APPLICATION OF ROTEC BELT CONVEYOR EQUIPMENT AT KAFUE GORGE LOWER PROJECT

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ABSTRACT

Rotec belt conveyor equipment has the following characteristics: simple and convenient operation, good adaptability to terrain, continuous production, high efficiency, low cost, and can be used all year round. The speed of the belt conveyor is fast, which can effectively reduce the temperature rise of the concrete and accelerate the paving speed of the concrete inside the dam. Crawler placer machine is applied in the Kafue gorge lower project. The belt speed is 3.6 m/s, the maximum concrete conveying capacity is 300m3/h, the belt truss has a total length of 1559m, the maximum length of single section is 582m, and there are 8 head sections. The longest span of the on conveyor the bank slope is 57m, and the steepest slope is 27°(The maximum angle between the conveyor and the horizontal plane), the height difference of the bank conveyor is up to 100m. During the operation of the belt conveyor, the belt different width of Rotec belt conveyor and the batching plant resulting in too slow feed rate is solved by adjusting the feeding speed of the batching plant. By increasing the generator, the problem that the long belt of the climbing slope conveyor cannot be restarted due to the system electrical quality problem is solved. At the same time, the Rotec conveyor belt system layout has been improved to ensure the normal pouring of the dam by means of dump truck transportation when a large failure occurs before T4.

1. PROJECT INTRODUCTION

Kafue Gorge Lower Hydroelectric Power Project (KGL Project) is located on the Kafue River. The catchment area upstream the Dam Site measures 153,000Km². The annual average inflow is 255m³/s. The main purpose is for power generation. At FSL of 579.00m, the reservoir capacity is 83×106 m³, and the active storage is 61×106 m³. The Dam foundation level is EL.450.5m. The main Dam is RCC gravity-type, with a maximum height of 130.5m, Dam crest 8m in width and 374.5m in length. The Spillway is equipped with three (3) radial gates with overall flow width of 62m and located at approximately the mid-point of the Dam length with weir crest at EL.561.00m. The Spillway maximum discharge capacity is 7228m³/s with ski-jump (Flip-Bucket) and downstream Plunge Pool for energy dissipation. The Low Level (environmental compensation flow) Outlet structure with inlet invert at El 523.0m, which is arranged on the right side of the Spillway, is designed to ensure a downstream discharge from the Dam of not less than 11m³/s of environmental compensation flow under Reservoir Minimum Operating Level of EL.530.00m.

The solution of the belt conveyor is actually a combination of the high-speed transportation of the belt conveyor and the flexible turning of the crawler placer. The belt conveyor is used to transport the concrete directly from the batch plant to the dam surface to achieve high-intensity and rapid Pouring RCC. The conveyor belt machine was first proposed and manufactured by the ROTEC company in the United States. It was successfully applied in Wheatstone Dam, setting a world record of 72,000 cubic meters per month. The belt conveyor generally adopts the “one Batch Plant, one machine, and one belt” method, that is, a dedicated batch plant to ensure mixing and feeding; a belt conveyor supply line to ensure rapid concrete transportation; and a dedicated crawler placer to ensure flexible distribution. The crawler placer places the RCC with a telescopic arm. The up and down angle of the boom of the spreader is generally + 20 ° ~ -15 °, Feeding height is generally 5-8 meters. When the pouring height is high, a special elephant nose tube is used at the hopper of the telescopic arm to prevent concrete aggregate from separating. Both the belt conveyor and crawler placer are equipped with climbing and jacking mechanisms in the dam for automatic climbing after the dam is poured to a certain height.

The belt conveyor of this project is installed in sections: On October 15, 2018, the first stage of the installation of the Rotec EL581 platform to EL494 was completed. lifting of Rotec construction is difficult, the truss span is large (the longest span is 57m), the slope is steep (the angle between the truss and the horizontal plane is 27°), and the crane adjustment position is small. The tail of the next section of the truss needs to pass through the nose of the previous section of the truss, like a needle lead on a cliff. The second stage installation from the batch plant to the EL581 platform was completed in January 2019. This installation scheme not only guarantees the construction period of the dam, but also creates a discharge point at the EL581 platform, so that when the belt conveyor at the batch plant to T4 fails, Rotec belt conveyors can be repaired without affecting the dam pouring.

