

# Treatment of Wastewater from Sand and Aggregate Processing

## Systems in Longtan Hydropower Station

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**Abstract:** construction of Longtan Hydropower Station requires some 8 million m<sup>3</sup> of concrete. Purification of the great quantity of the wastewater from the sand and aggregate flushing process was a difficult problem in environmental protection. In Longtan hydropower project's Macun and Dafaping sand and aggregate processing plants, advanced and effective techniques had been applied to have an all-round treatment on the 23 million tons of the wastewater and "zero wastewater discharge" had been realized, bringing a good result in environmental protection. This paper focus on the treatment techniques adopted by the Macun plant and the Dafaping plant, analyzes the existing problems, and an economical comparison of their performance have also been made, with some suggestions proposed.

**Key words:** Longtan Hydropower Station, wastewater treatment, environmental protection

Longtan Hydropower Station, located upstream on the Hongshui River in Guangxi Zhuang Autonomous Region, China, belonging to the Pearl River Basin, is a super-large hydropower project, with power generation as its main benefit, incorporated with flood control and navigation. Its installed capacity is 6 300 MW ( 4 900 MW in stage 1); the normal pool level is 400 m ( 375 m in stage 1) and the annual mean generation output is 18.7 billion kWh (15.7 billion kWh in stage 1). Construction of the project started on 1 July 2001; the impoundment started on 30 September 2006 and the first unit was put into production on 21 May 2007. Up to the present, 4 units have been put into operation since then. By the end of June 2008, Longtan hydropower station had generated some 9.5 billion kWh of electricity, exerting its great efficiency in power generating and flood control.

Longtan Project stage 1 construction required about more than 8 million m<sup>3</sup> of concrete. As limestone strata are distributed along the Hongshui river areas, natural sand and aggregate resources along the river are rare. In order to meet the huge demand for sand and aggregate material, through geological exploration, two sand and aggregate processing

systems, named the Macun and the Dafaping plants, had been built in a valley 4 km from the Longtan dam.

The Macun sand and aggregate processing system undertook a total of 1.6 million m<sup>3</sup> of sand and aggregate material supply for concrete production for the left/right bank-slope treatment and diversion tunnels, the underground powerhouse, the ship-lift navigation structure, as well as the casual construction. Its design capacity is 240t/h. It started operation on 22 September 2001 and it is still working at present.

The Dafaping sand and aggregate processing system undertook the sand and aggregate material supply for 6.42 million m<sup>3</sup> of concrete production for Longtan dam and the cofferdam projects. With a planned production of 14.12 million tons of sand and aggregate and a designed capacity of 2 250 t/h, it was Longtan's main material supply plant and the largest sand and aggregate system in world's hydropower construction history at that time. It was constructed in July 2002 and put into production on 10 January 2004. As stage 1 dam construction was finished, its operation was stopped by January 2008.

During the sand and aggregate processing in both Macun and Dafaping plants, in the course of flushing material, over 20 million tons of wastewater

were to produce totally, which contained over 1 million m<sup>3</sup> of waste residues, which could cause serious soil erosion and river pollution and threaten the water safety of 30 000 people in downstream Tian'e township, if discharging without purification treatment. To have these wastewater and residues in huge quantity properly treated and disposed of during construction period, no matter with the technology or the capability, was a difficulty in hydro-engineering environmental protection.

The owner of Longtan project, Longtan Hydropower Development Cooperation, attaches great importance to project's environmental protection. At the beginning of the construction, the goal of building a "Green Longtan" had been proposed. In order to have the wastewater effectively treated and to achieve the goal of "zero wastewater discharge" (i.e. no wastewater direct discharge, 100% being treated) so as to protect the water environment, two wastewater treatment systems had been built together with building the Macun and the Dafaping sand and aggregate processing systems. Advanced wastewater treatment technology and equipments had been applied and continuous improvements had been made. As a result, a total of 23.66 million tons of wastewater coming from the material processing had been effectively and fully treated. Zero wastewater discharge had basically been achieved. The total amount of waste residues disposed of was up to 1.59

