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POSSIBILITIES OF GRAVITATIONAL AND MECHANICAL SEPARATION OF SONICATED ACTIVATED SLUDGE SUSPENSIONS

Activated sludge preconditioned before thickening and dewatering with the use of ultrasonic wave was investigated. The aim of the studies was to estimate the effect of sonication parameters on the efficiency of sludge solid phase separation in the gravitational and mechanical processes. The ultrasound wave parameters were characterized by different sound amplitudes, propagation times and constant frequency values. The results of the experiments were also estimated, depending on input energy value. The improvement in settling properties and the reduction of final hydration during thickening were observed as a result of sonication. However, mechanical dewatering brought negative effects, namely: deterioration of capillary suction and final hydration values.

1. INTRODUCTION

Ultrasounds are used to enhance the effectiveness of unit processes in wastewater and sludge treatment. Sonication is a particularly promising technology for sludge utilization. Numerous researchers report that ultrasonic pretreatment of excess sludge before its anaerobic digestion intensifies biogas and methane production [1]. Sonication leads to sludge floc disruption, an increase in chemical oxygen demand and matter solubilisation. Ultrasonic disintegration of microorganisms releases the organic compounds into the aqueous phase and increases the biodegradability of substrates [2]. Ultrasonic pretreatment could be used to improve biological activity. A few steps in intercellular metabolisms may be supported by ultrasounds [3]. Sonication is also a promising technology for polymer degradation and the oxidation of organic contaminants in wastewater [4]. Ultrasounds can be used to improve solid/liquid separation processes. Ultrasonic treatment changes the settleability of sludge, accelerates sedimentation, and enhances thickening ability of sludge [5], [6]. The aim of this

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study was to find out the importance of sonication time and amplitude as the functions of ultrasonic energy in a form of the conditioning results obtained.

2. MATERIALS AND METHODS

The experiments were done with waste activated sludge (WAS) obtained from the municipal-industrial treatment plant in Koniecpol, which receives wastewater from fibreboards factory (10% flow rate of municipal wastes). Sludge suspension was sampled directly from an aeration tank. The following parameters were determined: sludge volume index, thickening degree, final hydration after sedimentation, capillary suction time, filtration velocity and final hydration after vacuum filtration. In order to investigate technological parameters of sludge, all analyses were conducted according to national standard methods: PN-EN 12879, PN-EN 12880, PN-EN 14701-1, PN-EN 14701-2, PN-EN 14702-1, and PN-EN 14702-2. Sonication was performed with an ultrasound generator Hielscher UP 400S operating at a frequency f = 24 kHz. The scope of the research covered determining the influence of the ultrasonic energy, the amplitude of the ultrasonic wave and the sonication time of the separation process. Conditioning procedures were based on constant ultrasonic energy, which required the application of changeable sonication time (the table).

Table

Sonication parameters used in experimental study

Amplitude A = 45 μm	Ultrasonic intensity I = 52.5 W/cm^2	Sonication time (s)	0	60	120	180	240	300	360
		Ultrasonic energy (kJ/cm^2)	0	3.15	6.30	9.45	12.60	15.75	18.90
Amplitude A = 90 μm	Ultrasonic intensity I = 105 W/cm^2	Sonication time (s)	0	30	60	90	120	150	180
		Ultrasonic energy (kJ/cm^2)	0	3.15	6.30	9.45	12.60	15.75	18.90

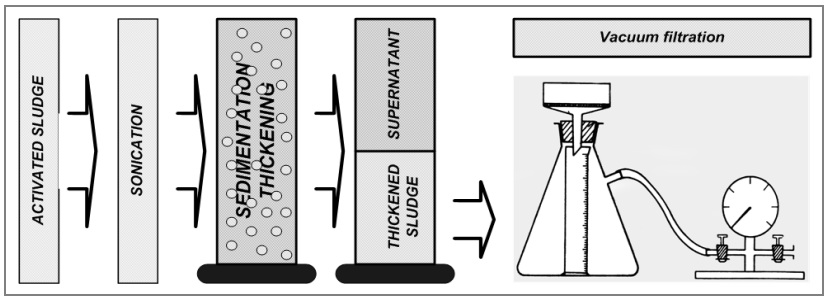

Fig. 1. Experimental stages of ultrasonic pretreatment

The effect of sonication was monitored on the basis of typical technological sequence of sludge dewatering (figure 1).