The entire belt conveyor system is mainly composed of truss, rollers, driving drums, motors, belt, crawler placer and electrical control system. Its mechanical structure and electrical control system are relatively simple. When the equipment fails, the fault point is easy to find, which is convenient for maintenance and maintenance. The RCC dam of this power station shall be poured by Rotec belt conveyor to transport concrete into the dam. See Table 1 for belt conveyor parameters. The putting into operation of the belt conveyor can replace the traditional way of entering the warehouse of a car and speed up the speed of entering the warehouse of concrete.

Table 1 : Rotec system parameter table

Total length of belt conveyor (m)	Maximum single belt length (m)	The maximum motor power (HP)	Maximum truss slope (degree)	Speed of belt conveyor (m/s)	Maximum concrete conveying capacity (m^3/h)
1559	582	250	27	3.6	500

2. THE RUNNING MODE OF THE BELT CONVEYOR

The belt conveyor arranges the trusses according to the terrain of the site. When the truss is on a relatively flat ground, arrange longer steel trusses and high-power motors. When the truss is in a section with a large slope, a lightweight aluminum alloy truss and a low-power motor are used. Material transfer between trusses via hopper. The head is provided with a turning device, which can rotate the trusses to a certain angle and change the angle between the trusses. Each head of the belt conveyor requires at least two workers on duty. On the one hand, during the operation of the equipment, failures can be discovered in time and the watchkeeper can be notified in time. The supervisor decides whether and when to arrange maintenance. On the other hand, there is a control cabinet at each head. When a certain section of the belt conveyor fails, the operator can press the emergency stop button according to instructions. After pressing the emergency stop button, only the belt on this section of truss and its previous belt will stop running, and the belt behind it will run normally to prevent the concrete from staying on the belt.

The limiting factors for the quality of the material on the belt are the angle of the rollers, the width of the belt, and the amount of material discharged from the batch plant. How to balance the relationship between these three to make the belt conveyor run normally and stably is the first problem to be overcome in this project. At the same time, some faults often occur during the operation of the belt conveyor. How to troubleshoot in a timely manner is also a key issue of the project. Such as: the belt runs off, material spills and the subsequent belt damage; A virtual connection or break of the control line causes a sudden stop of a certain section of the belt conveyor or the entire system; Unstable system voltage and uneven distribution of materials on the belt cause the motor current to increase, causing the control cabinet to overcurrent protect and stopping the system; During the running process, before the belt conveyor that can be automatically started with the concrete on the belt. Later, the belt conveyor cannot start automatically with the concrete on the belt. The downtime of the belt conveyor is limited by the RCC concrete hot joint and cold joint formation time. Explained one by one below.

3. THE BELT CONVEYOR AND BATCH PLANT COOPERATE

The belt conveyor of this project is supplied by two batch plant. The gap between the openings of the two batch plants is 10m. When the two batch plants unload at the same time, it will cause the concrete on the belt to overlap, overload the belt, and cause problems of leakage and spreading. Therefore, the project uses two batch plants to feed the belt alternately. According to the speed of the belt and the distance between the two mixing buildings, adjust the opening of the arc door of the feeding opening of the two batch plants to adjust the feeding speed and feeding time. By adjusting the feeding scheme, the belt transport capacity can reach 300 m^3 / h.

