Available online at www.sciencedirect.com
SciVerse ScienceDirect
Energy Procedia 17 (2012) 1242 – 1248
Energy Procedia

2012 International Conference on Future Electrical Power and Energy Systems

# Research of Multi-Fuel Burning Stability In A 300MW Coal-Fired Utility Boiler

REN Jianxing[a], LI Fangqin[a], ZHU Qunzhi[a], WU Jiang[a], YANG Yongwen[a], Liu Qingrong[a],LIU Hongfang[b]

[a]*Energy and Environment Engineering Institute, Shanghai University of Electric Power,Shanghai，China*
[b]*Zhejiang Jiaxing power Co.,Ltd,,Zhejiang，China*

**Abstract**

With China's economy growing rapidly, requirement of electricity is more and more. Now, 300MW coal-fired units are main units. With diversification of coal, there are big differences between actual coal and design coal, this affect on the safety of running. In this paper, a 300MW coal-fired unit was studied. A, B and C three kinds of mixed coal were chosen. Under the rated load, characteristics of coal were studied. Experiments of adaptabilities of mixed coal A, B and C with boiler were done. And results indicated that slag of boiler was related with distribution of fire box temperature, degree of flame-brush wall and degree of flue-gas turbidness. Slag of mixed coal C was serious, while mixed coal A was not easy lagging in superheater and water wall. Therefore, mixed coal A as fuel could meet the need of safe running of boiler.



Keywords:300MW;coal-fired unit; combustion; stability

## 1.Introduction

Energy is very important for country's national economy development. In China, coal is main primary energy to be used. Total energy output of China see table 1.

TABLE I. TOTAL ENERGY OUTPUT OF CHINA

| Years | Energy consumption | *Rate in total energy consumption %* | | | |
|---|---|---|---|---|---|
| | *Ten thousand ton standard coal* | *Coal* | *Oil* | *NG* | Hydropower/nuclear power /wind power |

1876-6102 © 2012 Published by Elsevier Ltd. Selection and/or peer-review under responsibility of Hainan University.
Open access under CC BY-NC-ND license. doi:10.1016/j.egypro.2012.02.233

| | | | | | |
|---|---|---|---|---|---|
| 1997 | 137798 | 71.7 | 20.4 | 1.7 | *6.2* |
| 1998 | 132214 | 69.6 | 21.5 | 2.2 | *6.7* |
| 1999 | 133831 | 69.1 | 22.6 | 2.1 | *6.2* |
| 2000 | 138553 | 67.8 | 23.2 | 2.4 | *6.7* |
| 2001 | 143199 | 66.7 | 22.9 | 2.6 | *7.9* |
| 2002 | 151797 | 66.3 | 23.4 | 2.6 | *7.7* |
| 2003 | 174990 | 68.4 | 22.2 | 2.6 | *6.8* |
| 2004 | 203227 | 68.0 | 22.3 | 2.6 | *7.1* |
| 2005 | 224682 | 69.1 | 21.0 | 2.8 | *7.1* |
| 2006 | 246270 | 69.4 | 20.4 | 3.0 | *7.2* |
| 2007 | 265583 | 69.5 | 19.7 | 3.5 | *7.3* |

With China's economy growing rapidly, requirement of energy, especially electricity is more and more. How to increase electricity quickly to meet the need of national economy development is hot problem to be solved. Now, 300MW coal-fired units are main units in China. By reason of requirement of power generation, coal supply for electric power was absence increasingly. Therefore, coal supplied for electric power was diverse. Based on the operating experience, only when coal used in the boiler was very similar with design coal, safety, economy and flexible peak shaving could be ensured. While when coal used in the boiler was different with design coal, economy and stability of boiler were affected. So study on multi-fuel burning stability of 300MW coal-fired utility boilers would increase operating economy and stability of boiler。

## 2.Main Design Parameters of 300MW Coal-Fired Boiler

In China, design fuel of typical 300 coal-fired boilers were soft coal, subcritical, single reheat, loop control drum boiler, medium speed unit pulverized-coal system, dry-bottom, π type, single furnace, balanced draft, tangential firing, swing adjustable nozzles. In this paper, a boiler with width 14022 mm and depth 12330 mm was studied. Whose width-depth ratio was 1.14:1.00, furnace cross-section was close to square. There were five HP-863 medium speed coal mills and barotropic unit pulverized-coal system. Main design parameters of boiler saw table 2.

