

BICARB BULLETIN



Desulfurization of Factory Flue Gases with Sodium Bicarbonate

SO₂ Removal with Dry Sodium Bicarbonate Injection at the OMNICAL Factory in Ewersbach, West Germany

The effectiveness of sodium bicarbonate for removing SO₂ from the flue gases given off by a coal-fired boiler was studied at the OMNICAL factory in Ewersbach, West Germany from November 25 to December 16, 1987. The tests were carried out in collaboration with Deutsche Babcock Anlagen AG.

Description of the installation

Average heating power: approx. 2 MW

Principles of Construction

Boiler:

Ducting of the flue gases into a cyclone separator for separation of fly ash, injection of bicarbonate or other absorbents into the flue gas, bag filter, fan, chimney.

The sodium bicarbonate used was pulverized in an Alpine UPZ 160 pulverizer and introduced pneumatically into the flue gases via a disk injector.

The volume of the chamber from the injection point up to the separation of the fly ash in the bag filter housing was around 5 m³. In other words, with flue gas throughflow of 3,600 m³/h, the contact time between the bicarbonate particles and the flue gas was 5 sec.

Fuel:

The fuel used was gas flame coal (10/15 pea coal).

Results of analysis:

Ash content: approx. 4.5%

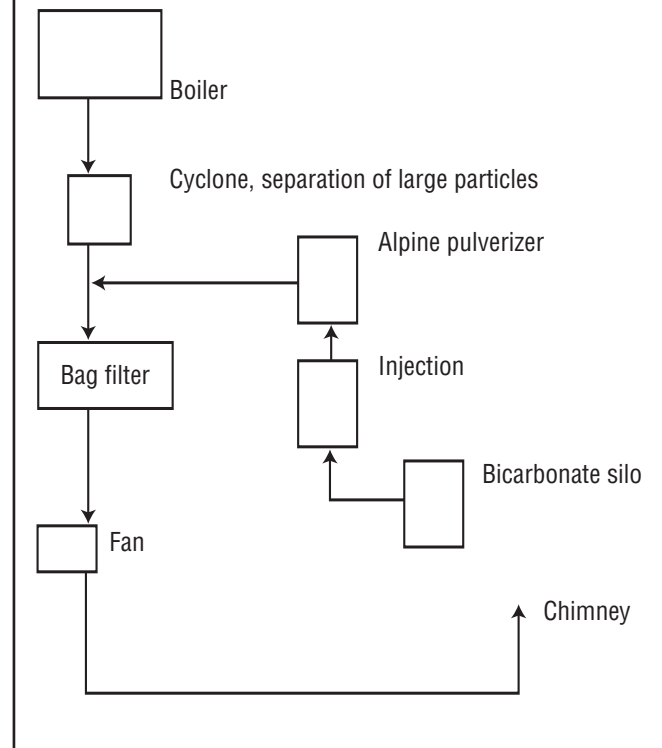
Water content: approx. 3.7%

Sulfur content: approx. 1.4%

Min. calorific value: 30 MJ/kg

Diagram of the Installation

Coal-fired boiler, average power = 2 MW



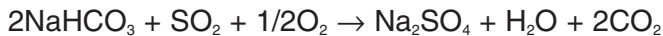
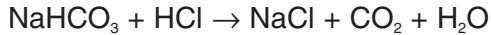
Absorbents:

Fine sodium bicarbonate was used. Pulverization took place in an Alpine model UPZ 160 pulverizer. The pulverized product had an average granulometry of 90% <30 µm and 50% <12 µm. Other tests were carried out using hydrated lime. The granulometry of this product was 90% <30 µm and 50% <6 µm.

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Stoichiometric Ratios

For removal of SO₂ and HCl, the following global reactions apply:



In other words,

84/36.5 = 2.301 kg of NaHCO₃ are required in order to remove 1 kg of HCl and

2 x 84/64 = 2.625 kg of NaHCO₃ are required in order to remove 1 kg of SO₂.

