has the responsibility of permitting the material being conveyed to exit the system. This is achieved by opening the belt and running it in a vertical loop. The belt is opened as it begins its descent in the vertical loop by arranging the idlers such that the two edges of the belt are separated to expose the full width of the belt and transform its profile from an enclosed shape to one that is flat.

The effect is to release the material from its confinement and allow it to fall away. This open profile is maintained as the belt reaches the bottom of the loop and begins its return journey. At the point immediately prior to that where the belt re-enters the main frame system the idlers are arranged such that over a short distance the belt is turned a further 180 degrees and the edges brought together, with the result that it travels back to the feeder system in an upright, closed manner.

A discharge unit can be stationary or mobile. The latter is achieved by placing the unit on wheels or tracks driven by hydraulic or electric means. As explained in previous sections, the ICS can be moved while in full operation. This enables a mobile discharge to function as a stacker, in the sense that it can move while depositing the material. This is a powerful feature of the system, offering cost efficient stockpile management.

A discharge unit can be built in low profile (for applications involving confined areas, such as tunnelling) or it can be constructed with a long overhang for stockpiling purposes. It can be used to load stationary trucks or it can coordinate with a slowly moving truck (such as the current method of salt harvesting).

Currently, discharge units are available in low and standard profiles. They are available as stationary units or in mobile form that can be controlled manually.

Installation

The modular nature of the ICS and the variety of configurations enables extensive customisation to suit particular circumstances. However, some configurations are quite standard, such as the Shortbridge System for the tunnelling industry. The mobility of the Shortbridge and its compatibility with existing processes makes it a low risk acquisition. The system can be introduced to the tunnel simply by driving it into position. No significant infrastructure or equipment changes are required. In the event that the Shortbridge does not integrate well with the particular tunnel operation, perhaps on account of unusual circumstances, it can be removed without fuss, allowing operations to continue as before.

Other applications require a custom built system. The process begins with the assembly of the relevant information, which is then used by the company to propose a configuration and indicate the cost of the respective system. Client feedback may result in some modifications to the proposed configuration. The system is then constructed and transported to site in modular form. Upon arrival the components are assembled.

A typical ICS configuration is simple to assemble and operate. However, there is provision for the initial assembly and testing to be conducted under the guidance of a company representative.

Maintenance

The belt is the most unique component of the ICS. The modular nature of the belt and its ease of joining make it a simple affair to attend to belt replacement tasks.

The remaining key components that require maintenance or replacement are the idlers, the caterpillar drives, and the drive motors. The latter are off-the-shelf items and can be replaced simply. The idlers and the caterpillar drives are easily replaceable and are not expensive to stock as spares.

The power and control systems can be diagnosed and repaired by professional tradespeople, which are to be found in most areas of the globe.

Summary

The ICS is a unique, patented materials handling technology that is ready for its first application to the Civil & Industrial market, which is defined by bulk solids in circumstances apart from the mining industry and a path shorter than 2 km. These constraints are simply a segmentation exercise. ICS units designed for other applications such as mining or long distance conveying do not need to abide by constraints, particularly that of length.

The features of the technology invest the ICS with remarkable capabilities. These include the ability to move while operating, simple extendibility and contraction of a system, high conveying rate (in terms of tonnes per hour), resistance to wet conditions, minimisation of dust, enhanced safety, and the ability to cope with rough ground or hostile terrain.

The ICS is simple to assemble and operate, is robust and easily maintainable, and offers excellent commercial advantages. The application to the Civil & Industrial market will not only offer new solutions to persistent material handling problems, but will also play a role in extending the reach of the technology to the remaining market segments of underground mining, long distance conveying, and surface mining.