

Sulphur Dioxide Pollution Control by Wet Scrubbing Methods

K C Biswal, *Non-member*

Dr G K Roy, *Associate Member*

The paper brings out the differences between the dry and the wet scrubbing methods of control of atmospheric pollution due to sulphur dioxide emission. Important wet scrubbing methods alongwith their relative merits and demerits have been enumerated. The mechanism of sulphur dioxide absorption in limestone slurry has been elaborately discussed with the help of kinetic models.

NOTATIONS

a = gas-liquid interfacial area, cm²/cm³ dispersion
 A = species to be absorbed
 A^* = interfacial concentration of A, gmole/cm³
 A_L = concentration of A in the bulk liquid phase, mole/cm³.
 A_p = surface area of solid particles, cm²/cm³ slurry
 B = concentration of dissolved solid component, gmole/cm³
 B_L = concentration of dissolved solid component in bulk liquid phase, gmole/cm³
 B_s = saturation solubility of solids, gmole/cm³
 C = concentration of liquid phase, mole/l
 d_p = average diameter of solid particles, cm
 D = liquid phase diffusivity, cm²/sec
 D_A, D_B = diffusivities of A and B, respectively in liquid phase, cm²/sec
 E_i = enhancement factor for dissolution with instantaneous reaction
 H = Henry's law solubility co-efficient, gmole/cm³-atm
 K_L = liquid film mass transfer co-efficient in the absence of chemical reaction, cm/sec
 K_s = mass transfer co-efficient for solid dissolution, cm/sec
 m =
 $M_b = VKC_{ai}D_BK_s^2$
 $N = K_sA_pZ_L^2/D_B$
 P = partial pressure of A, atm
 R = specific rate of chemical reaction
 R_A = rate of gas absorption, mole/cm² sec
 R_B = rate of diffusion of B to or from bulk liquid phase, mole/cm² sec

R_d = rate of dissolution of solid in bulk liquid phase, mole/cm² sec
 R = rate of chemical reaction, gmole/cm³ sec
 W = amount of solids, g solids/cm³ slurry
 X = distance into liquid film, cm
 y = radial distance from solid surface, cm
 Y = ratio of concentration in the liquid phase to that at the gas liquid interface or at the solid liquid interface
 Z = stoichiometric factor, cm
 Z_L = thickness of liquid film (for gas absorption), cm
 ρ = density of solids, g/cm³
 δ = film thickness, cm
 δ' = thickness of the liquid film around solid particle in the bulk liquid phase, cm
 λ = reaction plane in liquid film next to gas liquid interface, cm
 λ' = reaction plane in liquid film around solid particle in the bulk liquid phase, cm
 φ = enhancement factor

INTRODUCTION

The growing awareness of atmospheric pollution by sulphur dioxides (Fig 1) has resulted in massive efforts being made all over the globe to develop suitable processes to control them. Available sulphur dioxide pollution control processes of importance can broadly be categorized into (i) dry processes, and (ii) wet processes. The basic difference between the two methods is in the mode of contact of the pollutants with the controlling reagents. In case of the former, the control is achieved by dry absorption with alkali and alkaline earth-metal oxides whereas absorption takes place in slurries of the similar compounds in case of the latter. The paper, using various kinetic models, compares the important

K C Biswal and Dr G K Roy are with Regional Engineering College, Rourkela.

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wet scrubbing methods and the mechanism of absorption of sulphur dioxide therein.

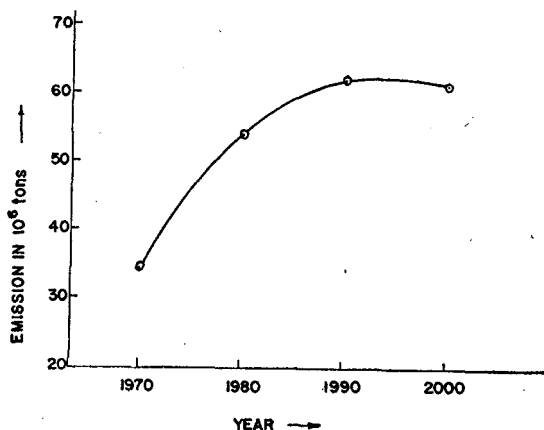


Fig 1 Annual emission of SO₂ to US atmosphere (extrapolated)

WET SCRUBBING METHODS

Scrubbing methods can broadly be divided into:

- (a) Limestone based scrubbing processes, which can be further categorised into
 - (i) Scrubber addition of limestone and
 - (ii) Boiler injection and
- (b) Scrubbing by lime and other alkalis.