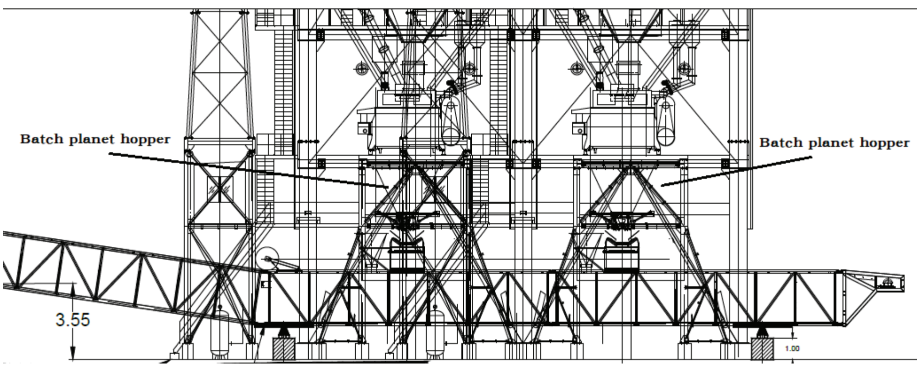

Figure 1 : Feeding layout of batch plant

4. IMPROVEMENT OF BELT CONVEYOR SYSTEM LAYOUT

Because the entire belt conveyor system operates on a single line, when a fault occurs, the entire line cannot work properly. If the maintenance time is too long, it will seriously affect the dam pouring quality. In response to this problem, the project and the manufacturer negotiated a plan to set two 8-cubic blanking openings and a section of transmission truss at the EL581 platform(see Fig .2), and the belt truss was overlapped to the T4-T5 section of the ROTEC truss.

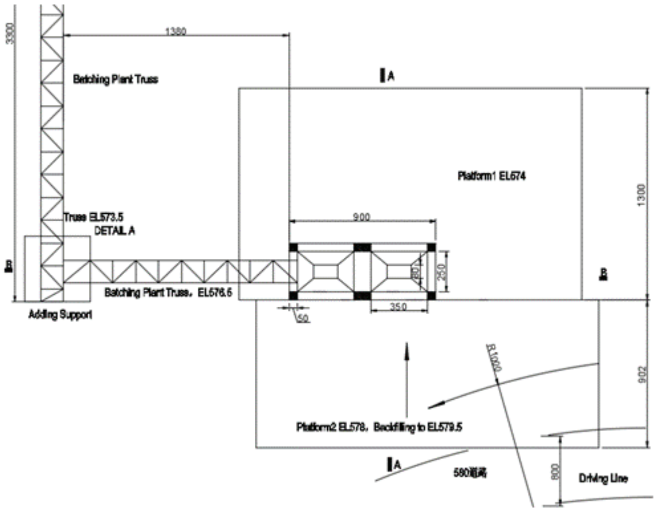

Figure 2 : layout of EL581 discharge platform

When the T4 section and the belt conveyor before it fails, you only need to adjust the cabinet wiring to achieve the belt conveyor system segmented operation. When repairing the front T4 belt, it will not affect the pouring of the dam, thus ensuring the quality of the pouring of the dam.

5. ELECTRICITY LOAD

The total quantity of RCC is 1,290,000m³, average of construction area of RCC placement is around 10,000 m³ and the area is around 4,000 m² at bottom of dam while it is around 2,500 m² at top part. The maximum placement area reach the maximum in the middle of the dam body. The area is more than 10,000 m² from EL460 to EL535m and between 13,000 to 14,000 m² from EL470 to EL510m. Below Chart show the relationship between RCC quantity of one layer(30cm thick) and the elevations.

