GASEOUS EMISSION CONTROL OF A BASIC CHROME SULFATE PLANT BY AN INNOVATIVE METHOD TO MEET ENVIRONMENTAL STANDARD

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Abstract

*In the production of **Basic Chrome Sulfate** (BCS) from sodium dichromate solution employing sulfur dioxide reduction method, effluent gases coming out from the reactor (Packed bed reduction tower) contain mainly unreacted sulfur dioxide/sulfurous acid mist, and air saturated with water vapor. These SO_2/H_2SO_3 mist may pollute the surrounding environment if not properly controlled. The conventional method of scrubbing the effluent gases with an alkaline solution produces another liquid effluent.*

This paper describes an innovative method adopted to control the gaseous emission within the environmental standard of Bangladesh. This method consists of recovery of SO_2/H_2SO_3 mist by cooling the effluent gases in a water-cooled shell and tube heat exchanger. The recovered sulfurous acid solution is separated and it is recycled to the feed tank of the reduction tower. The non-condensed gases before going to the stack are heated in a shell-and-tube heat exchanger with steam. This innovative method was found to be cost effective and environment friendly for a BCS plant of 10 t/day. The BCS reactor system has been further modified by incorporating this concept recently. Concentration of SO_2 gas in the exhaust today is 0.50 – 0.60 ppm.

Introduction

Wata Chemicals Ltd., a private company has small capacity (10 tpd) plant producing tannery grade Basic Chrome Sulfate (BCS) from sodium dichromate solution using sulfur dioxide reduction method. The plant is located at Bhulta about 25 km north-west of Dhaka city. On the same site the company operates a 40 tpd sulfuric acid plant and other facilities producing Zinc Sulfate, Alum, Magnesium Sulfate etc.

The BCS plant receives SO_2 gas from the sulfuric acid gas plant from the common SO_2 for the production of sulfuric acid. The production of BCS involves a reaction between aqueous sodium dichromate and SO_2 gas in packed bed reduction tower. The effluent gases leaving the reactor what is designated as reduction tower contain mainly N_2, O_2 and water vapor plus some unreacted SO_2 gas/ H_2SO_3 and the effluent gases leave at temperature 70 °C. SO_2 content in the effluent gases exceeds the limit set for a sulfuric plant. When this was reported to DOE in 1998, DOE asked the company to redress the emission problem or else close down the operation. Thereafter the company approached the Chemical Engineering Department at BUET to look into this problem.

This paper deals with how this emission problem was contained using innovative ideas.

The Production Process and the Problem[1]

The work involved the visit of the plant and study of the process in operation. The conversion of sodium dichromate to BCS by SO_2 is done batch wise. At first sodium dichromate solution is taken into BCS circulation tank and then it is circulated through packed bed reduction tower counter-current flow to SO_2 by BCS circulation pump. The SO_2 gas coming from the SO_2 combustion chamber is a mixture of N_2, O_2 and SO_2; and concentration of SO_2 is about 8 vol. %. It takes about 8 hrs for completion of the reduction process. The unabsorbed and unreacted N_2, O_2 and water vapor plus residual SO_2/H_2SO_3 at about 70 °C leave the reduction tower through the nozzle at the top and finally enter the atmosphere through the stack via a scrubber. The system as existed is shown in Figure 1.

Removal of SO_2 in the packed bed scrubber by Na_2CO_3 solution was not satisfactory leading to SO_2/H_2SO_3 emission problem. The stack emitted a white plume. The authors examined several options for removing SO_2/H_2SO_3 mist from the emission stream. The formation of H_2SO_3 was due to the reaction between SO_2 gas and mist.

Options considered were:

- ❖ Classical chemical absorption with an alkaline media
- ❖ Scrubbing with water

These involved additional equipment, chemicals etc. and recovery of disposal of the newly created effluents. The authors decided to do away with these options and planned something very simple but innovative [2].

