Perspectives in Science (2016) 7, 171—177

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Innovation in dewatering process of flotation tailings by study of particle interaction in colloidal environment☆

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Received 1 October 2015; accepted 19 November 2015
Available online 10 December 2015

KEYWORDS
Dewatering;
Flocculation;
Flotation tailing;
Turbidity;
Zeta-potential

Summary Many mining operations produce tailings that dewater very slowly under self-weight consolidation. On way of reducing the water content of such tailings is by coagulation/flocculation processes (C/F processes). This paper describes a study using aluminium chloride and pre-hydrated aluminium salts as aluminium chlorohydrate — ACH (F1.2A, F1AM, FD15, FDM17H, F1S) and polyaluminium chloride — PACl (PAX-18) in dewatering of flotation tailing slurries, resulting from coal flotation in the coal preparation at the Paskov Mine (Czech Republic). Experiments were conducted at different temperature and mixing conditions to simulate full-scale conditions. The results point to a potentially technique for reducing the water content of tailings streams, thus increasing storage space, improving economic and environmental aspects.

Introduction

Dewatering and disposal of mineral waste tailings pose a major technological and environmental challenge to mining and mineral processing industries world-wide. The production of fine coal particle wastes and by-products has increased as a result of continuous mining methods and coal cleaning processes in the coal industry. An inherent problem with the production of fines is relatively high moisture content of the de-watered product that introduces technical

☆ This article is part of a special issue entitled ''Proceedings ofthe 1st Czech-China Scientific Conference 2015''.

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http://dx.doi.org/10.1016/j.pisc.2015.11.028

Table 1 Chemical composition of the flotation tailings.

Abundance	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3
(wt%)	<1.00	2.40	15.00	42.10	0.20	2.10
Abundance	Cl^-	K_2O	CaO	TiO_2	MnO	Fe_2O_3
(wt%)	0.10	3.00	4.40	1.57	0.10	6.50

and economic difficulties in the handling, disposal, water removal and reuse of coal fines (Sabah and Erkan, 2006).

Flotation is widely used to clean fine coal particles by separating them from clay, silt, shale and other ash-producing matter using air bubble. After flotation either the coal or tailings slurries must be dewatered for practical and economic advantages. Typically, sedimentation and filtration are used to dewater the coal and tailings (Scheiner, 1996; Lockhart and Veal, 1996; Hogg, 2000).

The main driving force for coal tailing filtration is the elimination of unsustainable disposal of fine coal tailings in large tailings dams (Dentel and Gosset, 1988).

Coagulation/flocculation (C/F) is usually a necessary pretreatment step in dewatering streams containing significant quantities of very fine particles. For such systems, the effectiveness of the C/F step may determine the performance and, ultimately, the capacity of the dewatering system.

Effectiveness of the process depends not only on the use of appropriate chemical reagents (coagulants, flocculants, etc.) but also on how they are applied and how the process can be controlled so as to achieve optimum performance in the context of dewatering operations such as sedimentation and filtration (Van Benschoten and Edzwald, 1990; Letterman and Asolekar, 1990; Duan and Gregory, 2003). The interaction of colloidal particles with each other and with other chemical species has an enormous technological significance even in abrasive environments (Gryc et al., 2014). The objective of dewatering processes is often to obtain clear water with low percentage of solids.

The aim of experiments is testing suitability of the selected coagulants for potable optimization of flotation tailing slurries dewatering and to gain a deeper understanding of the interaction mechanism.

Materials and methods

All experiments and analyses were carried out in laboratories of Institute of Clean Technologies for Mining and Utilization of Raw Materials for Energy Use, at VŠB Technical University of Ostrava.

The basic concept of the experimental work focuses on the verification of the mutual interaction between the flotation tailings and the chemical agents specified below. Making use of the principles of measuring the zeta potential, turbidity and sedimentation, we acquired a description of the surface properties of the colloid coal tailings in the liquid medium.

Tailings

The tested flotation tailings are flotation tailings resulting from coal flotation in the coal preparation at the Paskov Mine, the Ostrava Coal Basin, the Czech Republic (CR). The mineralogical characteristics, along with the chemical composition, indicate SiO_2 and other oxides of aluminium, calcium, magnesium as the major components of the coal tailings. The chemical composition of flotation tailings is summarized in Table 1. The chemical composition of the tailings was determined by means of WD-XRF spectrometry, making use of Spectron, Spectroscan Makc-GV.

Coagulants

The coagulants used to destabilize the medium and supports the formation of separable floccules are the aluminium chloride and pre-hydrated aluminium salts as aluminium chlorohydrate — ACH (dialuminium chloride pentahydroxide) and polyaluminium chloride — PACl. 10% solution of $AlCl_3$ was prepared by dissolving solid $AlCl_3 \cdot 6H_2O$ (analytical reagent from PENTA, CR) in deionized water. Five ACH coagulants (F1.2A, F1AM, FD15, FDM17H, F1S) were provided by DEMPOL-ECO (PL) and PACl (PAX-18) was provided by Kemwater ProChemie (CR). Some characteristics of coagulants are mentioned in Table 2.

Table 2 Some specifics of coagulants.

Coagulant	Relative density (g/cm^3)	Chemical compositions	Type
F1.2A	1.280	Al^{3+} min. 11.0%, Cl^- max. 7.0%	ACH
F1AM	1.280	Al^{3+} min. 9.0%, Cl^- max. 13.5%	ACH
FD15	1.200	Al^{3+} min. 6.0%, Cl^- max. 4.0%	ACH
FDM17H	1.275	Al^{3+} min. 8.5%, Cl^- max. 9.5%	ACH
F1S	1.300	Al^{3+} min. 11.0%, Cl^- max. 13.0%	ACH
PAX-18	1.360	Al^{3+} min. 9.0%, Cl^- max. 23.0%	PACl
$AlCl_3$	N/A	Granular form, MW of 241.43 g/mol	Metal salt

N/A = not available, ACH = aluminium chlorohydrate, PACl = polyaluminium chloride, MW = molecular weight.