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bulk solids handling

3.2 km Long Pipe Conveyor with 90° Horizontal Curve at Birla Copper, India by Naveen Projects Ltd.

Introduction

This paper describes one of the largest single flight pipe conveyors in the world. Birla Copper selected Naveen Projects Ltd. for turnkey execution of 90° horizontally curved 3.2 km long pipe conveyor for transportation of copper concentrate/ rock phosphate/coal from the jetty to the copper smelter plant.

The pipe conveyor was selected for this installation because it enables the product to be conveyed from the berth to the plant by a single conveyor, without any transfer points. In addition, the pipe conveyor design enables the conveyed product to be enclosed by the conveyor belt, thereby shielding the product and preventing the product from spilling or being blown off the conveyor en route.

Owing to the length and the conveying capacity, it was necessary to provide drive units at both ends of the conveyor, i.e. two drives at the plant-end, and one drive at the tail-end i.e. the berth-end. Drives are provided with variable frequency drives for smooth start and variable speed.

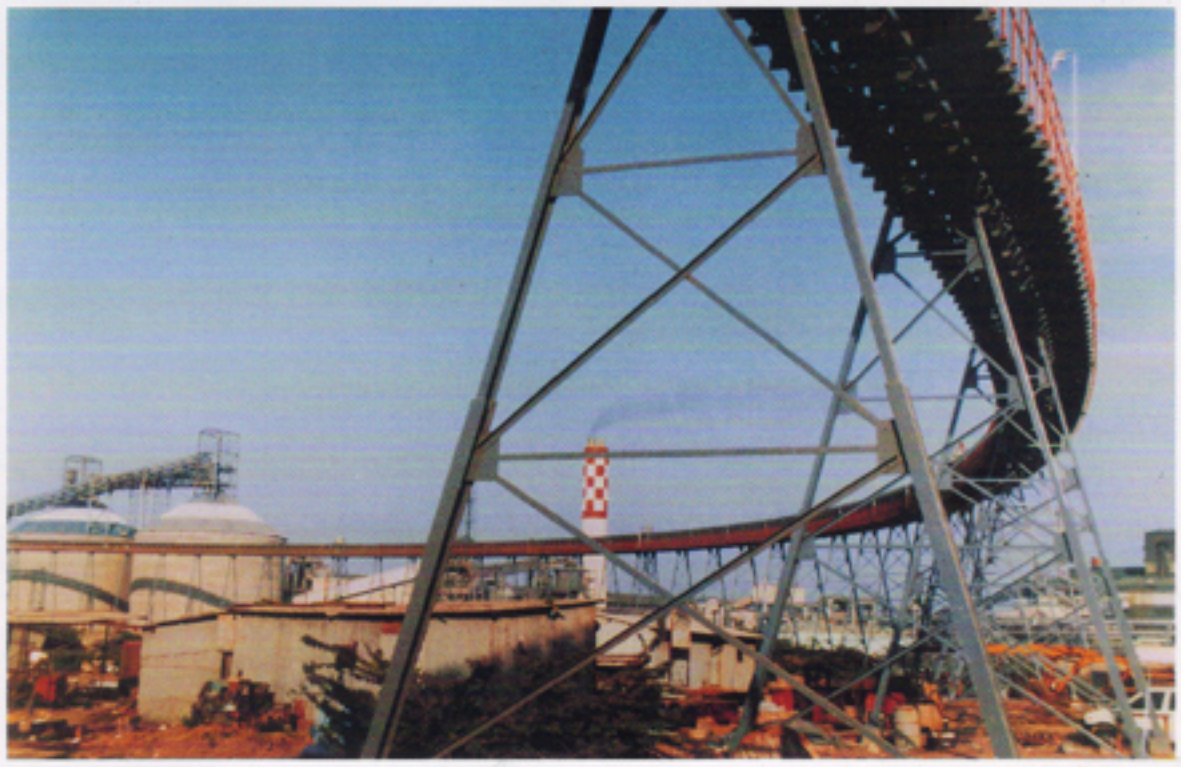

Fig.1: 3.2 km long pipe conveyor at Birla Copper

Conveyor Parameters

The pipe conveyor basic parameters are given in Table 1.