SCRUBBER ADDITION OF LIMESTONE

The process (Fig 2) is simple and favoured by the power industry at present. Its main drawback is that limestone is not as reactive as lime which makes necessary use of more limestone, installation of a larger scrubber and recirculation of more slurry. It also becomes essential to grind the lime to finer size.

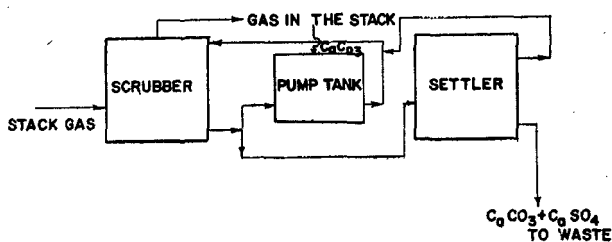


Fig 2 Scrubber addition of limestone

BOILER INJECTION

Fig 3 gives the schematic diagram for the process. The cost of calcination can be reduced in power plants by injecting the lime-stone into the boiler furnace. The gas then carries the lime to the scrubber. Problems include

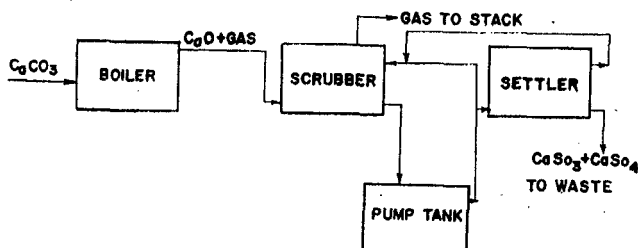


Fig 3 Boiler injection

possibility of boiler fouling, danger of over burning and in activating the lime and increased scaling in the scrubber when the lime enters with the gas. This process is unsuitable for refineries or sulphuric acid plants and smelters but widely favoured in power plants.

SCRUBBING BY LIME AND OTHER ALKALIES

This process can further be subdivided into :

- (i) Scrubber addition of lime,
- (ii) Scrubbing with magnesium oxide,
- (iii) Dual alkali process and
- (iv) Simultaneous absorption of SO₂ and NO₂ in aqueous solutions of NaOH and Na₂SO₃.

Scrubber Addition of Lime

Scrubbing efficiency is improved in case of addition of lime to the scrubber. First, the limestone is calcined to lime which is then introduced into the scrubber (Fig 4). The cost is much more than that for lime stone slurry scrubbing because of the installation of lime kiln. Use of lime also increases the problem of scaling in the scrubber.

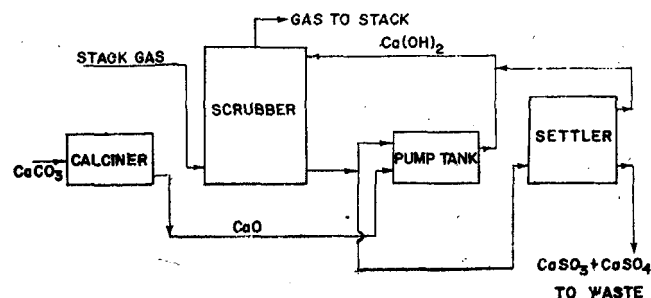
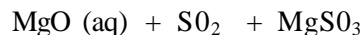


Fig 4 Scrubber addition of lime

Scrubbing with Magnesium Oxide

The process utilizes the SO₂ absorption characteristics of an aqueous slurry containing MgO and MgSO₄. The operation involves five steps: (i) absorption, (ii) centrifuging, (iii) drying, (iv) transportation, and (v) calcination.

The reaction between MgO and SO₂ is



In this case, SO₂ removal efficiency of about 90% is consistently obtained when oil of 2.1% sulphur content is burnt.

In this process the flue gas containing SO₂ enters the ventury absorber and contacts the aqueous slurry. The ventury absorber corresponds to a co-current packed vessel and the process of SO₂ removal is explained on conventional mass transfer principles. The advantage of ventury absorber lies in the potential which enables operation over wide ranges of output without the reduction of SO₂ removal efficiency, since surface area available for mass transfer is relatively invariant over a wide range of gas flow.