## 3.Experiments of Combustion Characteristics with Mixed Coals

To meet the requirement of diverse coal supplies, it was necessary to do experiments of combustion characteristics with mixed coals. Based on the characteristics of design coal and check coal, take characteristic of mixing coal into account, mixed coal A, B and C were made. Elementary analysis and industrial analysis of mixed coals saw table 4 and characteristic of ash saw table 5.

From table 4, sulfurs of mixed coal A, B and C were lower, sulfur, heat value and ash were close to design and check coal, volatiles were lower than those of design and check coal. DT, ST and FT of mixed coals were 1287℃, 1310℃ and 1371℃, higher than those of design and check coal, which was benefit for controlling slag. Experiment results saw table 6.

TABLE II. MIAN DESING PARAMETERS OF BOILER

| Items | Unit | BMCR | Nominal |
|---|---|---|---|
| *Load* | MW | 332.9 | 300 |
| *Superheated steam* | t/h | 1025 | 908.19 |
| *Outlet pressure of superheated steam* | MPa | 18.3 | 17.3 |
| *Outlet temperature of superheated steam* | ℃ | 540 | 540 |
| *Reheat steam* | t/h | 834.68 | 746.1 |
| *Inlet pressure of reheat steam* | MPa | 3.82 | 3.41 |
| *Outlet pressure of reheat steam* | MPa | 3.62 | 3.23 |
| *Inlet temperature of reheat steam* | ℃ | 321 | 316 |
| *Outlet temperature of reheat steam* | ℃ | 540 | 540 |
| *Feed water temperature of economizer* | ℃ | 281 | 273 |
| *Feed water of economizer* | t/h | 1025 | 881.5 |
| *Outlet water temperature of economizer* | ℃ | 314 | 307 |
| *Desuperheater water temperature of superheater* | ℃ | 175 | 170 |
| *Ⅰdesuperheater water* | t/h | 0 | 23.7 |
| *Ⅱdesuperheater water* | t/h | 0 | 3.0 |
| *Exhaust gas temperature(before correction)* | ℃ | 135 | 131.7 |
| *Boiler efficiency* | % | 92.7 | 92.9 |
| *Fuel consumption* | t/h | 124 | 112 |

Design coal and check coal saw table 3.

TABLE III. DESIGN COAL AND CHECK COAL

| Item | Unit | Design coal | Check coal A | Check coal B | Check coal C |
|---|---|---|---|---|---|
| $M_{ar}$ | % | 14.00 | 16.45 | 15.59 | 15.32 |
| $M_{ad}$ | % | 8.49 | 10.25 | 8.59 | 6.23 |
| $A_{ar}$ | % | 11.00 | 7.19 | 3.53 | 15.45 |
| $V_{daf}$ | % | 36.44 | 30.58 | 38.40 | 38.32 |
| $C_{ar}$ | % | 60.33 | 61.74 | 64.60 | 55.85 |

| | | | | | |
|---|---|---|---|---|---|
| $H_{ar}$ | % | 3.62 | 3.35 | 4.06 | 3.44 |
| $N_{ar}$ | % | 6.70 | 0.69 | 0.81 | 0.70 |
| $S_{ar}$ | % | 0.41 | 0.63 | 0.40 | 0.31 |
| $O_{ar}$ | % | 9.94 | 9.95 | 11.01 | 8.93 |
| $Q_{net.ar}$ | kJ/kg | 22760 | 22870 | 24550 | 21370 |
| *HGI* | | 56 | 63 | 48 | 55 |
| *DT* | ℃ | 1130 | 1120 | 1200 | 1197 |
| *ST* | ℃ | 1160 | 1150 | 1210 | 1221 |
| *FT* | ℃ | 1210 | 1180 | 1250 | 1263 |

