JAPAN PIPE BELT CONVEYOR SYSTEM

BY

C. BUCHANAN
Conveyor Engineer - Bateman Materials Handling Limited

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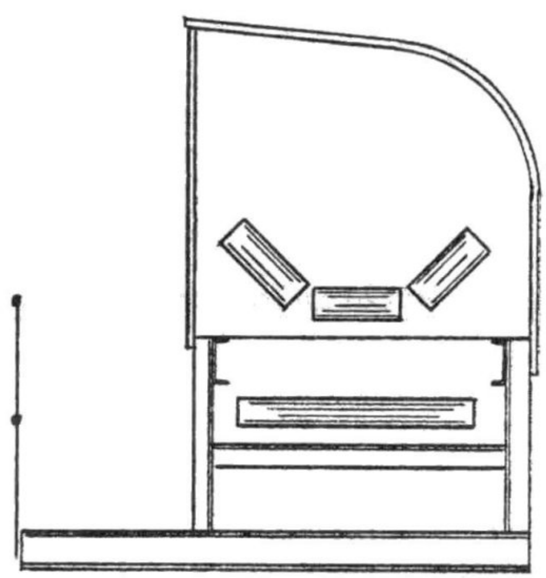
1. INTRODUCTION

Belt conveyors are one of the most commonly used methods of transporting bulk materials today. These conveyors are normally of a troughed cross sectional profile, the trough being formed by 3 to 5 rollers mounted in a frame where the outside rollers are tilted vertically to give whatever angle of trough is necessary for the rubber belting to conform to.



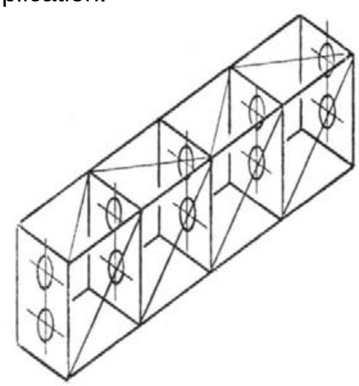
The troughed belt conveyor, although one of the cheaper forms of transporting materials, has inherent drawbacks.

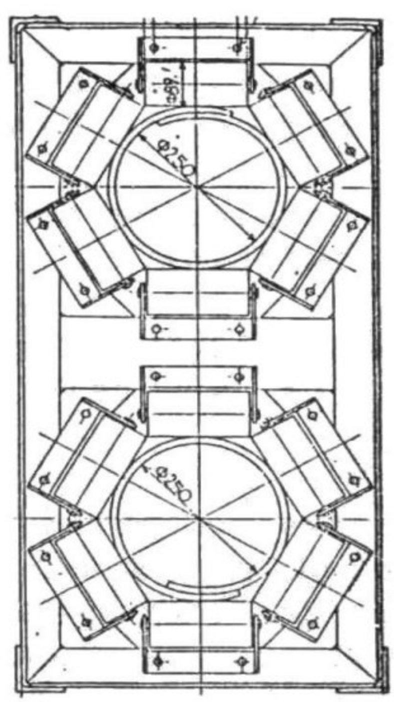
1. It does not promote a dust free environment unless expensive sealing arrangements are provided.
2. If for some reason the belt tracks badly, material spillage will occur and belt damage may result.
3. Incline conveying has limitations, the maximum angle of incline for any material conveyed being from approximately 17° to 20°. This causes process plant to be spread out over large areas.
4. It cannot negotiate horizontal curves therefore necessitating multiple transfer points.

Because of these limitations, engineers have, for many years, been exploring the possibility of having the transported material completely enclosed. One of the methods thought of was conveying material in a tube. This idea in turn was divided into two categories :-

1. The material would be encapsulated and would travel within a stationary tube.
2. The material and tube would move together.

It is the second solution which we are about to present. The Japan Pipe Conveyor Company (JPC) is responsible for the development of this technique and has patented the technology which has led to its successful application.





At present there are more than one hundred and fifty pipe belt conveyors in operation or shortly to be commissioned. Twenty three of these conveyors are for installations in South Africa. Of these 11 have been commissioned and a further 2 will be commissioned during the next few weeks. There are seven pipe conveyor installations in Taiwan, two in Australia, two in Europe and the balance are in Japan.

2. EVOLUTION OF THE JAPAN PIPE CONVEYOR

Mr. S. Hashimoto, today President of Japan Pipe Conveyor Company, began to develop the concept of forming a flat belt into a pipe shape as early as 1959. By 1964 the basic design was established and patent applications were made.