The generation step is the reverse, a thermal decomposition of MgSO₃ which because of its low solubility can be separated easily from the absorbing slurry.

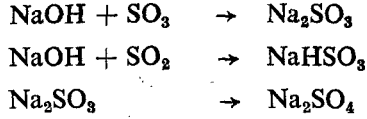


Dual Alkaline Process

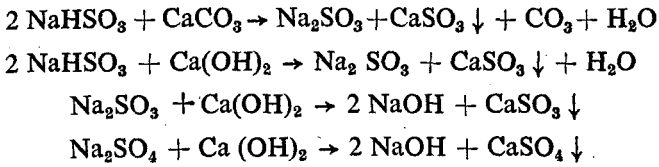
In this process, SO_2 is absorbed in a solution of sodium salts to produce a solution of Na_2SO_3 .

During absorption, 5-10% of the sulphite is oxidized to sulphate at excess oxygen concentrations.

Absorption reactions are:



Regeneration reactions are:



Sufficient sulphate must be reacted in order to regenerate sulphate at the rate at which it is being formed in the scrubbing system. After regeneration solids are separated from the regenerated liquor and the clear liquor containing very low atms of suspended and dissolved calcium is returned to the scrubber.

The system overcomes the inherent difficulties of direct calcium slurry scrubbing. All precipitations occur outside the scrubbing system under controlled reactor conditions. The dual alkali process therefore combines the high reliability aspects and high SO_2 removal capabilities of solution based scrubbing with the advantages of a solid waste disposal. In this process, SO_2 removal in excess of 90% is maintained.

Simultaneous Absorption of SO_2 and NO_2 in Aqueous Solution of NaOH and Na_2SO_3

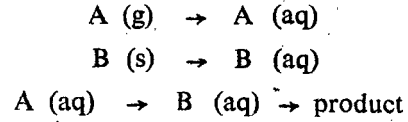
When SO_2 and NO_2 are simultaneously absorbed from an SO_2 - NO_2 - N_2 mixture, the rate of NO_2 absorption into aqueous NaOH solution was enhanced more than in absence of SO_2 , while for aqueous Na_2SO_3 solution the rate was reduced. Such absorption behaviour arises essentially from the change of SO_3 concentration at the gas-liquid interface. The rate of NO_2 absorption with SO_2 is predicted according to the mechanism with the competitive reactions of NO_2 with sulphite and water.

MECHANISM OF GAS ABSORPTION IN SLURRY

MODEL BY RAMCHANDRAN AND SARMA

Primary studies relating to the absorption of gas into slurry based on the film concept have been made by Ramchandran and Sarma¹. They derived analytical equation to predict the effect of simultaneous solid dissolution in a liquid film on the specific rate of absorption. Under certain circumstances the specific rate of absorption in the presence of fine suspended solids in a suitable medium can be considered higher than that in the absence of solids. When the solids are sparingly soluble in the

medium, the reaction that occurs between the dissolved gas and dissolved species can be represented as



The two general cases have been considered by them taking dissolution of solid in the liquid film first as unimportant, and then as important.

Solid Dissolution in the Liquid Film Unimportant

This is the case when either the concentration of solids is relatively small or the particle size of the solid is relatively large compared to the liquid film. The condition under which this assumption is valid can be shown as

$$\frac{K_s A_p D_A^2}{4 K_L^2 D_B} \ll 1 \quad (1)$$

The above condition is valid if the average diameter of the particles is greater than five times the liquid film thickness

$$\delta = \frac{D_A}{K_L}$$

The reaction scheme for this case involves:

- (i) Diffusion of gaseous species A through the gas film,
- (ii) Dissolution of the solid species B, and
- (iii) Diffusion and simultaneous chemical reaction of dissolved gas in the liquid film near the gas-liquid interface. The rates are same under steady state conditions. The rate of 1 and 2 are given by

$$R' = K_g a [p_g - p_i] \quad (2)$$

for diffusion through the gas film

$$R' = K_s A_p (B_s - B_i) \quad (3)$$

for solid dissolution.

