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Study on the Technology Conditions of Flue Gas Desulfurization with Organic Solvent

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Abstract:

The technology experiment on Flue Gas Desulfurization (FDG) by DMSO method is studied in this paper, and the desulfurization efficiency is set out in various conditions. The results show that the desulfurization efficiency can be over 94% under the condition as follows: the rate of flow of DMSO=100 L/h, L/G = 40 ~ 50, absorbent concentration = 100 %DMSO, *T*=room temperature, the gas flow=60 ml·min^{-1}, inlet SO_2 concentration= 0.1-0.5 %, the time of operation must be controlled in 30 minutes.

Key words: FGD, Organic solvent, SO2, desulfurization efficiency

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1. Introduction

Removal of SO_2 from flue gas is one of very important research projects in the world. In order to find effective method, various desulfurization techniques, 1-8 such as activated carbon, molecular sieve, the electron-beam radiation technique, chemical method, physical solvents etc. are all attempted. Compared with these methods, organic solvent absorption has some advantages as low investment, high SO_2 absorption efficiency and desorption efficiency and worth to further research. In this paper, based on the selected liquid organic absorbent with a high absorption and desorption efficiency with low toxicity and low price,6 the technology experiment in various conditions on FDG by DMSO method is studied.

2 Experimental

2.1 Experimental apparatus

The experimental apparatus for removal SO_2 is shown in Figure 1. The absorption apparatus of technological condition is an absorption tube with sandglass. The sulfur dioxide with a mole fraction purity x (SO_2)≥0.997, pure nitrogen with a purity x (N_2) ≥0.99999; are both from cylinders. The sulfur dioxide and nitrogen are mixed by a gas mixer with static agitation unit to simulate the flue gas. A flowrator is used to control the flow. The SO_2 analyzer with SO_2 sensor (type NTS 100, Nanjing, China) was used for the SO_2 analysis of the gas phase from the feed gas and the tail gas. The SO_2 concentration in the gas phase before and after absorption is analyzed by SO_2 analyzer, then the purification efficiency is calculated.

The desulfurization efficiency (η) is: $\eta = \frac{C_0 - C}{C_0} \times 100\%$

In which C_0- The SO_2 concentration before absorption

C- The SO_2 concentration after absorption

2.2 Material

All the chemical reagents used are AR grade. The water is purified and deionized with a conductivity <0.06 μ S.cm-1.

3. Result and discussion

3.1 The effect of absorbent concentration on the desulfurization efficiency

Experiment condition: temperature: 24℃, gas flow: 60 ml·min-1, inlet SO_2 concentration: 0.1792%. The results are shown in Table 1 and Figure 2.

Figure 2 shows that DMSO has a good desulfurization efficiency for low SO_2 , and desulfurization efficiency increases with DMSO concentration increase.

3.2 The effect of absorbent temperature on desulfurization efficiency

Experiment conditions : gas flow: 80 ml·min-1, inlet SO_2 concentration: 0.1783%, the results are shown in Table 2 and Figure 3.

Figure 3 show that the temperature influences desulfurization efficiencies. And the sulfur dioxide desulfurization efficiency decreases when the temperature increases.

3.3 The effect of flow rate of flue gas on desulfurization efficiency

Experiment conditions：temperature: 24 ℃, inlet SO_2 concentration: 0.1783 %.The effect results of flow rate of flue gas on desulfurization efficiency are shown in Table 3 and Figure 4. From Figure 4, it can be found that flow rate of flue gas influences desulfurization efficiencies, the smaller the gas flow, the higher the desulfurization efficiency. When flow rate of flue gas is 60 ml·min-1, the desulfurization efficiencies are over 95% within the experimented time, when flow rate of flue gas is higher 60 ml·min-1,the desulfurization efficiency dropped quickly.

If the gas flow is too large, SO2 was discharged with flue gas without much the mass transfer and absorption with absorption liquid, gas-liquid entrainment phenomenon will also be occurred, and lead to the decrease of the purification efficiencies. Consideration of high efficiency and economy, therefore the suitable flow rate of flue gas is selected at 60 ml·min-1.

