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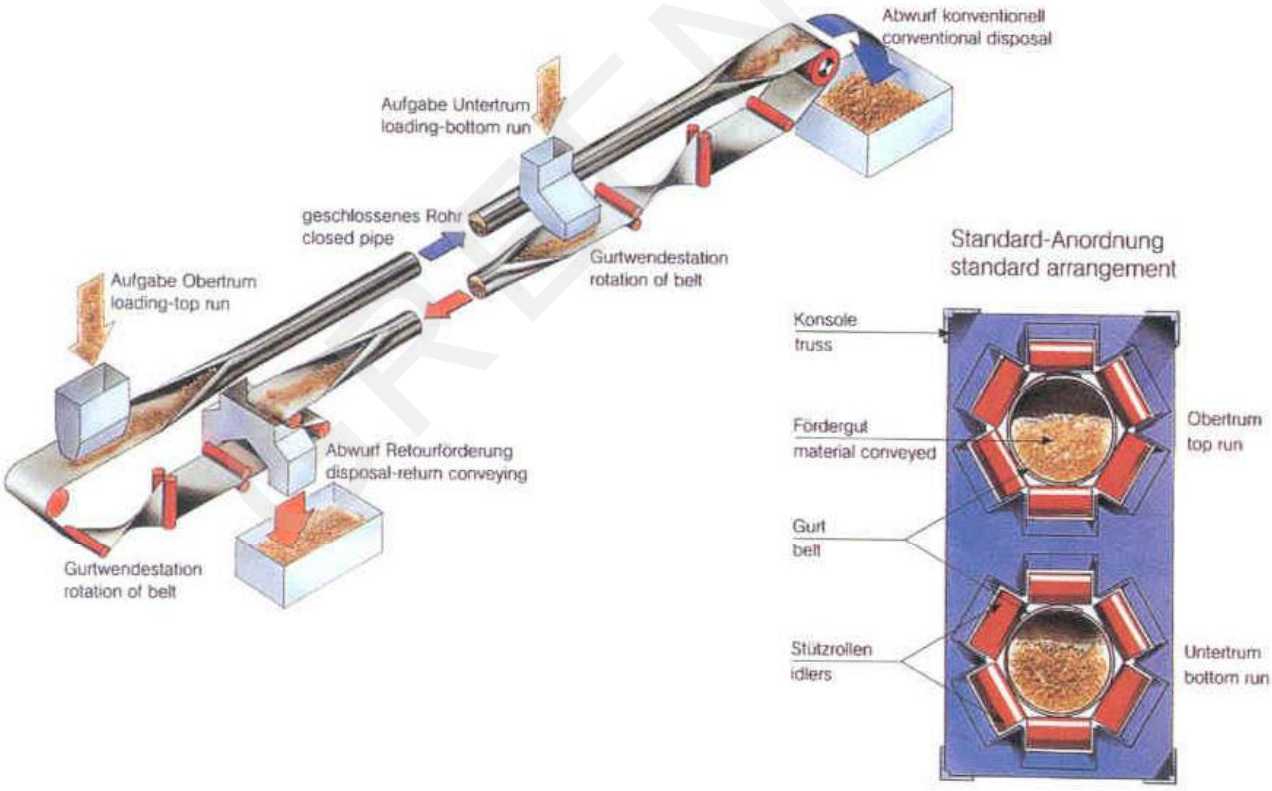
The evolution of the pipe-conveyor

A general introduction of the pipe-conveyor as an important medium for conveying of bulk materials

Introduction:

For over a 100 years belt conveyors are used for the transportation of bulk goods.
Limited investment and low operational costs per ton conveyed caused major developments in the design and utilization of this concept with respect to the capacities conveyed and the uninterrupted length without transfers per conveyor.
Despite all the advantages a disadvantage of the conventional troughed belt conveyor is the occurrence of dust because of product becoming airborne, and spillage of product at the return side of the conveyor due to inadequate cleaning of the belt at the head section.
The increased demands for the reduction of spillage and dust have been a stimulus for the development of several kinds of enclosed/folded belt conveyor systems.
It is a fact that in many instances commonly used systems are utilized when the use of another conveyor system would give advantages with respect to economics, technique and environmental reasons.
However it remains difficult to introduce new systems and displace the more conventional systems. The pipe-conveyor concept has already existed for more than twenty years and over a thousand systems have been installed worldwide, operating at a reliability that in many occasions is superior to conventional systems. Still most of the users of belt conveyor systems are not really familiar with this concept.



