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DOWNHILL CABLE BELT CONVEYOR AT

CRAIGMONT MINES LIMITED

MERRITT, B.C.

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ABSTRACT

The Cable Belt Conveyor installation at Craigmont Mines Limited has the greatest vertical fall in one stage of any conveyor installed overland in Canada.

Since late summer of 1961, this conveyor has carried over 5,000,000 tons of copper ore from open pit to concentrator site.

When the conveyor is loaded, the drive motor acts as an induction generator, delivering power to an external circuit.

This paper covers the selection, the operation, the performance statistics and the installation and operating costs of this conveyor system.

INTRODUCTION

The Craigmont Mine is located in the southwestern interior region of the Province of British Columbia, approximately 240 miles northeast of Vancouver. A moderate climate, good roads, service by the Canadian Pacific Railroad, power from the British Columbia Hydro Authority, gas from the nearby main line of the Inland Natural Gas Company, and close proximity to the Village of Merritt provide a favourable location for this mining operation.

The ore occurrences at Craigmont have a vertical extent of 1,500 feet, lying between elevation 4,100 and elevation 2,600. Ore above elevation 3,500 will be recovered by open pit methods.

In the period from commencement of operations in late summer of 1961 to June 1964, the concentrator treated over 5,000,000 tons of copper ore with an average grade of 1.9 percent. Approximately 95 percent of this mill feed was supplied by the open pit operation, with the remainder being supplied from underground development.

The selection, the operation, and the performance of the method of transporting this ore from the open pit to the mill site is the subject of this paper.

DESCRIPTION OF PROBLEM

Economic studies indicated the feasibility of getting the open pit into operation first, with an increasing percentage of mill feed to be extracted by underground mining methods in later years.

Since a greater tonnage of ore would ultimately be mined by underground methods, it was decided to locate the concentrator at elevation 2,400, thus permitting gravity flow of all underground ore to a main haulage level which could be driven below all ore reserves known at the time. A number of other factors influenced the decision to locate the concentrator at elevation 2,400. Among these factors were: (1) presence of a suitable site; (2) lower static head on the water supply system since water is pumped through 20,000 feet of pipe from the Nicola River at elevation 1,850; (3) proximity to tailing disposal area.

Once the concentrator location had been determined, and the decision to open pit the upper reaches of the orebody in the early years of the life of the property had been made, it was possible to assess the various methods of transporting ore from the open pit area to the concentrator. An analysis of the characteristics and location of crushing facilities was made in conjunction with the transportation studies.

TRANSPORTATION ALTERNATIVES CONSIDERED

The alternatives considered were as follows:

1. Truck haulage.

2. Skipway.
3. Underground orepass system.
4. Conveyor system.

Alternative One - Truck Haulage

This alternative had the advantage of a single primary crusher installation at the concentrator to serve both the open pit and the future underground haulage system. However, the truck haulage distance of over five miles at a five percent downgrade with consequent operating difficulties and anticipated high costs ruled out this alternative.

Alternative Two - Skipway

The possibility of installing a skipway to handle run of pit ore to a crusher at the concentrator was eliminated because of the following reasons:

a) High capital cost.
b) Flat slope of the incline.
c) The number of changes in grade of the incline.
d) Topographic limitations which would require a considerable length of heavy trestles.
e) Required speed of the skips on flat slopes.
f) The length of the incline.

Alternative Three- Ore Pass System with Primary Crusher Underground.

Again, this alternative offered the possibility of a single primary crusher installation, with the crushed product of both underground and open pit conveyed to surface. The ore pass system was eliminated for the following reasons:

a) The possibility of open pit ore, mixed with snow, freezing in the ore pass.

b) The possibility of hangups in the ore pass due to oversize pit ore, or wearing and sloughing of the ore pass in weak ground.

c) Vertical length of the ore pass system.

d) The length of time required for the driving of the 2,400 level adit would defer the commencement of milling operations.

Alternative Four - Conveyor Systems

The possibility of conveying pit run ore to a primary crusher at the 2,400 level was eliminated due to the fact that the conveyor feed would be material handled by 4½ cubic yard electric shovels. The size of this material would be excessive for the size and capacity of conveyor which was under consideration.

The results of the economic studies of the transportation problem resulted in the decision to install a 42 x 65 inch gyratory crusher in close proximity to the open pit with dumping point at elevation 3,700 and, when required at a later date, a 48 x 60 inch jaw crusher at the 2,400 portal for the underground mine.

