DESIGNING TO OVERCOME

Kesavan Vijayanand, TAKRAF, India, outlines the possible design features and challenges that may need to be overcome when designing an overland conveyor.

Belt conveyor systems cover a wide range of applications – from mining or extraction to in-plant or overland, where they convey material over long distances, passing through curves and rough relief areas. Overland conveying has found increasing popularity due to its potential to continuously and efficiently transport material, while offering other advantages such as high conveying capacities, safe and reliable materials handling, and environmental considerations. However, for 100% effective availability and to avoid challenges such as material blockages, carryback and spillage, focus needs to be placed on optimising material flow along the entire conveying system, based on a thorough understanding of the properties of the material being conveyed. This is particularly critical when conveyors are required to traverse complex routes, such as those with steep inclines and declines, multiple and/or tight curves, and numerous crossings.

Case study: Utkal Alumina, India

A contract from Utkal Alumina International Ltd (UAIL) called for an overland conveyor system to transport bauxite from the mines to a new 4.5 million tpy alumina plant. TAKRAF successfully completed the approximately 19 km overland conveyor system for UAIL's green fields project in Tikri, Raigada, in the Orissa state of India. This also included the longest single-flight conveyor system to be installed to date within Indian territory.

With a high quality bauxite as its input, and tightly integrated logistics between the mines and the refinery, Utkal Alumina's operating cost per tonne of alumina is among the lowest in the world. The bauxite for

Utkal Alumina is sourced entirely from the Baphlimali mines, some 16 km (aerial distance) from the plant site in the Doragurha village. Prior to being conveyed overland to the processing plant, the bauxite is crushed to a size of -150 mm, with the fixed crushing package having been provided in 2012/2013 by a sister company, the then Bateman India (acquired by Tenova in 2012).

Conveying ore from mine to plant

The scope of the overland conveyor project covered design, basic and detailed engineering, procurement and fabrication, right through to erection – which included civil and structural work, commissioning, performance guarantee test runs, and handover of the 2850 tph conveyor system. An intermediate transfer point and unloading station, including silos and buildings, were also supplied with complete electrical and instrumentation systems.

The system design brief called for the primary crushed bauxite ore of size -150 mm to be fed from the mine end junction house, through a chute to an overland conveyor of 14.5 km. This overland conveyor, ending at an intermediate junction house, in turn feeds a 3.6 km overland conveyor. The latter, shorter conveyor ends at a plant end junction house, feeding a 500 t material surge hopper via a two-way chute. The overland system comprises 2000 and 4000 tensile strength steel cord conveyor belting, with a minimum belt safety factor at a steady state of >5.5, supported on a series of underslung-type idlers. These, in turn, are supported on a structural system made up of ground modules and gantries, with the overland conveyors routed partly along the ground and partly along an elevated portion. From the surge hopper, material is fed either directly to plant conveyors or to a stockpile through stockyard conveyors supplied by others.

Figure 1. A very undulating terrain typified the path of the conveyor moving bauxite ore from the mine to the Utkal Alumina plant.

Figure 2. Blasting and excavating were required for creating a suitable route through the hilly region of the conveyor path.

Advanced design and engineering

The execution of the project represented a group-wide effort, drawing on the global overland conveying expertise of TAKRAF Group, with the length of the required conveyor system and the challenging topography along the conveyor path calling for state-of-the-art design and engineering. Industry-leading software was used to maximise routing and equipment utilisation and specifications. The conveyor design was supported by horizontal curve analysis and dynamic analysis to optimise the long-distance conveyor power and belt tensions. Global procurement was followed in order to optimise costs and also to source the most advanced and reliable components.

Initially, two technologies were considered, overland trough belt conveying and cable belt, with the client selecting the former due to its many advantages in such inhospitable and remote terrain. In addition, a major advantage of using trough belt conveying was that almost all the components and spares for trough belts are available in India, with a very small percentage of imported components.

Designing for a complex terrain

In its final configuration, the system's two conveyors traverse a highly undulating and complex terrain. Dropping in total by 250 m over its course from material loading to discharge, the conveyor system passes through 11 nalas (branch rivers), the Ratachuan River, one forest stretch of nearly 470 m in length, a high voltage line crossing, 37 road crossings, a paddy field adjacent to the plant boundary with a stretch of approximately 2.5 km, eight hills, and several villages. The elevated structures were provided with cage ladders spaced at approximately 150 m, and pile foundations were provided for the river crossing and one of the downhill crossings.