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History of the pipe-conveyor:

The pipe conveyor has been developed at the end of the nineteen-seventies by Japan Pipe Conveyor. In 1979 the first pipe conveyor was successfully put into operation.
From this basic system a number of other systems with a minor deviation have been developed as the New Pipe Conveyor of Mitsubishi, the Mitsui Pipe Conveyor and the Tubular Conveyor of Bemire/Clouth. In these systems 6 idlers were positioned 3 each on opposite sides of the supporting panel. This is the same configuration as TBO Bulk Handling uses for its Pipe-Conveyors.

Pipe-conveyors have been installed so far for capacities up to 3000 t/h with a pipe-diameter of 700 mm. The maximum length for one system is approx. 5,000 meters.

Pipe-conveyor near Rotterdam the Netherlands

History of the pipe-conveyor in the Netherlands:

In 1987 and 1989, the first two pipe-conveyors were put into operation in the Netherlands at Pechiney Aluminum in Vlissingen and Frans Swarttouw Stevedoring Company in Rotterdam. A few years later a pipe conveyor was installed for CEMIJ in IJmuiden.
A fourth and fifth pipe-conveyor system was designed and built by TBO.
TBO has an exclusive relation with Svedala. Technicians of TBO were trained by Svedala-Scholz in Hamburg and have been supervised intensively during the first pipe-conveyor project.
The pipe-conveyor in operation at an electricity plant on the “Maasvlakte” in Rotterdam was designed and produced by TBO and its 740 meters over all length make it by far the longest pipe-conveyor in the Netherlands and Belgium. The trajectory of this conveyor, put into operation in 1998, includes many bends in horizontal as well in vertical direction. The total length of curves is even more than 500 meters. The capacity of this pipe conveyor is 350 M3/hr (250 mtph).
The pipe diameter measures 300 mm. The rather limited tonnage is due to the relatively low density of the product. This installation has seen limited use due to the customers situation.
The next pipe-conveyor designed and produced by TBO is used to convey zinc ore and was put into operation at the end of 1999 for Pasminco Budel Zink in Budel.
This pipe conveyor was selected because of the reduction of dust and spillage and also for

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economical reasons. The conveyor connects the low level zinc storage building with the day-bins.
The 135 meter long conveyor has an angle of inclination of 14 degrees and is designed for 500 mtph. This pipe has an outside diameter of 250 mm.
This conveyor was originally a 800 mm wide conventional troughed conveyor that needed replacement and had to be installed in a closed gantry.

By using a 900 mm OAW pipe-conveyor belt TBO managed to re-use the complete drive section, including drive pulley, drive and the support for the drive station. The pipe-conveyor eliminates the need for a gantry, which made the solution with a pipe-conveyor a financially sound one.
The loads, static and dynamic, on the existing buildings and foundations were reduced because of the new design with an open gantry.
The last pipe-conveyor built in the Netherlands until the present time, is in operation at Vagron in Groningen since 2000. This system, engineered without support of Svedala by an inexperienced low budget supplier was more or less a commercial and technical disaster.

Pipe-conveyor systems in the Netherlands:

Client	Comple-tion	belt width in mm	Product	pipe diam. in mm	Length of Conveyor in m	Angle of incline	capacity in mt/h	belt-velocity in m/sec
Pechiney	1987	750	Petroleum cokes	200	61	29	100	2,2
Swartouw	1989	1.900	Phosphate and petroleum cokes	500	120	8	1.450	2,5
Cemij/Enci	1993	1.300	Gypsum, clinker, anhydrite	350	165	18	650	2,5
PPG	1997	780	Glass	200	61	29	100	2,2
Bio-Mass	1997	1.100	Sludge and Paperpulp	300	730	2	250	2,2
Vagron	1999	1.600	Waste	400	139	0	30	
Budel zink	2000	900	Zinc ore	230	135	14	500	1,95

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Technical aspects of the pipe-conveyor

