Economic Analysis of Wet Flue Gas Desulphurization Project Operation

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Abstract: After the flue gas desulphurization (FGD) of the #6 unit of Jiujiang Power Plant, the cost of electricity production is increased. This paper list the operation cost of FGD system and draw a conclusion that optimizing system design and operation management, and decreasing electrical consumption are critical to reducing the cost.

Keywords: FGD, Economic Analyze, Operation Cost

1 INTRODUCTION

Jiujiang Power Plant is located at Jinji Slope where 5km to the east of Jiujiang City, Jiangxi Province. It is bounded to the north by Changjiang River and to the east by Poyang Lake. There are six plant units, and total installed capacity is 1350 MW. 6 units went into operation in 1983, 1984, 1991, 1992, 2002 and 2003 respectively. The capacity of #1 and #2 unit is 125 MW each; #3 and #4 have a capacity of 200 MW each and the last two are increased to 350 MW each. Because of historical and geological problems, sulphur content of the coal is high. Without FGD, discharge amount of SO_2 is so large that local environment is damaged to a certain extent. To reach the increasing SO_2 control limits of the country and local government, Jiujiang Power Plant decided to construct a FGD project on #6 unit between January, 2006 and July, 2007 to meet the specified discharge standard and minimize the pollution to environment.

Limestone-gypsum wet FGD process is used in #6 unit FGD project (one boiler is equipped with one absorption tower). The FGD project layouts of #5 and 6# units are finished simultaneously, and implements are divided into two phases, but the civil works are accomplished at the same time.

2 FGD SYSTEM

2.1 The Principle

After dust collection, flue gas of boiler enter into absorption tower through suction ventilator and booster fan. In absorption tower, flue gas runs upwards against the direction of grout mixture. It will be washed in the reverse current. Then acidic contents such as SO_2, SO_3, HF, and HCl etc. can be removed from flue gas. Limestone grout is pumped into a grout pond of absorption and mixed with the gypsum grout, which has been generated already. The grout mixture is transferred to the spraying layer by a recirculating pump and atomized by a spraying nozzle. Then a high efficientive gas-liquid mass transfer will happen between flue gas and grout mixture. At the bottom of absorption tower, air from oxygenation pump and washing products react ulteriorly to generate gypsum ($CaSO_4 \cdot 2H_2O$), which will be pumped out to dewatering system. In a two stage demister, purified flue gas is demisted. Meanwhile, the demister is cleaned by fresh water according to fixed procedure. At the outlet of absorption tower, flue gas is cooled down to 40□ to 55□ and saturated by vapour. At last, purified flue gas is discharged into air through chimney. Fig. 1 describe the process flow sheet of FGD system as above.

2.2 FGD System Configuration

FGD system of #6 unit of Jiujiang Power Plant includes seven parts:

- Limestone grout preparation system(with a ball mill);
- Flue gas system(without GGH);
- SO_2 aborsption system;
- Accidential grout mixture discharging and recycling system;
- Gypsum dewatering system;
- Recycled water system;
- Electrical/Thermal control system.

2.3 Main Parameters of FGD System (Table 1)

Table 1

Flue gas parameters at FGD inlet			
Flue gas flux: Nm^3/hr	1250000.00 Standard state, dry basis, full oxygen		
Temp. ℃:	113.00	Pressure Pa:	0
Flue gas contents		Standard state, dry basis ,6% O_2	
CO_2-Vol %:	13.1	SO_2- mg/m^3	2778.00
O_2-Vol %:	5.1	SO_3- mg/m^3	100.00
N_2-Vol %:	74.9	HCl- mg/m^3	80.00
H_2O-Vol %:	6.9	HF- mg/m^3	25.00
		ASH-mg/m^3 (Maximum)	170.00

3 ECONOMIC ANALYSIS

3.1 Water Cost

According to Table 3, recycled water cost can be calculated by an inner price of 1.00 RMB/m^3. The results are as follows:

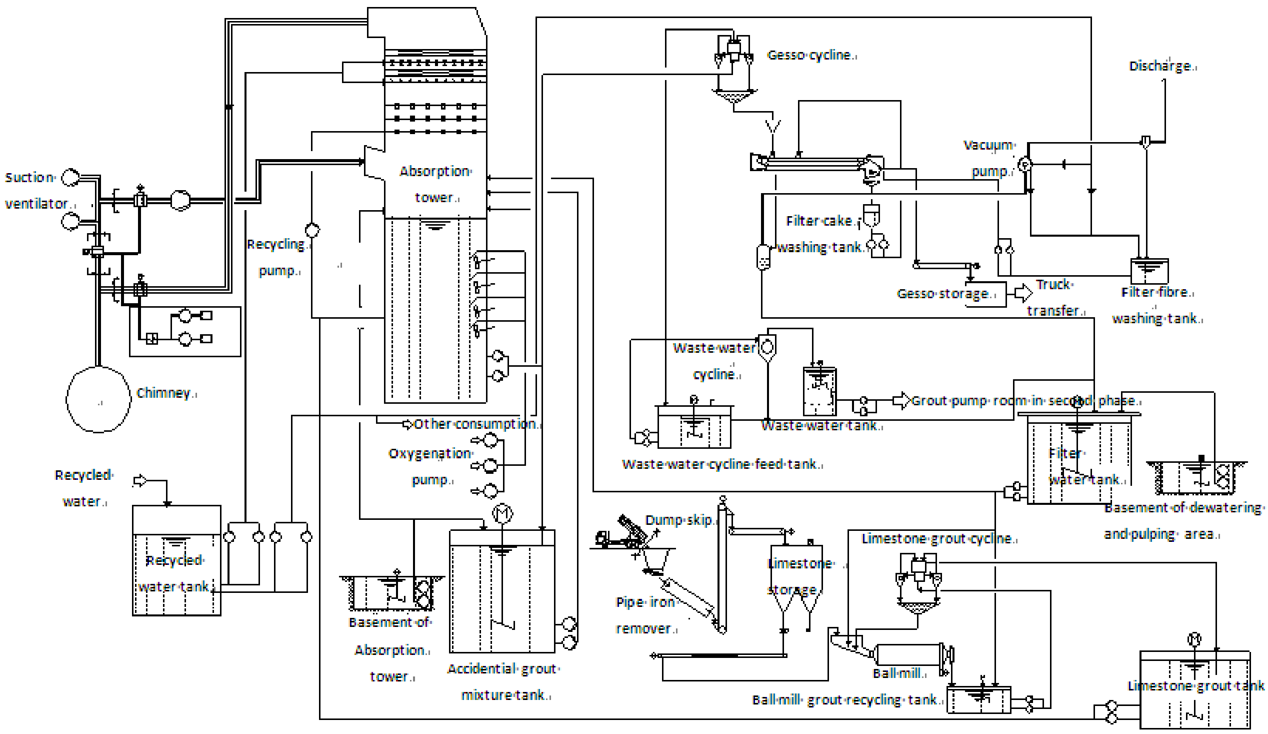

Fig. 1 Process flow sheet of FGD system

Table 2

Flue gas parameters at FGD inlet Standard state, dry basis, 6%O_2		Contamination remove efficiency	
SO_2- mg/m^3	≤139	SO_2	≥95%
SO_3- mg/m^3	≤50	SO_3	≥50%
HCl- mg/m^3	≤1.6	HCl	≥98%
HF- mg/m^3	≤0.5	HF	≥98%
ASH-mg/m^3 (Maximum)	≤43	ASH	≥75%
Flue gas temp. before chimney			≥44.5
Liquid droplet content at the outlet of demister (standard state, wet basis): mg/m^3			≤75

Table 3

	Hour consumption	Day consumption	Annual consumption
Limestone	6.3 t/h	151.2 t/d	34650 t/y
Recycled water	64.3 m^3/h	1543.2 m^3/ d	353650 m^3/y
Electricity	3335 kWh	80040 kWh/d	18342500 kWh/y

Note: 5500 hours operation per year; Electrical consumption: continuous 7 days average under full load operation in performance test phase[1].

Table 4

Contaminants	Before FGD t/h	After FGD t/h	Discharge reduction per year ×10^4 t/a
SO_2	3.4725	0.173625	1.8144
ASH	0.2125	0.053125	0.8765625

Note: 5500 hours operation per year.

Table 5

	Hour cost	Day cost	Annual cost ×10^4
Recycled water	64.3 RMB	1543.2 RMB	35.365 RMB

3.2 Labor Cost

FGD needs a technologist. Meanwhile, there are four teams of operators. Three teams work per day alternately. Each worker's salary is 80,000 RMB. So the labor cost per year can be calculated: 80,000 RMB×13 = 1,040,000 RMB.

3.3 Limestone Cost

The price of limestone is 80.00 RMB/t. According to table-3, the calculating results are as follows:

Table 6

	Hour cost	Day cost	Annual cost ×10^4
Limestone	504 RMB	12096.00 RMB	277.20 RMB

3.4 Maintenance Cost / Other Costs

In the life cycle of FGD system. The costs of daily examination, maintenance, small and large scale repair, material and production management account for 10% of the capital asserts. It is total 670,000,000 RMB per year.

