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Study on Wastewater Treatment of Marine Exhaust Scrubbing Desulfurization

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The device for washing SOx in engine exhaust is a major measure to reduce SOx emission from ship combustion machinery. This paper reports on the methods of reducing suspended solids and polycyclic aromatic hydrocarbons (PAHs) in bleed off wastewater. Through the detailed tests on wastewater and by comparing the effects of coagulation sedimentation on suspended solids in wastewater with that of coagulation air floatation treatment, the influences of different factors on suspended solids are discovered. Meanwhile, by testing on polycyclic aromatic hydrocarbons adsorption processes, the study on the method of polycyclic aromatic hydrocarbons treatment is carried out and the relationship between different factors and polycyclic aromatic hydrocarbons adsorption rate are drawn. As a result of the research, the optimized compositions of coagulation and the optimized operation conditions of coagulation sedimentation and coagulation air floatation treatment are obtained in this paper. The results of this research and of the final exhausted wastewater examinations show that, the combined method of coagulation, dissolved air floatation and active carbon adsorption is an effective measure to treat wastewater from SOx scrubber and can make the turbidity, polycyclic aromatic hydrocarbons concentration of exhausted wastewater meet International Maritime Organization requirements.

Keywords: Coagulant, Dissolved air floatation, Activated carbon, Suspended solids, Wastewater treatment, Desulfurization.

INTRODUCTION

In view of the serious harm of the desulfurization wastewater, International Maritime Organization for developed strict emission standard for emissions of ship emissions washing water, the emission standard has the clear rules for turbidity, polycyclic aromatic hydrocarbons, pH, *etc*., with specific criteria in Table-1.

TABLE-1
THEEMISSION STANDARD OF WASHING WATER

Ingredient	Value of emission standard
pH	≥ 6.5
Turbidity	≤ 25 FNU
Polycyclic aromatic hydrocarbons	≤ 2.250 μg/L

EXPERIMENTAL

Coagulation is the operation that chemicals are thrown into the wastewater to destroy the colloidal stability, so that colloidal and tiny suspensions in the wastewater gather into separable floc, coupled with the process of separation to remove[1]. The coagulation action principle is summed up with four aspects.

Double layer compression mechanism: The double electric layer structure of colloid determines the maximum concentration of counter ions on the surface of the colloid. The largest distance from the surface of the particles is, the lower the concentration of the counter ions are and finally the ion concentration is the same with that in solution[2]. It can seen from Fig. 1.

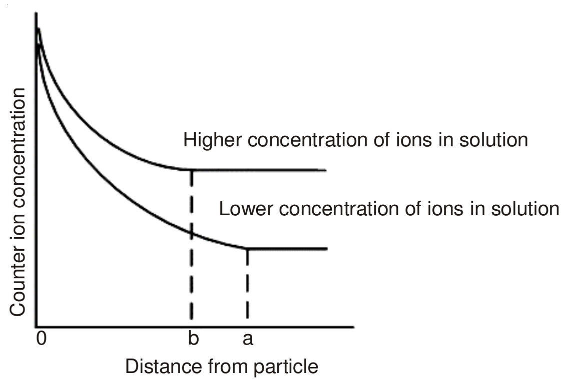

Fig. 1. Relationship between the concentration of ions in solution and the diffusion layer thickness

Mechanism of adsorption and charge neutrality: When the inorganic coagulant is dosed into the wastewater, they will be electrolyzed and dissociated under certain conditions. Coordination ions and electrons of colloidal potential ions layer generated by the dissociation happen to neutralization. In this case, Φ potential and ζ potential will be reduced, colloidal destabilizes and agglomerates[3].

Adsorption bridging mechanism: If coagulant dosed into the wastewater is water-soluble polymer chain with the active site for colloid adsorption, then it will connect colloidal bypass into one flocthrough electrostatic forces, van der Waals forces and hydrogen bonding, *etc*. This role is adsorption bridging role.