The pipe-conveyor has, with exception of the head and tail section, the shape of a pipe in between idlers in hexagonal positions.
The pipe-conveyor is loaded as a conventional troughing conveyor and discharges at the head pulley as a conventional conveyor as well. Past the loading area the rubber belt in the intermediate sections is folded like a pipe for both carrying part and return.
A special cross-rigid ply in the rubber belt makes the belt suitable for this purpose and arranges for the constant surface contact of the belt with the idlers. If a conventional rubber belt would be used as a pipe conveyor, after a short while the belt would experience severe sagging at the upper part of the pipe-shape, causing loss of surface contact with the idlers.
The rubber belt must be cross rigid enough to keep the round form but in longitudinally flexible in order to negate the pulleys in as a conventional conveyor belt.
In case the belt trajectory includes one or more horizontal or vertical curves the belt must be rigid enough to absorb the additional tension forces in the belt that try to lift the belt from the lower idlers in the hexagon. From the outside, the rubber belt itself looks exactly the same as a conventional troughing belt and a specialist can tell the differences. If the combination of pre-tensioning of the conveyor belt, belt width, the specific hexagon configuration and the center to center spacing of the hexagon idler stations is correct and well designed the pipe conveyor belt will keep its folded pipe-shape with the right overlap. By changing the idler position gradually the belt will fold or unfold. This is the way the conveyor is closed from some meters after the loading section up to a few meters before the discharge at the head pulley. The pipe-shape belt protects the product inside from the environmental influences. Not only at the upper part, the carrying side, but at the return side as well the belt runs in a pipe shape, which makes the pipe-conveyor dust and spillage free. Sticky material, that loses contact with the rubber belt at the return is still contained within the belt and can only leave the conveyor after the belt unfolds near the tail-end pulley.
In case material drops off the belt before it is completely enfolded a small spillage conveyor or screw conveyor that runs in the direction of the head pulley will return the spillage to the main product flow. In case of limited amounts of pipe-spillage, the installation of a spillage plate is an effective and economical solution.

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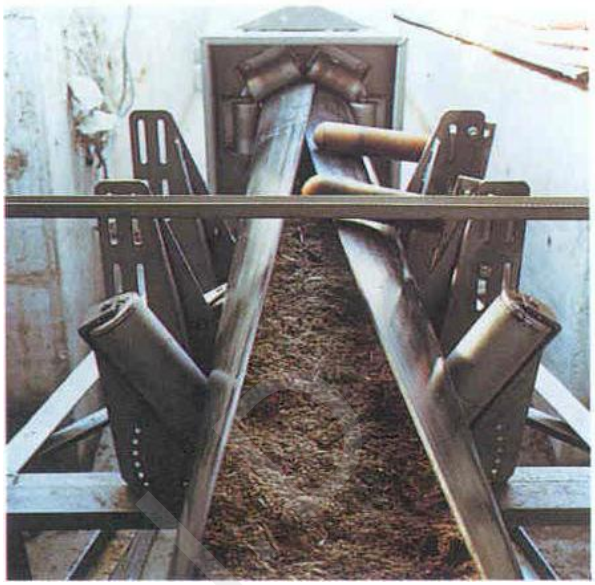
More about the pipe-conveyor

Some technical details:

In order to transform the belt from a troughed to a pipe-shape after negating the pulley the following procedure needs to take effect. Directly after the tail end pulley, while observing the transition length that is required for a troughed belt, the belt will be supported by impact idlers or impact bars. In this section the belt conveyor is provided with an intake provision. The length of this inlet chute is dictated by the belt speed and the specific characteristics of the product conveyed.
The troughing angle will gradually increase until the position is reached where finger shaped stub idlers will direct the belt into an overlap of the nearly pipe-shaped belt.



From this moment on the belt is kept in a circular form by idlers positioned in a hexagonal configuration. The belt will stay that way until the head section is reached.
The first meters after the transformation from touched belt into pipe-conveyor and a few meters before the unfolding takes place the pipe-conveyor needs to follow a straight trajectory. Beyond that the pipe conveyor can make upturn and downturn bends, make right and left turns or even a combination of vertical and horizontal curves. The radius for the curves is determined by the occurring forces in the belt at various positions; the combination of bend/turn and the total angle of the bend/turn that is between 300 up to 800 times the diameter of the pipe for synthetic plies.
For vertical curves some shorter radii are accepted. Similar for the pipe-conveyor as for the conventional conveyors for long overland conveyor systems or systems that convey high tonnage's it might be necessary to install steel cable belts.
The elastic elongation of the belt will be reduced but the steel cable belt requires longer radii; starting 60 times up to 1,200 (one thousand two hundred) times the diameter of the pipe.
During the transition from pipe to trough the product-carrying belt is be supported by idlers in a touched configuration with a decreasing angle.
At the return the same process repeats itself. For the transition from the flat belt to the pipe-shape and back TBO uses special troughing stations with idlers that differ in length and an adjustable troughing angle suitable for the specific requirements per position.
To support the idlers in the hexagonal configuration TBO also developed special clamps that lock the idlers completely and fix their positions.