As a result of the topography, and due to the conveyor length, the conveyors were designed with head and tail drives and multiple, very tight compound horizontal and vertical curves. In total, the conveyor system features 10 right hand curves, four left hand curves, and horizontal curve radii of 2500 m across all locations but one – a critical zone on the shorter conveyor where the horizontal curve is 1800 m. This portion of the conveyor passes over a hill and through the plant boundary. The longer conveyor has a ground module and a graded portion. The ground module comprises 17 straight sections, one left hand curve and one right hand curve section, while the graded portion consists of 12 straight sections, two left hand curves, and four right hand curves. The overland gallery on both conveyors together features 403 straight sections, 154 right hand curves and 61 left hand curves, with a maximum gallery length/support interval of 49.5 m and standard gantry length of 27 m.

The idler spacing for the straight and inclined portions of the galleries on both conveyors is 4.5 m for the carry idlers and 9 m for the return idlers, except for one section on the longer conveyor where the carry idlers are spaced at 3.5 m and the return idlers at 7 m. On both conveyors, the carry idler spacing for the horizontal curved galleries is 2.25 m and the return idlers are spaced at 4.5 m. With an installed power of 6 x 850 kW and 2 x 850 kW, the conveyor system features six drives at the tail end and four at the head end on the longer conveyor, while the shorter conveyor has two drives at the head end only. There are two belt turn-overs on each conveyor, one at the tail end and one at the head end. Each conveyor features a fail-safe hydraulic disc brake at the tail end. A take-up winch with capstan brake arrangement has been provided at the head end of both conveyors.

The intermediate transfer point between the two conveyors is located in hilly terrain and, since the four head end drives of the longer conveyor are also located there, the conveyor drive and take-up areas are mounted on a portal steel structure. These lightweight but high strength structures provide the design flexibility to accommodate the terrain. Advanced material flowability testing and modelling were used in the design of the transfer chutes at the intermediate transfer point and the plant end junction house to minimise risks, such as: environmental pollution and spillage, accelerated belt wear, and blockages. To facilitate maintenance, approach roads and a mine road were made available all along the conveyor length, with the cage ladders provided on the elevated structures enabling ease of access.

Conveyor erection focuses on zero harm

Erection of the conveyor system was complicated by the requirement to accommodate and minimise disturbance of the population of the various villages through which the conveyor system passes, as well as the need to blast and excavate a suitable route through the hilly region of the conveyor path. Approach roads for erection of elevated structures on the hilly terrains also had to be provided. With major equipment, such as heavy cranes and excavators, being used for the erection of the elevated structures, particularly in the challenging hilly terrain, TAKRAF India placed particular focus on safety, strictly conforming both to TAKRAF's global promise of zero harm and to the client's safety protocols.

Performance guarantee testing was carried out over nearly one week, with the system consistently achieving its present capacity of 1500 tph. As a result, the conveyor system was handed over to the client in December 2016 at a special event where celebratory Pooja rituals were carried out in the presence of top management of both companies.

Case study: Chile

TAKRAF also delivered the world's most powerful belt conveyor system for Chuquicamata in Chile, one of the world's largest copper ore mines, moving ore extracted underground to an above-ground processing plant. The system, with a total installed drive power of 58 MW, transports crushed copper ore from underground storage bins to the surface along a 7 km underground tunnel that overcomes 1 km of vertical elevation. Once on the surface, the ore then travels along an overland conveyor that transports it the final 6 km to the distribution silo. The underground system, comprising two conveyors of about equal length, as well as the overland conveyor, has advanced gearless drive technology.

Conclusion

The Utkal project demonstrates that, despite the increasing complexity of conveyor systems, access to the latest technologies supported by advanced design principals and expertise will result in a robust, reliable, and cost-effective overland belt conveying system.

Additional factors that can play a major role in the success of a project like this one include taking an integrated approach to the system design and construction methodology for a seamless erection and commissioning phase.

Furthermore, placing the focus on an owner/operator and supplier interaction can ensure that the designed system is not only fit-for purpose for its specific application and the project's unique requirements, but that it is also best-integrated with upstream and downstream processes for overall system effectiveness.

GMR