3.4 The effect of liquid/gas ratio (L/G) on desulfurization efficiency

The liquid/gas ratio directly affect rationality of investment (such as tower, pump, pipe etc.) and the running cost (such as electric power consumption etc.), is an important parameters for influencing desulfurization efficiency. The effect of L/G on desulfurization efficiency is shown in Table 4 and Figure 5. Figure 5 shows that the desulfurization efficiency increases with the increase of liquid/gas ratio, when liquid/gas ratio is higher, the absorption liquid is adequate enough, it is larger interface with SO2 from flue gas, mass transfer coefficient is larger, the absorption time is longer, therefore the desulfurization efficiency is higher. When L/G is 45 L/m3，desulfuration efficiency is up to 96％，Continue to increase the L/G，the desulfuration efficiency only increase slightly, so the suitable liquid/gas ratio is selected in 45-50 L/m3.

3.5 The effect of inlet SO_2 concentration on desulfurization efficiency

The effect of inlet SO2 concentration on desulfurization efficiency is studied, as shown in Table 5 and Figure 6, Figure 6 shows that the desulfurization efficiency increases with the inlet SO2 concentration increases. When the other condition was constant, the increase of the inlet SO2 concentration is equivalent to increase gaseous phase SO2 partial pressures, consequently, the propulsion of mass transfer between the gas and liquid phase is increased, the effect of mass transfer is heightened, the desulfurization efficiency is increased. But the extent to which desulfurization efficiency is raised decrease gradually with the inlet SO2 concentration increases.

4. Conclusions

Main parameters (absorption liquid concentration, the temperature, the gas flow, liquid/gas ratio, inlet SO2 concentration, etc.) affecting SO2 removal efficiency were studied. The results show that SO2 purification efficiency increases with DMSO concentration increase, the sulfur dioxide purification efficiency decreases when the temperature increases, the smaller the gas flow, the higher the SO2 removal efficiency, the desulfurization efficiency increases with the increase of liquid/gas ratio, the sulfur dioxide purification efficiency decreases with the inlet SO2 concentration increases.

Basing on the consideration of the experimental results and economic cost, the suitable technological conditions is: L/G＝40～50，absorbent concentration= 100%DMSO, T= room temperature, the gas flow=60 ml·min-1, inlet SO2 concentration=0.1-0.5%;on the above process parameters, SO2 purification efficiency can up to more than 94%.

The result provided a reference for the industrial application of removal of SO2 from flue gas.

REFERENCES

[1] Li, H., Chen, W. R.,Liu, D.Z. 2002. Study on Removing Sulfur Dioxide from Flue Gas with Liquid Absorbents. Environ. Protect. of Chem. Ind. 22(4), 193-196.

[2] Li, H., Chen, W.R. 2006. Solubility of Dilute SO2 in DMSO+Mn2+ Mixture Solvents and EOS Model-(Ⅱ).Phy. and Chem. of L. 44(1), 83-93.

[3] Li, H., Chen, W.R. 2006. Solubility of Dilute SO2 in DMSO+Mn2+ Mixture Solvents and EOS Model-Ⅰ. Phy. and Chem. of L. 44(2),183-191.

[4] Li, H.,Chen, W.R. 2007. Solubility of SO2, CO2 in desulfuration solution from 293.15K to 313.15K. Phy. and Chem. of L. 45(1), 57-65.

[5] Li, H. 2009. Thermodynamic Model of Solubility for CO2 in Dimethyl Sulfoxide. Phy. and Chem. of L. 47(3), 296-301.

[6] Li, H., Chen, W.R., Liu, D. Z. 2003. Desulfurizing Absorbent for Flue Gas and its Absorption Mechanism. J. of Environ. Sci.. 15(1), 92-96.

[7] Li, H., Chen, W.R. 2007. Solubility of SO2 ,CO2 in DMSO+Mn2+ Mixture Solvents and EOS Model. Phy. and Chem. of L. 45(2), 207-213.

[8]. Li, H.,Hu, G. Q.,Chen, X.S. 2010. Research on mechanism of gas liquid separation in SO2 removal from flue gas by liquid absorption with catalyzed reaction. Phy. and Chem. of L. 48(5), 652-660.