It was proposed to cool the effluent stream from 80 °C to 40 °C in a heat exchanger and then heat the cold stream to some 50 °C. Since the stream is saturated with water vapor carrying SO_2, Figures 2 and 3 respectively indicate that the proposed idea would substantially reduce SO_2/H_2SO_3 from the effluent stream in the cooler. For example, if saturated air at 80 °C is cooled to 40 °C, the vapor load is reduced from 0.95 lb H_2O/lb air to 0.018 lb H_2O/lb air, a reduction of 98.1% while that for SO_2 (based on partial pressure of SO_2 over 1 gm SO_2 in 100 gm water) is 66.5%. Once water has started to condense, SO_2/H_2SO_3 also gets dissolved in water condensates and removes simultaneously.

Implementing the Scheme

The plant personnel as a part of implementing the scheme put two double pipe heat exchangers as proposed with a stream from the stack as inlet stream to the inner pipe of the cooler. The arrangement is schematically shown in Figure 4.

When the scheme was put into operation by installing two shell-and-tube exchangers as shown in Figure 5, it worked well. No significant SO_2/H_2SO_3 emission was observed. The unsightingly white plume disappeared from the stack. DOE found the plant acceptable

This system was operated for three years. Based on operational experience, the plant personnel reorganized BCS reaction system by incorporating the above concept as shown in Figure 6. The system worked very satisfactorily. The gases leaving the BCS plant now contains SO_2 in the range 0.5 to 0.6 ppm measured with GASTEC tube method[3] while the DOE's guidelines state the SO_2 concentration in industrial area shall be 120 ppm while that for rural area 80 ppm.

Achievement of the Implementation of Innovative Idea

Besides meeting the DOE's requirement for the emission of SO_2 the other benefits derived from this simple innovative modification include:

- ❖ Recycling of the condensed acidic stream to the reactor has led to decrease in the reaction time from 8-9 hrs to 6-7 hrs.
- ❖ Less consumption of make-up water
- ❖ Less consumption of SO_2
- ❖ The almost invisible white plume and the tall stack have disappeared.
- ❖ Disposal of liquid effluent has been eliminated.

This has done away with the hassle of the conventional ETPs.

References

1. Plant Documents of Wata Chemicals Ltd.
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3. Ahmed, M. and M. Shahinoor Islam, "The Measurements and Control of Sulfur Dioxide Emission from Sulfuric Acid and Basic Chrome Sulfate Plant in WATA Chemicals", B.Sc. Engg. Thesis, Chemical Engineering Department, BUET (2002).
4. Perry's Chemical Engineers' Handbook, 7th edn., McGraw-Hill (1997).

