FLUID-BED BOILER BURNING PARTICULATE MAOMING OIL SHALE

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ABSTRACT

Fluid-bed boiler burning particulate oil shale developed by Maoming Petroleum Industrial Corporation is the first fluid-bed boiler in China, which got appraisal from the Ministry of Petroleum Industry entrusted by State Commission of Science and Technology in 1967. It was recommended for burning low-grade coals. Two scale-up plants of power station fluid-bed boiler burning particulate oil shale with capacity of 35 t/hr were built in Maoming at the end of 1987 and now put into trial operation.

INTRODUCTION

Maoming fluid-bed boiler burning particulate oil shale of capacity 14.5 t/hr is the first fluid-bed boiler in China developed according to the experience in fluid-bed roasters of pyrite and zinc blend ores. Hot-flow modelling was made in 1964. It was built and commissioned in 1965, later at the end of 1967 it got appraisal from the Ministry of Petroleum Industry entrusted by State Commission of Science and Technology and was recommended for burning low-grade coals with boiler capacity below 20 t/hr.

Since then the application of fluid-bed boiler technology entered a new stage, the number of fluid-bed boilers burning low-grade coals and coal waste reached over 2000 in mid-seventies. However, low thermal efficiency and wearing problems, deviation from fluidized flow owing to inappropriately decreased pressure drop across air distributor limited the development of coal burning fluid-bed boiler. In the same period,

the operation of Maoming fluid-bed boiler burning oil shale was suspended due to some reasons other than its own defects.

Two scale-up plants of capacity 35 t/hr power station boiler was developed based on the experience in 14.5 t/hr boiler and the advanced technique of fluid-bed boiler at home and abroad. They were built and commissioned in December 1987 and put into trial operation.

14.5 t/hr FLUID-BED BOILER

Hot-flow modelling was made in 1964, giving required information of combustion and utilization of shale ash. A 14.5 t/hr fluid-bed boiler was designed in 1965, with adoption of technically matured equipment and the guideline of comprehensive utilization. Three fluid-bed processes of drying, combustion and cooling were used in boiler design, see Fig.1.

