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CLASSIFICATION OF LAKE SEDIMENTS BY USING HYDROCYCLONES

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ABSTRACT: The present work provides a result from the preliminary experiment for hydrocyclone technology. In this work, local lake sediments and waste coal fly ash were used as test samples, prior to the application of hydrocyclone technology to the waste sludge thickening. A few cyclones based on the Rietema standard geometry were prepared. Chemical analysis of the sediments showed that more organic contaminants were in smaller particles. The experimental tests further showed that physical characteristics of particles, configuration of the cyclone and operation condition would affect the separation efficiency. The current results showed that small size cyclones might improve the separation and concentration of the lake sediments, and higher inlet velocity would increase the concentration rate of under flow and absolute concentration of sediment particles.

KEYWORDS : Centrifugal separation; hydrocyclone; lake sediments; separation efficiency, sediment concentration

INTRODUCTION

In order to secure the irrigation water and to reduce the internal loading by the bottom sediment in domestic lakes of Korea, dredged method including settling process has often been applied. But it has some problems in space and treatment time, and also re-entrainment of the dredged mud containing a large volume of organic matters into the public hydrosphere arises odour problems. The solid-liquid hydrocyclones have been used in mining, pulp and juice industries, and recently being applied to a part of dredged systems. In this work, a basic study for hydrocyclones as a pre-treatment for separation and concentration of lake sediments was carried out focusing mainly on the optimum operation condition.

As like any conventional centrifugal forced devices, the hydrocyclone consists of inlet tube, apex bottom outlet, and over flow through vortex finder. Major parameters regarding cyclone configuration and operation conditions are cyclone body size, inlet shape, depth of vortex finder, geometrical structure of over and under flow discharges, cyclone length, and cone angles, besides the concentration of feed sludge, fluid retention time and inlet velocity.

EXPERIMENTAL METHOD

Test cyclones were designed according to the Rietema's standard; 30mm, 50mm, 80mm in body diameter, and summarized in Fig. 1. An additional set was prepared with a different geometry in body length and apex diameter. Malvern Master Sizer(Malvern instrument, MSS)was used for the evaluation of the reduced separation efficiency with particle size. The efficiency are defined as Eq. (1) and Eq. (2).

■ Overall efficiency

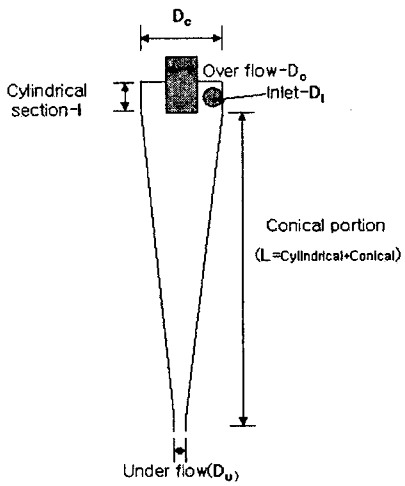
$$E_t = \frac{C_u \times Q_u}{C_i \times Q_i} \qquad (1)$$

■ Reduced efficiency

$$E'_T = \frac{M_u \times C_u \times Q_u}{M_i \times C_i \times Q_i} \quad (2)$$

Where, C_i : Concentration of the feed inlet
C_u : Concentration of the underflow
Q_i : Flow rate of the feed inlet
Q_u : Flow rate of the underflow
M_i : Mass fraction of solids in feed
M_u : Mass fraction of solids in underflow

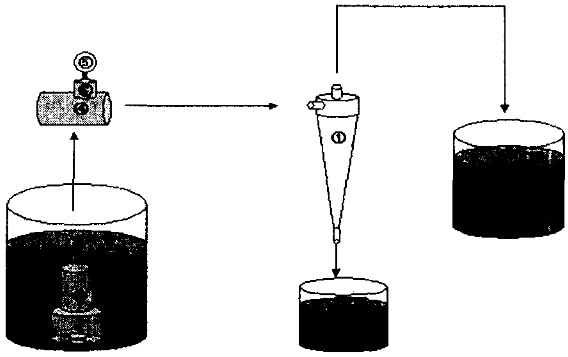
The experimental set-up is schematically depicted in Fig. 2. A mixing pump is sunk in the test slurry tank in order to ensure the complete dispersion of test particles.



