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Transporting and Loading of Bulk Materials

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Schüttgut-Transport und -Beladung
Transport et chargement des matériaux en vrac
Transporte y carga de materiales a granel
バルク材料の輸送及び積込み
散装物料的运输与装卸
نقل وتحميل المواد السائبة . بقلم ي . ديفز

Summary

Background details, basic design criteria, operational constraints and performance of two major materials handling installations are presented. The 18.8 km aerial ropeway installed by BRECO for the Calcimine Company, Iran and which runs over very rugged mountainous terrain which for the early part of the year is covered with deep snow, solved certain severe bulk materials handling problems which due to the extreme weather conditions made transportation by conventional means a virtual impossibility. The aerial ropeway currently provides a simple cost effective, continuously operational solution.

The Hunterston shiploader supplied by BRECO is the largest of its kind in the UK, being 43 m high and weighing 425 t, and incorporates a number of special features designed with functional economy in mind. Jetty length is reduced by excluding the orthodox trailing tripper and there is no requirement for separate bucket elevators. The shiploader also incorporates other novel design features which are detailed.

1. Introduction

With much of world industry in recession, engineering companies are not having an easy time and competition is sharper than ever, especially for any high-value contracts on offer in bulk materials handling. It follows therefore that tendering companies looking for an edge over international competitors must not only be cost conscious and have all the essential technical expertise; they must put themselves squarely in the position of their potential customer and make his problems their own.

In many instances the customer knows very clearly what he wants to achieve — how much material has to be moved from A to B in a specified time, for example — but he is far from sure about the precise method and type of plant that will do the work with maximum economy, efficiency and reliability. Ease of maintenance, minimal operational labour, slow depreciation, satisfaction of environmental constraints, these and many other factors have to be studied with great care and everything assessed within the total estimated cost of the system or project.

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To estimate cost in real terms, the plant user should of course take into account both capital cost and operating cost, the latter being projected over a specified period. In some cases it may be found that high initial costs are offset by low operating costs, and vice versa. This has been demonstrated effectively by a member of the Capper Neill Group, British Ropeway Engineering Company (BRECO), of Sevenoaks, England who have designed well over a thousand aerial ropeways for installation in remote areas of the world where, in many instances, other methods of transport were considered unsuitable.

2. Aerial Ropeway for Iran

An example is the recent commissioning of a monocable ropeway for the Calcimine Company of Iran. The system crosses 12 miles of rugged country and is a vital factor in enabling the company to meet the increasing demand for zinc and lead calcinates (Fig. 1).

Fig. 1: Ore-carrying monocable aerial ropeway crossing over a barren stretch of country in the edge of the Khamseh mountains in Iran

High in a remote part of the Khamseh mountains lies a rich deposit of zinc and lead ore which the Calcimine Company mines mainly by opencast methods. The ore was formerly calcinated in kilns close to the mine and the calcinates transported by road trucks down a steep and tortuous mountain road to Dandi, then on to the stores at Zanjan.

The geography and altitude of this area make for severe winters and during January and February there are heavy snowfalls which block out the mine and make the roads impassable. It had therefore been necessary to close down all operations between mid-December and mid-April, a loss of four months' production each year. But with the increased world demand and rapidly rising price of zinc it is not surprising that it was decided to invest in modern processing equipment and revise the whole operation to give controlled output throughout the year (Fig. 2).

Fig. 2: View from the ore loading station

To achieve this it was decided to relocate the processing plant at Dandi where year-round working was easier owing to its lower altitude, and to increase production at the mine during the eight months when working was possible.

Basic to the success of the revised plan was the choice of a transport system that could continue operating under adverse winter conditions. The aerial ropeway system recommended by BRECO was adopted after careful consideration of the alternatives. Belt conveyors, it was realised, would be buried by deep snow on the higher section of the route where it would also be equally impossible for trucks to operate and maintain capacity on the treacherous mountain road.

Design and supply of the ropeway was entrusted to BRECO, with civil engineering and erection the responsibility of their Indian associated company. The main characteristics of the ropeway are given in Table 1.