On rearranging the above equations,

$$A^* = H p_g - \frac{R' H}{K_g a} \quad (4)$$

$$B_L = B_s - \frac{R'}{K_s A_p} \quad (5)$$

After knowing A^* and B_L , the usual expression for the gas absorption with chemical reaction can be used to predict the rate of absorption of the gas.

The following equation obtained as the basis of film theory holds when absorption is accompanied by an instantaneous reaction.

$$R' = \frac{H p_g + \frac{D_B}{D_A} B_s}{\frac{H}{K_g a} + \frac{1}{K_L a} + \frac{D_B}{D_A} \frac{1}{K_s A_p}} \quad (6)$$

When the Solid Dissolution in the Liquid Film is Important

For normal values of K_s , and for the cases when the average diameter of the particles is considerably less than the thickness of the liquid film ($d_p \ll \delta$), the solid dissolution in the film becomes important. For this case, the solid dissolution and the chemical reaction become parallel steps. The effect of solid dissolution in the film is to increase the local concentration of the relative species in the film, thereby enhancing the rate of absorption. The reaction between the dissolved gas and dissolved species is assumed to be instantaneous and there is no gas-side resistance to mass transfer. The dissolution of the solid in the liquid film shifts the reaction plane closer to the interface and thereby increases the rate of absorption.

For $0 < x < \lambda$ the material balance for the diffusing gas gives

$$D_A \frac{d^2 a}{dx^2} - K_s A_p B_s = 0 \quad (7)$$

The term $K_s A_p B_s$ takes into account the amount of solid dissolution in the region 0 to λ .

The reaction is assumed to be instantaneous so that the concentration of the liquid phase in the region 0 to λ is assumed to be zero.

$$D_B \frac{d^2 B}{dx^2} + K_s A_p (B_s - B) = 0 \quad (8)$$

The term $K_s A_p (B_s - B)$ takes into account the amount of solid dissolution in the region λ to δ .

At $x = 0$,

$$A = A^*; -D_A \left(\frac{dA}{dx} \right)_{x=0} = R \quad (9)$$

At $x = \lambda$,

$$A = B = 0; -D_A \left(\frac{dA}{dx} \right)_{x=\lambda} = D_B \left(\frac{dB}{dx} \right)_{x=\lambda}$$

At $x = \delta$

$$B = B_s \quad (10)$$

Solution of equation (7) gives the concentration profile of dissolved gas A

$$D_A A = D_A A^* \left(1 - \frac{x}{\lambda} \right) - \frac{K_s A_p B_s x}{2} (\lambda - x) \quad (11)$$

Similarly, solution of equation (8) gives the concentration profile of B

$$B = B_s \left[1 - \sinh \frac{\sqrt{K_s A_p} (\delta - x)}{D_B} \left\{ \sinh \frac{\sqrt{K_s A_p} (\delta - \lambda)}{D_B} \right\}^{-1} \right] \quad (12)$$

Boundary conditions (9) and (10) enable the rate of absorption to be predicted

$$R = \frac{(D_A A^*)}{\lambda} + K_s A_p B_s \frac{\lambda}{2}$$

$$R = B_s \sqrt{(D_B K_s A_p)} \coth \sqrt{\left(\frac{K_s A_p}{D_B} \right) (\delta - \lambda)} + K_s A_p B_s \lambda \quad (13)$$

As a special case the absorption of gas in a solution containing extremely fine solids is analyzed as follows.

Under certain conditions solid dissolution becomes extremely rapid and reaction plane shifts to the gas-solid interface ($\lambda \rightarrow 0$) the rate of absorption being

$$R \approx B_s \sqrt{(D_B K_s A_p)} \quad (14)$$

Equation (14) suggests that the rate of absorption is proportional to the square root of the amount of solids for a fixed particle size since the surface area of dissolution A_p is directly proportional to the amount of solids.

Equations (13) and (14) hold good only if the reaction is instantaneous.

UCHIDA'S MODIFIED MODEL — A CASE STUDY

Uchida, *et al.*^{2,3} modified Ramchandran and Sarma model by taking the concrete case of SO_2 in limestone. This is based on the fact that the rate of limestone dissolution into an acid solution is accelerated by the concentration of hydronium ion or the pH value of the solution.