3.5 Capital Cost

The project of FGD system is started on January 2006, and finished on December 2007. It starts to run on January 2008, and starts to pay bank loan at the end of 2008. The calculation of annual principle plus interest in system life cycle is as follow:

- Initial total investment of FGD system(fixed cost): 67,000,000 RMB;
- Loan repayment period is equal to system life cycle, which is 20 years;
- Residual value of system 3 %;
- Annual interest 6.48 %.

$$\left[6700(1+0.0648)^2-6700\times 0.03\times\frac{1}{(1+0.0648)^{20}}\right]\cdot\left[\frac{0.0648(1+0.0648)^{20}}{(1+0.0648)^{20}-1}\right]=6{,}831{,}400\text{RMB}$$

3.6 Electrical Cost

The industrial electricity price is 0.5 RMB/kwh, and the calculation is as follows:

Table 7

	Hour cost	Day cost	Annual cost $\times 10^4$
Electrical cost	1667.50	40020.00	917.125

3.7 Cost/expense analysis

According to the analysis above, the proportion of each kind of cost in annual operation cost is shown in Figs.2 and 3.

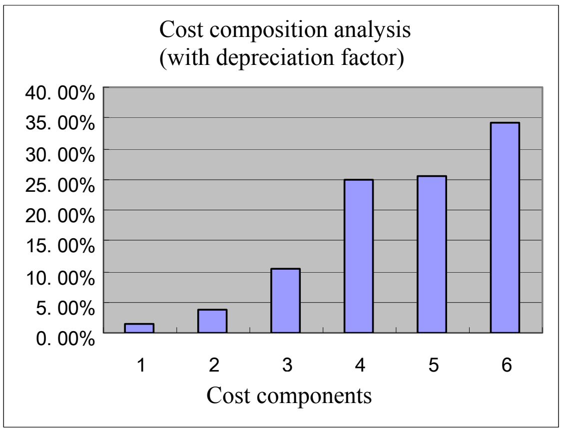

Fig. 2

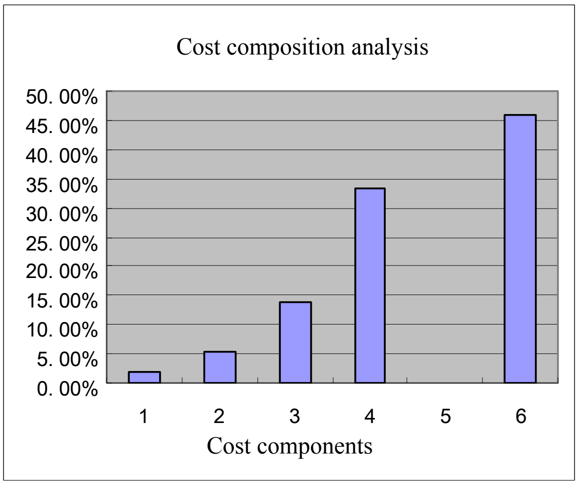

Fig. 3

Note: 1-Water cost; 2-Labor cost; 3-Limestone cost; 4-Maintenance cost/ Other costs; 5-Capital cost; 6-Electrical cost.

Table 5

	Annual cost	Proportion (with depreciation factor) %	Proportion (without depreciation factor) %
Water cost	353,650	1.32	1.77
Labor cost	1,040,000	3.87	5.19
Limestone cost	2,772,000	10.32	13.83
Maintenance cost/ Other costs	6,700,000	24.94	33.44
Capital cost	6,831,400	25.42	/
Electrical cost	9,171,250	34.13	45.77
Annual operation cost: 26,868,300 (with capital cost)			
Annual operation cost: 20,036,900 (without capital cost)			
Annual SO_2 emission reduction: 18,144 t			
Annual electricity production:1,925,000,000kwh			
SO_2 removing cost analysis		With depreciation factor	Without depreciation factor
SO_2 –RMB/t		1,480.84	1,104.33
Added electricity production cost -cent/kwh		1.396	1.041

4. CONCLUSIONS

As description above, with regard to FGD system of #6 unit of Jiujiang Power Plant, the cost of one ton SO_2 removing is 1,480.84 RMB/t without considering capital cost. Because of FGD system operation, the added cost of electricity production is 1.396 cent/kWh without considering capital cost. Meanwhile, the compensation from government is higher than 1.4 cent/kWh, so the actual cost of electricity production will not be increased if the FGD system is under normal operation state.

According to the cost composition analysis, maintenance cost, capital cost and electrical cost account for 84% of total operation cost (79% if without considering capital cost).

In the FGD construction and operation management processes, three points should be considered:

1) Optimizing system design and configuration and decreasing initial investment are important ways to reduce FGD operation cost;

2) Equipped with high efficient setups, optimizing system operation and reducing energy consumption are critical to reducing FGD operation cost;

3) Enhancing daily maintenance and management of FGD system, prolonging the lives of damageable parts and related setups, reducing the cost of maintenance are important.

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