A monocable ropeway uses a single continuous rope both supporting and transporting the load carriers. The level of the Calcimine Company's loading terminal is approximately 2,700 m and of the unloading terminal 1,965 m, a difference of 735 m, and the distance between terminals is about 18,800 m, with mountainous and very rugged terrain at the upper end.

Table 1: Design Characteristics of the Calcimine Iranian Aerial Ropeway

Type	— monocable
Capacity	— 140 t/h
Material carried	— lead and zinc ore
Weight of material	— 1,960/2,520 kg/m³
Bucket payload	— 950 kg
Speed of travel	— 230 m/min
Number of loads	— 147.4/hour
Time interval	— 24.43 seconds
Spacing between buckets	— 93.64 m
Length of line	— Section 1 — 2090 m)
	— Section 2 — 8449 m) 18,814 m total
	— Section 3 — 8275 m)
Difference in level	— Section 1 — 268 m)
	— Section 2 — 207 m) 735 m total
	— Section 3 — 260 m)
	(All loads travel downhill)
Motors	— Sections 1, 2 & 3; 140 HP DC 1000 rpm 440 V (motor for each section)
Control gear	— Ward Leonard. All sections fully interlocked. Group and local control.
Loading of buckets	— Automatic by pan feeders
Discharge of buckets	— Automatic (clam shell bucket)
Communication	— Telephone

With a downhill ropeway of this type there is the problem of cumulative tension developed in the rope by the gravity of the loaded buckets. This made it necessary for BRECO to split the alignment into three sections. The upper section is steep and therefore short, and the other two sections are both long and undulating, roughly of equal length.

Buckets travel the full length of the ropeway without slowing down or stopping, transferring from section to section via the intermediate sections at full speed (230 m/min). Because of the mountainous or uneven terrain, trestle heights vary between 5 m and 54 m with spans between them up to a maximum of 376 m. There are 170 trestles with an average span of 110 m.

Each section of the ropeway has its own driving gear and rope-tensioning equipment at its upper end. As the loads travel downhill from the loading station, surplus power is developed in each section and this is realised as a regenerative source of power for use in reducing the power consumption of the other electrical equipment at the mine. To ensure that, whatever the loading of the three sections, their speeds are constant, and that the controlled accelerating and decelerating periods during starting and stopping are synchronised, Ward Leonard control was adopted, using DC work motors. The power conditions of the three sections were sufficiently similar to allow the use of three identical drives, giving uniformity and simplifying spare part replacement.

Control equipment is arranged with key selection for full speed and one-third of full speed running under group control, the master control being at the loading station. All sections can be run individually on local control and the two-speed gearbox enables four separate speeds to be obtained: full speed, half speed, one-third and one-sixth speed. The slow speeds are for maintenance work.

The operating sequence of the ropeway begins at the loading station. After ore from the mine has been crushed to a maximum size of 80 mm it is delivered to a 2,000-t bunker and from there, by a conveyor, to the feed hopper of the ropeway. The ore is fed to the ropeway buckets by two pan feeders, one operational and one standby, each easily providing full capacity.

Weight of the ore varies between 1.96 and 2.52 t/m³ and as the buckets are designed to take a full load of the lighter material it was necessary to provide a means of ensuring that they were not overloaded with the heavier material. This was achieved by using weigh cells in the form of a weigh rail at each feeder to measure a specified weight of material into the buckets.

Mechanical and electronic equipment, including automatic marshalling of the buckets, is incorporated in the loading station; attendants are necessary only to ensure smooth running and proper filling and despatch of the buckets.

Starting and stopping periods of the ropeway are 120 seconds and during this period three buckets can enter and leave the stations. The accelerating and decelerating grades of the terminal stations are designed for full-speed running. This means that whereas a bucket entering the station at full speed will comfortably negotiate the grade, during the stopping of the plant or when running at slower speeds a bucket would have insufficient kinetic energy to attain the crest of the slope and would run back to collide with the following carrier.