Secondary and tertiary crushers, 14 x 84 inch and 5 x 84 inch Hydrocones respectively, were located at the concentrator.

In conjunction with the crusher selection, it was then decided to consider conveyor installations capable of handling a product crushed to minus six inches. Both 30 inch and 36 inch belts were considered.

COMPARISON OF CONVEYOR SYSTEMS

Having decided on a conveyor system, quotations were obtained from Cable Belt Limited, and from manufacturers of conventional conveyor systems.

The advantages of the Cable Belt Conveyor, as opposed to conventional conveyors, were considered to be as follows:

1. The Cable Belt Conveyor lends itself to overland systems as ground contours are easily followed.
2. The material, once on the belt, is more static, thus eliminating spills and belt wear caused by bumping over idlers.
3. The alignment problem is not as critical as with a standard belt, thus reducing installation costs, particularly where frost conditions are prevalent.
4. The Cable Belt System could be installed in a single flight which:
   a) simplified the electrics since only one drive was required;
   b) eliminated the need for transfer points and consequent maintenance and potential belt wear;
   c) required only one belt take up;
   d) required only two terminal points which on a standard conveyor are a maintenance point;
   e) reduced the number of lubrication points;
   f) eliminated potential belt slippage on terminals during freezing weather.
   g) eliminated excessive belt tension on the long single flight conveyor. The tension is taken up in the steel cables of the Cable Belt.

The disadvantages of the Cable Belt System were considered as follows:

1. Required periodic cable replacement - estimated to be every $2\frac{1}{2}$ to 3 million tons.
2. The belt carried on the two cables could become dislodged. This factor could be overcome by installation of a trip out safety device.

The advantages of a conventional conveyor belt were considered as follows:

1. Proven in years of experience.
2. Equipment and belting standard to the North American industry.
3. By using a two belt system, as offered by one manufacturer, the operating cost might be lower than the Cable Belt providing that no belt replacement would be required for the life of the open pit ore reserves.

The disadvantages of the conventional belt systems were listed as follows:

1. Higher capital cost.
2. Risk of belt damage was greater than on the Cable Belt.
3. Alignment more difficult, consequently more costly.
4. Extra transfer point or points.
5. Required two or more drives and motors.
6. Required minimum of four terminals and two take up points.
7. Lubrication required at more points.
8. Belt wear would be higher due to belt tension, extra loading points, and shorter belt cycles. This factor

could be discounted if the belt handled the total tonnage without requiring replacement.

9. Required expensive braking to avoid overstressing of belt.

10. Higher installation costs were anticipated due to:
    a) more components to handle;
    b) more components to assemble and fit;
    c) major equipment installations in three or more locations.

11. Installation of a conventional belt would make necessary the covering of the belt at an estimated cost of more than $75,000.

COVERING THE BELT

Covering of a conventional belt would be required as the underside of the belt could become wet during rainy or snowy weather. This could cause slippage between the belt and the drive pulleys. During extremely cold weather the conventional belt has a tendency to stick to the idlers and if the head pulley were icy, the conveyor would be difficult or impossible to start.

The estimated cost of covering the belt, and the installation of wind sheeting, was in excess of $75,000.

With the Cable Belt there are no idlers in contact with rubber belt and as a result, difficulty in starting is not experienced and there is not any build-up of fines which could result in misalignment.

The Cable Belt at Craigmont Mines Limited is not covered and to date, this lack of covering has not seriously hampered production. During heavy snowfall, uncommon in the Merritt area, it has sometimes been necessary to shut down the belt. Seldom have these shutdowns resulted in a loss of more than 24 hours conveying time in a thirty day period.

TOTAL INSTALLATION COSTS

Site Preparation, including clearing, grading of right of way (63,000 cu. yd. cut) and culverting		$ 30,159.00
Foundations		
Contracted installation	$ 13,830.00	
Materials and supplies	2,926.00	
Steel	394.00	
	$ 17,150.00	$ 17,150.00
Building		
Contracted installation	$ 16,843.00	
Materials	6,495.00	
	$ 23,338.00	$ 23,338.00
Installation		
Contracted	$ 31,732.00	
Materials and supervision	4,492.00	
Splicing cable	1,491.00	
	$ 37,715.00	$ 37,715.00
Purchase of Conveyor System		
Main conveyor	$251,005.00	
Sundry material	5,768.00	
Mechanical accessories	2,371.00	
	$259,144.00	$259,144.0
Electrical Equipment		
Installation costs	$ 5,169.00	
Motors and controls	23,252.00	
Electrical supplies	1,157.00	
	$ 29,578.00	$ 29,578.00
TOTAL		$397,084.00
Cost per foot		$ 69.50