The first full scale trials took place In 1970 but failed because the vital criteria necessary to ensure that the belt could be maintained in pipe form were not yet fully understood.

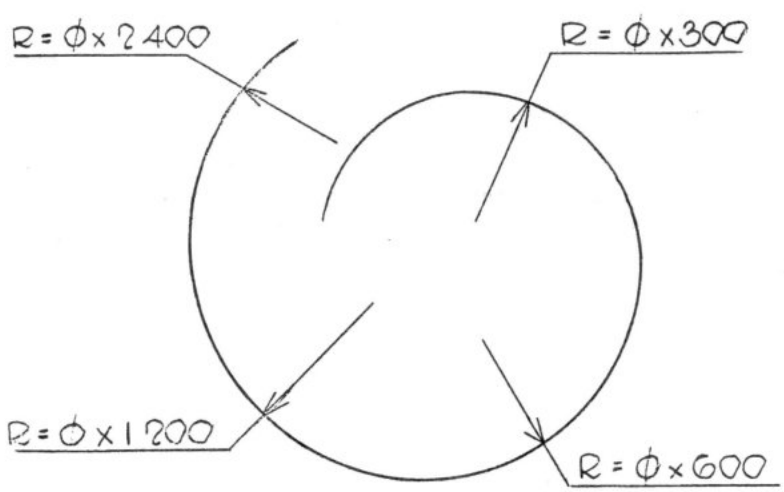
Mr. Hashimoto persevered with the development of his idea, and in 1975 the Bridgestone Rubber Company agreed to participate in the development of a suitable belt, in exchange for the manufacturing rights in Japan. The second trial of the pipe conveyor concept took place in 1975 and indicated the validity of the concept and in 1976 the third trial, that of a straight, level pipe conveyor succeeded. Thereafter development accelerated. In 1977 a curved conveyor trial succeeded and later in the same year a steeply Inclined conveyor trial was accomplished.

The major difficulties that had been overcome were :-

i. Developing a belt with the relative rigidity to allow a flat belt to be formed and maintained in a pipe shape.
ii. Developing the technique of correcting belt misalignment and twisting.
iii. Developing the best arrangement of carrying and controlling the pipe belt i.e. in the hexagonal idler nest.

The first commercial Installation of Japan Pipe Belt conveyors was made at Kitakyushu Sand Co-op in Japan in 1979. Two 300 mm diameter conveyors, 20 and 28 metres long respectively were installed and have been operating up to the present without difficulty. The Japan Pipe Conveyor Company was formed in 1982. With the standard JPC pipe belt conveyor system now firmly established, the research and development department of JPC is now concentrating on applying the principles of pipe belt conveying to vertical conveying.

Vertical conveying will take on one of two profiles either that of a 'Z' shape or a helix shape, similar to that of a spring, having ever decreasing radii starting from the tail end. There are inherent problems which have to be overcome before either both or one of the systems become commercially possible.



VERTICAL SPIRAL CONVEYOR

3. GENERAL DESCRIPTION OF THE JAPAN PIPE CONVEYOR

Essentially, the Japan Pipe Conveyor is a development of a conventional belt conveyor system, and comprises a head and tail pulley, one of which is driven, over which an endless conveyor belt

is spanned. The belt is tensioned in a similar manner to conventional belt conveyors. Beyond the loading point, the belt passes through a series of pipe forming idlers which effect the transition from conventional to rolled form. This transition takes place over a distance calculated to minimise belt stresses, usually 25 x pipe diameter. Once formed, the pipe shape is maintained by six idlers set in a hexagonal pattern at each Idler frame. Idler frame spacing depends on pipe diameter and ranges from 1 - 3,5 metres.
The return belt is formed into a pipe shape in a similar manner with 'dirty' side 'inside'.
To assist the flat belt to form into a pipe shape at the first idler set after the transition, twelve idler rolls (six on each side of the panel) are installed forming a duo decagon which resembles a circle more closely than a hexagon. This arrangement overcomes the tendency for the belt to adapt a hexagonal rather than circular form.
The belt pipe shape is formed with an overlap to maintain sealing. It was found in practice that the belt developed a good deal of friction and wear at the belt edges as it closed together basically because both sides scraped against each other at the moment the pipe formed. This was corrected by the installation of a guide roller in the transition length at both the load and return entry to the PSK (Pipe Shape Keeping) idler section.
This guide idler is carefully set to depress one belt edge just sufficiently to feed it below the other belt edge as the belt edges come together, thus eliminating the edge abrasion. Once the belt edges have overlapped they slide one upon the other to form the correct overlap as the belt completes its entry into the PSK idler section.
The major advantages of the JPC pipe conveyor are :-