Testing

Tests were differentiated according to the following four parameters:

1. Flue gas temperature
2. Stoichiometry of the absorbent
3. Water vapor content of the flue gas
4. Differential pressure at the bag filter

Test Results

1. Test with hydrated lime

Test showed that in the presence of untreated (dry) flue gas, under the chosen reaction conditions, no removal of SO₂ could be observed (test 11). In subsequent tests on flue gases with a temperature of 115-120°C, a water vapor level of 20-22 vol. % and a stoichiometric ratio for Ca(OH)₂: SO₂ of 4:1, a reduction of SO₂ levels of the order of 50-60% was noted.

2. Tests using sodium bicarbonate

a) Influence of temperature

Trials have shown that very good results can be obtained at temperatures of 120°C upwards. No diminution of the reaction was noted at high temperatures (up to 210°C). It is interesting to examine how the reaction suddenly occurs at a certain temperature; by heating the flue gas slowly, it was noted that the absorption reaction was suddenly activated at 115-116°C. A subsequent test, with even slower heating, no longer showed this phenomenon. But in this case very good reaction levels were observed from 107-108°C upwards. This may be due to the fact that the sodium bicarbonate settling on the bag filters could be converted into a sufficient quantity of active sodium, at this low temperature as well, given the long cleaning cycles.

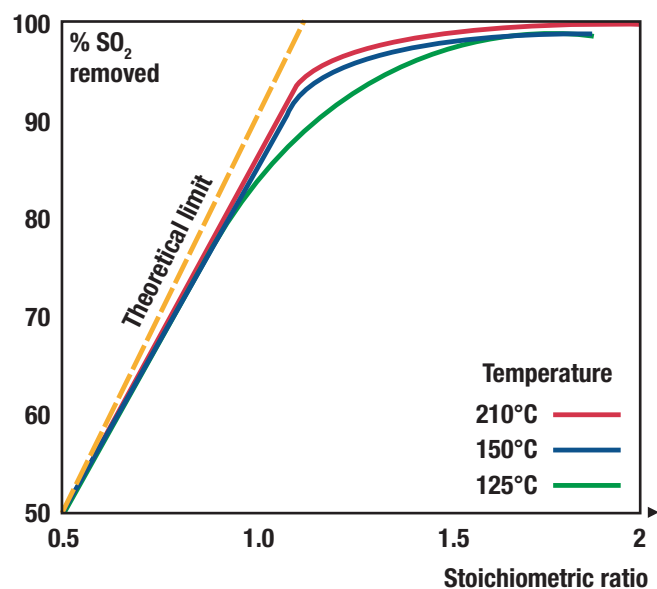
b) Stoichiometry

The 2NaHCO₃/SO₂ ratio was set from 0.58 to 1.72. At high ratios, a complete absorption of SO₂ was observed, particularly at high flue gas temperatures.

c) Conditioning with steam

In a purely qualitative test, feeding in approx. 10 vol. % of steam (approx. 300 kg/h) improved the purification performance by around 30%.

Graph 1: % SO₂ removed as a function of the stoichiometric ratio



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d) Differential pressure (Δp) – bag filter unit

With gas cleaning regulated at $\Delta p = 1-2$ mbar, an approx. 40% reduction in the absorption of SO_2 was observed, i.e., in the given test conditions (stoichiometric factor of 0.85-0.90 and at a flue gas temperature of around 125°C), 40% of the SO_2 is removed in the layer of dust in the bag filter and 60% as the bicarbonate moves from the injection point up to the bag filter (measurement not shown in the table).

Conclusion

In general, results can be considered as very positive. The correlation between level of SO_2 removal and the chosen stoichiometry (graph 1) particularly stresses the aptitude of sodium bicarbonate for desulfurizing flue gases in this type of installation.