Mechanism of net tape: When iron, aluminum and other high valence metal salts are used as coagulants and its dosage and medium conditions is sufficient to enable the rapid generation of insoluble hydroxide in water, precipitation of hydroxide will be able to removen colloids as nuclei or adsorbate together.

Flotation mechanism: The realization of flotation separation must meet the following three basic conditions: (1) The need to produce a sufficient number of micro-bubbles in the water; (2) The need to ensure the formation of insoluble solid or liquid suspended substance from segregative contaminants; (3) The need to ensure adhering bubbles to particulates.

In the flotation process, not all of the material will be adsorbed air bubbles, depending on the water wettability of the substance. The wettability of the substance for water can use the contact angle θ with water to express, as shown in Fig. 2 the substance with contact angle θ > 90° is called hydrophobic substance, the substance with θ < 90° is called hydrophilic substance[4].

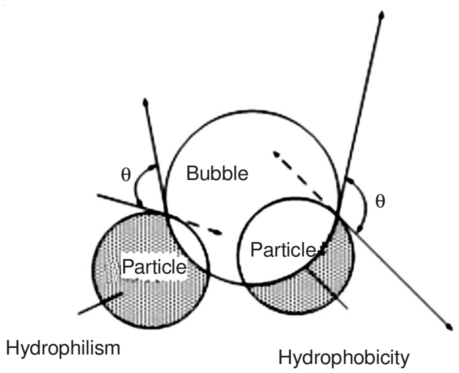

Fig. 2. Contact angle hydrophilic and hydrophobic material

No any substance in water can add here to the bubbles. When θ tends to zero, this material can't realize flotation. When θ < 90°, the substance isnot attached strongly. when θ is close to 180°, substances will most likely realize flotation. When θ > 90°, this kind of substances is beneficial to flotation. Particles are more hydrophobic, *i.e.*, the contact angle is larger, the greater probability air bubbles have to adhere on the surface.

RESULTS AND DISCUSSION

Optimum conditions of coagulation precipitation verification test: The best action range ofcoagulant dosing concentration, water conservancy condition, sediment time and other conditions will vary with different wastewater quality and therefore require the use of different water quality tests on the best coagulation and sedimentation process conditions for validation. Desulphurization washing wastewater generated from 25, 50, 75 and 100 % operating mode were taken to test in optimal coagulation and sedimentation conditions, to verify whether the turbiditymeets International Maritime Organization standards or not by coagulation sedimentation process.

Table-2 shows that the optimal coagulation and sedimentation condition meets the requirement of ship exhaust gas desulfurization washing wastewater under different operating mode. The waste water after treatment can meet International Maritime Organization requirements of ship for turbidity of washing water.

TABLE-2
OPTIMUM CONDITIONS OF COAGULATION PRECIPITATION VERIFICATION TABLE

Operating mode (%)	Turbidity before treatment (FNU)	Turbidity after treatment (FNU)	Standard value (FNU)	Decontamination rate (%)	Whether standard
25	36.4	3.6	25	90.6	Yes
50	45.6	3.3	25	92.8	Yes
75	54.8	4.1	25	92.6	Yes
100	63.9	2.9	25	95.4	Yes

Optimum conditions of mixed air flotation verification test: The optimal interval of coagulant dosing concentration, dissolved air pressure, reflux ratio and other conditions will vary with different wastewater quality and therefore require the use of different water quality toverifythe optimum conditions of flotation. Desulphurization washing wastewater generatedfrom 25, 50, 75 and 100 % operating mode were taken to test in optimal flotation conditions, to verify whether the turbidity meets International Maritime Organization standards or not by flotation process.

Table-3 shows that the optimal flotation condition meets the requirement of ship exhaust gas desulfurization washing wastewater under different operating mode.The waste water after treatment can meet International Maritime Organization requirements of ship for turbidity of washing water.

