The Study on the Reform of Water Circulation System for 300 Tons Converter Vaporization Cooling System

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Abstract. The productivity of converters is almost increased with oxygen supply intensity, recently, the amount of large and medium conerters has been increased largely in china. to the converter of 300 tons, vaporization cooling system is Key equipment for stable operation of converter production, Once some problem is happened that would directly leads to maintenance, Upset the rhythm of production, Most of the faults are concentrated in the Stationgary Hood, This paper starts from the water circulation flow rate of the vaporization cooling system, we Make a series of transformation. Finally, the water circulation flow rate of Stationgary Hood was improved. To ensure the stability of steelmaking production, also Prolong the service life of the Stationgary Hood.

Background Introduction

Many leakages have been found mostly in the area of Stationary and Moveable Hood during the first two years of operation at the Converter cooling stacks No. 1 to 3 in the steelworks Shougang. The reason for this was thin layer of deposits on the heated side of the heating tubes because of bad water quality. This layer of deposits reduced heat transfer on the heated side of tubes and the wall temperature of tube increased excessively during the blowing time. Tube cracks have been caused by this thermal-cycling and thermo-shocks, which grew from inside to outside. Some tube cracks can appear because of hidden cracks by the original boiler parts also in the future, even the boiler water quality was improved by Nalco since May 2010. So some problem must be resolved quickly. in the Next text I will introduce something that we have change on the study of water circulation system for 300 tons converter vaporization cooling system.

Heat balance of the Gas side. At first was made a thermal balance for the gas side. The data, which cannot be measured directly as for example primary gas temperature, analysis, hot metal charge etc. were taken from the contract. Additionally some operation data are directly measured (red color) and some data are results of the theoretical calculation (blue color).

Table No 1

		Operation date	Theoretical data Normal case
Ave.molten steel output per heat/tapping size	T	315	315
Hot metal input quantity/heat(max)	kg/t	980	980
Combustion air factor	-	0.25	0.13
Oxygen blowing quantity	Nm3/h	56200	72000
Oxygen blowing time	min	13.7	13 – 15
Tap to Tap time	min	34.8	35 – 40
Carbon content in hot metal	%	4.5 – 5.0	4.5 – 5.0
Carbon content in liquid steel	%	0.05	0.05

Primary gas temperature approx.	°C	1 700	1 700
Analysis of primary as CO	%	approx. 90	approx. 90
CO2	%	approx.10	approx.10
Primary gas flow approx.	Nm3/h	112 400	158 000
Waste gas flow approx.	Nm3/h	215 000 (160 000)	192 000
Waste gas temperature at outlet	°C	780	900 + 50

Comparison between the operation and theoretical data shows that there are two significant differences: The oxygen blowing quantity is lower than design and the combustion air factor is higher than design. The result is approx. the same operational heat load as designed, because the higher air factor leads to higher combustion of primary CO-gas, but the amount of primary CO-gas is lower than designed.

Heat Balance of Water Side. The heat balance on the water side is based on the measured feed water flow, steam flow, steam drum level and pressure increase during the blowing time. The mass balance between the produced steam quantity and feed water amount was verified at first. Provided that both flows are measured in t/h and not in Nm3/h the mass balance is in a good accordance and the difference can be explained by inaccuracy or by the blow down rate. The results see in the Table No. 2.

Table No 2

		Blowing time
Feed water quantity	t	22.3
Water level difference	t	4.8
Steam production	t	26
Pressure increase	MPa	2.0 – 2.3 (max. 2.5)
Water level+feed water quantity	t	27.1
Steam production	t	26
Δ quantity	t	+1.1*

Heat Balance between Gas and Water Side. The heat balance between the gas and water side should be in accordance. According the heat balance from the Chapter 2 (Gas side) and 3 (Water side) results a significant difference:

Gas side: approx. 118.5MW

Water side: approx. 73.5MW

Difference: approx. 45.0MW

Small part of this difference can be clarified by the measured waste gas outlet temperature at the outlet of the converter cooling stack (780°C). The real waste gas temperature is mostly just a little bit higher than the measured temperature. The next small part of this difference can be then explained by measuring inaccuracies again mostly on the gas side as for example: fluctuating values, amount of reacting oxygen, amount of carbon in hot metal and primary gas temperature. But still for the major part of this difference we don't have any explanation at the present time. For sure we recommend checking the feed water and steam flow measurement for accuracy, because both values should be higher according the theoretical calculation.

High Pressure Circulation System: Forced Circulation

The following Table No. 3 summarizes the theoretical and operation data.

Table No. 3

		Non-blowing time	Blowing time	
		Operational data	Design data	Operational data
Stationgary Hood	t/h	241	300	250
Moveable Hood	t/h	790	770	830
Deflection Bend	t/h	581	560	570
Inspection Cover 1	t/h	41.3	40	36.4
Inspection Cover 2	t/h	39.7	40	36.8

The deviation between the theoretical (design) and operation data during the blowing time can be mainly explained by the different pressure loss in the water flow measuring orifice and different heat load. There are also other influences as possible different length of tubes, number of elbows and other local pressure losses. From these design and operational data result following water flow velocities.