If the rate of SO_2 absorption is much faster than the rate of limestone dissolution, the reaction plane shifts to the liquid film near the solid-liquid interface and the reaction products $CaCO_3$ and $CaSO_4$ are deposited on the surface of the limestone preventing further dissolution. Therefore, recovery of pH value of the slurry cannot be expected and limestone utilization efficiency is lowered. The rate of dissolution of solid is enhanced by the reaction between the absorbed gas and the dissolved solid species in the liquid film around the solid species. The general reaction-mechanism can be of two main categories depending upon whether the solid dissolution in liquid film next to the gas-liquid interface is unimportant or important.

Solid Dissolution in Liquid Film Next to the Gas-Liquid Interface Unimportant

This category can further be divided into three cases:

Case I—Reaction Plane in the Liquid Film Near the Gas-Liquid Interface (Case of Slow Gas Absorption):

When the rate of gas absorption is relatively slow compared to the rate of solid dissolution, the concentration of the dissolved solid in the bulk liquid phase is maintained at a certain value under the steady state condition. The reaction plane between the two species A and B is in the liquid film near the gas liquid interface. The rate of gas absorption is

$$R_A = \frac{A^* + \frac{D_B}{Z D_A} B_s}{\frac{1}{K_s} + \frac{D_B a}{D_A K_s A_p}} \quad (15)$$

the condition being $K_L a A^* < K_s A_p B_s$.

Case II—Reaction Plane in the Liquid Film Around the Solid Particles in the Bulk Liquid Phase (Case of Fast Gas Absorption):

When the rate of gas absorption is relatively fast as compared with that of the solid dissolution, the dissolved solid species B in the bulk liquid phase is consumed and

the reaction plane shifts to the liquid film around the solid. The solid dissolution is enhanced by the reaction and the enhancement factor is

$$\beta = 1 + Z \frac{D_A}{D_B} \frac{A_L}{B_s} \quad (16)$$

the condition being $K_s A_p B_s < K_L a A^*$.

Case III—Reaction Plane in the Liquid Film Near the Gas Liquid Interface; Concentration of B in the Bulk Liquid Phase Constant at the Saturation Concentration B_s .

Here, the solid is abundant in the liquid phase and the rate of gas absorption is much slower than that of the solid dissolution. Now the concentration of dissolved species B in liquid phase is maintained at saturation solubility B_s . The rate equation is

$$R_A = K_L \left(1 + \frac{D_B}{Z D_A} \frac{B_s}{A} \right) A^* \quad (17)$$

Solid Dissolution in the Liquid Film Next to the Gas—Liquid Interfaces Important

Case I—Reaction Plane in the Liquid Film Near Gas-Liquid Interface; Concentration of B in Liquid Phase is Maintained at Saturation Concentration Phase B_s :

This is similar to Case I earlier. Equation for concentration profiles A and B are

$$A = \left(A^* + \frac{D_B B_s}{D_A Z} \right) \frac{\sinh m(\lambda - x)}{\sinh m\lambda} + \frac{D_B B_s}{D_A Z} \left(\frac{\sinh mx}{\sinh m\lambda} - 1 \right)$$

for $0 \leq x \leq \lambda$ (18)

$$B = B_s \frac{1 - \sinh m(\delta - x)}{\sinh m(\delta - \lambda)},$$

for $\lambda \leq x \leq \delta$ (19)

The rate equation is

$$\begin{aligned} R_A &= m D_A A^* \coth m\lambda + \frac{m D_B B_s}{Z} \left(\coth m\lambda - \frac{1}{\sinh m\lambda} \right) \\ &= \frac{m D_B B_s}{Z} \coth m(\delta - \lambda) + m \left(D_A A^* + \frac{2 D_B B_s}{Z} \right) \\ &\quad \times \left(\coth m\lambda - \frac{1}{\sinh m\lambda} \right) \quad (20) \end{aligned}$$

Case II—Reaction Plane in the Liquid Film in Gas-Liquid Interface; Concentration of the Dissolved Solid Species B in the Bulk Liquid Phase Lower Than Saturation Concentration B :

The case corresponds¹ to when the solid concentration is very low or the concentration of the dissolved gas at the gas-liquid interface is high. The rate of gas absorption is relatively fast and the concentration of B is less than the saturation solubility B_s . The rate equation is

$$R_A = m D_A A^* \coth m\lambda + \frac{m D_B B_s}{Z} \left(\coth m\lambda - \frac{1}{\sinh m\lambda} \right) \quad (21)$$