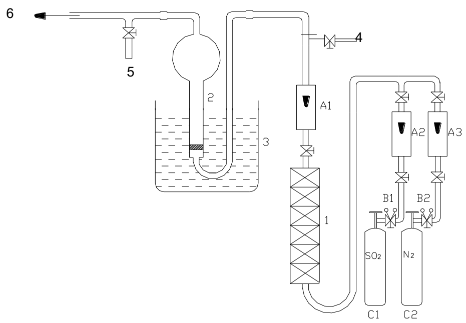

Fig 1. The technological process of SO_2 absorption

C1: SO2 cylinder, C2: N2 cylinder, B1-B2: walve, A1-A3: flowrator,

1- a gas mixer with static agitation unit, 2-absorption tube 3- constant temperature bath.

4-inlet gas to SO2 analyzer, 5- outlet gas to SO2 analyzer, 6- to fume hood

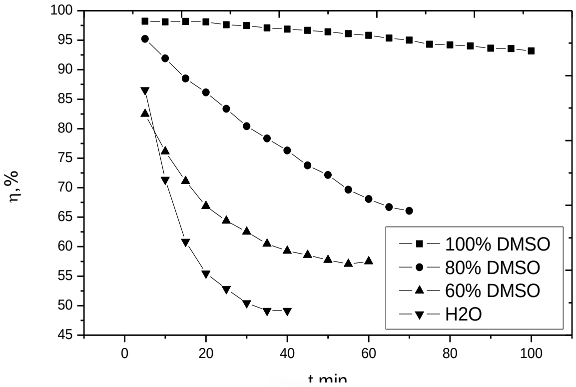

Fig. 2 The effect of absorbent concentration on desulfurization efficiency

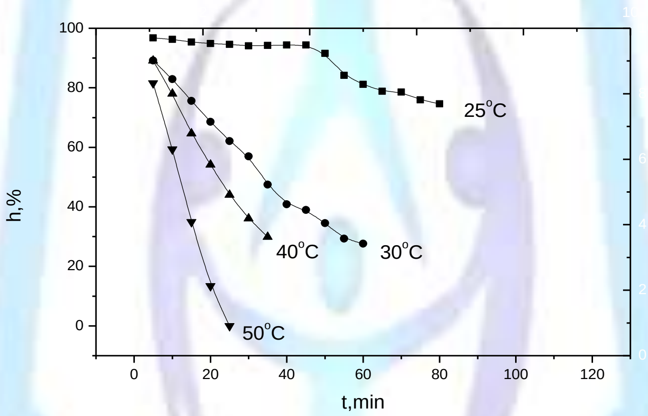

Fig. 3 The effect of absorbent temperature on desulfurization efficiency

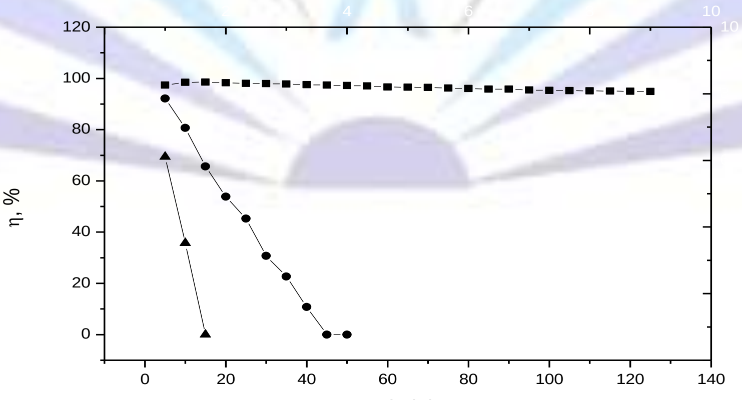

Fig. 4 The effect of flow rate of flue gas on desulfurization efficiency

■, 60 ml·min^{-1}; ●, 100 ml·min^{-1}; ▲, 200 ml·min^{-1}

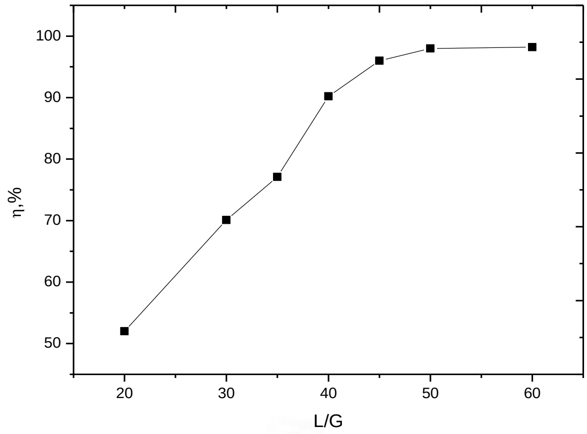

Fig. 5 Relation between L/G and desulfuration efficiency

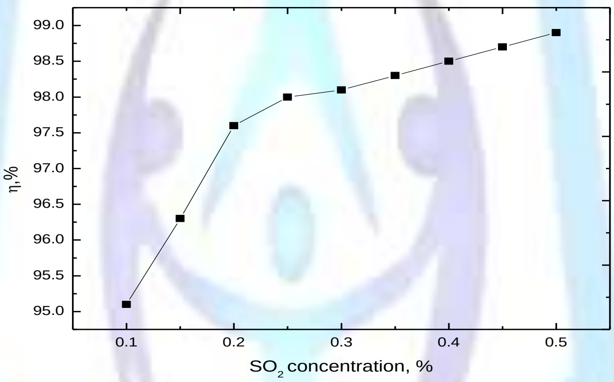

Fig. 6 Relation between inlet SO_2 concentration and desulfuration efficiency

Table 1 The effect of absorbent concentration on desulfurization efficiency

t, min	100% DMSO	80% DMSO	60% DMSO	H_2O
5	98.21	95.20	82.49	86.57
10	98.09	91.90	76.11	71.36
15	98.15	88.50	71.08	60.85
20	98.09	86.16	66.89	55.48
25	97.59	83.37	64.37	52.85
30	97.48	80.41	62.52	50.44
35	97.09	78.34	60.45	49.16
40	96.86	76.28	59.28	49.16
45	96.64	73.77	58.55	--
50	96.42	72.15	57.71	--

55	96.08	69.64	57.04	--
60	95.80	68.08	57.49	--
65	95.35	66.68	--	--
70	95.02	66.07	--	--
75	94.29	--	--	--
80	94.18	--	--	--
85	94.01	--	--	--
90	93.62	--	--	--
95	93.56	--	--	--