Table 1 : Pipe conveyor basic parameters

Conveyor length	3,200 m	
Overall lift	22.0 m	
Belt Speed	4.5 m/s, variable 10% to 100%	
Conveyor capacity		
- copper concentrate	880 t/h (initial),	1760 t/h (future)
- rock phosphate	770 t/h	1540 t/h
- coal	550 t/h	1100 t/h
Pipe diameter :	450 mm	
Belt specification and covers	ST1000, 8×6 mm covers, M-24, 1650 mm width	
Horizontal radius and angle:	300.0 m, 90°	
Location & type of take-up	Horizontal trolley, gravity mass at head end	
Installed power	Head 1 × 500 kW, Tail 1× 500 kW + 1 × 500 kW future of head end	
Idler diameter / length / Brg. size	152 mm / 325 mm / 25 mm	
Number of idlers per panel	6 carrying side and 6 return side	
Pitch of idlers	2000 mm normal, 1000 mm on curve	
Fly wheel	On head end for smooth starting and stopping	
Conveyor Starting time	100 sec. following 'S' shape velocity curve	
Method of Speed synchorisation	By giving speed reference to each variable frequency drive from PLC	

Description of the Pipe Conveyor

The pipe conveyor comprises loading section, intermediate section head/discharge section and conveyor belting. Each of these sections are discussed below :

Loading Section

This section incorporates the tail drive pulley, the loading point and the pipe-forming sections of the conveyor. The section is approximately 37 m in length and is enclosed in a closed gallery to prevent the ingress of rainwater and high winds on the open portion of the conveyor at the coastal area

The tail drive unit consists of 500 kW motor with variable frequency controller, helical gear box, geared coupling, tail drive pulley and snub pulley. A pulse encoder is provided at motor shaft extension to give speed feed back to the variable frequency drive.

On the carrying side of the conveyor (moving in the direction of travel of the belt), the belt is gradually troughed via transition idlers to a 20 degree trough angle, which is required at the loading point. The idlers are pitched at 2.0 m along this section ex-cept at the loading point, where the Impact idler pitch is 400 mm.

Moulded rubber skirts are provided to prevent spilage of the loaded product and to centralise the material on the conveyor belt. In addition, a de-dusting system is provided to remove all dust generated during transfer onto the pipe conveyor.

A belt weigher has been provided along this transition section, and the feed rate and quantity of product conveyed is recorded.

After the loading point an over-fill detector is located above the load stream to ensure that the conveyor belt is not excessively loaded. Should excessive loading occur the conveyor is automatically tripped. At the outlet of the skirt place, a baffle plate is provided to guide material to the centre

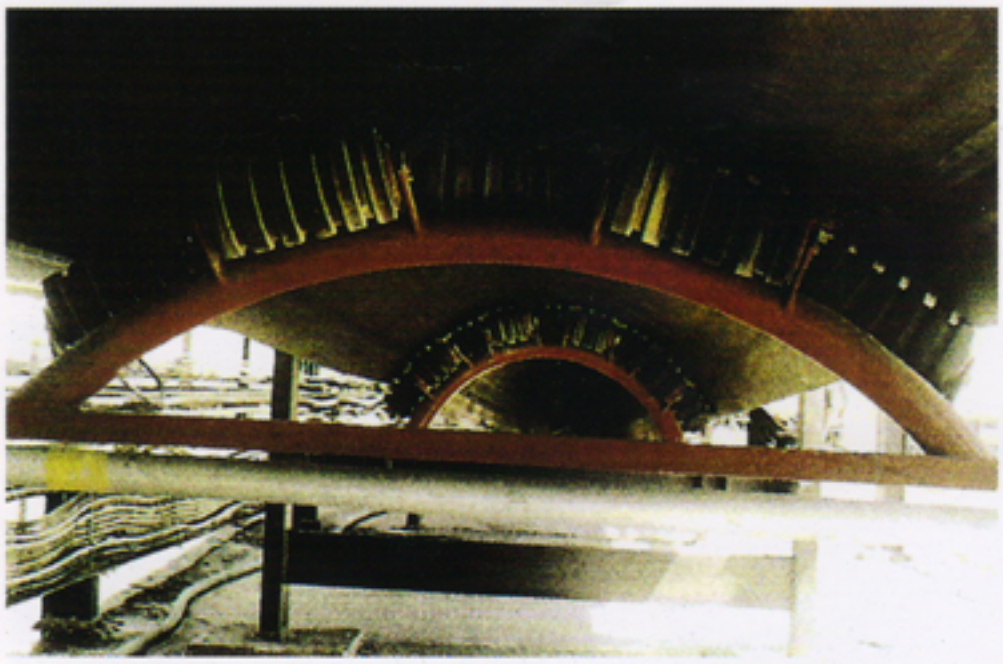

Fig. 2: Return Belt near tail end transition portion

of the belt. This is important for a correct formation of the pipe conveyor and the correct positioning of the overlap section.

From the loading point, the conveyor belt is troughed further i.e. from 20 degree to 45 degrees and to 90 degrees over a length of approximately 25 m. Idlers at a pitch of 2.0 m along this transition section guide the belt into the formation of the pipe shape. The correct training of the belt ensures that the overlap in the belt remains at the top of the pipe formation.

At the end of the transition section, the first pipe conveyor idler support panel guides the two edges of the belt into the final pipe enclosing the product inside the belt.