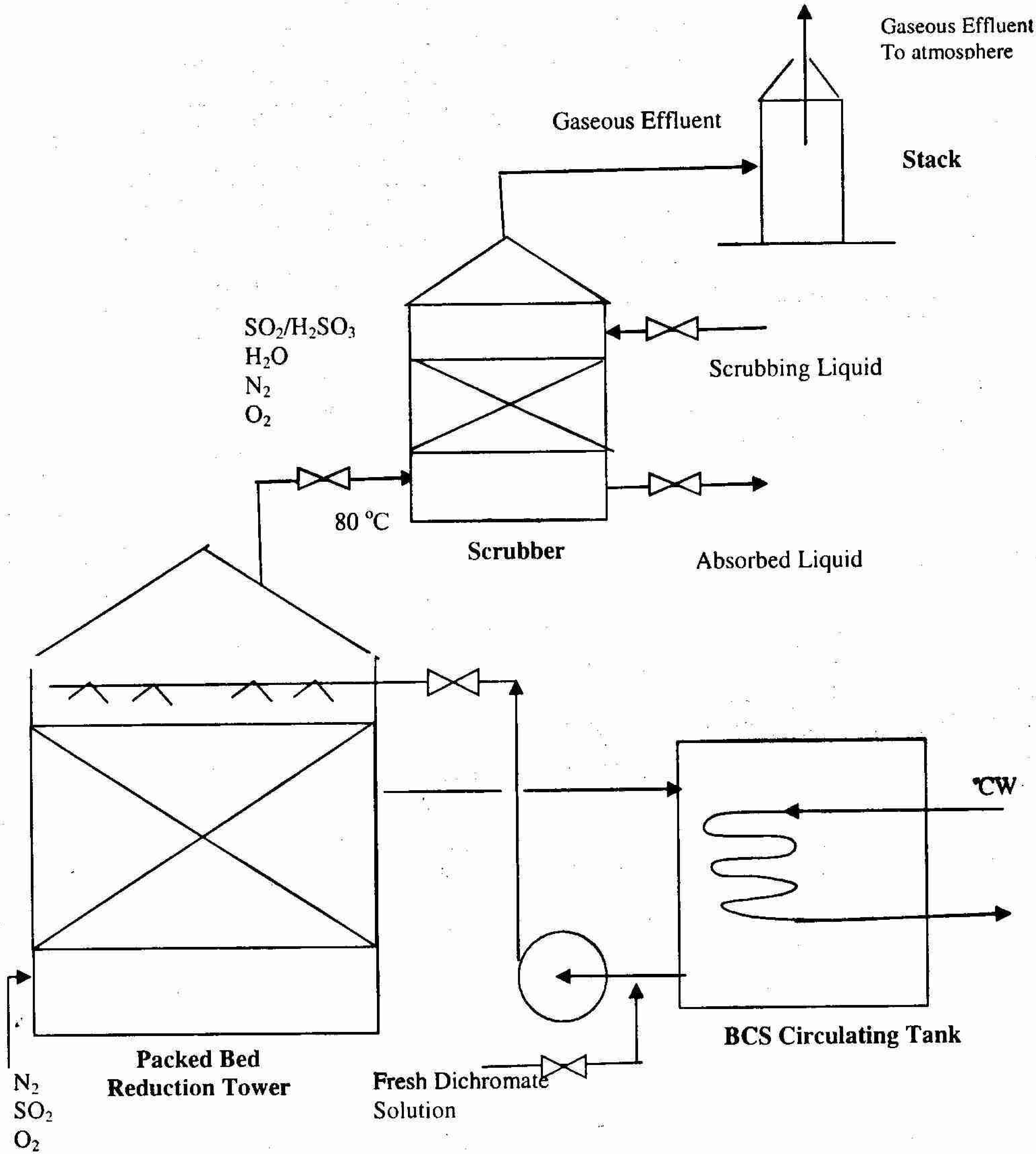

Figure 1: Schematic Diagram of the Reaction System BCS Production