100	93.17	--	--	--

Table 2 The effect of absorbent temperature on desulfurization efficiency

t, min	25 ℃	30 ℃	40 ℃	50 ℃
5	96.75	89.18	89.12	81.55
10	96.24	82.89	77.96	59.34
15	95.34	75.60	64.61	34.94
20	94.9	68.59	54.12	13.40
25	94.56	62.09	44.03	0.00
30	94.11	56.93	36.06	--
35	94.22	47.45	29.89	--
40	94.39	40.83	--	--
45	94.39	38.98	--	--
50	91.59	34.55	--	--
55	84.18	29.33	--	--
60	81.16	27.65	--	--
65	78.80	--	--	--
70	78.58	--	--	--
75	75.94	--	--	--
80	74.59	--	--	--

Table 3 The effect of flow rate of flue gas on desulfurization efficiency

t, min	60 ml·min^{-1}	100 ml·min^{-1}	200 ml·min^{-1}
5	98.43	92.15	69.36
10	98.42	80.66	35.75
15	98.54	65.64	0.00
20	98.31	53.81	--
25	98.09	45.24	--
30	97.98	30.72	--
35	97.81	22.65	--
40	97.53	10.82	--
45	97.37	0.00	--
50	97.20	0.00	--
55	97.03	--	--
60	96.64	--	--
65	96.52	--	--
70	96.47	--	--
75	96.24	--	--
80	96.08	--	--
85	95.85	--	--
90	95.780	--	--
95	95.52	--	--
100	95.29	--	--
105	95.24	--	--
110	95.12	--	--
115	95.07	--	--
120	95.01	--	--
125	94.90	--	--

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Table 4 The effect of liquid/gas ratio (L/G) on desulfurization efficiency

liquid/gas ratio, L/m^3	desulfurization efficiency, %
20	52.00
30	70.10
35	77.10
40	90.20
45	96.00
50	98.00
60	98.20

Table 5 The effect of inlet SO_2 concentration on desulfurization efficiency

inlet SO_2 concentration, %	desulfuration efficiency, %
0.10	95.10
0.15	96.30
0.20	97.60
0.25	98.00
0.30	98.10
0.35	98.30
0.40	98.50
0.45	98.70
0.50	98.90