- Because of the pipe form of both the feed and return side of the conveyor, it is possible to curve the conveyor in both the horizontal and vertical planes. Curves of up to 45° with a radius of 300 x belt diameter are easily achieved, making in-plant curves feasible and reducing the number of transfer points required. Recent on-going development at JPC now permits curves through 90° with a radius of 600 x belt diameter.
- Because of the load distribution within the pipe conveyor and the resulting contact area between the material and the belt, it is possible to convey material at an inclination of up to 27° - 30°, an attractive feature when compared with 17 - 20° of a conventional belt conveyor, again a particularly useful feature within the restricted confines of a plant, mine shaft etc.
- Material within the pipe is effectively protected from the elements and from contamination, or contaminating.
- Dust is effectively controlled and even the immediate vicinity of the belt is dust free, an important point for maintenance and operating staff. Since it is not necessary to encase the conveyor in a 'dog-house' type structure, visibility all around the belt and idlers is excellent, a feature which encourages a high standard of maintenance.
- Because the return belt is formed with the 'dirty side' inside, spillage is virtually totally eliminated, since build-up of dirt on the return idlers is not possible, resulting in an extremely clean plant and reducing the need for ever increasing costly clean-up labour.

Other features of the pipe belt conveyor system are :-

- The even distribution of the load within the pipe results in an extremely smooth and quiet action.
- One of the major causes of premature belt wear in a conventional belt conveyor, that is tracking problems causing edge damage, is largely eliminated.
- The width required by a pipe conveyor installation is considerably less than that of a conventional conveyor, a particularly useful feature for installations which are indoors, in tunnels, or in other confined spaces. Lighter support structure is also possible on elevated sections.

Conveyors built to date include belt diameters ranging from 100 to 500 mm, and capacities ranging from 36 - 1800 m^3/hr. Pipe conveyors are operated at speeds comparable with

conventional belt conveyors - from 1 m/s to 4 m/s. The speed of smaller diameter conveyors is kept relatively low to keep idler speeds to under 1000 RPM to ensure adequate life.
A number of conveyors installed to date have a length of ±400 m. JPC are busy manufacturing a 720 m x 1500 t/h x 500 diameter unit at present for commissioning in 1986.
Japan Pipe Conveyors have been installed to convey sand, ferrite, earth, coal, salt, charcoal powder, alumina, clinker dust and fly-ash, amongst other materials. Both fine material and large particles can be conveyed.

LOADING THE JPC

Lump size is a criterion which is normally one third of pipe diameter for a load ratio of 0,75 and up to two thirds of pipe diameter for a load ratio of 0,18. Care should be taken to ensure that the material conveyed is not of a slab nature and that the belt is not overloaded. Loading should be controlled by use of a vibrating feeder or a carefully designed loading chute which feeds the correct flow of material.
As a safeguard against poor feed control, it is recommended that a special spring loaded idler be installed before the final pipe form. This will actuate a micro switch which in turn will shut down the system.

BELT TRAINING

A JPC pipe conveyor belt is entrapped within sets of idlers and cannot wander off line as can a conventional belt.
A JPC belt can however twist within the idler sets and if the twist is excessive, training may be accomplished by adjusting the idler sets to steer the belt back into position in much the same way as a conventional belt is trained.
There is a tendency for the JPC to twist on horizontal curves. This can be overcome by adjusting the idlers starting from the middle of the curve progressing outwards towards the tangent points.

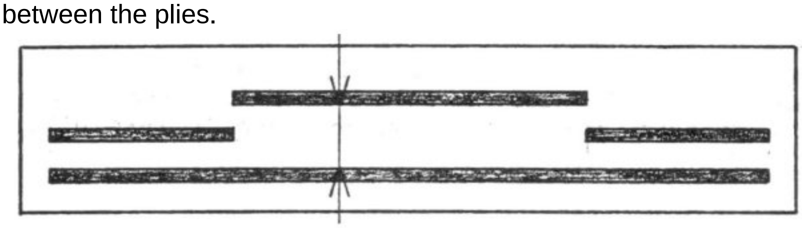
4. COMPONENTS OF THE JAPAN PIPE CONVEYOR