TABLE IV. ELEMENTARY ANALYSIS AND INDUSTRIAL ANALYSIS OF MIXED COALS

| | Industrial analysis % | | | | | Heat value | Elementary analysis % | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $M_t$ | $M_{ad}$ | $A_{ad}$ | $V_{ad}$ | $FC_{ad}$ | *MJ/kg* | $C_{ad}$ | $H_{ad}$ | $N_{ad}$ | $S_{ad}$ | $O_{ad}$ |
| **Mixed coal A** | 10.1 | 4.04 | 13.48 | 28.56 | 53.92 | 24.25 | 67.69 | 3.83 | 0.74 | 0.44 | 9.78 |
| **Mixed coal B** | 8.1 | 2.96 | 17.66 | 25.40 | 53.98 | 23.70 | 65.35 | 3.71 | 0.71 | 0.59 | 9.02 |
| **Mixed coal C** | 13.4 | 5.29 | 11.18 | 28.94 | 54.59 | 23.62 | 68.11 | 3.89 | 0.75 | 0.27 | 10．51 |

TABLE V. CHARACTERISTIC OF ASH OF MIXED COALS UNIT: %

| Coal | $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | TiO | $SO_3$ | $P_2O_5$ |
|---|---|---|---|---|---|---|---|---|
| **Mixed coal A** | 44.9 | 30.73 | 7.06 | 8.85 | 1.25 | 1.72 | 4.10 | 0.28 |
| **Mixed coal B** | 46.67 | 39.32 | 6.36 | 3.41 | 0.84 | 1.66 | 2.40 | 0.48 |
| **Mixed coalC** | 39.51 | 29.88 | 10.3 | 11.87 | 1.17 | 1.68 | 4.16 | 0.38 |

## 4.Analysis of Experiment Data

| Items | Unit | Mixed coal A | Mixed coal B | Mixed coal C |
|---|---|---|---|---|
| **Load** | *MW* | 301.20 | 300.83 | 299.60 |
| **Drum pressure** | *MPa* | 18.19 | 18.30 | 18.06 |
| **Feed water** | *t/h* | 1067.90 | 1082.03 | 1076.00 |

| | | | | |
|---|---|---|---|---|
| **Feed water pressure** | ***MPa*** | 18.77 | 19.01 | 18.74 |
| **Feed water temperature** | ℃ | 273.65 | 273.48 | 274.31 |
| **Superheated steam** | ***t/h*** | 994.94 | 988.03 | 989.16 |
| **Superheated steam temperature** | ℃ | 519.09 | 521.55 | 530.40 |
| **Superheated steam pressure** | ***MPa*** | 16.61 | 16.86 | 16.55 |
| **A side outlet pressure of reheat steam** | ***MPa*** | 3.90 | 3.92 | 3.94 |
| **B side outlet pressure of reheat steam** | ***MPa*** | 3.88 | 3.90 | 3.92 |
| **Outlet pressure of reheat steam** | ***MPa*** | 3.49 | 3.51 | 3.52 |
| **A side outlet temperature of reheat steam** | ℃ | 535.49 | 536.78 | 538.63 |
| **B side outlet temperature of reheat steam** | ℃ | 537.32 | 537.46 | 531.40 |
| **Exhaust gas temperature** | ℃ | 127.27 | 129.82 | 137.67 |
| **Cool air temperature** | ℃ | 7.74 | 9.53 | 4.99 |
| **$O_2$ in flue gas** | % | 5.0 | 5.4 | 6.1 |
| **CO in flue gas** | ***ppm*** | 0.0 | 2.3 | 19.8 |
| **Unburned combustible in flue** | % | 1.63 | 4.02 | 2.14 |
| **Unburned combustible in slag;** | % | 2.28 | 1.96 | 0.38 |
| **$q_2$** | % | 5.469 | 5.671 | 6.597 |
| **$q_3$** | % | 0 | 0.001 | 0.006 |
| **$q_4$** | % | 0.250 | 0.820 | 0.293 |
| **$q_5$** | % | 0.421 | 0.433 | 0.430 |
| **Counter balance thermal efficiency ηsl** | % | 93.859 | 93.075 | 92.673 |

Based on operation status of boiler and experiment results, under the condition of 300MW, average temperature in burning area was very high, and average temperature burning mixed coal C was higher about 140℃ than that of mixed coal A and B. In platen superheater area, average temperature burning mixed coal C was higher 50℃ than that of mixed coal A and 26℃ than that of mixed coal B.