Rate of solid dissolution in the bulk liquid phase R_d is

$$R_d = K_s \left(\frac{A_p}{a} \right) (B_s - B_L) \quad (22)$$

R_B , the rate of diffusion of solid species from bulk liquid phase is

$$R_B = D_B \left(\frac{dB}{dx} \right)_{x=\delta} = m D_B \left(\frac{B_s}{\sinh m(\delta - \lambda)} \right) \quad (23)$$

Combining equations (22) and (23) which are same at steady state condition, the concentration of the solid species in the bulk liquid phase is

$$B_L = \frac{m}{a} B_s \left\{ \frac{1}{\sinh m(\delta - \lambda)} + \frac{m}{a} \right\}^{-1} \quad (24)$$

When the solid concentration is high or interfacial area in the absorber is small, $B_L = B_s$. If the concentration of the absorbed gas in the gas-liquid interface is high, $A > 8$ and $B_L \rightarrow 0$.

Case III—Main Reaction Plane is in the Liquid Film Around the Solid Particle in the Bulk Liquid Phase:

This case corresponds to Case II, where the solid dissolution in the liquid film near the gas-liquid interface as well as in the bulk liquid phase are important. The boundary conditions are:

$$x = 0, A = A^*, R_A = -D_A \left(\frac{dA}{dx} \right)$$

$$x = \delta, A = A_L$$

The concentration profile in the liquid film next to the gas liquid interface is

$$A = \frac{\left[\left(A^* + \frac{D_B}{Z D_A} B_s \right) \sinh m(\delta - x) + \left(A_L + \frac{D_B}{Z D_A} B_s \right) \times \sinh mx - \frac{D_B}{Z D_A} B_s \right]}{\sinh m\delta} \quad (25)$$

The rate equation is

$$R_A = m D_A (A^* \coth m\delta - A_L) + \frac{m D_B B_s}{Z} (\coth m\delta - 1) \quad (26)$$

$$R_d = K_s \left(1 + \frac{D_A Z}{D_B} \frac{A_L}{B_s} \right) \left(\frac{A_p}{a} \right) B_s \quad (27)$$

Rate of diffusion of absorbed gas into bulk liquid phase, through the plane $x = \delta$ is

$$R_A = -D_A \left(\frac{dA}{dx} \right)_{x=\delta}$$

$$= \frac{m D_A \left(A^* + \frac{D_B}{Z D_A} B_s \right) - \left(A_L + \frac{D_B}{Z D_A} B_s \right) \cosh m\delta}{\sinh m\delta} \quad (28)$$

Under steady state condition,

$$R_d = Z R_A$$

$$A_L = \frac{A^* + \frac{D_B}{Z D_A} B_s}{\cosh m \delta + \frac{m}{a} \sinh m \delta} - \frac{D_B}{Z D_A} B_s \quad (29)$$

where $m \rightarrow 0$, $A_L \rightarrow A^*$, in equation (13) $R_A \rightarrow 0$.

If $m \delta$ or m/a increases in equation (29), $A_L = 0$ at a certain value and Case III becomes same as Case II.

The rate of solid dissolution in liquid film which is enhanced by absorbing gas into slurry, the equation of the diffusing gas is

$$D_A \frac{d^2 A}{dx^2} - \frac{K_s}{Z} \left(1 + \frac{Z_A D_A}{B_s D_B} \right) A_p B_s = 0 \quad (30)$$

for $0 < x < \lambda$.

The rate is enhanced by $1 + \frac{Z_A D_A}{B_s D_B}$ due to the absorbed gas A . The concentration of B in the liquid phase is between 0 to λ for $\lambda < x < \delta$ and the equation is reduced to the same as given by Ramchandran and Sarma¹

$$A = A^* + \frac{D_B B_s}{D_A Z} \left(\frac{\sinh m (\lambda - x)}{\sinh m \lambda} \right) + \frac{D_B B_s}{D_A Z} \left(\frac{\sinh m \lambda}{\sinh m \lambda} \right) \quad (31)$$

$$\text{where } m = \sqrt{\frac{K_s A_p}{D_B}}$$

The rate of absorption of gas A is

$$R = - D_A \left. \frac{dA}{dx} \right|_{x=0} = \frac{D_B}{Z} \left(\frac{dB}{dZ} \right)_{x=\lambda} = \lambda \left[\frac{K_s A_p B_s}{2} + \frac{D_A K_s A_p}{D_B} \right] A \quad (32)$$

