A case study of biomass co-firing in a 55 MW pulverized coal fired furnace

X.B. Wang[1], L. Zhang[2], Y.M. Zhu[1], S.H. Deng[1], Z.M. Lv[1], R.H. Ruan[1], H.Z. Tan[1]

[1] Department of Thermal Engineering, Xi'an Jiaotong University, Xi'an, Shaanxi, 710049, China
[2] Henan Province Boiler pressure vessel safety inspection institute, Zhengzhou 450016, China

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Presenting author email: wxb005@mail.xjtu.edu.cn

The deterioration in the greenhouse effects has attracted more and more attention, and numerous techniques have been proposed in order to reduce the emission of CO_2. Among all the cheaper alternatives, biomass co-firing with coal has been widely recognized as a feasible and economic way for the reduction of CO_2(Sami et al., 2001). Biomass is considered as a CO_2-neutral fuel, since biomass consumes the same amount of CO_2 from the atmosphere during its growth as that released during its combustion. Meanwhile, the content of sulphur and nitrogen in biomass is much lower, and the emission of SO_2 and NOx can also be reduced when the biomass co-firing is implemented(Kazagic and Smajevic, 2009). Furthermore, because the content of alkali and chlorine is high, combustion of 100% biomass will result in severe problems of slagging and corrosion, and this can be effectively avoided if co-firing biomass with coal. Despite of the advantages in the co-firing biomass mentioned above, co-firing biomass in high-capacity pulverized coal-fired furnaces can still not be applied widely in China (Wang et al., 2011).

In this study, biomass direct co-firing was carried out in a 55 MW tangentially fired pulverized coal furnace equipped with ball mill and warehouse pulverizing system. The effects of biomass co-firing on the safety and performance of pulverizing system, furnace efficiency and pollutant emissions were studied. As shown in Fig. 1, biomass powders and raw coal were first mixed in the fuel storing filed, passing through the milling and transporting system, finally were blown into the furnace through the primary air and tertiary air.

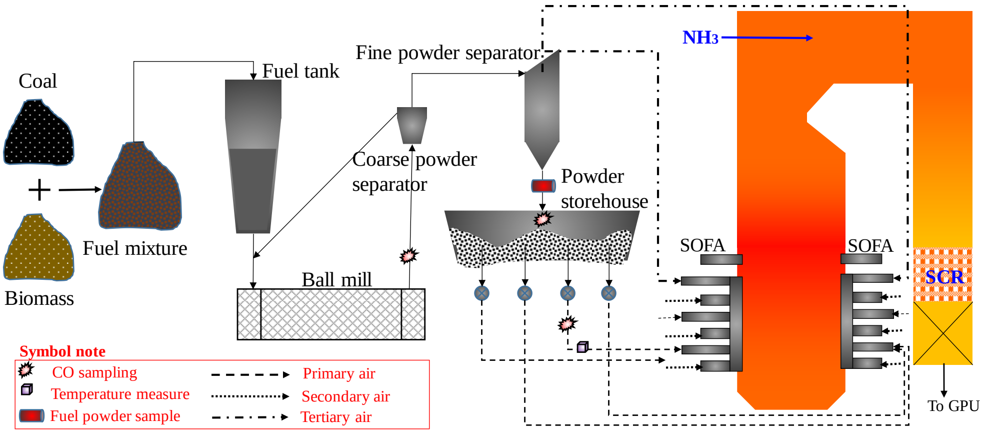

Fig. 1 Biomass co-firing process and combustion system.

The test results show that in this studied pulverizing system, with a co-firing ratio ≤20 wt.%, there is no risk of explosion or spontaneous burning in the pulverizing system, because the concentrations of CO at the outlet of ball mill is negligible (<6 ppm, Fig. 2a) and biomass particles cannot be separated into the warehouse by the fine-powder separator. In biomass co-firing cases, the CO concentration of hot primary air (>230°C) is in the range of 115-173 ppm, which is comparable with the value of 130 ppm in 100% coal case (Fig. 2b).

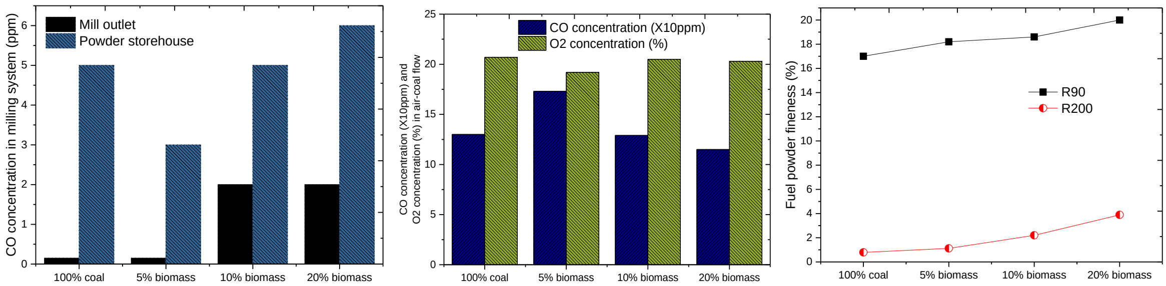

Fig. 2. Effect of biomass co-firing on CO concentrations of millling system (a-b) and fuel fineness (c).