TABLE-3
OPTIMUM CONDITIONS OF COAGULATION FLOATATION VERIFICATION TABLE

Operating mode (%)	Turbidity before treatment (FNU)	Turbidity after treatment (FNU)	Standard value (FNU)	Decontamination rate (%)	Whether standard
25	36.4	3.0	25	91.7	Yes
50	45.6	3.1	25	93.2	Yes
75	54.8	3.3	25	94.1	Yes
100	63.9	1.6	25	97.5	Yes

Optimum condition of activated carbon adsorption verification test: The interval optimal carbon dosage, activated carbon adsorption time and other conditions will change with wastewater quality, thus requiring the use of different income water quality to validate the optimum activated carbon adsorption conditions. Desulphurization washing wastewater generated from 25, 50, 75 and 100 % operating mode were

TABLE-4
OPTIMUM CONDITIONS OF ACTIVATED CARBON ADSORPTION VERIFICATION TABLE

Operating mode (%)	Polycyclic aromatic hydrocarbons concentration before treatment (μg/L)	Polycyclic aromatic hydrocarbons concentration after treatment (μg/L)	Standard value (μg/L)	Decontamination rate (%)	Whether standard
25	2643.5	245.8	2250	90.7	Yes
50	2842.1	312.6	2250	89.1	Yes
75	2996.9	289.6	2250	87.0	Yes
100	3120.0	430.6	2250	86.2	Yes

TABLE-5
EXPERIMENTAL VERIFICATION RESULTS

Operating mode (%)	Turbidity before treatment (FNU)	Turbidity after treatment (FNU)	Polycyclic aromatic hydrocarbons concentration before treatment (μg/L)	Polycyclic aromatic hydrocarbons concentration after treatment (μg/L)	pH after treatment	Whether standard
25	36.4	3.0	2643.5	245.8	7.5	Yes
50	45.6	3.1	2842.1	312.6	7.5	Yes
75	54.8	3.3	2996.9	289.6	7.5	Yes
100	63.9	1.6	3120.0	430.6	7.5	Yes

taken to test in the optimal conditions of activated carbon adsorption, to verify whether the turbidity meets polycyclic aromatic hydrocarbons International Maritime Organization standards or not by activated carbon adsorption treatment.

Table-4 shows that the optimal condition of activated carbon adsorption meets the requirement of ship exhaust gas desulfurization washing wastewater under different operating mode. The waste water after treatment can meet International Maritime Organization requirements of ship for the polycyclic aromatic hydrocarbons content of washing water.

Ship wastewater treatment device verification test: To verify whether the quality of waste water from washing the ship gas desulfurization meets the International Maritime Organization emission norms related to the washing water, the verification of waste water treatment apparatus was done for experiment. Desulphurization washing wastewater generated from 25, 50, 75 and 100 % operating mode were taken to test in the optimal coagulation condition, optimal flotation condition and optimal conditions of activated carbon adsorption, to verify whether the turbidity meets the International Maritime Organization standards of turbidity, polycyclic aromatic hydrocarbons and value of pH or not.

Table-5 shows the ship treatment device of flue gas desulphurization wastewater fully meets the needs of the wastewater standards for flue gas desulphurization of ship under different operating modes. Wastewater after treatment can meet the standards of International Maritime Organization for the turbidity, polycyclic aromatic hydrocarbons and pH requirements of washing water.

Conclusion

Wastewater after treatment by the devicecan meet the standards of International Maritime Organization for the turbidity, polycyclic aromatic hydrocarbons and pH requirements of washing water.

REFERENCES

1. J. Lorentz, *J. Sci*., 3, (2004).
2. F. Lian, C. Chang, Y. Du, L. Zhu, B. Xing and C. Liu, *J. Environ. Sci. (China)*, **24**, 1549 (2012).
3. J. Sanchez-Martin, J. Beltran-Heredia and M.A. Davila-Acedo, *Chem. Eng. Technol*., **34**, 2069 (2011).
4. R. Quiroz, J.O. Grimalt, P. Fernandez, L. Camarero, J. Catalan, E. Stuchlik, H. Thies and U. Nickus, *Water Air Soil Pollut*., **215**, 655 (2011).