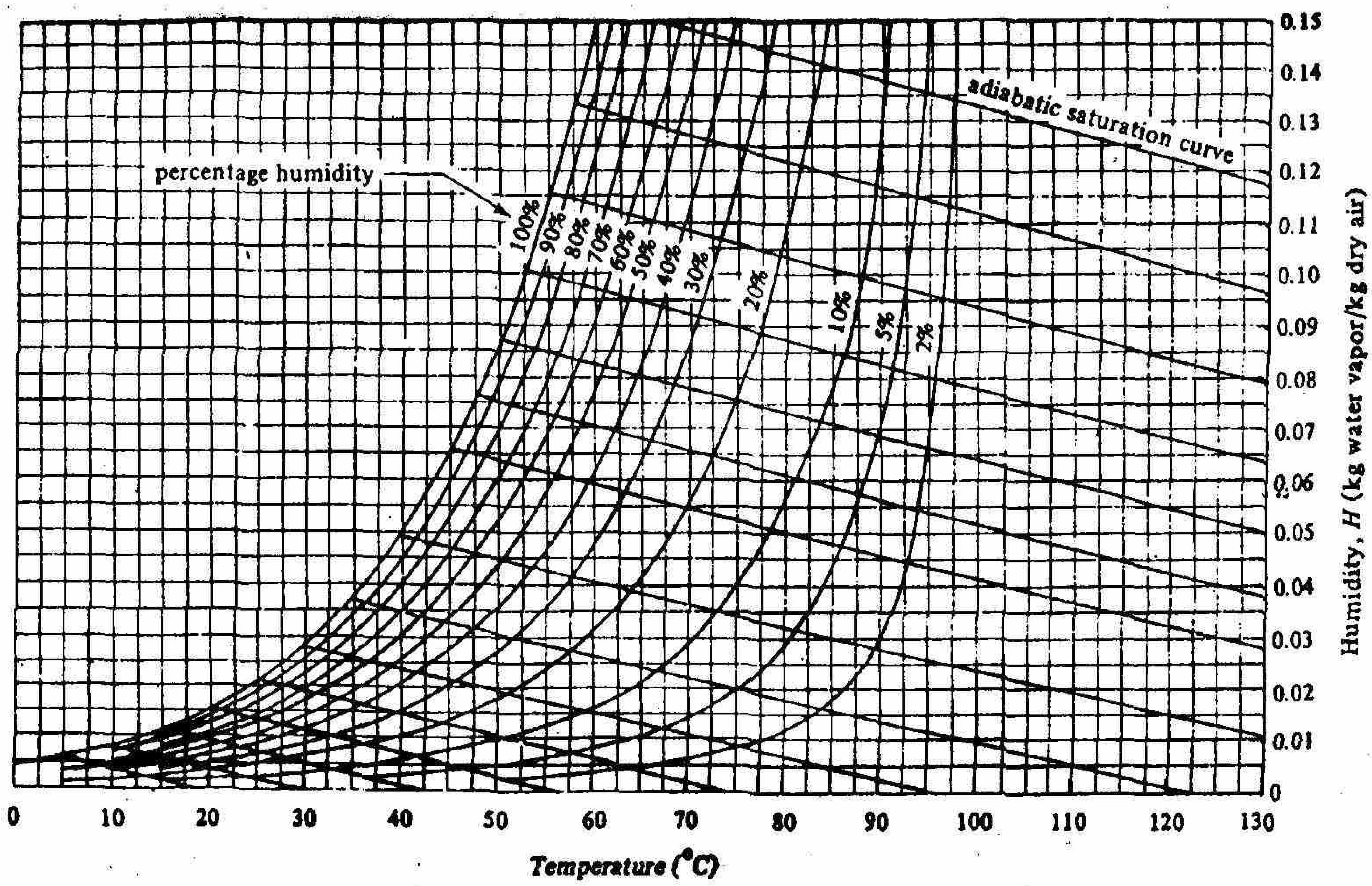

Figure 2: Humidity Chart for Mixtures of Air Water Vapor at a Total Pressure of 101.325 kPa (760 mm Hg)