Biomass co-firing affects the performance of pulverizing system at a certain degree, that with the biomass co-firing ratio increase from 0 to 20 wt.%, the values of R200 and R90 respectively increase from 17% and 0.79% to 20% and 3.89% (Fig. 2c).

As shown in Table 1, the properties of fuel powders sampled from storehouse in co-firing cases are similar to that in 100% coal case. This indicates that because of the low density of biomass particle, most biomass particles escape from the fine-powder separator and then goes into furnace through the tertiary air ports.

Table 1. Properties of co-milled fuel powders sampled from storehouse and raw fuel.

Conditions	Ultimate analysis (%)					*C/H* (1)	Proximate analysis (%)			Heating value
	C_{ad}	H_{ad}	O_{ad}	N_{ad}	S_{ad}		M_{ar}	V_{ar}	A_{ar}	$Q_{net,ar}$ (MJ/kg)
100% coal	55.35	2.97	3.84	1.15	3.44	18.65	3.20	17.01	32.22	22.70
5% biomass	54.23	2.87	3.26	1.14	3.54	18.88	3.79	16.07	33.67	23.19
10% biomass	54.40	2.95	4.60	1.14	3.36	18.45	4.38	17.72	32.20	22.32
20% biomass	55.58	2.99	4.03	1.14	3.15	18.59	5.56	23.69	31.67	22.55
100% biomass	42.36	4.77	35.11	0.75	0.54	8.88	15.00	65.01	12.04	16.68

As shown in Table 2, with biomass co-firing ratio increasing from 0 to 5 wt.% and 10 wt.%, the unburned carbon contents (UBCs) in ash and slag generally increase, however, when the biomass co-firing ratio further increases from 10 wt.% to 20 wt.%, the UBC in ash decreases. In addition, the exhaust temperature slightly decreases with the biomass co-firing ratio, thereby the furnace efficiency reaches the minimum in 10 wt.% biomass co-firing case.

Table 2. Unburned carbon contents (UBC) and furnace efficiency.

Conditions	UBC in fly ash (%)	UBC in bottom slag (%)	Exhaust temperature (ºC)	Furnace efficiency (%)
100% coal	4.71	11.48	138.4	90.88
5% biomass	4.68	14.06	139.2	90.82
10% biomass	5.77	15.96	135.5	90.09
20% biomass	5.16	15.99	134.1	90.11

As shown in Fig. 3(a), at 20 wt.% biomass co-firing ratio, the NOx emission before De-NOx system decrease by 24.5%, compared with that in the case of 100% coal combustion. It is also interesting to observe that biomass co-firing promotes the De-NOx process, that with the increase of biomass co-firing ratio increases from 0 to 20 wt.%, the De-NOx efficiency increases from 56% to 71%.

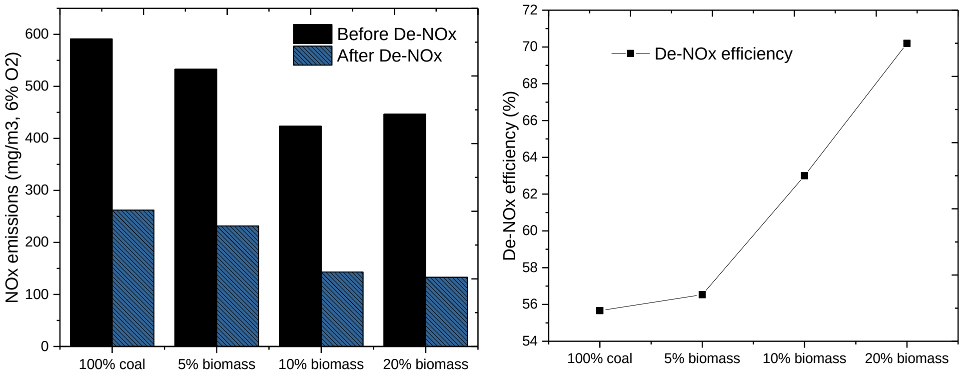

Fig. 3 Effect of biomass co-firing on NOx emissions and De-NOx efficiencies.

Based on the test results, four biomass co-firing schemes are proposed and economic analysis is made for different co-firing schemes.

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