Loading the conveyor:

One of the most elementary operational requirements is to load the pipe-conveyor (like every other conveyor system) in a correct way. Loading the conveyor in the central line is required to obtain a good alignment. A constant filling rate of the pipe is even more important. The capacity of a pipe-conveyor is dictated by volume, not by weight.
An overload or a peak load that exceeds the capacity of the conveyor during a short period will result in the spilling of product in case a conventional conveyor is used. Using a pipe-conveyor an over 100% filling percentage of the pipe conveyor leads to a jammed belt.
For this reason it is very important to have a regular feed and an adequate remedy in case of the occurrence of excessive peaks. For that reason a level detection system, or a switch activated in case of an unacceptable force on the idlers in the hexagonal configuration need to be implemented in the system.
Long objects in the product conveyed can cause problems as well.
The maximum size of the product being conveyed shall not be more than 1/3 of the pipe diameter. All enfolded/closed conveyor systems are subject to the same limitations.

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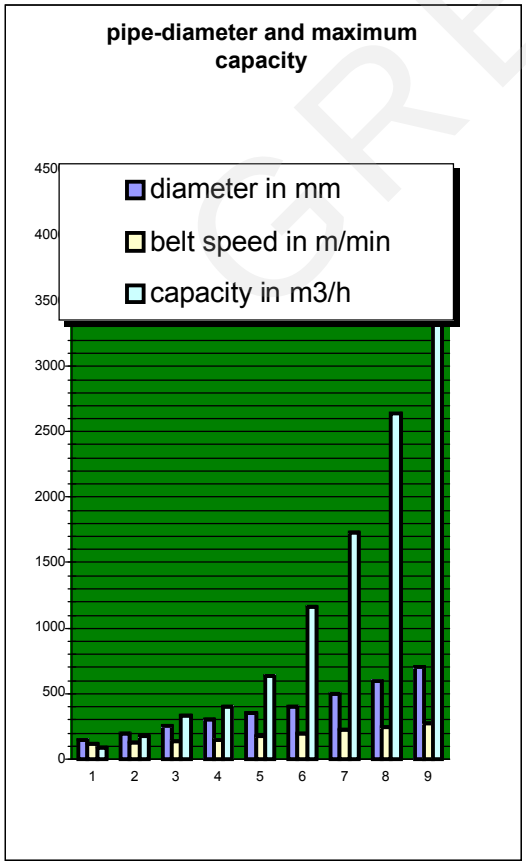
The tensioning of the belt:

Because the belt is returned in pipe-shape as well the available positions for installing a gravity tension unit is either close to the head pulley or the tail pulley of the pipe-conveyor, or in other positions where the belt is not formed into a pipe.
The position near the head pulley is mostly preferred because here the lowest tension forces and the greatest belt stretch occur. In case not enough height is available underneath the pipe-conveyor a horizontal traveling tension trolley with cables connected to a tension weight is be a good alternate.
A second best option is to install the tail-end pulley in a tension trolley. It is also possible to connect the tension trolley with an electric winch or to use an hydraulic tensioning unit.
All technical solutions as mentioned do not differ from the systems that are used for conventional belt conveyor systems.
However, during the engineering process it is important to keep in mind that the pipe conveyor requires a longer tension way than a conventional conveyor. After the rubber belt is put onto the system, a certain elongation will occur during the first hours of operation without product. Due to the higher friction resistance of the pipe-formed belt in between the hexagon idler configurations is not possible to achieve an effective and sufficient pre-tensioning over the entire length of the pipe conveyor while vulcanizing the belt.



Extra advantages of the pipe-conveyor system:

- Protection of the product against contamination with other products, protection of the product against climatological circumstances like rain, wind, temperature and protection of the environment
- Flexibility in the determination of the trajectory by the option of making curves in horizontal or vertical directions or even a combination of both.
- An increase in angle of incline angle in comparison with conventional conveyors.
- A reduction in the required space especially with respect to the width.
- The possibility of re-using belt frames and pulleys in the process of changing a conventional conveyor into a pipe-conveyor because of the fact that loading, unloading and cleaning of the belt do not differ while the same capacities can be conveyed with the same or less belt width.
- Fewer discharge points resulting in less pollution and lower maintenance costs.
- The pipe conveyor can run in reverse direction as well.
- The pipe conveyor can convey product in the return part as well.
- The pipe conveyor can be loaded in more than one position.
- The pipe conveyor can be provided with a longer loading section.

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Radius per Curve:

Type of Fabric	nom. Diam. in mm	Curve radius in mm			Transition Length
		<30°	30°- 45°	45°- 90°	
Nylon	150-300	300xD	400xD	600xD	25xD
	350-500	400xD	400xD	700xD	30xD
Polyester/ Nylon	150-300	400xD	500xD	700xD	30xD
	350-500	500xD	500xD	800xD	35xD
Kevlar	150-300	500xD	600xD	800xD	35xD
	350-500	600xD	700xD	900xD	40xD
Steel Cord	150-250	600xD	700xD	800xD	40xD
	250-350	700xD	800xD	1000xD	45xD
	400-500	800xD	1000xD	1200xD	50xD

The product in the belt at a maximum filling rate of 70% will be responsible for the positioning of the center of gravity and will keep the belt in the right position with the overlap on top.
At the return part the overlap will define the center of gravity which is on the opposite side of the overlap. This will keep the overlap at the bottom side.

