Conference Paper

Thermal Neutralization of Excessive Heat Transfer Agent in Coke Dry-Quenching Plants (CDQP)

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Abstract

The paper considers the problem of reducing emissions of harmful substances in the process of coke dry quenching. It proposes an option for thermal neutralization of excessive heat transfer agent in the coke dry-quenching plants as well as preheating of heat transfer agent and air by exhaust combustion products. The paper presents a process diagram and main process parameters of plant operation. It shows efficient recovery of secondary energy resources in the form of chemical heat in the proposed plant.

Keywords: coke dry-quenching plant, excessive heat transfer agent, thermal neutralization, afterburner process diagram, afterburner performance parameters

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The technology of coke dry quenching gets a widespread use in the coke-chemical industry for cooling of coke delivered from the furnace chambers with the temperature of 1000-1100°C. In Russia, out of 32-35 million tons of annually produced coke approximately 40% are cooled in the coke dry-quenching plants (CDQP).

During dry quenching 1.47 to 1.68 GJ of heat per ton of coke is recovered, which amounts to ~75% of heat input for coking. The mechanical strength of coke increases by 4-7% for M40 index and by 1-1.5% for M10 index as compared to wet quenched coke.

However, in the process of coke quenching an excessive heat transfer agent is formed and this heat transfer agent is discharged through the cold vent of the exhaust fan. The excessive heat transfer agent goes into the atmosphere together with hydrogen sulphide, ammonia, phenols and other harmful substances in the quantity not exceeding 13 g per ton of coke. Major pollutants of the atmosphere are carbon monoxide and coke dust as their quantity reaches 7.5 kg and 1.1 kg per ton of coke respectively. In Russia, neutralization of the excessive heat transfer agent against harmful substances and coke dust removal is not performed.

The quantity and composition of the excessive heat transfer agent can significantly vary for different chambers of the coke dry-quenching plants. Table 1 gives parameters of the discharged heat transfer agent from CDQP in one of the coking plants [1]. These

Chamber No.	Gas composition, %				Gas flow rate, nm^3/h
	O_2	CO	CO_2	H_2	
1	0.7	12.8	10.4	3.4	4784
2	1.0	10.6	10.7	4.7	4848
3	0.6	10.0	9.8	5.6	4571
4	0.9	6.8	13.4	2.7	3911
5	0.4	9.6	12.0	3.9	3207
Average	0.7	10.0	11.3	4.1	4264

Table 1: Quantity and composition of excessive heat transfer agent discharged from cold vents of exhaust fans.

parameters are typical of CDQP with the chamber capacity of 70 t/h. The quantity of the excessive heat transfer agent for different chambers ranges between 3207 and 4848 m^3/h, the total quantity of five chambers is 21321 m^3/h. The temperature of the excessive heat transfer agent is 140-178°C and the pressure is 2.3-3.1 kPa.

The volume content of carbon monoxide and hydrogen does not exceed 12.6% and 4.7% respectively. The excessive heat transfer agent is an incombustible gas due to low combustion heat not exceeding 1.1 MJ/m3. The discharged heat transfer agent contains coke dust in the quantity of ~0.9 g/m^3.

The presence of combustible components in the excess gas coolant creates favorable technological conditions for the introduction of facilities for its neutralization by thermal methods. That will receive heated air, hot water or steam [2, 3].

In practice, the process of low-calorie gas combustion shows that if the content of carbon monoxide is less than 12-14%, recovery of gases is restricted by temperature and concentration conditions of ignition and in the conditions of conventional flare combustion it is characterized by low efficiency of gas utilization [4, 5]. Stable combustion of low-calorie gases can be achieved only with preliminary heating of the gases up to the minimum temperature of 300-400°C.

The solution to discharge excessive gas into the gas pipeline of reverse coke-oven gas is difficult to implement due to low combustion heat and high concentration of coke dust. Therefore, combustion of excessive gas in a special reactor shall be considered as the main way of excessive gas neutralization in the CDQP [1].

If there are heat consumers at the factory, combustion of gases with a low content of combustible components can be successfully implemented in an integrated recovery plant (Figure 1). For this purpose, it is necessary to provide a deep two-stage dust removal from gases, keeping the same quantity of combustible components, thermal conditions for stable ignition of the gases by an external heat source and heat recovery of waste gases.