For different mixed coal, burning status of mixed coals in burner area was: burning of mixed coal A was earliest, then was mixed coal C, and then was mixed coal B. Burning situation of mixed coal A was better.

In upper area of burners, considering of flame transparency and brushing wall degree, flame transparency of mixed A was better while mixed B and C were poor, and there were not brushing wall phenomena of three mixed coals. There were good relationship between flame transparency and unburned combustible in flue gas. That was flame transparency was good, unburned combustible in flue gas was lower. Based on

the results of experiments, for three mixed coals, unburned combustible in flue gas of mixed coal A was 1.63%, lower than that of mixed coal B and C, while unburned combustible in flue gas of mixed coal B was 4.02%. There was 2.39% discrepancy between mixed coal A and mixed coal B.

Under the condition of 300MW, exhaust gas temperature of mixed coal C was higher 10℃ than that of mixed coal A. Oxygen in flue gas of mixed coal C was higher 1.1%, flue gas loss was higher 1.13% and boiler efficiency decreased 1.18%.

Under conditions of experiments, on water wall and upper superheater, there was slag to some degrees. On upper superheater, it was asymmetrical of slag degree. Slag in left side of boiler was serious, while in right side, slag was light. Slag severity was related with temperature distribution, brushing wall degree and flue-gas turbidness degree. Serial arrangement of three mixed coals according to slag severity: mixed C, mixed B and mixed A.

Therefore, to control slag, burning mixed coal A could not make upper superheater and water wall slag seriously, and could meet the requirement of safe-economical operation.

## 5.Conclusions

In China, 300MW coal-fired units are main units. With diversification of coal, there are big differences between burning coal and design coal, this affect on the safety of running. In this paper, based on the typical coal, mixed coal A, B and C were made. In a 300MW coal-fired unit, burning characteristics were experimented. Results showed that: mixed coal A, B and C could meet the requirement of boiler burning; from temperature in furnace, no matter distribution uniformity of total temperature or quadrangle temperature in furnace, or temperature deviation between right side and left side of superheater, or temperature distribution uniformity of two-side wall, burning mixed coal A was better than burning mixed coal B and C. Serial arrangement of three mixed coals according to slag severity: mixed C, mixed B and mixed A. Boiler efficiency of mixed coal A was higher than that of mixed coal B and C.

## Acknowledgments

This paper is partly sponsored by the Fifth Key Subject of Shanghai Education Commission (Grant No. G51304) and the Third Phase of Undergraduate Education Center Construction Project of Shanghai Education Commission.

## References

[1] Information Office of the State Council of the People's Republic of China. Energy status and policy of China.2007,12:1-4

[2] Verband der Chinensischen Kohle Industrie. Statistics of Kohlen industrie of 2008. 2009,2,5:1-2

[3] Chen Xinjiang. Discussion of adaptability of coal change with adjusting burning style boiler[J], Energy and environment, 2005,(1):17-18

[4] QIU Lichun, ZHANG Jianhua. Coal fired boilers combustion optimization technology based on carbon monoxide [J]. Zhejiang electric power, 2005,(3):10-12

[5] YAN Shunlin, WANG Dongsheng, LI Yonghua, ZHU Weiping. Analysis of the influential factors to boiler combustion stability [J]. Power system engineering, 2005,(1):29-30

[6] ZHOU Maode, SHI Zhan shan, YU Zhiyuan. Effects and policies of the change of coal quality on coal – fired boiler [J]. Shanxi electric power, 2005,(2) : 9-11

[7] LIU ying. Effect of coal changing on safety-economic operation of power plant and policy [J]. Panzhihua sci-tech & information, 2008(4):42-46

[8] SA Yinglu, ZHANG Jun, SHENG Changdong, ZHENG Shijin. Stable combustion for pulverized coal-fired boilers and coal-blended optimization

[9] Jiangsu electrical engineering, 2005（6）：11-15

[10] DING Weixiong, NI Peilin. Two measures taken in boiler aiming at decrease in coal quality [J]. Guangdong electric power, 2006(5):65-67