Summary of Test Conditions

Sodium bicarbonate:

Granulometry: 90% $<30 \mu\text{m}$
50% $<12 \mu\text{m}$
After pulverization

Trial conditions:

1. Flue gas temperature: $125-210^\circ\text{C}$
2. Contact time between bicarbonate and flue gas: 3-5 sec.
3. SO_2 level in the flue gas: $1575-2320 \text{ mg/Nm}^3$ dry basis
4. Stoichiometric ratio:
 $2\text{NaHCO}_3/\text{SO}_2 = 0.58$ to 1.72
5. Δp . bag filter 12 to 16 mbar

Trial results:

1. Bicarbonate conversion: $>90\%$
2. Removal of SO_2 : 66-99% (conditioned by stoichiometry and Δp . of the bag filter). The zones in which SO_2 was removed for the selected test temperatures are given in graph 1.

Table 1

Test	1	2a	2b	3	4	5	6	7	8	9	12a	12b	12c	12d	11
Date	25.11.87	25.11.87	25.11.87	26.11.87	26.11.87	26.11.87	26.11.87	27.11.87	27.11.87	30.11.87	16.12.87	16.12.87	16.12.87	16.12.87	1.12.87
Temperature of gases before filtration in °C	208	210	209	210	147	152	151	124	125	125	107	108	128	128	115
Gas flow m ³ /h	5200	5240	5200	5500	4600	4600	4520	3300	3300	3920	4650	4650	4650	3450	4900
Gas flow (dry) Nm ³ /h	2863	2873	2857	3015	2990	2955	2910	2269	2260	2690	3340	3330	3165	2350	3450
O ₂ content % by volume (initial gas)	7.4	7.8	9.5	8.4	13.5	13.6	13.5	17.4	18.3	13.4	15.5	15.5	12.8	12.8	
O ₂ content % by volume (scrubbed gas)	7.9	8.2	9.7	8.8	13.9	14.6	14.1	17.4	18.3	13.6	16.3	16.3	13.7	13.7	
SO ₂ mg/Nm ³ , (initial gas, dry)	2320	2250	1950	2050	1800	1740	1470	1800	1740	1900	1575	1650	1770	1750	1800
SO ₂ mg/Nm ³ , (scrubbed gas, dry)	0	30	20	100	260	30	90	50	440	340	280	80	550	520	Exceeds measurement range
SO ₂ mg/Nm ³ , corrected* (scrubbed gas, dry)	10	41	30	113	381	43	106	60	585	494	451	104	864	792	
Addition of steam % by volume	-	-	-	-	-	-	-	-	-	-	-	10.6	10.9	14.7	
Dust separation delta p	12.16 mbar	←	←	←	12-15 mbar	←	←	←	←	←	12.5-15 mbar	←	< 2 mbar	←	12-15 mbar
Reduction** %	99.6	98.2	98.5	94.5	78.8	97.5	92.8	96.7	66.4	74.0	71.4	93.7	51.2	58.4	
Stoichiometry***	1.72	1.16	1.35	0.89	0.68	1.29	0.84	1.18	0.63	0.77	0.98	0.99	0.58	0.78	1.1-1.8
Addition NaHCO ₃ g/min	500	329	329	240	159	290	158	211	109	172	226	237	143	140	120-960
Analysis reaction product mixture/% insoluble loose ash	22		10.9	7.9	10.9		8.2	13.0	10.0	11.6			24.9		54.5
NaHCO ₃ %	2.8		3.8	5.3	4.9		4.3	20.8	9.2	7.2			4.6	Ca(OH) ₂	3.0
Na ₂ CO ₃ %	16.0		25.3	5.6	3.6		4.2	8.8	4.5	2.1			65	CaCO ₃	27.8
Na ₂ SO ₄ %	52.7		53.9	75.2	71.7		75.9	50.9	70.2	70.9			56.5	CaSO ₄	6.5
NaCl %	4.1		3.9	5.2	5.3		5.0	2.4	3.2	4.3			4.8	CaCl ₂	4.3
NaF ppm	641		486	840	641		575	442	619	376			-		
H ₂ O %	0.4		0.3	-	1.8		1.1	2.8	1.1	1.6			-		2.35
Σ %	99.0		98.1	99.2	98.2		98.7	98.5	98.2	98.1			97.3		98.5

*Corrected SO₂: measuring errors have been corrected by standard values.**Separation rate: refers to corrected SO₂***Stoichiometry: 2NaHCO₃/SO₂ = 1