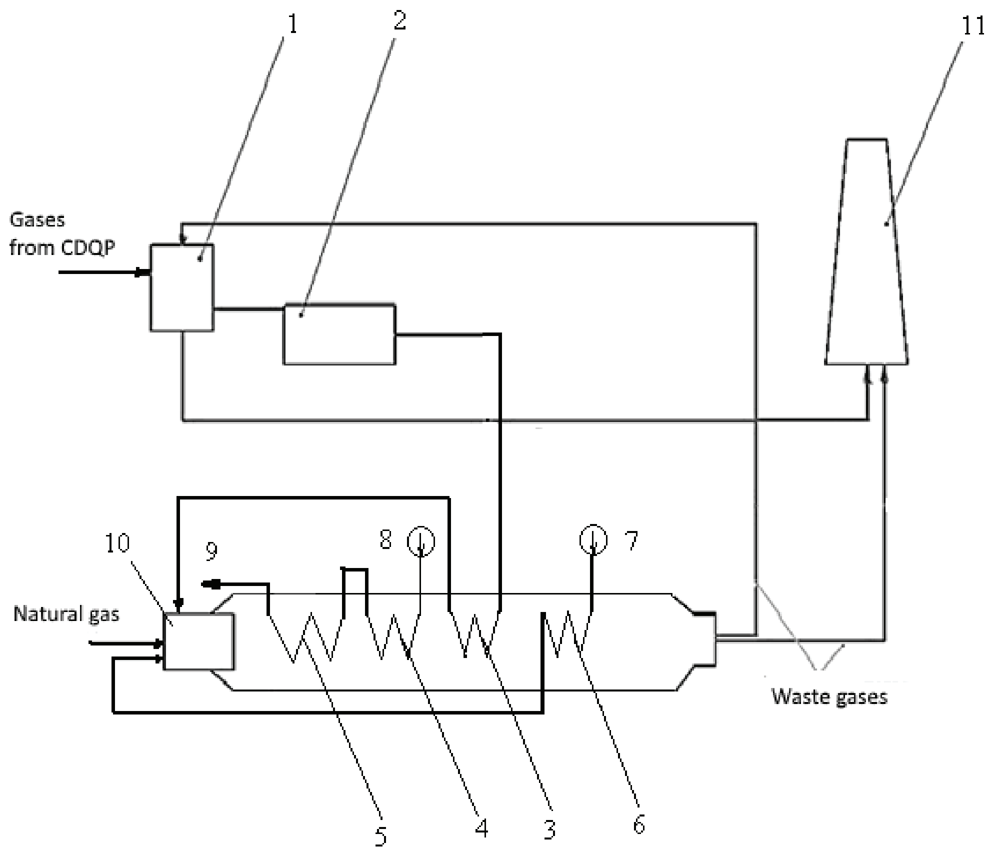

Figure 1: Diagram of CDQP Gas Recovery: 1 – inertia-type dust-trapping unit; 2 – bag filter; 3 – preheater of discharged gases; 4 – water economizer; 5 – heat-exchanging surfaces of the boiler; 6 – air preheater; 7 – air fan; 8 – water pump; 9 – steam to consumer; 10 – combustion chamber for discharged gases; 11 – chimney stack.

The first stage of cleaning of the discharged heat transfer agent is executed with the use of an inertia-type dust-trapping unit, for example, a cyclone 1. Deeper cleaning of CDQP excessive gases is executed at the second stage with the use of bag filters 2.

In this case, the overall degree of dust removal from waste gases reaches minimum 99% without changes in their chemical composition. In order to extend the range of ignition, the free-of-dust excessive heat transfer agent is preheated to 300-400°C in a separate recuperative looping preheater 3. Parameters of the initial gas preheater are given in Table 2.

Carbon monoxide and hydrogen of discharged gases are combusted in a separate combustion chamber 10, where the gas/air mixture is formed from CDQP preheated gases and cold atmospheric air, with the use of a pilot burner running on natural, coke-oven or other gas. To provide safe and long-time operation of the chamber for combustion of combustible components, the process is restricted by the maximum temperature of combustion products. This value shall be not less than 800-1000°C and it is determined by the design of heat exchangers installed after the reactor.

Parameter	Unit	Value
Quantity of preheated gases	m^3/h	21320
Quantity of waste gases	m^3/h	25000
Final preheating temperature of discharged gases	C	400
Initial temperature of discharged gases	°C	130
Temperature of waste gases before the preheater	C	770
Heat losses	%	10
Coefficient of heat transfer from hot gases to the pipe wall	$kW/(m^2 \cdot K)$	84,1
Coefficient of heat transfer from the wall to the preheated gas	$kW/(m^2 \cdot K)$	45,8
Required heat exchange area	m^2	291,3
Quantity of pipes 70 mm in diameter	pcs	324

Table 2: Parameters of Preheater for CDQP Gases.

Sensible heat of gaseous combustion products can be used in the boiler installed after the combustion chamber 10. It includes an economizer 4 with the total surface area up to 185 m^2 where purified water 8 is supplied and heat exchanging surfaces 5 with the total surface area of 300 m^2. At the maximum temperature of 800°C in the combustion chamber, it is possible to provide the heat capacity of the boiler at the level up to 13.9 t/h with the temperature of superheated steam up to до 335°C supplied to the consumer 9. In this case, the temperature of waste gases from the boiler will not exceed 375°C.

For deeper use of waste gas heat, it is possible to install an additional counterflow air heater 6 preheating air blast from the fan in the quantity up to 4000 m^3/h to the temperature of 200°C. In this case, the waste gas temperature will reduce to 135°C.

Thus, the proposed option of recovery of gases discharged from the coke dry-quenching plant enables to receive dust-free waste gases with the maximum temperature of 135°C without combustible components. As a result of using chemical heat of the discharged excessive heat transfer agent and combustion heat of natural or coke-oven gas, it is possible to receive superheated steam in the quantity up to 13.9 t/h with the minimum temperature of 335°C and preheated air in the quantity up to 4000 m^3/h with the temperature of ~400°C.

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