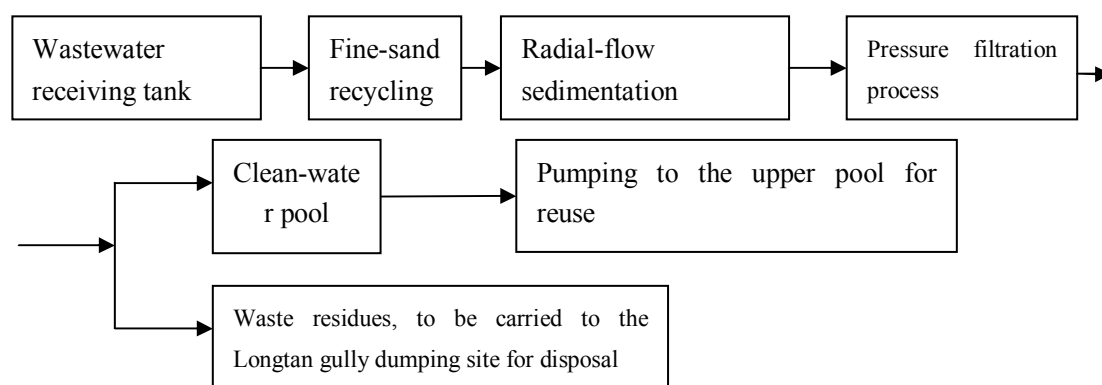
million tons. The tough problem in environmental protection had been properly solved and the river water environment protected. The goal of "Green Longtan" has been realized.

## 1. Wastewater Solution for Macun sand and aggregate processing system

Mechanical crushing for sand process is used in Macun plant. For washing away the mud and the stonepowder in the sand and aggregate material, the system's wastewater amount reaches 500t/h, in which the main pollutants are suspended material, sand, stonepowder, etc.; in which the sand content can be up to 160 kg /t at peak, which would lead to a serious pollution in the river if discharging directly into the river. In order to protect the river-water quality, a radial-flow sedimentation and pressure-filter dewatering wastewater treatment system (hereinafter referred to as Macun Treatment System) was built in the Macun sand and aggregate processing system.

Macun treatment system's design goal is to protect the environment, to recycle the wastewater and the fine sand, and to achieve zero wastewater discharge.

The treatment procedures of the Macun wastewater treatment system is as follows:



Macun treatment system's wastewater sedimentation pools comprise two 20-m diameter radial-flow sedimentation pools. Wastewater collected through the receiving trough will go through fine sand recycling, flocculant adding, and sedimentation ,

when the water becomes up to the standard, it will flow directly into the clean-water pool and then will be pumped to the regulating pool ( at el.340 m ) for reuse. The sediment deposited in the sedimentation pools is pumped by the sludge pump into two pressure

filters set in the platform at ele.270 m, where the dewatering process takes place, and sediment and water are separated and dehydrated, and then, the dehydrated solid waste residues will be carried by truck to the appointed residue site for disposition, while the separated clean water will flow back to the clean-water pool for recycling.

The Macun treatment system is advanced from its design concept, construction planning, to its equipment selection. Since its start in operation on 18 September 2002, it has been strictly controlled based on the zero wastewater discharge. Up till 30 June 2008, a total amount of 6.531 million tons of wastewater has been treated, of which recycling water is 4.245 million tons, accounting for 65.2% of the total; 85,000 tons of fine sand had been recycled and reused, and 0.183 million m<sup>3</sup> of solid residues had been disposed of. By monitoring, the wastewater treatment efficiency by the Macun treatment system has reached 99.92%, indicating an excellent result. At present, this system is still in operation.

## **2. Wastewater solution for Dafaping Sand and aggregate processing system**

The Dafaping sand and aggregate processing system had a big design capacity. At the beginning, the radial-flow sedimentation pressure-filter measure was used for treating the wastewater. Four 40-m diameter radial-flow sedimentation pools and eight pressure-filters were set up. As the system was disposed at the valley bottom, the blasting rocks threatening the facilities. Besides, it was found that Macun plant's operation cost was high by using this measure. In order to ensure a safe operation and to have an economical management cost, through serious study, it was decided to adopt the sedimentation pools incorporated with the Pneuma pump (hereinafter to referred as Pneuma pump treatment system).