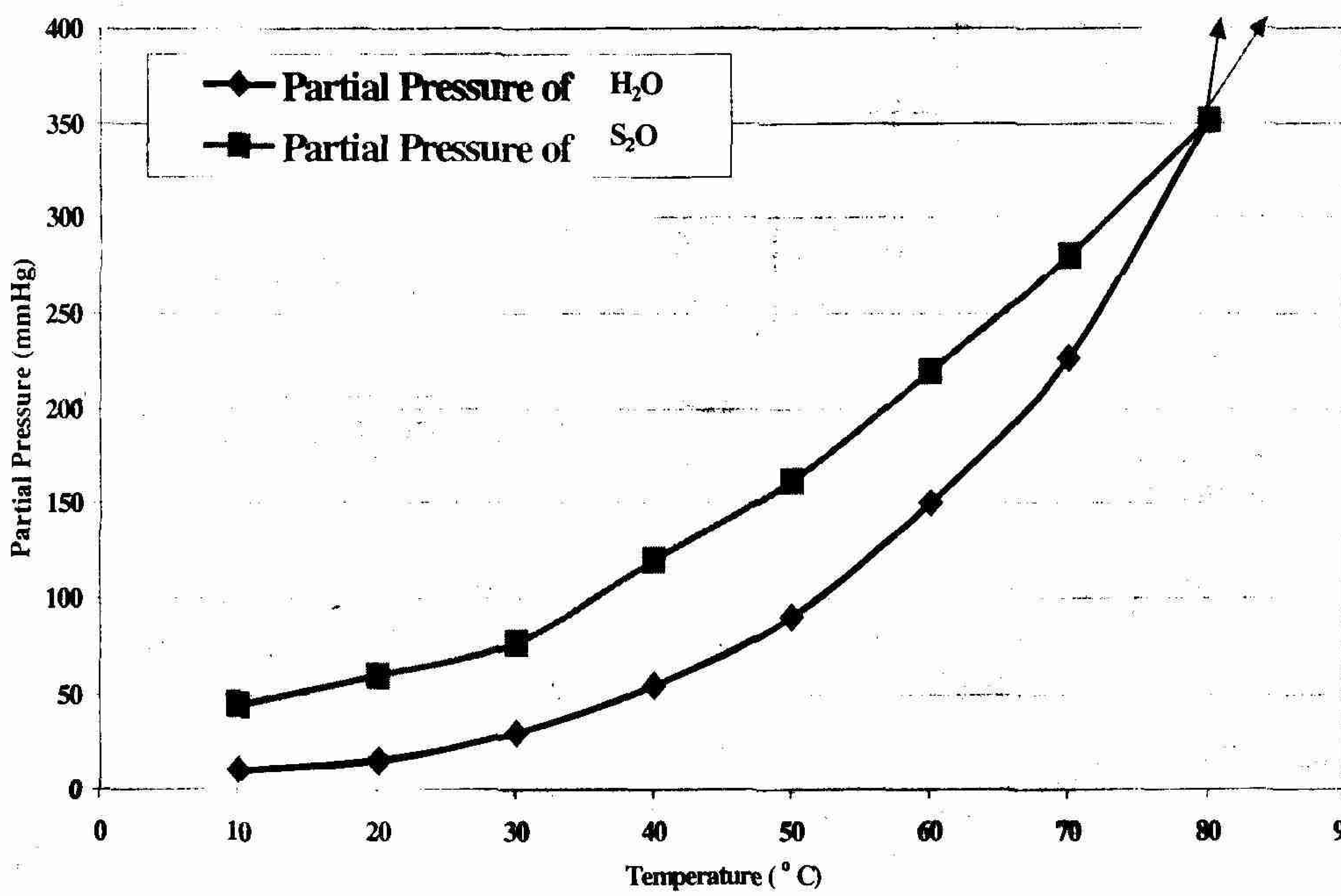

Figure 3: Partial Pressure of H_2O and SO_2 over aquous solution of sulfur dioxide (1.0 gm SO_2/100 gm Water)[4]

