PRAXAIR

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Water & Wastewater Treatment

Case Study

CO_2 for pH Control to Prevent Scaling in the BOF/BF Scrubber Water Circuit in Steel Mills

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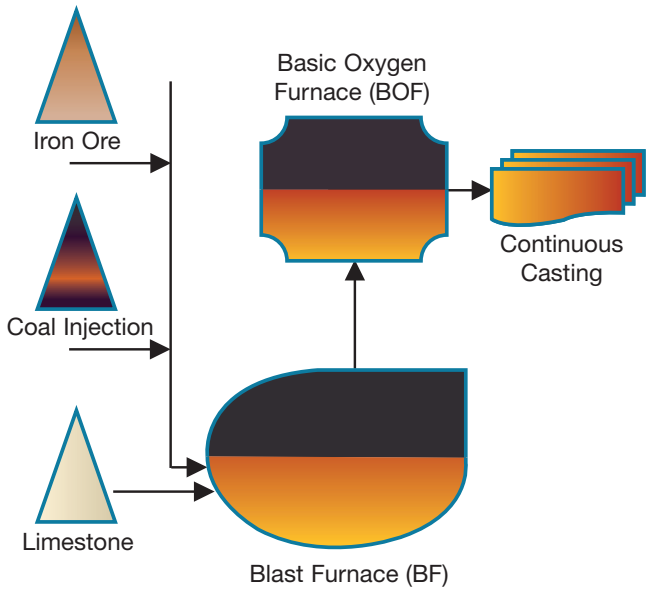
Overview

The Blast Furnace (BF) is a critical process unit in the iron and steel industry, which converts iron ore into molten iron and is the beginning of the process in the manufacturing of steel. The Basic Oxygen Furnace (BOF) is a vessel that is used to reduce carbon in liquid iron from ~4%, down to 0.04%. The combustion of carbon in the BOF is enabled by blowing pure O_2 into the melt.

During the operation of both, great quantities of gas are generated containing very fine particles of dust which must be removed. Scrubbers are used to clean the gas with water, producing wastewater with high pH and elevated temperature. The purpose of waste water treatment is to allow for recycling of the process.



The Challenge

Lime is added to meet the requirements of steel customers in the blast furnace process. A wet scrubber device is used to clean the exhaust gases of combustion of various pollutants and dust particles.

The pH of the scrubber water is very alkaline (pH >12,5). At pH levels > 9,0 there is an increased risk of calcium carbonate precipitation in process lines, which would result in serious scaling problems.

Steel mills are sometimes forced to shut down a number of BOF units due to scaling problems, both from the BOF/BF scrubber water circuit or the cooling water circuit. Reduction of the scaling problem can be achieved by feeding the system with a softening agent like CO_2.

BOF/BF Recirculation Wastewater Characteristics After First Clarification

Flow rate	m^3/h	600-1.500
Temperature	°C	> 45
pH		> 12
Alkalinity (CaCO3)	mg/l	300-1.800

Potential Issues in the BOF/BF Recirculating and/or Discharge Wastewater

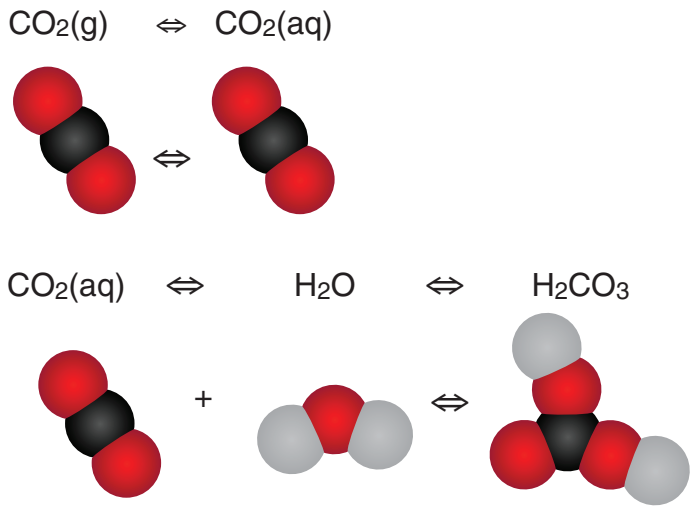
- Scaling of pipe lines
- More frequent shutdown of BOF
- Malfunctioning of cooling tower due to scaling problems
- Exceed ph, SS, metal, temperature values permissible
- Maintenance costs of installations (pumps, scrubber, pipes)
- Acid handling and storing

The Praxair Proposal

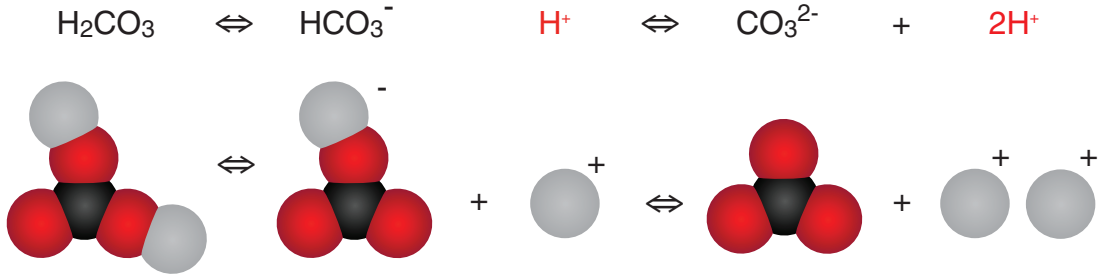
CO_2 requirements on each case are related with: Flow rate of recirculating water, pH and alkalinity:

BOF/BF Recirculation Wastewater Characteristics After First Clarification			CO_2 Requirements Tons CO_2/Day
Flow rate	m^3/h	15.000	15,76
Temperature	°C	45	
pH		12	
Alkalinity (CaCO3)	mg/l	1.800	
Flow rate	m^3/d	15.000	1,24
Temperature	°C	45	
ph		10	
Alkalinity (CaCO3)	mg/l	300	

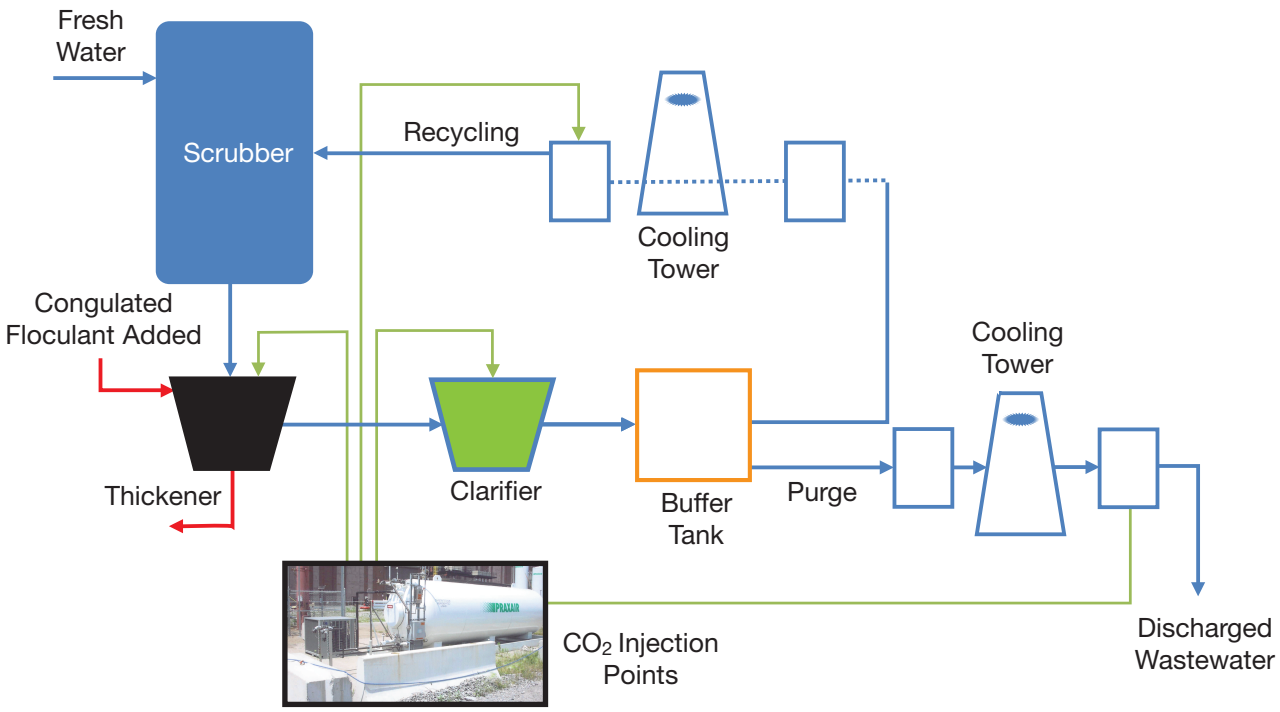
Carbon dioxide gas, written as CO_2 (g), will dissolve in water, written as CO_2 (aq). The dissolved CO_2 (aq) will react with water molecules. It will combine with water to H_2CO_3 (carbonic acid). This step is called hydration.



In a next step, carbonic acid can loose one of the two protons (dissociation):



The dissolution of CO_2 in water leads to the production of H+ and thus, to a decrease in pH. With alkalinity and pH, the total amount of carbon dioxide dissolved in the water can be calculated. Both parameters decide if given water can take up more CO_2 or if it is already saturated with CO_2. The alkalinity also influences the amount of CO_2 to adjust the water to certain pH value. The higher the alkalinity of a given water the more CO_2 to reach a certain pH.



The Results

The BF/BOF scrubber water circuit in steel mills is as follows:

- Wastewater is produced in the gas cleaning system of the BF or BOF scrubber with high pH and temperature
- Thickener or pre-settling tank, were approx.. 30% of the solids are removed
- Subsequently, wastewater flows through clarifiers, where most part of the solids are removed
- The resultant overflow is collected in a buffer tank from where part is recirculated into the BF/BOF scrubber system and the rest is finally discharged to the sewer
- Cooling towers are used in the middle and at the end of the process to reduce the temperature Praxair's CO_2-based pH control system can be installed at several injection points in the process:

  1) in the thickener,

  2) at the inlet or/and outlet of the clarifier

  3) throughout the cooling water loop

  4) before the final discharge of water. The CO_2 gas injection system can be controlled manually or with automatic feedback of based on the pH of the wastewater or its conductivity. Various target points throughout the process were chosen since pH values differ throughout the process. For example, a higher pH is desired (10 – 11) in the thickener for the precipitation of calcium and magnesium carbonates to reduce scaling potential. Lower pH is required (< 9) in the discharged wastewater to meet the effluent target.

  CO_2 can be injected through diffuser grills, sintered metal, pump/venturi and loop contact, depending on the application and the existing installation

CO_2 Storage Unit

Process Control

Dissolver Unit

Praxair's CO_2 based pH control system allowed the steel mill to reduce the following:

- Clogging and scaling of transfer lines
- Acid handling and storage
- Downtime for cleaning and dredging
- Maintenance costs

The system also helps maintain compliance with wastewater regulations for suspended solids, metals, sulfites and pH.

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