On the return-side of the conveyor the tubular form of the belt gradually opens from the point where the belt exits the last idler support panel, to the snub pulley adjacent to the tail/drive pulley. The return belt is supported throughout this section by a series of inverted idlers ranging from 90° to 15° at intervals of 4.5 m. First set of inverted idlers is made of PVC to take care of excessive load due to belt opening.

Intermediate Pipe Conveyor Section

The intermediate section of the pipe conveyor is at ground-level, horizontal structure of initial length 2250 m and thereafter the belt line is elevated at an angle of 5.7° to a height of approximately 7.3 m for future road crossing. From this point the belt line gradually rises at 1.3° to a finished height of 26.5 m above the local ground level at the discharge pulley. In this portion, the horizontal curve is located.

A 90° horizontal curve is being included in the pipe conveyor section, with a radius of 300 m. The inclusion of this curve eliminates the need for a transfer point midway along the conveyor.

The overland section is made up of a series of idler support panels at intervals of 2.0 m and are secured in a box girder type structure. For the ground-line section the gantry is supported on end portals. The top of the gantry is approximately 2.6 m above the local ground level of the structure. Expansion joints are provided at 30 m intervals to take care of longitudinal thermal expansion due to temperature variation.

Access is provided on both sides of the conveyor via a 500 mm and 1000 mm walkway respectively at the point where the conveyor elevates.

The gantry is supported on trestles and the pitch of the idler panels ranges between 2.0 m for straight sections, and 1.0 m at the horizontal curve. The closer pitch is to ensure that the load on the idlers is maintained within design limits and to prevent collapse of the pipe.

Throughout the length of the pipe conveyor all panels are perpendicular to the belt gantry. 1mm tolerance is maintained throughout the steel structure of pipe conveyor. Due to accurate erection and close tolerance, the conveyor could be commissioned within a few hours of empty running.

The horizontal curve was maintained by fabricating the gantry at a radius of 300 m.

Longitudinal thermal expansion and contraction of the entire pipe conveyor structure was considered during the design of the gantry.

Each idler panel includes two training idlers (one for the carrying and one for the return belt) to ensure that the conveyor belt maintains its correct alignment i.e. the overlap must remain at the top and bottom of the carrying and return paths respectively.

The training idlers are mounted on an adjustable support bracket with slotted holes, to enable the pipe to be trained by adjusting only one of the size idlers per panel.

The location of the training idler is selected so as to have maximum force.

The idlers are arranged on alternate sides of each panel and the gauge length of the idlers ensures that it is impossible for the belt to come into contact with the roller edges.

Head Discharge Section

At the end of the elevated conveyor, the pipe form is gradually opened from the point of the last panel, to the head pulley. The belt is supported throughout this section by a series of idlers, ranging from a troughing angle of 90° down to 15°. In this way the belt conveyor is opened without over-stressing and the product being conveyed remains in the centre of the opened belt.

Misalignment switches are provided to trip the conveyor in the event that the belt alignment is disturbed to the extent that could result damage to belt.

Roof and side sheeting is provided at the head-end of the conveyor where the belt is opened, to prevent rainwater contaminating the product on the belt.

Fig. 3: Intermediate section of pipe conveyor

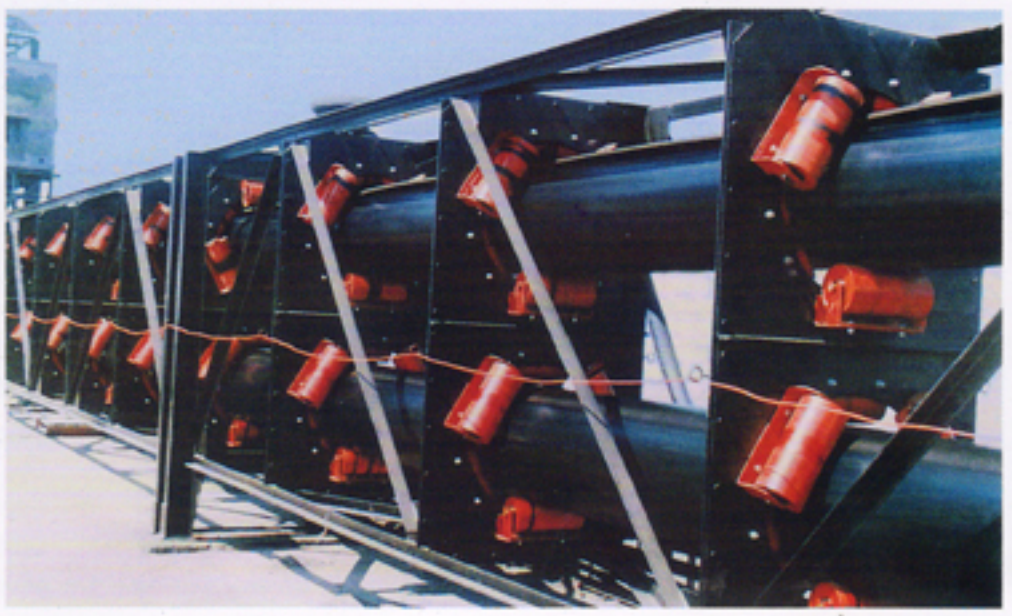

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Fig. 4: Straight portion of pipe conveyor at jetty

The head pulley is the point of discharge of the pipe conveyor and all the conveyed product is discharged into the receiving chute for onward handling. The discharge chute is fitted with adjustable deflected plates which are set during commissioning to guide the material trajectory to ensure correct loading of the downstream conveyor.