To overcome this and to relieve the operators of pushing sluggish carriers up the steeply sloping rail, another haulage is installed between the rope/rail transfer point and the top of the sloping rail to propel forward any buckets unable to negotiate the slope unaided.

Similarly, on the departure side of the station, the grade is designed to accelerate a bucket to the same speed as the rope's for smooth transfer. A retarder is fitted which controls the speed of the gravitating bucket so that it travels at the same speed as the rope at the point of transfer, particularly during start-up and shut-down.

2.1 Intermediate Stations

At the two intermediate stations linking the three sections together the cars enter at full speed, transfer to the station shunt rail and gravitate through to the exit without losing speed (Fig. 3).

Fig. 3: One of the two intermediate stations

In the case of one intermediate station, the opportunity is taken by the shape of the shunt rails to change the direction of the route by 3 deg. 57 min.

As both intermediate stations contain return shunt rail loops, by changing over switches any section can be run alone and the carriers returned along the same section. This is useful for maintenance and bucket parking.

2.2 Unloading Station

At the unloading station the buckets enter and negotiate an upward grade to reduce their speed, tipping into a floor-level hopper from which ore is fed by a belt feeder to the conveyor of an automatic stacker. The empty buckets gravitate round the return loop and then run down an accelerating grade which is graded upwards to reduce their speed. At the top of the decelerating grade the carrier engages with a continuously running auxiliary haulage travelling at 0.3 m/sec.

Although the buckets do not stop in this station, they deposit their load into a receiving hopper by striking a trip lever after negotiating the decelerating grade. Each bucket empties and moves on without stopping.

The buckets are of the BRECO clam-shell type which split open in two halves to deposit their load vertically, automatically close when empty and relatch ready for refilling without manual assistance. Completely automatic operation is a major advantage of this type of bucket, and as the load is dropped vertically it is stable whatever the speed of emptying.

This smooth-running aerial ropeway system now plays an important part in the new development at the mine, transporting 140 t/h reliably and economically to the process plant lower down the mountain.

3. Shiploading System for British Steel

Another area of bulk handling in which BRECO have developed special expertise is shiploading. Contracts successfully completed in Spain and the Middle East were followed by a major undertaking for the British Steel Corporation. Now in operation at BSC's Hunterston ore terminal on the Firth of Clyde is the largest shiploader of its kind in the UK — 43 m high and weighing 425 tonnes (Fig. 4).

This travelling machine, with its associated loading and transfer conveyor, forms part of the £98 million deep water jetty, stockyard and rail loading-out system, one of the largest in the world. The jetty, extending about 1,150 m offshore, accommodates incoming ore carriers of up to 350,000 dwt on the seaward side and vessels of up to 150,000 dwt on the landward side for loading.

The BRECO shiploader receives bulk material at up to 5,000 t/h from a conveying system linking with the stockyard 3 km away, and loads vessels ranging in size from 15,000 to 150,000 dwt. It handles iron ore varying in density from 1.6 to 3 t/m³ and in size from fines to 150 mm and pellets. Normal loading rate is 4,000 t/h, with peaks of 5,000 t/h on overload. The shiploader conveyor belts are 1,400 mm wide and run at 3.2 m/sec.

Some of the latest developments for this type of plant are incorporated in the shiploading machine, including a specially designed tripper for transferring material from the conveyor system to the shiploader. In deep water, jetty construction costs are high, so its length had to be kept to a minimum. With this in mind, the tripper has been cantilevered above the jetty conveyor, allowing the shortest approach distance to be

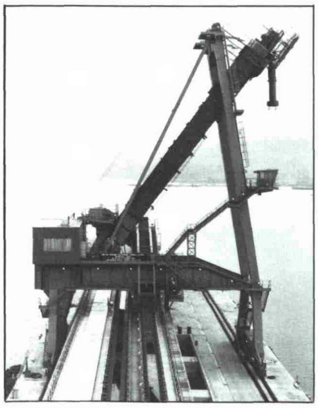

Fig. 4: 4,000 t/h travelling shiploader operating at British Steel Corporation's ore terminal at Hunterston on the Firth of Clyde

maintained between the loader and unloader. Jetty length is reduced by excluding the orthodox trailing tripper. In BRECO's design the tripper, cantilevered forward of the machine, directs the material to an inclined conveyor which in turn feeds the boom conveyor. This development obviates the need for two vertical bucket elevators, each of 4,000 t/h capacity (one being for standby duty).