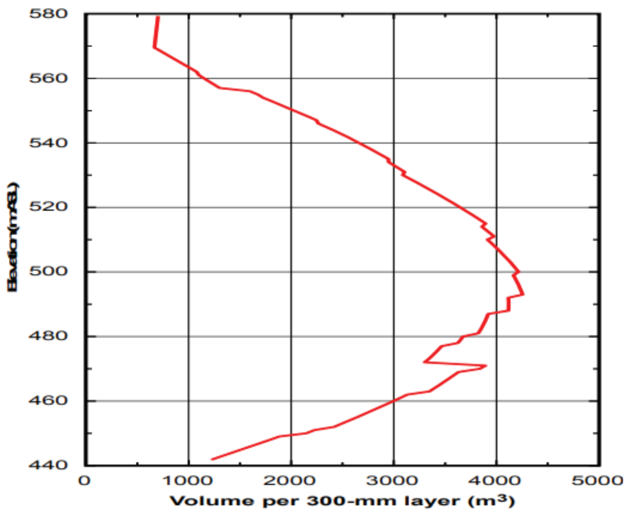

Figure 3 : Relation between pouring volume and elevation

It can be seen from the figure 3 that when the elevation of the dam is at EL500, the pouring strength reaches the maximum, and the requirements for the stable operation of the belt conveyor are also increased. At this time, it is another peak period for the construction of the entire project, and the load of on-site electricity consumption is also increasing. The capacity of the distribution transformer in the field has been calculated which meet the construction requirements, however, the belt conveyor has a problem that the long belt that climbs the slope cannot be started with concrete on the belt due to the electrical quality of the system. By analyzing the increase of the electric load in the whole field and observing the relationship between the motor current and voltage when the belt conveyor starts with load, it is found that when the motor starts, the voltage of the motor changes from 430V to 320V, and the voltage drops severely. In general, the voltage drop when the motor starts should not be lower than 85% of the rated voltage. When the motor starts to run, it is similar to a blocked rotor. There is no induced magnetic field in the rotor that obstructs the alternating magnetic field of the stator, which results in a very large stator current and a certain voltage drop on the line. The rotating power of the motor requires insufficient reactive power to establish a magnetic field. The reactive power is too much lost on the line. Both the transformer and the motor are devices that generate and consume reactive power. During the transfer process, a part of the reactive power is consumed in the form of heat, and the lost reactive power is usually compensated at local. According to the above theory, it is necessary to add a reactive power compensation cabinet to perform reactive power compensation for the entire system, but due to the long procurement cycle, an initial increase in generators is used to perform power compensation.

The reactive power loss is calculated as follows:

Reactive power loss of the motor:

$$Q_{\mathrm{M}} = Q_{\mathrm{m}} + Q_{\sigma} = \frac{U^2}{X_{\mathrm{m}}} + I^2 X_{\sigma}$$

Note: Q_m : the excitation power,

Q_σ :the leakage reactance loss,

X_m : the excitation point

X_σ : the leakage reactance.

$$Q_{\mathrm{LT}} = \Delta Q_0 + \Delta Q_{\mathrm{T}} = \frac{I_0\%}{100} S_{\mathrm{TN}} + \frac{U_s\% \, S_{\mathrm{TN}}}{100} \left(\frac{S_{\mathrm{TL}}}{S_{\mathrm{TN}}} \right)^2$$

Note: △Qo excitation branch loss,

$\triangle Q_T$ winding leakage reactance loss,

S_{TN} is the rated capacity of the transformer MV · A,

S_{TL} is the rated capacity of the transformer MV · A,

Io% no-load current is about 1% -2%, The loss in leakage reactance is approximately 10% at full load.

Through calculation, the reactive power loss of the electric equipment in the field was obtained, and the corresponding equipment was equipped to compensate, and good results were obtained.

6. CORRECT THE BELT DEVIATION

Because the Rotec equipment used in this hydropower station is relatively old, the truss strength is lower than the design value. At the same time, the truss section in the dam is gradually skewed because the support columns cannot be lifted vertically during jacking. During the operation of the truss transformation area, the uneven feeding of the funnel will cause the belt to deviate and scrape the truss. Each truss head hopper is a device for guiding and controlling the direction of the material flow, and can also be used for dust prevention. At a certain elevation, the angle between the trusses in the dam changes with the lifting of the dam body, and the angle at which the material falls on the belt changes with the angle. For example, below EL510, the truss in the T7-T10 dam rises with the lifting of the dam surface, and its front T6 at this elevation does not need to be jacked up. The belt rotates at a constant speed, and the parabola formed by the concrete material will hit one side of the belt, resulting in uneven force on the belt, the belt deflects, and the material spills. The first step of the solution is to change the refraction angle of the material at the head so that it can land on the center of the next belt. Then a guide roller is added to control belt on the long truss. The Belt deviation caused by uneven distribution of materials can be controlled better.