Pneuma pump treatment system had a wastewater recycling pool with a capacity of 200,000 m<sup>3</sup>. The wastewater was collected and gathered in the wastewater treating pool for sedimentation. The clean water, after sedimentation, was directed to a water pool of 4,000 m<sup>3</sup> and then is pumped back to the system for material washing, while the deposit of the

fine sand and the stonepowder were pumped to 1# tailing reservoir, 2.3 km away, for storage, by using an Italian Pneuma pump with a piping system. The water of the waste residues, after being settled in the tailing reservoir, became clear and finally discharges into the Hongshui river through discharge culvert. Pneuma pump treatment system is the first case for wastewater treatment in hydro-engineering sand and aggregate system in China

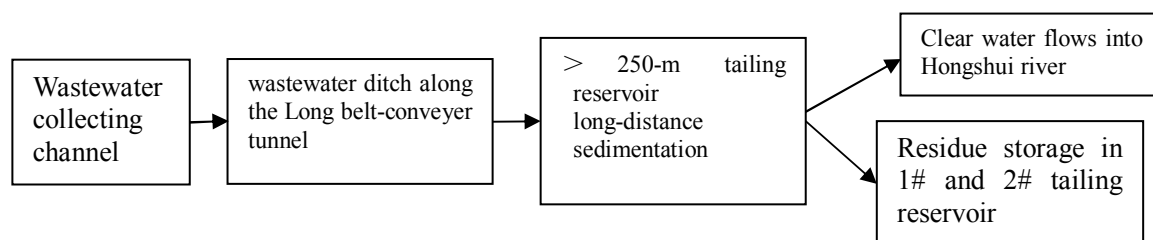
Pneuma pump treatment system was put into operation together with the Dafaping sand and aggregate processing system. According to monitoring, although the main pollutant removal efficiency was greater than 95%, meeting the environmental standard, soon a problem came out. Because of the continuously high intensity construction of Longtan concrete dam, the wastewater quantity increased from 300 m<sup>3</sup>/h to 2000 m<sup>3</sup>/h, while a Pneuma pump's capacity was only 360 m<sup>3</sup>/h, and the stone powder of the wastewater sediment became harden quickly in the sedimentation pool, the Pneuma pump's pumping capability failed to meet the design requirement, consequently, the waste residues in the sedimentation pool failed to be able to be pumped promptly to the tailing reservoir. The treatment capability of the whole wastewater treatment system was unable to meet the production requirement. Waste residues fully jammed in the pool had only to be removed by mechanical excavation, which caused not only an increased operation cost but also certain pollutants spreading on the inside-roads. Therefore, an expansion and an modification of the system had to be done right away.

As the Dafaping plant's wastewater quantity reached 2000 m<sup>3</sup>/h at peak, if taking the capacity expansion solution, it would need at least 4 additional Pneuma pumps, with which, a single equipment item would need an increase of 36 million yuan on investment, and the wastewater-residue getting hardened was a problem making a very poor pumping, further more, as limited by terrain condition, there was no space for three sets of pump boats in the pool. Therefore, the expansion solution was neither economical nor practicable.

With careful investigation, technical personnel

suggested to abandon the Pneuma pump method and use the tailing reservoir long-distance sedimentation instead (hereinafter to referred as tailing reservoir treatment system). By making full use of the long-belt conveyer tunnel, a 2.3 km-long concrete drainage ditch could be constructed along the tunnel, through which, all of the wastewater from the Dafaping sand and aggregate processing system could

be collected and gathered in 1# and 2#tailings reservoirs, and this wastewater, by running about 250 m-distance through the ditch, could be settled and become clean water and could be discharged, through an inclined spilling orifice in the tailing reservoir, into the river; while the residues would be deposited and to be in storage there. The wastewater treatment procedures were as follows:



The system started modification in January 2005 and was put into operation on 1 April 2005 and terminated running by January 2008 when the production task had been finished, totaled 34 months of operation. The total treated wastewater volume was 13.333 million m<sup>3</sup>; waste residue treated volume 1.053 million m<sup>3</sup> (of which, 503 000 m<sup>3</sup> stored in 1# tailing reservoir, 550 000 m<sup>3</sup> in 2# tailing reservoir). According to monitoring, the main pollutant removal efficiency in wastewater was 95% and above, indicating a satisfactory treating result. This approach features with low construction cost, strong wastewater treating capability and excellent treating effect, being

economic and convenient in operation and management, and fully meeting the production demand.

### 3. Comparison on economic benefits

Both Macun and Dafaping wastewater treatment systems' construction, operation and management costs are listed in table 1.