The loader has four motions: travel, luffing, shuttle and telescopic chute operation.

3.1 Travel

The machine is mounted on four bogies running on two of the four unloader rails at 26 m gauge. Each fully articulated bogie unit has its own drive consisting of a slipring motor, helical gearbox and spur gearing driving through two of its four wheels. To prevent crabbing, all four bogies are connected electrically through tied rotor control to balance the speed and loads.

Speed variation and control are important, for the machine has to be fast-travelled to its required position along the jetty, and then manoeuvred accurately over the hold of the ship with the more controllable slow speed. The fast speed is 30 m/min and the slow speed 3 m/min provided by four geared motors coupled to and driving through the main bogie motors.

The loader is fitted with two rail clamps which are fully floating, weight operated, pneumatically released and grip the head of the rail when the machine is working but not travelling. Four storm anchor pins mounted on the bogies drop into holes in the jetty deck. Then, should the wind speed rise above the working level, both the rail clamps and the storm anchor mechanisms are electrically interlocked with the travel gear to prevent running unless they have been correctly released.

3.2 Luffing

The luffing motion operates on a multi-part rope system from identical winches allowing single winch operation at half speed. In addition to dual electro-mechanical brakes, pneumatically released safety brakes operate directly on the winch barrels.

The boom can be luffed over a range from minus 10 deg to 55 deg, at which point the automatic latch gear operates, holding the boom in a safe position for storm conditions or rope maintenance.

3.3 Shuttle

The shuttle motion operates on a rope system from double-drum winches moving the shuttle boom at a speed of 9 m/min. Shuttle boom travel is 21 m, giving the variation in reach necessary for the wide range of vessels to be loaded.

3.4 Telescopic Chute

As with other rope systems, the purpose of the telescopic chute is to direct the material flow accurately into the hold while minimising the escape of dust. In the BRECO design the dust problem is dealt with in this way: at the bottom of the telescopic chute three probe-type limit switches are fitted which when displaced, energise the winches, automatically raising the chute 750 mm and ensuring that the gap between the bottom of the chute and the material pile remains minimal. Telescoping range is 18.5 m, with a speed of 10 m/min (Fig. 5).

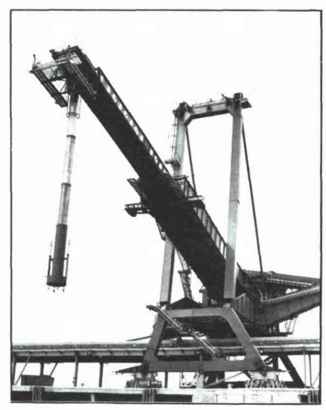

Fig. 5: Travelling shiploader with telescopic chute in extended position

On most loaders the winches to control different motions are located at convenient positions around the machine, but as shiploaders increased in size it became clear that a change was needed. Recent BRECO loaders have centralised all winches — as at Hunterston — in a common machine house with an overhead crane for servicing. The shiploader is under the immediate control of an operator handling all motions from an elevated cabin. The main controls and levers are mounted on consoles positioned on either side of the operator's seat, with a visual display unit above. Although the loading procedure will probably be decided by the ship's captain, the loader operator has complete control of loading including, via a telephone link, control of material delivery and reclamation from the stockyard.

In addition to shiploaders and aerial ropeways, BRECO's technical skills cover a wide range of industrial applications including belt conveyor plants, stackers, elevators, drag scrapers, skip hoists, cableways and slackline excavators. The company welcomes consultation at the earliest stage of project planning, so that their design engineers can make recommendations for the best solution of materials handling problems wherever they may occur.