When the belt is twisted upside down before it transforms into a pipe-shape it is possible to carry product in the return part of the belt as well. In such system the clean side of the belt is always on the outside and the product carrying side on the inside. Only the clean side of the belt will be in contact with the idlers.

Lifetime of the rubber belt:

The life of the rubber belt for a pipe-conveyor is not surpassed by the life of a conventional troughed conveyor. As long as no mechanical damage occurs, a lifetime of 10 or 15 years is a possibility. With conventional systems mis-alignment of the rubber belt can result in a contact with supports and beams leading to mechanical damage of belt and structure. With pipe-conveyors however, as long as the belt is in pipe-shape this will not occur. At the transition damage will not occur either because the rubber belt will enter and leave the hexagon configurations on the centerline of the pulleys.

Energy consumption and maintenance costs:

If the power consumption of pipe-conveyors at a long curved trajectory would be compared with the power consumption for the same trajectory with a number of conventional conveyors, the use of energy will be nearly the same. The extra inclinations as the result of the several transfer points from one conveyor to another, the extra belt cleaners, the inlet provisions, the pulley resistances and the energy needed for start up of various conveyors, will increase the energy consumption. For a pipe-conveyor, extra energy is required by the larger number of idlers, the greater total load on the idlers, the transforming of the rubber belt into a pipe-shape and the product filled pipe while negotiating the hexagon configurations.

The larger the number of conveyors needed to cover the trajectory, the better the position of the pipe-conveyor will become with respect to energy consumption, initial investment and especially with respect to the maintenance costs.
A sound justification for the installation of a pipe-conveyor is the total cost per ton of product conveyed. With respect to maintenance costs the conventional conveyor will always be more expensive than the pipe-conveyor.

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Available rubber compounds:

The rubber belts can be supplied in:
- High abrasion resistant (grade 1)
- Heat resistant
- Flame retardant (MSHA)
- Oil resistant (MOR)
- High oil resistant (SOR)
- White rubber (FDA)

This makes the pipe conveyor suitable for:
- Abrasive materials
- Hot materials
- Flamable products
- Oil- and fat containing products
- Food industry

Possibilities in the market:

We feel the pipe-conveyor will offer great possibilities to numerous companies that at the present time struggle to optimize their bulk handling process.

- Cement, clinker, dry cement pre-mixtures, filter-dust, fly-ash, sawdust, wood chips.
- Waste water treatment sludge, dredging sludge, pulp and filter cake.
- Ore concentrates, minerals, bauxite, animal feed, fertilizers and potash.
- Wet fly ash, gypsum, petroleum and coke.
- Refined sugar, cocoa.
- Over land conveyors for surface mining, underground mining.

Pipe-conveyor at Pasminco Budel Zink

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Transformation of an existing conventional conveyor system into a pipe-conveyor:

In contradiction with other systems a pipe-conveyor can be installed on existing belt frames of conventional conveyors. In many situations the drive pulley, tail pulley and tension pulley can be re-used. The inlet provision can remain the same and the transition idler stations can be installed on the existing belt frame as well.
There may be just a few situations where the available height is insufficient for the installation of the panels with the idlers in the hexagon configuration. Every now and then (for instance conveyors with short length supports, or conveyors located in a gantry) there will be insufficient space to return the belt in the pipe-form.
As long as spillage from the return part of the belt was not the main reason for considering a pipe-conveyor, there is no problem if the belt is returned as a conventional belt while using the existing return idlers. In that case the transformation will be easier and the costs will be reduced considerably.
In comparison with conventional conveyors with a troughing angle of 15 to 20 degrees, carrying product with a limited surcharge angle, the pipe-conveyor will have the same capacity if the belt width and the belt speed would remain unchanged.
To replace conventional conveyors with a troughing angle of 25 degrees or more that run at a maximum volumetric capacity conveying products with a higher surcharge angle into a pipe-conveyor the belt-width and/or the belt speed must be increased to maintain the same capacity.
Normally a pipe conveyor will run at a higher belt speed than troughed conveyors. Because of that there will be only a few situations where the transformation of a conventional conveyor into a pipe-conveyor is not possible because of capacity concerns.

For additional technical information please refer to the author:

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