Substituting values of A and B ,

$$R = m D_A A^* \coth m \lambda + \frac{m D_A B_s}{Z} \left(\coth m \lambda - \frac{1}{\sinh m \lambda} \right)$$

$$= \frac{m D_A B_s}{Z} \coth m (\delta - \lambda) + m \left(D_A A^* + \frac{2 D_B B_s}{Z} \right) \times \left(\coth m \lambda - \frac{1}{\sinh m \lambda} \right) \quad (33)$$

is obtained by the trial and error method or by following equation derived from the boundary condition

$$\frac{D_B B_s}{Z} \left[\coth m \lambda + \coth m (\delta - \lambda) - \frac{1}{\sinh m \lambda} \right] - \frac{D_A A^*}{\sinh m \lambda} = 0 \quad (34)$$

BJELE'S MODEL: WITH GAS PHASE RESISTANCE CONSIDERED

In the models developed earlier, the gas phase resistance was neglected. Bjele, *et al*² considered the laminar jet theory, where the gas phase resistance is taken into account. In the reactor, $\text{SO}_2\text{-N}_2$ system has been studied, especially SO_2 absorption in CaCO_3 slurry. The rate of

absorption of SO_2 in CaCO_3 slurry is slightly greater than in water due to their reaction between SO_2 and HCO_3 . As it is unsuitable to work with low concentration of SO_2 , a gas mixture of $\text{SO}_2\text{-N}_2$ was used with H_2O , NaOH and CaCO_3 slurry as absorbing fluids.

Assuming stagnant film on both sides of the boundary surface, total mass transfer co-efficient is

$$\frac{1}{K_G F} = \frac{1}{K_G} + \frac{H}{K_L} \quad (35)$$

$$K_L = 2 \sqrt{\frac{D_{eff}}{\lambda t x}}$$

By absorbing SO_2 in strong alkali solution, K_G is obtained as

$$\frac{G (P_i - P_{AG})}{V P_{tot}} = K_G a' P_{AG}$$

From Hirschfelder's equation, D_{12} the diffusion co-efficient for SO_2 is calculated as

$$D_{12} = 1.858 \times 10^{-3} \frac{T^{3/2}}{P \sigma_{12}^2 \Omega D} \sqrt{\frac{M_1 + M_2}{M_1 M_2}} \quad (36)$$

When the average particle diameter is much less than the film thickness, $d_p \ll \frac{1}{10} \delta$, K_s the mass transfer co-efficient for solid dissolution is in the average of 2 to 8×10^{-3} cm/sec. The dissolution and the chemical reaction steps are parallel and the chemical reaction rate increases in the boundary layer. The rate of absorption is given by

$$R = D_{eff} C^* + K_s A_p B_s \frac{\lambda}{2}$$

$$= B_s \sqrt{D_B K_s A_p} \coth \sqrt{\frac{K_s A_p}{D_B}} (\delta - \lambda) + K_s A_p B_s \lambda \quad (37)$$

The model proposed by Sada, *et al*^{4,5} for the absorption process with a finite rate of reaction was an extension of the model prepared by Uchida, *et al*^{2,3}. Numerical results were derived in terms of enhancement factors, as proposed by Uchida, *et al*, and was compared with the available data. Single gas absorption with reaction into a slurry containing fine particles has also been satisfactorily predicted with the help of this model.

They have given the kinetic rate of absorptions of lean sulphur dioxide into aqueous slurries of calcium carbonate and magnesium hydroxide. The rate is influenced by the dissolution of the particles. The rate of solid dissolution can be promoted by the reaction between the absorbed gas and the dissolved solid near the gas liquid interface.

CONCLUSIONS

At present wet scrubbing is being practised as the basic method of controlling SO_2 emission mainly from the power plants. Wider application of this method to industries that emit SO_2 depends on the solution of certain inherent problems such as (i) slow settling rate of waste solids and the resulting high waste pond volume, (ii) slow rate of limestone dissolution in the scrubber, and (iii) the point of introduction of limestone to the process. The technology is now only in the beginning phases of development and numerous pilot plant projects and fundamental research studies are underway to further understand the process.

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