

Development of the 2200t/d Shen-ning Gasification Technology: Combination of Fundamental Research and Engineering Development

Kuang Jian-ping², Yao Min¹, Zhang Yu², Zhang Jia-shuo², Huang Bin¹, Shi Ya-jun², Xia Zhi-wen², He Shu-min², Nie Jie², Ma Le-bo², Bai Yun-bo², Chen Yi-lie²

¹Shen Hua Ning Industry Group, China,

²Ningxia Shenyao Technology Ltd., Co., China

email (Presenter): kuangjianping@nxsytc.com

In November of 2017, four sets of 2200t/d Shen-ning pulverized coal entrained flow gasifier achieved full capacity in the world largest CTL plant which located in Ningxia province, China. The 560MW Shen-ning gasifier (SNG) run under pressure of 4.5MPag, each gasifier with syngas throughput around 160,000Nm³/h; carbon conversion exceeds 98% for the designed coal; slag to ash ratio is 6.1:3.9, and waste water effluent is less than 40t/h. Comparing to other pulverized coal entrained flow gasification technologies, the Shen-ning gasification process shows the following advantages: higher effective syngas fraction (CO+H₂), higher carbon conversion, lower specific coal and oxygen consumption, lower solids carry-over in syngas as shown in Table 1 [1, 2].

Table 1 Comparison of various pulverized coal entrained flow gasification technologies

Index	SNG	SCGP	GSP	HXL	CCG
Coal consumption, kg/kNm ³ effective syngas	500-580	500-650	550-650	520-700	520-680
Oxygen consumption, Nm ³ /kNm ³ effective syngas	275-320	300-360	310-360	300-380	300-360
Effective syngas volume fraction, %	≥93	≥90	91-93	90-93	≥90
Carbon conversion	≥98	99	>95	96	>98.5
Solids carry-over in syngas, mg/Nm ³	≤0.5	<1	≤1	≤1.5	≤1
Carbon mass fraction in filtrate of black water, %	20-25	30-60	20-30	30-50	25-35
Applications of larger scale gasifier exceed 2000tpd	Yes	Yes	Yes	No	No
Capex of 2000tpd scale gasifier	Low	High	High	Low	Medium
Coal suitability	Bituminous coal, inferior anthracite coal	High quality bituminous coal, inferior anthracite coal	Bituminous coal, inferior anthracite coal	High quality bituminous coal, inferior anthracite coal	High quality bituminous coal, inferior anthracite coal

The combined swirling flow burner with functions of ignition, flame detection and in-situ video camera was implemented in the Shen-ning gasifier. During the development of Shen-ning gasification technology, fundamental research and engineering development were integrated seamlessly. The fundamental research focused on coal study, pressurized pure oxygen combustion, CFD simulation of reactor and water quench chamber. A comprehensive 3D full scale 2200t/d Shen-ning gasifier model was developed [3, 4]. Different types of burner configurations coupled with gasifier reactor, were tested by numerical simulation to verify their performance. The gas phase turbulent reaction process was simulated by PDF model. Moreover, the pulverized coal particles' motions and reaction behaviours were tracked by discrete phase model (DPM). Meanwhile, the CFD model was validated by the industrial operation data. Then, the validated mathematical model was applied as powerful tool to guide the design of gasifier and combined burner, and evaluated the performance of the prototype gasifier.

The quench ring sitting on top of the downcomer is usually the most critical part of internals. This part is always vulnerable to erosion and corrosion since it face the hot syngas and slags. To make it more robust, the structure of the quench ring and slag tap were optimized according to numerical simulation, and tested in hot model running [5, 6]. By means of seamless combination of fundamental research and engineering development, the 2200t/d Shen-ning gasification process achieved high capacity, high efficiency, low cost, and significant water conservation.

References

- [1] Wang Shoujian. Development and application of modern coal gasification technology. *Chemical Industry and Engineering Progress* 2016;35:653-664.
- [2] Wang Fuchen, Dai Zhenghua. Coal gasification-core technology of the efficient and clean utilization of coal. *Chemical Word* 2015;56:51-55.
- [3] Kuang Jianping, Guo Wei, Jing Yunhuan, Luo Chuntao, Huang Bin, Zhang Shicheng, Cen Kefa. Research on matching performance of gasifier and single top spraying pulverized coal gasification burner. *Coal Science and Technology* 2015;43:102-105.
- [4] Guo Wei, Kuang Jianping, Zhang Shicheng, Cen Kefa. Analysis and application on flow field characteristic simulation on gasifier with top-blown pulverized coal. *Coal Science and Technology* 2016;44:188-195.
- [5] Guo Wei, Kuang Jianping, Luo Chuntao. Study on water quench process for high temperature syngas from dry pulverized coal gasifier. *Contemporary Chemical Industry* 2016;45:809-812.
- [6] Li Xiaodong, Zhang Jiashuo. Comparative analysis on the membrane wall structure design and application of pulverized coal gasifier slag tap. *Chemical Fertilizer Design* 2016;54:23-26.