CABLE BELT CONVEYOR EQUIPMENT DATA

Length	5,710 ft.
Horizontal Distance	5,525.8 ft.
Vertical Drop	1,121.0 ft.
Grade Varies from	0° 00' to - 16° 06'
Average Grade	- 11° 28'
Total Number of Changes in Grade	- 12
Belt Width	- 30 inch

Belting Supplied in 180 Ft. Lengths

Belt Fasteners - Hadyn - Nilos

Belt Speed - 335 Ft./Minute (loaded)

Average Hourly Capacity to Date - 319 Tons/Hour.

ROPES - Each length 11,840 ft.

1.47 inch Diameter 6 x 9.9.1

Round Strand Seale Construction, Right Hand Lang's Lay.

Preformed, Fibre Core, Improved Plow Steel, Approximate

Breaking Strength - 90 Tons.

LINE STANDS - Interval 25 feet, Lines Stands Installed to the

Following Limits:

2 inch Longitudinally,

1 inch Vertically,

¼ inch Transversely.

OPERATING PERSONNEL - 2 men per shift, 3 shifts per day, 7 days per week.

(One at the feed end, responsible for feeders and the loading of the conveyor.)

(One at the discharge end responsible for the radial stacking conveyor, and the feeders to the secondary crusher.)

DESCRIPTION OF CONVEYOR

The Craigmont Mines Cable Belt Conveyor is a downhill one flight conveyor, 5,710 feet from centre of head pulley to centre of tail pulley with a fall of elevation of 1,121 feet. It is a 30 inch belt resting on twin drive ropes and designed to carry 400 tons per hour of ore weighing 125 pounds per cubic foot. This conveyor has the greatest vertical fall in one stage of any conveyor installed overland in Canada.

CONVEYOR DRIVE

The conveyor is driven from the top end by a 370 horsepower 3 phase, 4,160 Volt wound rotor motor directly connected to a triple reduction unit, with an input speed of 720 R.P.M., and output of 12.5 R.P.M. Incorporated in the second reduction is a differential to assure identical speed of the twin drive cables regardless of wear of the winder sheaves, which are mounted on the output shafts of the reduction unit.

Tension is taken up by twin steel wire ropes riding on pulleys placed on line stands 20 to 25 feet apart. The rubber belt is of single ply reinforced with transverse imbedded 3/16 inch square spring steel rods at 3 inch intervals; the outer edges of the belt are formed to fit the cables and the belt is supported by the cables over its full length.

CABLES

At the drive end, the belt is lifted off the cables and passed around a belt tensioning device, the cables continue and the horizontal spacing is widened by double idler pulleys to align withem with the drive sheaves. Passing two and one half times around the sheaves, the cable spacing is narrowed and the belt is placed upon the supporting cables.

The original wire cables had a diameter of 1.47 inches and were round strand construction, right hand Lang's Lay, special galvanized plow steel, with a fibre core. The outside wires of the cable flattened very quickly due to plastic flow of the metal, and impression into the fibre core with decrease in diameter gave a false indication of rope wear. Replacement of the cable was recommended when the diameter was reduced to 1.30 inches. The north rope was replaced after transporting 2,250,000 tons of ore, and the south rope was replaced six months later when 2,750,000 tons had been moved. Rope wear was found to be concentrated in the tucks of the splice which wore rapidly. Silver soldering of the tucks was attempted, but would not stand up to flexing over the winder sheaves. Tucks are now squeezed together using a hydraulic jack and special clamps, lengthening the time between splicing to about five months.

The replacement cables are special plow steel with fibre core. Galvanizing is considered unnecessary due to the relatively short cable life.

Tension of the cables is accomplished by the use of boggies mounted on tracks at the discharge end of the conveyor.

CONTROL AND MODIFICATIONS

The wound rotor motor is controlled through a primary magnetic oil circuit breaker and a timed six stage resistance controller. A special circuit is provided to enable the belt to be operated at reduced speed of 40 feet per minute for cable and belt inspection. Auxiliary equipment originally installed included a lubrication pump, a thruster brake, and a rotary belt cleaning brush. The conveyor was provided with protection by the installation of the usual over current and overload relays, mechanical overspeed device and an arrangement of belt dislodgement devices.