The head discharge section comprises belt scrapers to clean the dirty-side of the belt mechanically. All scrapings are kept inside the discharge chute. .

Having passed through the scrapers the belt is washed by means of water sprays before it enters the drive station. Dribblings from the washing station are collected in a trough and piped to a setting tank.

From the head pulley, the return-side belt is supported on flat return idlers and is guided through the head-end drive and take-up stations In the open or flat form. Once the belt has passed through the head pulley, drive and take-up, the belt is again formed into the tubular cross-section by a series of troughed idlers and fed into the idler panels along the return side.

The 'dirty' side of the belt is on the inside of the pipe form and the overlap is at the bottom of the cross-section.

Drive Stations

Having passed over the head pulley and through the belt cleaning facility, the belt is routed from the gantry to ground level. The head end drive station comprises two drive pulleys.

The drives are 500 kW units each comprising helical reducers, geared couplings and fly wheels, all mounted on the common base plate.

The drives are variable speed units controlled by variable frequency controller thus fluid couplings are not required. The thyristor controllers provide the facility to control the starting and stopping of the conveyor under the various load conditions.

Each of the two drive pulleys are 100 mm in diameter and are lagged.

Provision has been made for maintenance of the equipment by the inclusion of hoisting units overall pulleys and drives.
The entire drive arrangement and take-up assembly are enclosed in removable guards.

Take-Up Section

The horizontal gravity take-up is provided to maintain the required tension in the conveyor belt during all operating conditions. The take-up comprises a horizontal travelling trolley onto which the take-up pulley is mounted and is positioned directly after head end drive station.

Space for vulcanising is provided between head end drive and take-up unit. The trolley and take-up structure are positioned at ground level and the belt path is diverted from the elevated gantry by means of a series of bend pulleys. Take-up tension is provided by the adjacent vertical gravity take-up tower where the take-up mass is connected to the take-up pulley by means of the steel rope and series of sheave wheels. The rope is terminated onto an electric winch which is used to raise and lower the take-up mass for maintenance purposes.

The take-up length of 19 m takes into consideration the dynamic travel of the take-up pulley and the permanent elongation expected in the belting.

Over travel limit switches are provided in take-up tower to stop the conveyor in case of excessive travel of counter weight.

Conveyor Belting

Belt selection was a very tricky issue. Nylon-nylon belting was not selected due to high elongation and control of very long take up travel. This left only steel cord belt. Only three known references were available where steel cord belting was used. However, the performance of steel cord belt was never tested with 90° curves.

It was decided to adopt steel cord belting due to the following reasons:

i) Expected life of steel cord belting is 10 - 12 years compared to 3-4 years of nylon-nylon/EP belting.

ii) Starting control is easy due to less take up travel.

Belting was sourced from South Korea through Hyundai Corporation.

In pipe conveyor belting the following considerations are extremely important:

i) Belt should be rigid enough to form a desired radius during continuous operation and belt should not deform at curve points.

ii) Rigidity should not be too high otherwise unnecessary force will be on idlers due to the opening tendency of belt.

iii) Corners of belt should be soft to make smooth pipe formation.

Based on the above requirements, every precaution was taken during belt cross-section selection. It was decided to have two layers of 1 mm thick fabric inside cross-section to have sufficient rigidity and 148 Nos. of steel wire cords of 3.4 mm dia were selected to ensure the desired tension.

Conveyor Starting

For smooth starting of conveyor, 100 sec. acceleration time was selected. Both drives are started in 'S' curve pattern restricting torque limit of motors at 100% and simultaneously synchronising both motors. From PLC both drives can be started at any speed for 10% to 100%. Based on load requirement, drives are suitable to run the conveyor at any speed between 10% to 100%. Proportionate load sharing is observed between both head end and tail end drives.

TECON PROJECTS PVT. LIMITED

Sister Concern of Naveen Projects Ltd.

B-159, Sector-63, Noida-201 307, U.P. (India)
Tel.: +91-120-4341000, Fax: +91-120-4341020
E-mail : marketing@teconprojects.com, mail@teconprojects.com
Website : www.teconprojects.com, www.pipe-conveyor.com

An ISO 9001-2000 Certified Company