As with any conventional conveyor the essential components of the JPC are :-

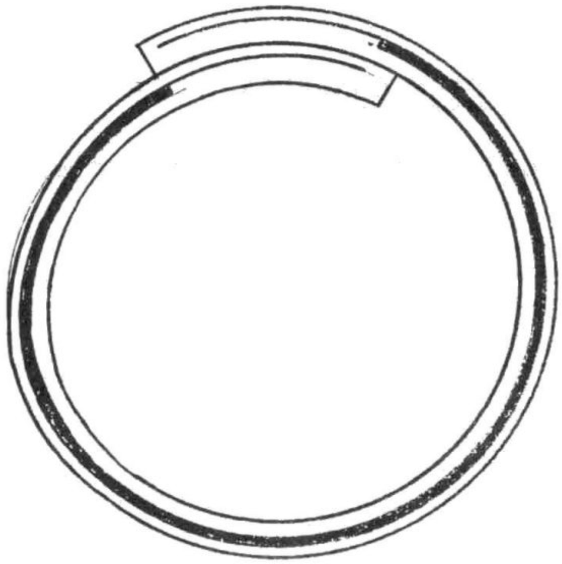
1. Belting
2. Idlers
3. Support Structure
4. Pulleys and bearings
5. Drives

BELTING

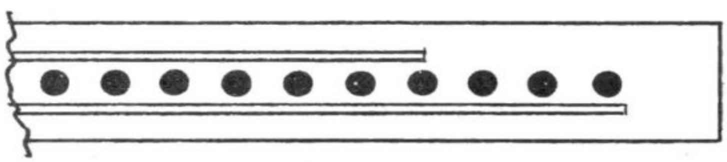
Conveyor belting is constructed using a nylon carcass made up in plies and covered top and bottom with rubber. The belting is supplied in a number of strengths ranging from 200 KN per metre width to 1250 KN per metre-width at present and from 1.5 mm to 5.0 mm rubber cover thicknesses.
To give the necessary rigidity required for the belting to maintain its pipe shape and not collapse on itself an intermediate rubber monofilament of from 2.0 mm to 4.0 mm thickness separates two of the plies making the belting more rigid than its conventional counterpart which has only a skim coat of rubber between the plies.



The reason for the step ply configuration is to allow the belt to be more flexible at the edges to enable it to seal the overlap effectively.



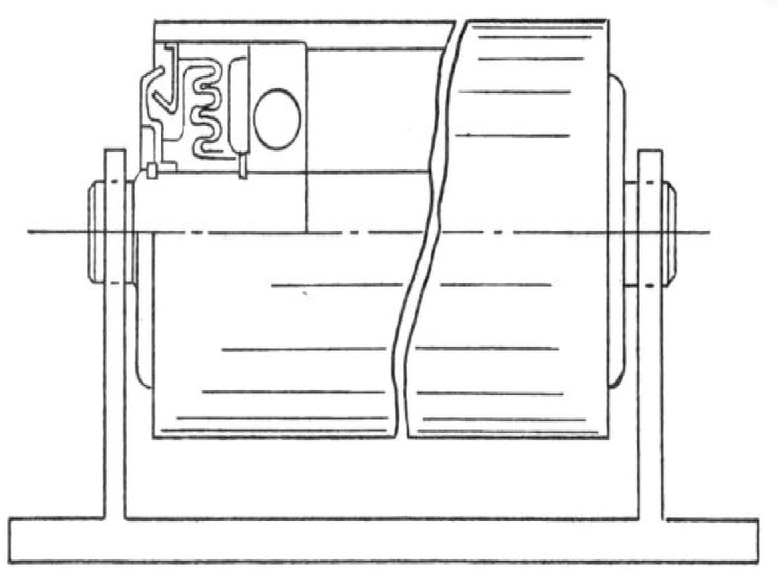
Steelcord belting is used where belt tensions exceed the maximum for fabric and when belt lengths are so long that the take up length becomes impractical. The cut off point for fabric belting as a rule of thumb is about 1000 metres pulley centres, where the take up length would be 20 metres. Another consideration would also be acceleration and deceleration forces - as also with conventional conveyors, on the elasticity of the fabric carcass belting.
The construction of steelcord belting is similar to that of conventional belting. The steelcord belting used in JPC installations has a stepped transverse reinforcing cord usually made in nylon fabric. This also gives the rigidity and flexibility required as in fabric carcass belts.



Steelcord belting strengths range from 500 kN/m to 5000 kN/m. Rubber covers are of Styrene Butadine for both normal and high temperature installations.