OVERSPEED

During the initial run-in period an overspeed condition developed and the mechanical overspeed switch functioned after the leads from the motor rotor had thrown. A tachometer generator was then installed, driven from the rope and supplying voltage to a relay calibrated to disconnect the power and apply the brakes at about 110 percent of synchronous speed.

A further problem was encountered when starting the conveyor after an emergency stop under load. The acceleration of the loaded belt by gravity brought the speed up to and beyond synchronous speed while the timed sequence starting relays in the rotor circuit were still in an intermediate stage. This was corrected by adding another relay in the tachometer generated circuit to close the final rotor stage when the motor had reached 70 percent of synchronous speed.

BRAKES

The conveyor was originally equipped with a single brake released by a hydraulic thruster incorporating a ½ H.P. 3 phase 220 Volt pump. Smooth application of the brake is accomplished by adjusting the orifice and metering the hydraulic fluid back into the pump sump.

Severe heating of the brake drum developed when stopping the loaded conveyor and it was found necessary to increase braking capacity by installation of a second thrustor brake, adjusted to apply 4 seconds after the first brake.

REDUCTION UNIT

Original gears and pinions in the reduction unit, made of 40 and 55 carbon normalized cast steel, having a surface stress factor of 1,900 and 2,000 pounds, were replaced after 1,400,000 tons of ore were transported. This change was necessitated by an extreme wear pattern and chipping of the teeth. New gears have been installed, of nickel-chrome alloy, having a stress factor of 3,000 pounds. These gears are marking much the same as the original gears.

DRIVE SHEAVES

The drive sheaves are fitted with replaceable cast iron shoes shaped in a flat V form with the included angle being 160 to 166 degrees. The original shoes were replaced when worn by the drive ropes, but now, when worn, are being ground to original shape while in place.

LINE STANDS

The original line stand sheaves did not have a machined rope groove but were rough chilled cast iron, many were out of round and wear was rapid. These sheaves are being replaced by mild steel sheaves with a machined groove. Bearing seals have been installed in the replacements.

BELT DISLODGEMENT PROTECTION

The original belt dislodgement device was a scissor-like arrangement of levers, where the weight of the dislodged belt dropping upon the lever sheared a loop of wire and de-energized the control circuit. This device was found unsatisfactory since vibrations and movement of the lever broke down the insulation on the wire, which in turn grounded out the safety wire to complete a circuit through the cables carrying the belt.

A new system of limit switches with positive action was mounted on the axles of the line stands at 150 foot intervals, under the upper and lower belts. These limit switches are equipped with long feeler type probes and, when touched by the dislodged belt, energize a relay which cuts the control voltage to the conveyor and initiates a normal stop of the conveyor. Incorporated in this system is a series of 10 ohm resistors arranged in progression along the conveyor belt. The line stand switches make it possible to locate the site of a belt dislodgement by reading a calibrated meter located at the discharge end of the conveyor.

OPERATION

Starting

Pressing of the start button energizes a time delay relay, whose instant contact operates an audible alarm of 30 seconds duration, after which the thruster brakes and lubrication pump start, and the primary oil circuit breaker closes, starting the conveyor drive motor.

With full resistance in the rotor circuit, and starting an unloaded conveyor, the acceleration is slow and the pre-timed steps of the starting switch are very noticeable. However, when starting a loaded conveyor, acceleration is rapid and at 70% of synchronous speed all timed steps are bypassed and the final contactor is energized.

Loading

Ore is recovered from a stockpile of 4,000 tons live load capacity, and is fed by two Lockers vibrating feeders onto a cross conveyor, which discharges its load onto the Cable Belt Conveyor. Each feeder is capable of transmitting full load to the conveyor, either by manual or automatic control. However, normal practice is to manually control a base load of about 200 tons per hour drawn from one feeder and to have the second feeder set to automatically trim the load and maintain a near constant tonnage.

Automatic control of the Lockers feeders is accomplished through a reference voltage delivered from the tachometer generator of the weightometer to a saturable reactor. This reference voltage is proportional to the tonnage delivered and, acting upon the flux of the variable D.C. voltage transformer, governs the amount of flow from the second feeder.

Running

Full loading of the conveyor takes approximately 20 minutes. During this period the conveyor accelerates gradually until the motor is about 105 per cent of synchronous speed, and the motor, driven above synchronous speed and connected to the A.C. power source for excitation, delivers power to its external circuit, and therefore becomes an induction generator.

