Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 146 (2016) 594 – 603

Procedia Engineering

www.elsevier.com/locate/procedia

8th International Cold Climate HVAC 2015 Conference, CCHVAC 2015

Research and application of flue gas waste heat recovery in co-generation based on absorption heat-exchange

Feng Li[a], Lin Duanmu[a], Lin Fu[b, *], Xi ling Zhao[b, †]

[a]*School of Civil Engineering, Faculty of Infrastructure Engineering, Dalian University of Technology, Liaoning, PR China*
bDepartment of Building Science, School of Architecture, Tsinghua University, Beijing, PR China

Abstract

For gas cogeneration system, there are problems to be solved. There is great heat transfer temperature difference in the heat-exchange progress. It can cause huge irreversible loss of heat transfer. More seriously, exhaust temperature of flue gas is generally more than 90℃. The part of the heat is equal to the 40 percent of heating load. The return water conventionally has a high temperature, so the flue gas waste heat is difficult to recover. Based on the situation, this paper introduced the technique of flue gas waste heat recovery in gas cogeneration based on absorption heat-exchange. Absorption heat-exchange units are set up in thermal station to lower temperature of water in heat network to about 20℃. The return water is heated orderly by gas-water heat exchanger, absorption heat pump and the peak load heater. Compared with the traditional systems, this system runs with a greater circuit temperature drop so that the delivery capacity of the heat network increases dramatically. The heating capacity and the energy efficiency of the cogeneration plant is increased by the exhausted heat recovery from the flue gas. Finally, this paper has analyzed the advantages on energy-saving benefit, environmental benefit and economic benefit by one example that a gas cogeneration plant is reformed using the technology.

Peer-review under responsibility of the organizing committee of CCHVAC 2015

Keywords: flue gas waste heat; heat and power cogeneration; absorption heat-exchange; energy saving and emission reduction

* Corresponding author. Tel.: +861062773885; fax: +861062770544.
E-mail address: fulin@tsinghua.edu.cn(Lin Fu)
* Corresponding author. Tel.: +861062773885; fax: +861062770544.
E-mail address: zhaoxiling@126.com(Xiling Zhao)

Peer-review under responsibility of the organizing committee of CCHVAC 2015
doi:10.1016/j.proeng.2016.06.407

1. Introduction

Heating energy consumption of the northern towns accounts for about 40% of the urban building energy consumption in China [1]. Compared with other ways, the cogeneration has the advantages of saving energy and reducing emission. So it’s an effective way of district heat supply. In recent years, environmental emissions of important cities have been given a great attention. Taking Beijing as an example, the gas cogeneration systems have been developed rapidly as the central heating source in heating season.

The exhaust gas generated from the burning natural gas contains large amounts of water vapor. The latent heat of vapor accounts for 10%-11% of the natural-gas lower calorific value. Thus the effective utilization of the latent heat has important significance to saving energy and improving the economics.

For gas cogeneration, the coefficient of excess air is more than the boilers, so the waste heat of exhaust gas is greater. Recovering the waste heat as more as possible has great significance to energy conservation, environmental protection and raising economic benefits [2].

In recent years, numerous researchers have conducted researches on waste-heat recovery of flue-gas from gas boiler or coal-fired boiler.

Zhao et al. [3] designed a type of system for coal-fired boiler, which can reduce exhaust flue gas temperature to 60-70℃ and recycle waste heat in the flue gas to heat the return water. It utilized plate heat exchangers and absorption heat pump systems to heat return water, which helps improve the heating efficiency. Yang et al. [4] designed low-temperature gas waste heat recovery system by heat pipe technology and did economic analysis. Li et al. designed associated heating system of solar energy and boiler afterheat [5]. Hu et al. found that low pressure economizer was able to reduce exhaust flue-gas temperature and coal consumption [6].

For gas boiler, some developed countries have studied and produced condensing boilers to utilize the waste heat in flue gas. The domestic and foreign research institutes have also studied this boilers [7-11]. Seungro Lee et al. [12] used the optimal designed heat exchangers for improving the heating efficiency about 10%. Che et al. [13-15] put forward that the most economical exit flue gas temperature is 40-55℃, studied the law of heat transfer with water vapor condensation both theoretically and experimentally when wet flue gas passes downwards through a bank of horizontal tubes and obtained the normalized formula for convention-condensation heat transfer coefficient based on the experimental data. Pan et al. [16] installed a flue gas condensing waste-heat exchanger in gas-fired vacuum hot water boiler and the boiler thermal efficiency could be increased by 6.6% and the emissions of CO_2 could be decreased by 0.34 m^3/h. Li et al. [17-21] researched on the flue gas heat exchanging characteristics in natural gas fired boilers and demonstrated the feasibility and the economic characteristic of reclaiming residual heat of flue gas of a condensation boiler burning gas.

In contrast, there are much fewer technologies to recover the flue-gas waste heat deeply in gas-fired plant. T. Srinivas et al. [22] used lithium bromide/water vapour absorption refrigeration system for cooling the inlet air to enhance the performance of GT-ST power plant. In this work, the lithium bromide-water ($LiBr/H_2O$) absorption refrigeration system has been powered by waste heat from heat recovery steam generator (HRSG). However, the exhaust temperature would be still high restricted to the temperature of generator. So the effect of energy saving is not obvious. Chen et al. [23] established a simulation heating system utilizing exhaust smoke heat of plants and studied the energy saving and emission reduction potential of flue gas condensing heat recovery. The energy saving rate is researched with the inlet water temperature of the gas condensing heat recovery unit. Nevertheless, how to make the low-temperature water has not been studied.

In summary, lots of scholars have researched the recovery of flue-gas waste heat and reached large amounts of valuable conclusions. However, the high temperature of return water has actually constrainted the recovery of flue-gas waste heat. Thus the temperature of exhaust is still high. To the flue gas from gas boiler and the gas-fired plant, a large amount of latent heat of vaporization will be released while the flue-gas temperature is decreased to below 60℃ and 40℃.

Fu et al. [24-29] designed a district heating system with cogeneration based on absorption heat exchange (co-ah cycle), which improved the capacity of heating system and energy efficiency of cogeneration plant dramatically. In the district heating system substations, the return water temperature of the primary heating network is reduced to about 20℃ through the absorption heat-exchange units. In the power plant, the return water of the primary heating