<u>IDLERS</u>

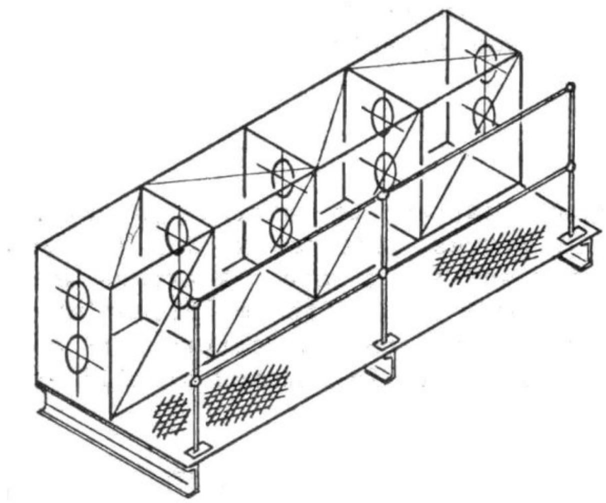
Idlers are set in hexagonal pattern to maintain the pipe shape and are spaced at from 1.0 metres centres to 3.5 metres centres, depending on pipe diameter and idler load. Bearings used are deep groove ball bearings and seals are of the multilabrinth type with dust covers. Shaft diameters and roll pipe diameter. Idler brackets are fabricated of mild steel.



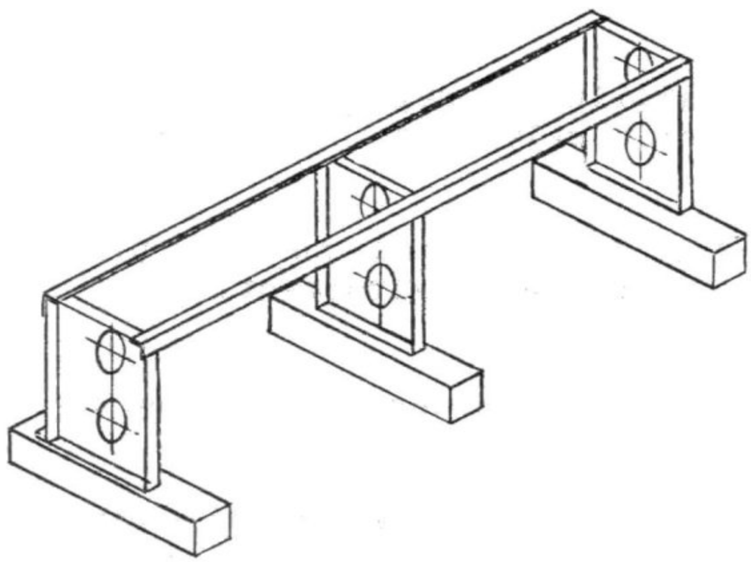
Idler dia mm	Belt dia mm	Face Width mm	Shaft Dia mm
48.6	100	64	10
60.5	150	96	20
60.5	200	126	20
76.3	250	157	20
76.3	300	187	20
89.1	350	216	20/25
89.1	400	245	25
114.3	500	304	30/35

<u>SUPPORT STRUCTURE</u>

The support structure is made up of a series of pressed steel or fabricated idler panels set at the standard idler pitch. These are joined together by angle stringers, the size of which are determined by whether or not the structure will span long distances and also whether the structure will support a walkway or not.



Typical overland modules for the larger pipe sizes will consist of fabricated idler panels, each supported by either a concrete sleeper or mini piles and tied together at the top only with light angle stringers. Vertical bracing may be used at between every 5th or 6th idler panel.



PULLEYS AND BEARINGS

Pulleys and bearings are no different from conventional conveyors.

As with conventional conveyors, bearing centre distances are dictated by pulley face widths, chute widths and bearing sizes. Standard conventional conveyor bearing centres may be used.

CONVEYOR DRIVES

Pipe conveyors are driven in the same way as conventional conveyors. The smaller units are powered by a shaft mounted helical gearbox, V-belts and pulleys.

The larger units by shaft mounted / flange mounted or direct coupled spiral bevel helical or worm units and high speed fluid couplings.

CONCLUSION

While the commercial use of the pipe conveyor is new, many of the techniques of design, general engineering and maintenance are common to the conventional conveyor. Plant maintenance staff do not require any specialised knowledge of equipment other than a basic understanding of the system.

The pipe conveyor is a natural evolution of the conventional conveyor having all the advantages and few of the disadvantages. Summarising the advantages, we have :-

1. The pipe conveyor's ability to negotiate horizontal curves largely eliminates the need of costly transfer points.
2. Because the material is enclosed in the pipe form, the pipe conveyor promotes a dust free environment.
3. Outside contamination of the material conveyed is not possible.
4. Because of the load distribution within the pipe form, high angle conveying up to 30° is possible.
5. Compared with the conventional conveyor, the width of the pipe conveyor is approximately half the width for same duty, therefore more cost effective as far as associate civil work Is concerned.