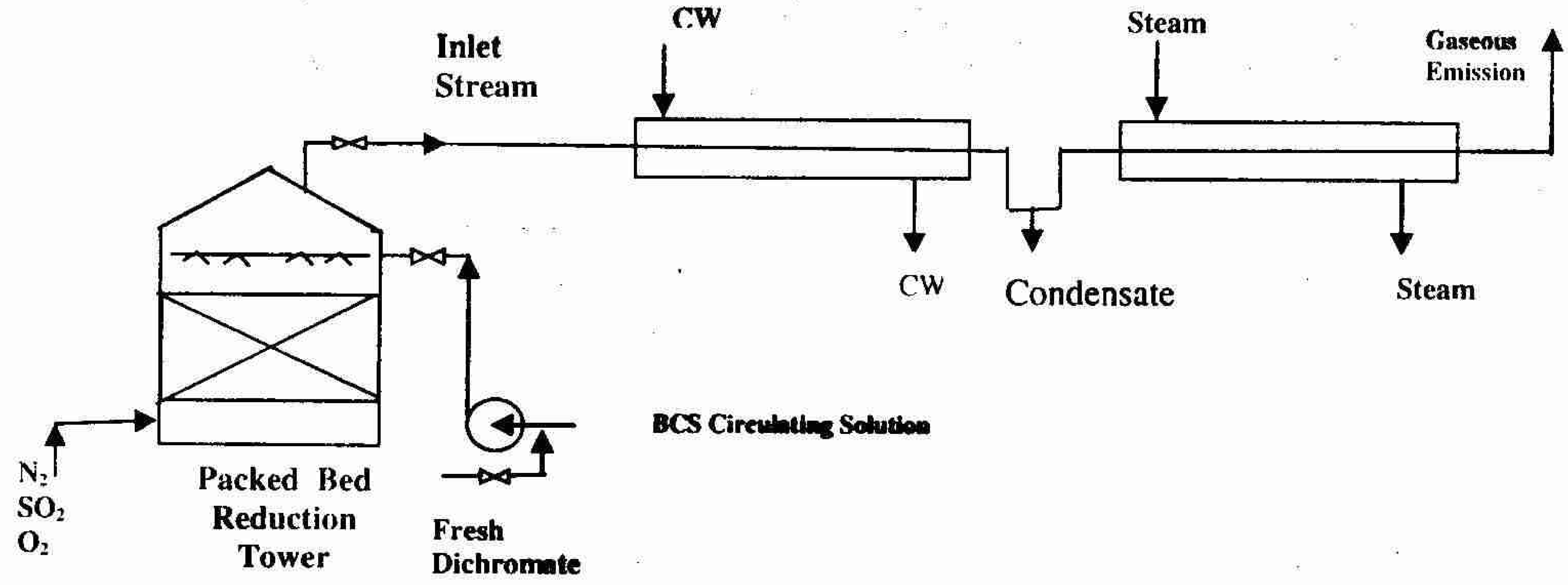

Figure 4: Arrangement of Double Pipe Exchanger

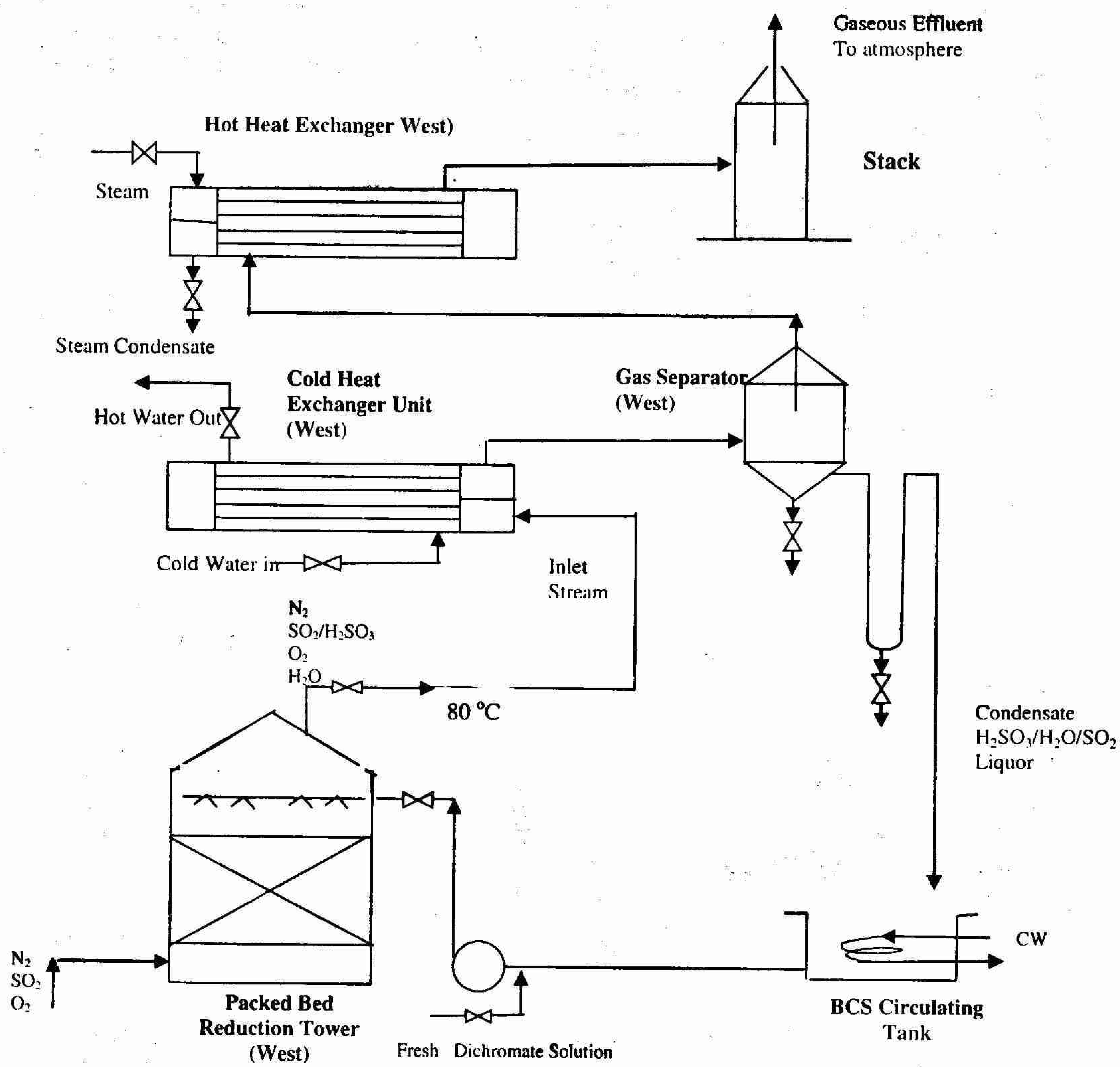