(Unit : mm)

Type	Size	Cyclone Dia.(Dc)	Inlet dia. (Di)	Under flow (Du)	Over flow (Do)	Body length(L)	Cone angle
Cyclone I	S	30	8.4	6	10.2	150	10
	M	50	14	10	17	250	10
	L	80	22.4	16	27.2	400	10
Cyclone II	M	50	14	15	17	200	11

Fig. 1 Geometry of Hydrocyclone.



① Hydrocyclone ② Overflow ③ Underflow ④ Screw pump
⑤ Pressure gauge ⑥ 3-way valve ⑦ Slurry tank ⑧ Mixing pump

Fig. 2 Schematic diagram of experimental set-up.

RESULTS AND DISCUSSION

Physicochemical characteristics of solid particles

Brief characteristics of test samples are summarized in Table 1. Table 2 shows the content of organic contaminants in natural sediment. Fly ash as reference particles was larger and heavier than sediments. Smaller particles contain more organic materials and VSS.

Table. 1 Properties of sediment and fly ash.

Material	Source	Density	Chemical elements	Median dia.
Sediment	Giheung Reservoir	1.5	Al, Si, Na, Mg, Mn, F, S, N, P, Org-C	5 μm
Fly ash	Samcheonpo Power station	2.5	Al, Si, Fe, etc.	11μm

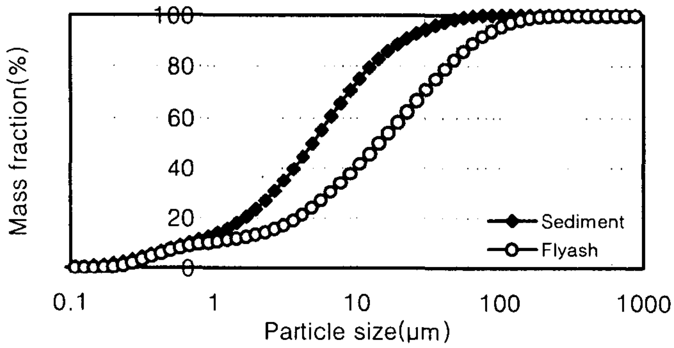


Fig. 2 Particle size distribution.

Table. 2 Contaminants in the sediment according to particle size.

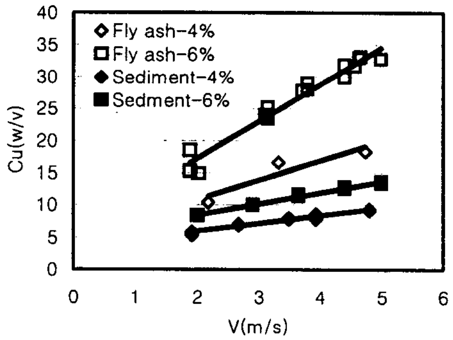
Size	PH	VSS(%)	TOC(%)	T-N(mg/kg)	T-P(mg/kg)
Raw	7.22	9.97	1.81	1054	145
~ 106µm	7.09	9.24	1.95	1492	191
~ 213µm	6.82	8.69	1.82	1467	160
~ 405µm	6.84	5.39	1.20	639	101
~ 850µm	6.88	4.68	0.98	638	73

Effect of density

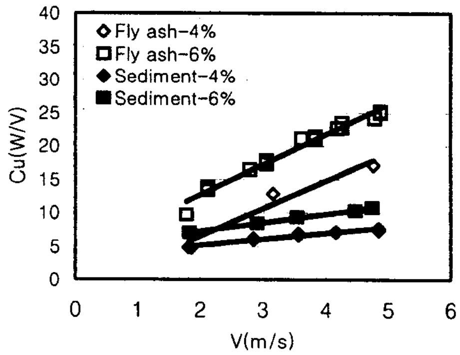
Fig. 3 shows the solid concentration which is collected in underflow with variation of the two different feeding loads (4% and 6%). The solid load for in-situ dredgement is about 4~6%. The coal fly ash results in more effective separation for both cyclones than the sediment.

Effect of configuration

In order to investigate the effect of configuration of the device, two medium sized cyclones (Dc = 50mm) were selected from Cyclones-I, and Cyclone-II. More strictly speaking, the effect by the length of cone and apex diameter was examined with reference to the grade efficiency. As far as in the present condition, no significant difference was found, just only a little better performance in a longer cyclone. It might be achieved by longer retention time of the fluid flow.