Table No. 4

		Non-blowing time	Blowing time	
		Operational data	Design data	Operational data
Stationgary Hood	m/s	1.15	1.43	1.20
Moveable Hood	m/s	1.55	1.51	1.64
Deflection Bend	m/s	1.24	1.17	1.19
Inspection Cover 1	m/s	1.38	1.34	1.22
Inspection Cover 2	m/s	1.33	1.34	1.23

All operation data are in the recommended and safety range and ensure a sufficient cooling of heating surface. The only significant difference between the design and operation data is by the Stationary hood.

Advantage of this heating surface is that all individual heating tubes have exactly the same length and number of bends. That means that the water flow distribution into individual heating tubes is uniform and there are no deviations from the average inlet water velocity between individual tubes. Additionally during the blowing time the water flow increases because of positive influence of steam buoyancy in the outlet piping.

Stationary Hood: Change of Design. At first no other changes in the high pressure circulation system (on piping) and HP circulation pumps have been considered. The new theoretical water circulation calculation have been made for the non-blowing time and for the blowing time with the actual heat load based on the heat calculation of water side. As presupposition at least the same water inlet velocity in the heating surface of Stationary hood should be reached as by the existing Hood design during the non-blowing time.

The original and new design are summarized in the following Table No. 5

Table No. 5

	Design of Stationgary Hood	
Stationgary Hood	Original design	New design
Number of inlet pipes	4 x DN100 (additionally 8 x DN80)	4 x DN100 4 x DN80
Number of parallel pipes	112	168
Number of ioutletpipes	4 x DN150	4 x DN150

The results of theoretical water circulation calculation for the NON-BLOWING TIME are summarized in the following Table No. 6

Table No. 6

	Non-blowing time			
	Present operation data		New design data	
	Total flow [t/h]	Water inlet velocity[m/s]	Total flow [t/h]	Water inlet velocity[m/s]
Stationgary Hood	241	1.15	360	1.15
Moveable Hood	790	1.55	751	1.48
Deflection Bend	581	1.24	571	1.20
Inspection Cover 1	41.3	1.38	40.3	1.35
Inspection Cover 2	39.7	1.33	38.6	1.30

The results of theoretical water circulation calculation for the BLOWING TIME are summarized in the following Table No. 7

Table No. 7

	blowing time			
	Present operation data		Present operation data	
	Total flow [t/h]	Total flow [t/h]	Total flow [t/h]	Total flow [t/h]
Stationgary Hood	250	1.20	338	1.08
Moveable Hood	830	1.64	805	1.59
Deflection Bend	570	1.19	560	1.16
Inspection Cover 1	36.4	1.22	35.8	1.20
Inspection Cover 2	36.8	1.23	35.8	1.20

The theoretical results of calculation show that the circulation flow in the Stationary hood would decrease during the blowing time. The reason for this is the lower steam ration in the outlet water-steam mixture and the results is lower buoyancy positive influence. Additionally the higher water flow by the Stationary hood has a negative influence on other heating surfaces because of decreasing of their cooling water flows. To get at least the water inlet velocity in the heating surface of Stationary hood of 1.2 m/s during the blowing time, additionally changes on the HP circulation pumps would be necessary, because the existing circulation pumps are not able to get enough water through this heating surface.

Stationary Hood: Changing of La Mont nozzles. We insists on the more operation safety by the increasing of water flow through the Stationary Hood.so there is a possibility to change the La Mont nozzles for La Mont nozzles with a bigger bore diameter. Several water circulation calculations have been done and as optimum have been chosen the La Mont bore diameter of 7mm. There sults of theoretical calculations are summarized in the following Tables.

Table No.8

	Non-blowing time			
	Present operation data		Present operation data	
	Total flow [t/h]	Total flow [t/h]	Total flow [t/h]	Total flow [t/h]
Stationgary Hood	241	1.15	288	1.38
Moveable Hood	790	1.55	771	1.53
Deflection Bend	581	1.24	578	1.23
Inspection Cover 1	41.3	1.38	41.1	1.38
Inspection Cover 2	39.7	1.33	39.4	1.32
	blowing time			
	Present operation data		Present operation data	
	Total flow [t/h]	Total flow [t/h]	Total flow [t/h]	Total flow[m/s]
Stationgary Hood	250	1.20	290	1.39
Moveable Hood	830	1.64	818	1.62
Deflection Bend	570	1.19	568	1.18
Inspection Cover 1	36.4	1.22	35.9	1.21
Inspection Cover 2	36.8	1.23	36.2	1.22

Table No.9

As shown in the Tables No. 8 and 9 the inlet water velocity in the heating surface of Stationary hood is increased with a minimal impact on the circulation flows of other heating surfaces. Higher water flow would be not economical.

Conclusions

Vaporization cooling system is Key equipment for stable operation of converter production, after a series of transformation and practical application, The stability of vaporization system is greatly improved. The life of the Stationgary Hood is extended from the previous 2 years to the present 4-5 years.This paper involves the transformation has a very good significance.

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