Figure 5: Schematic Diagram of Modified BCS Process Plant

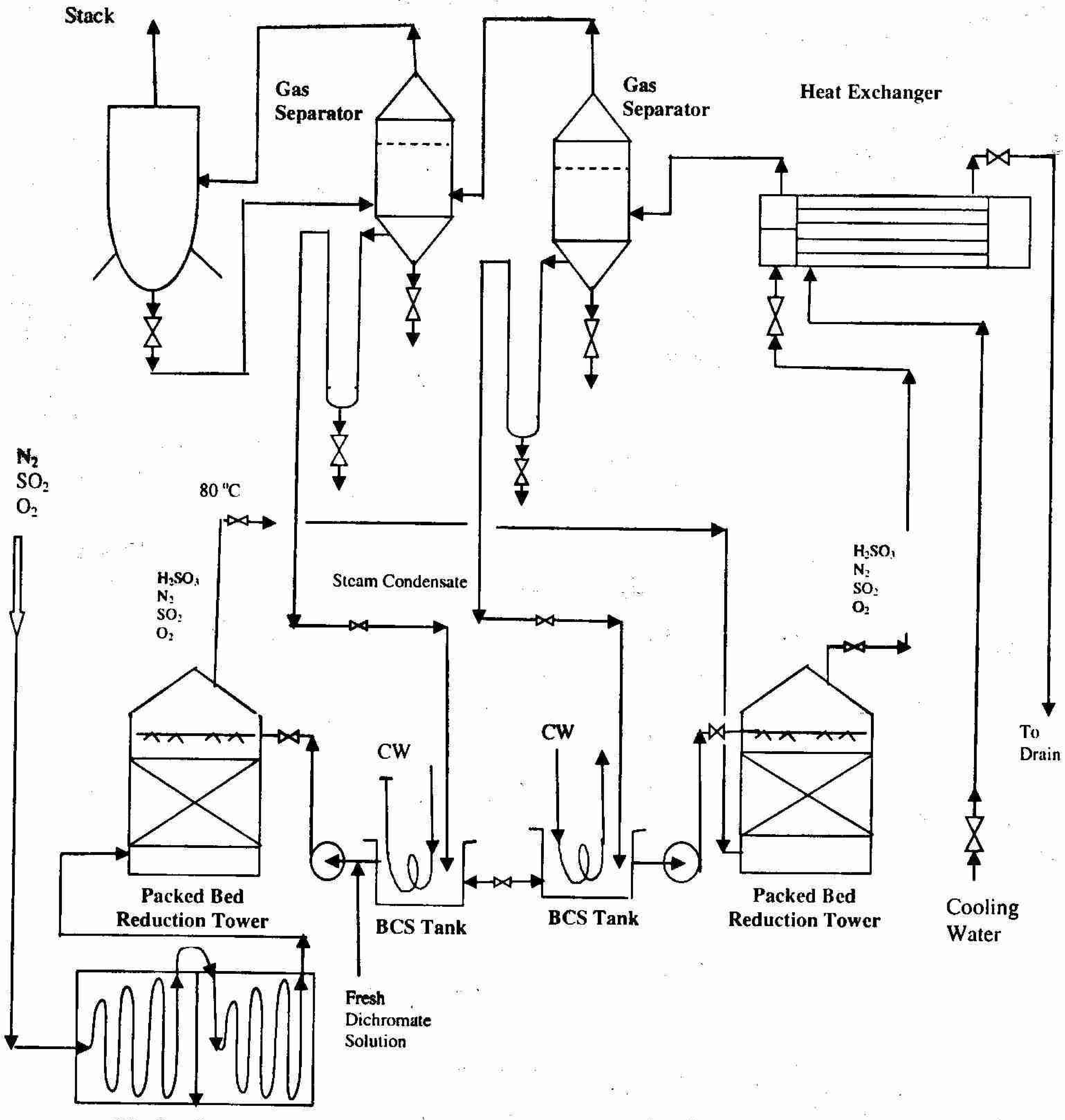

Figure 6: Control Scheme for Sulfur Dioxide Emission for BCS Plant[1]