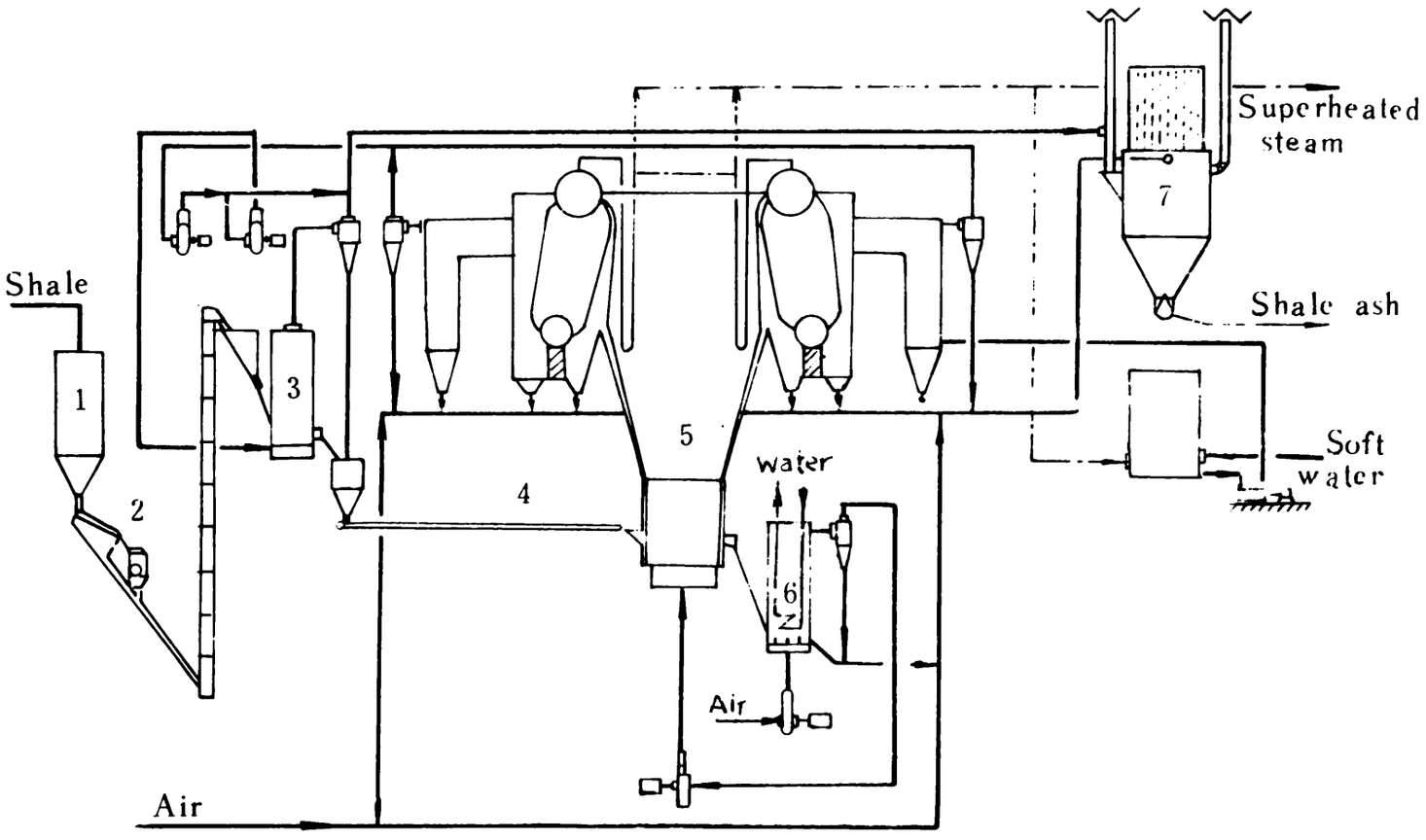

Fig. 1 Flow diagram of 14.5 t/hr fluid-bed boiler
1--shale hopper; 2--crushing, screening; 3--fluid-bed dryer; 4--charge conveyor; 5--fluid-bed combustor; 6--fluid-bed cooler; 7--bag filter.

1. Fluid-bed dryer

Moisture removal reached 5% in treating oil shale particulate in rainy season and preliminary drying was favorable to fluid-bed combustion. Drying was not needed for low pressure boiler in dry season.

2. Fluid-bed combustor.

The European technology was investigated. The fluid-bed combustor was designed, based on domestic experience of pyrite roasting. The oil shale used had a calorific value of 1,000 kcal/kg with the size of below 10 mm. Bed temperature 800°C, temperature in upper firebox 800°C, combustion efficiency 95-98% at flue gas oxygen content 3.5%, combustion efficiency lowered to 92% for the same oxygen content but lower combustor temperature of 650°C. Unburnt carbon in flue gas accounted for 7% of total calorific value, while the unburnt carbon in shale ash was still below 2%.. The overall thermal efficiency of combustor was 78.09%. Shale ash mixed with equal parts of cement clinker with additional 4% of gypsum could produce 400-500# cement.

3. Fluid-bed cooler of overflow ash. It was designed according to the experience of cooling in zinc blend roaster. Hot shale ash of 750°C could be cooled down to 170°C, cold air was heated from 45°C to 170°C. Hot air after a single stage dedusting entered a blower to be introduced into combustor as primary air. The cooler performed normally in a long period.

The technical data of three fluid-bed processes are list in Table 1.