(a) Dc = 30mm



(b) Dc = 50mm

Fig. 3 Concentration of underflow with inlet velocity according to the feed load.

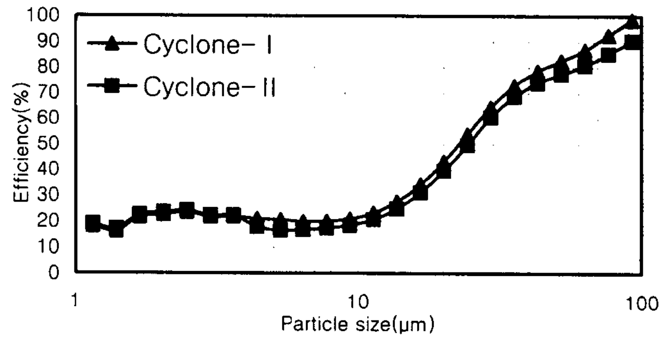
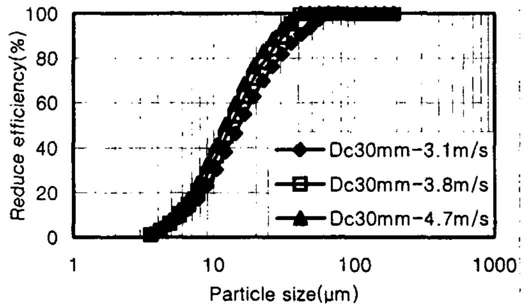


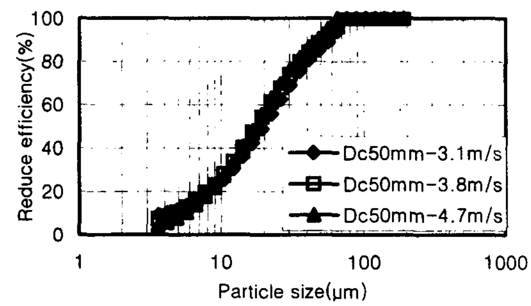
Fig. 4 Separation efficiency depending on cyclone size.

Effect of inlet velocity

Inlet flow velocity affects the separation of most centrifugal devices. Different sized cyclones were tested with the variation of inlet velocity. As can be expected, Fig. 5 shows higher separation efficiency when higher velocity applied, with the cut diameters of 13μm, 14μm, ad 16μm, respectively. As can be seen in Fig. 5(b), however, larger cyclones presented less difference depending on inlet velocity.



(a) Dc = 30mm



(b) Dc = 50mm

Fig. 5 Grade efficiency with inlet velocity.

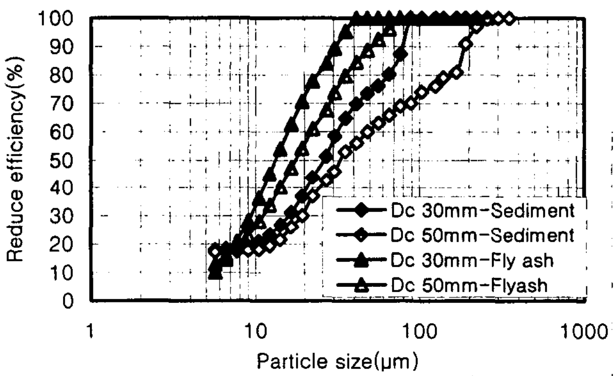


Fig. 6. Effect of cyclone size (Sediment and Fly ash).

More obvious results could be seen in Fig. 6 heavier fly ash was more easily separated in a small cyclone. In practical application, we need large cyclones in order to meet cost effectiveness. However, the obtained results in the present work require further detailed and wide comprehensive works. In particular, low efficiency for the fine particles less than 10μm must be up-graded by discovering the optimum design and operation condition.

CONCLUSIONS

The present study has been carried out as a basic research in order to apply the hydrocyclones to the primary process of particulate separation in waste sludge treatment and dredging operation of the lakes. Application of hydrocyclones to the in-suit dredging operation can lead to the rapid treatment and narrower area. Although small particles contain large volume of organic contaminations, its separation efficiency was so low. Thus, more experimental works including process arrangement and adjustment of configuration design must be followed in near future.

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