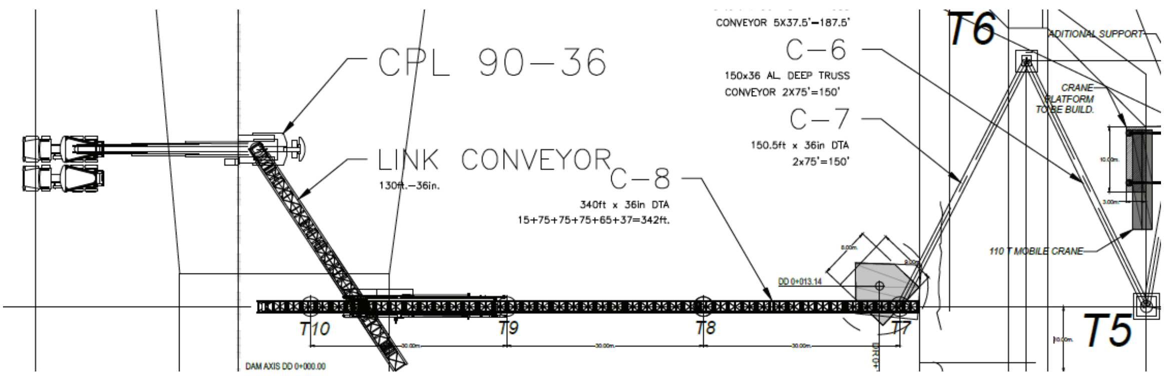

Figure 4 : Layout of trusses in the dam

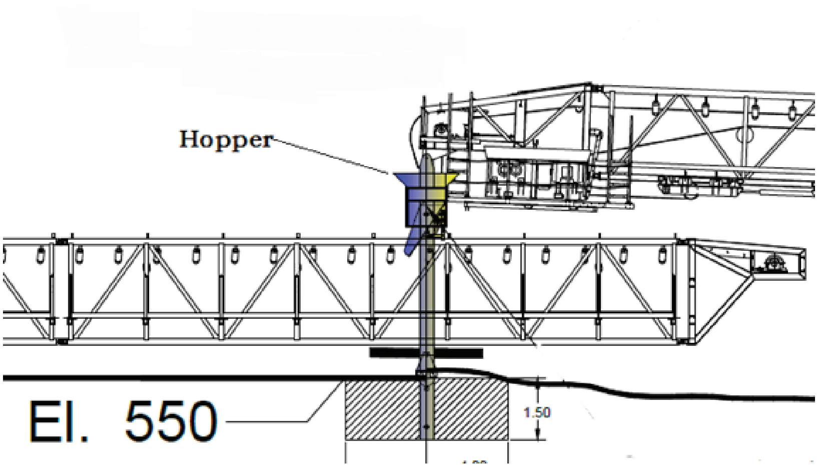

Figure 6 : Hopper between trusses

For the problem that the falling point of the material cannot be in the center of the belt, the method of modifying the structure inside the funnel at the corresponding head is used to deal with it. A circular track is welded in the hopper, and a movable tongue is arranged at the track to allow the material to impact the tongue to change the feeding point to improve the belt deviation caused by the incorrect feeding point.

For the problem of incorrect belt itself, you need to adjust the belt. When adjusting, when the amount of adjustment is small, the adjustment bolts at the head or the tail need to be adjusted or some of the supporting rollers can be adjusted to change the running direction of the belt. When the adjustment amount is large, a special hydraulic jack can be used to adjust the belt by adjusting the drum at the tail of the truss. Preventing belt misalignment is the most effective way to increase belt life.

7. SUMMARY

The application of the Rotec belt conveyor in the Kafue Gorge Lower project was relatively successful, which ensured the pouring quality and construction period requirements of the dam. Reasonable maintenance of the entire system is a prerequisite for the stable operation of the entire system. In the process of operation and maintenance, some experiences were summarized, which provided a rich practical basis for the application of similar belt conveyor systems for dams in the future.