Generating power into the external circuit creates a load on the motor nearly equal to or equal to, the full load rating of the motor, provided that an electrical load of this magnitude, or greater, is connected to the circuit. Loss of load, or loss of excitation voltage, will cause an acceleration of the motor as the retarding torque diminishes with loss of load, or in direct ratio to the square of the excitation voltage.

On 26 January 1964, a severe sustained drop in voltage on the incoming Hydro 4 KV Powerline supplying Craigmont Mines Limited, occurred due to a fault in the voltage regulator in the substation. This voltage drop caused a loss of torque on the Cable Belt Conveyor motor, and rapid acceleration of the conveyor occurred. The braking system failed to retard the conveyor, resulting in complete destruction of both thrustor brakes, the motor winding, the motor and bracket, and severe damage to the gears of the reduction unit.

One thousand feet of rubber belting was thrown from the drive ropes and deposited at the discharge end of the conveyor.

Investigation revealed that the brake drums, 30 inches in diameter and made from cast iron, had a safe peripheral speed of 85 feet per second, while normal operating speed of the brake drum is 95 feet per second. The brake band material was good only to 600 degrees F. with a coefficient of friction of 0.35.

Brake drums of ductile iron with a safe peripheral speed of 130 feet per second, and brake band material capable of withstanding temperatures to 1000 degrees F. with a 0.56 coefficient of friction have since been installed.

Stopping

Stopping of the conveyor under normal conditions is accomplished by depressing the stop button, which immediately starts application of the thruster brakes. The disconnection of the motor primary circuit is delayed 5 seconds to hold the retarding effect of generation until the thruster brakes are effectively applied.

PRODUCTION STATISTICS

From date of start up in July, 1961, the Craigmont Cable Belt Conveyor transported over 5,000,000 tons of ore in the period ending in June, 1964.

Since commencement of operations the belt has been run loaded for an average of 453 hours, or 62 percent, of the total hours in a given monthly period. It has been run empty 68 hours per month (9% of total available hours) and has been shut down an average of 208 hours per month (29% of total available hours). When conveying it has averaged 319 tons per operating hour. Since December, 1961, the highest monthly average of conveyor operation has been 363 tons per hour. Average moisture content of the mill feed has been 1.43%.

Re-occurring downtime is primarily caused by line sheaves and axle changes, cable splicing, and line stand kickouts due to misalignment of belt caused by washouts, etc. A total of eleven splices have been made, with an average downtime of 36 hours to complete a splice. The two cable changes required an average of 63 hours per cable change.

OPERATING COSTS

Repair and maintenance costs to date, on 5,000,000 tons, have averaged 2.89 cents per ton. Of this total, repair and maintenance labour is 40% and materials cost is 60%. These costs do not include the cost of lubricants, general operating supplies, operators' wages, or credit or debit for power consumption or generation. These costs also do not account for the fact that some life remains in the second set of cables, which are now on the belt.

Repair and maintenence costs on the last 1,000,000 tons conveyed are running at the rate of 2.37 cents per ton. By projecting this cost over the remaining life in the second set of cables, an estimated repair and maintenance cost of 2.82 cents per ton is anticipated over the life of the first two sets of cables, approximately 5,500,000 tons.

Total Operating Cost per Ton Conveyed on Cable Belt

Repair and Maintenance	2.82¢/ton
Operators' Wages	1.48¢/ton
Credit for Power Generation	-0.25¢/ton
Total Cost Per Ton Conveyed	4.05¢/ton

CONCLUSION

The Craigmont Mines Limited downhill Cable Belt Conveyor has operated satisfactorily since it commenced operations in the late summer of 1961.

To date, cable life has been up to expectations, and the belting shows very little sign of wear after having transported 5,000,000 tons of material.

A number of modifications were necessary before the conveyor operated at required efficiency. The original scissor type dislodgement signal system was inadequate and was replaced with a system of limit switches. A second thruster brake was necessary and was installed after the conveyor had been placed in operation. Provision for this second brake had been made in the original design by having the brake shaft supplied in a length capable of taking the second brake drum.

Repair and maintenance costs are higher than originally estimated due to the cost of replacing the line stand sheaves and components of the gear train. If a similar installation were now under consideration, further study would be given to the possibility of installing a larger speed reducer and rubber covered line stand sheaves, along with the modifications already completed.

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