Table1. Comparative listing of the construction, operation and management of the wastewater treatment systems in Longtan's sand and aggregate processing plants

Serious number	Item		quantity	Macun treatment system	Dafaping Pneuma pump treatment system	Dafaping tailing- reservoir treatment system	Total
1	Sand and aggregate production total		million tons	3.917	4.75	12.275	20.942
2	Wastewater treated total		Million tons	6.531	3.799	13.333	23.663
3	Wastewater recycling total		Million tons	4.245	0.336		4.581
4	Fine sand recycling total		Million tons	0.085			0.085
5	Treated waste-residue total		Million m <sup>3</sup>	0.183	0.357	1.053	1.593
6	wastewater treatment systems	6.1 + 6.2	Million yuan RMB	15.94	10.91	5.84	32.69
		6.1 construction and equipment investment	Million yuan RMB	9.00	9.75	5.51	24.26

		6.2 Operation and management	Million yuan RMB	6.94	1.66	0.33	8.93
7	sand/aggregate product's wastewater treatment costs		yuan/t	4.07	2.3	0.48	
8	Treating capability			high	low	The highest	
9	Treatment efficiency %			99.92%	> 95%	> 95%	

According to the above table, following conclusions can be reached:

1. For wastewater treatment expenses, the cost of wastewater treatment in Macun plant is 4.07 yuan/t; 2.3 yuan/t for the Dafaping Pneuma pump treatment system; and, 0.48 yuan/t for the Dafaping tailing- reservoir treatment system. The modification by using tailing-reservoir long-distance sedimentation approach had saved not only 36 million yuan RMB on equipment investment, but also 22.345 million yuan RMB on operation/management fee ( $1227.5t \times (2.3 - 0.48)$  yuan/t), as compared with the Pneuma pump solution. Therefore, Longtan Dafaping wastewater treatment system's modification scheme had been very successful, increasing the treating capability substantially while decreasing in production cost substantially.

2. In wastewater treatment capability, the Dafaping tailing-reservoir sedimentation treatment system had the biggest and almost unlimited capability; the Macun treatment approach, with 500t/h, is placed secondly; and, the Dafaping Pneuma pump treatment system, less than 200t/h, was the lowest one.

#### 3. Wastewater treatment efficiency

The Macun approach has the best performance, its treating efficiency is up to 99.92%; and the Dafaping Pneuma pump system and the tailing-reservoir sedimentation treatment system gave the same fairly good effect, both higher than 95%.

Since the Macun and the Dafaping wastewater treatment systems' going into operation, as accumulated, some 23.663 million tons of wastewater have been treated, 4.581 million tons of water recycled, 85 000 tons of fine sand recycled, and 1.593 million m<sup>3</sup> of waste/abandoned residue treated and deposited of, a remarkable result on environmental protection having been achieved.

#### 4 Several suggestions

1. In large-scale hydropower/water conservancy engineering, although a great quantity of wastewater is produced from material processing, the engineering practice in Longtan proved that zero wastewater discharge can be achieved as long as practicable and effective measures, incorporated with actual engineering conditions , are taken by strictly following national law on environmental protection.

2. Because of the soft nature in limestone's lithology, a large amount of stone powder in the wastewater become hardened quickly at the bottom of the pool, which decreases Pneuma pump's efficiency. Therefore, using this kind of equipment and approach in limestone area or similar place is not recommended. The use of Pneuma pumping system in Dafaping, having caused substantial loss financially, was a failure in Longtan's wastewater treatment, which should become a lesson for engineers.

3. The use of tailing-reservoir long-distance sedimentation was a success in wastewater treatment in Longtan Dafaping. This approach has not only strong capacity with good result but also save money, with lower operation fee and convenient management, if a clear water recycling system is additionally adopted at time of planning in order to increase water reusing efficiency so as to save water resources greatly, the result would be even perfect.

4. Although the cost of the construction and the operation of the Macun's radial-flow sedimentation and dewatering treatment technology is higher, but the wastewater treatment effect is very good, being able to greatly save water resources, therefore , it is still worth to be popularized for utilization for areas where water resources are rare and environmental protection

requirements are higher.

**Notes:** The data and information, concerning the Macun and Dafaping operation management, used in this paper are provided by the project contractor.

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