Table 1 Technical data of three fluid-bed processes

	Combustor	Cooler	Dryer
Capacity, t/hr	14.5	4	12.5
Steam pressure, kg/cm²	13		
Superheating temp. °C	250		
Feedwater, temp., °C	70		
Inlet water, temp., °C	180	45	--
Inlet flue gas temp. °C	---	--	180
Exit flue gas temp. °C	180	--	80
Exit air temp., °C	---	180	--
Shale particle size, mm	<10	<10	<10
Air chamber pressure, mm H_2O	650	520	500

continued in next page.

Table 1 continued.

	Combustor	Cooler	Dryer
Thermal efficiency, %	78	Recover 3.5%	Recover 5%
Stationary bed height, mm	650	350-400	350-400
Height of overflow, mm	1400	200	200
Net height, mm	11	5	5
Cross section thermal intensity, kcal/m² / hr	185,225	99,900	54,400
Volumetric thermal intensity, kcal/m³ / hr	119,500	33,300	18,000
Bed area, m²	5	3	3

35 t/hr FLUID-BED BOILER

A scale-up plant of 35 t/hr fluid-bed boiler burning particulate oil shale was designed in the eighties after suspended operation of Maoming 14.5 t/hr fluid-bed boiler.

The fluid-bed boiler consists of crushing, pneumatic lift and drying, fluid-bed combustor, fluid-bed cooler, cyclone separator, etc. It was designed on the basis of experience in 14.5 t/hr boiler and new achievements of coal burning fluid-bed boilers at home and abroad. Several features were included:

1. A system of crushing, elevating, drying and sizing
2. A new auxilliary distributor, guide disk
3. Adoption of typical start-up method-hot air furnace
4. A fluid-bed cooler of overflow shale ash
5. In-boiler desulfurization with limestone
6. Apron sealing of fluid-bed combustor

These features helped to solve the problems of combustion, thermal processes and environmental impact, the shale ash quality also favored its comprehensive utilization, giving better economic results.

Many years experience of oil shale boiler indicated the difficulty in handling shale ash. Both dry and wet methods of ash discharge were used to ensure normal operation of power station boiler.

Steam generated was used for 6,000 kw back pressure turbine. Water jet discharge of shale ash was used at the initial stage of operation. In the future it will be used as cement blend in a 120,000 t/year cement works under Maoming Petroleum Industrial Corporation and other cement

works.

Operation control:

1. Oil shale feed--29 t/hr, by screw feeder
2. Combustion air flow rate--50,000 m^3/hr
3. Boiler feed water--36 t/hr
4. Fluid-bed temperature--800-900°C, controlled by feed rate
5. Fluid-bed pressure, mm H_2O

Air chamber	700-800
Bed bottom	300-400
Combustor top	2-5

6. Ash temperature leaving cooler--170°C
7. Ash discharge--Conveyor transfer in dry method, water jet discharge in ash sedimentation tank in wet method.

Design parameters:

1. Rated steam capacity, t/hr	35
2. Superheated steam pressure, kg/cm^2	39
3. Superheated steam temperature, °C	450
4. Feedwater temperature, °C	150
5. Flue gas temperature, °C	155
6. Cold air temperature, °C	30
7. Hot air temperature, °C	160
8. Boiler drain rate, %	3
Shale and ash characteristics	
1. Shale size, mm	<10
2. Shale moisture, %	8-10
3. Shale calorific value, kcal/kg	1,150
4. Fly ash carbon content, %	<2
5. Overflow ash carbon content, %	<0.5

CONCLUSION

1. Maoming fluid-bed boiler was designed to utilize particulate oil shale below 10 mm, which cannot be processed in lump shale retorts.

Shale ash from fluid-bed boiler can be used in cement production. This technology has opened a way of reasonable utilization of shale resources to generate steam, electricity and making building materials.

2. A 14.5 t/hr fluid-bed boiler was built in the sixties and operated satisfactorily. Two scale-up plants of 35 t/hr fluid-bed boilers were built in the eighties. Trial operation is now under way.

3. The near future target in Maoming is to build two 130 t/hr boilers coupled with two 25,000 kw generators, with cement as by-product.