3. RESULTS AND DISCUSSION

As is commonly known, solid–liquid separation and such parameters as sludge volume index, separation degree and final hydration of thickened sludge determine the efficiency of wastewater treatment and affect sludge treatment. Sedimetation is an important step in the concentration of the activated sludge and it will always be difficult when particle size and density are decreasing and porosity is growing. Another biological parameters characteristic of activated sludge flocs have an important effect on its settleability and thickening ability. In the initial phase of the study, sedimentation properties were estimated through the changes of values in the sludge volume index (SVI) (figure 2). The values of SVI test showed a decreasing tendency, depending on the level of ultrasonic energy. After comparing sonication variants, it was observed that settling velocity may be increased by increasing sonication time at the lower amplitude of ultrasonic wave.

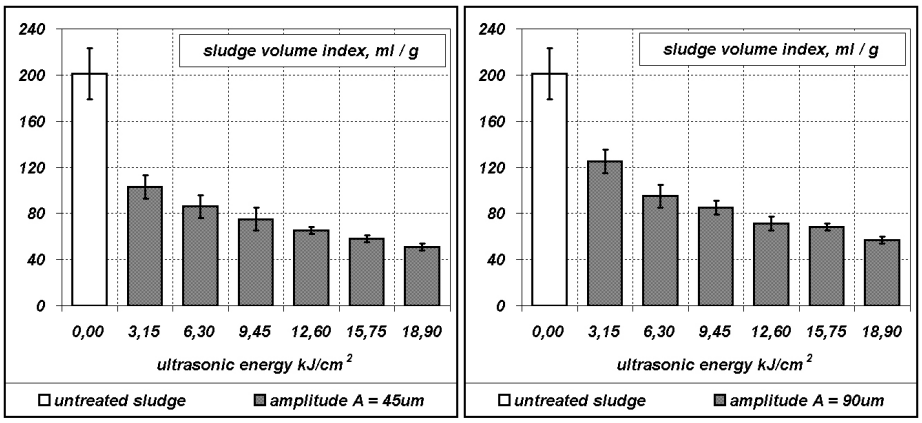

Fig. 2. Changes of SVI values resulting from sonication treatment

Two parameters determined the efficiency of separation process – final hydration of thickened sludge and thickening degree (figures 3, 4). Sonication of sludge led to breaking up the floc structure into smaller pieces, which resulted in compressibility improvement and reduction of final hydration. Data analysis of the thickening degree showed that extending both sonication time and ultrasound amplitude had an unfavourable influence on the efficiency of solid–liquid separation. The application of ultrasonic wave at the amplitude of A = 90 μm was more effective both in the case of the decrease of final hydration and a smaller reduction of thickening degree. The

thickening degree indicated the occurrence of a large quantity of unsettled suspended solid in the volume of supernatant.

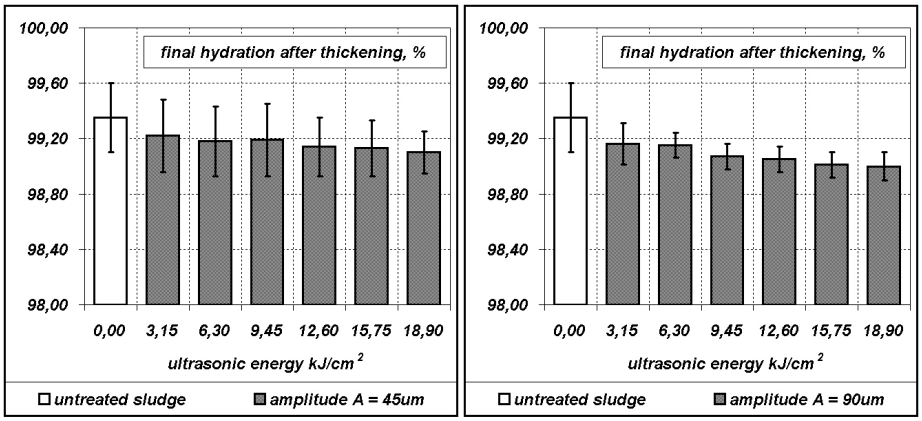

Fig. 3. Final hydration of sonicated sludge after thickening

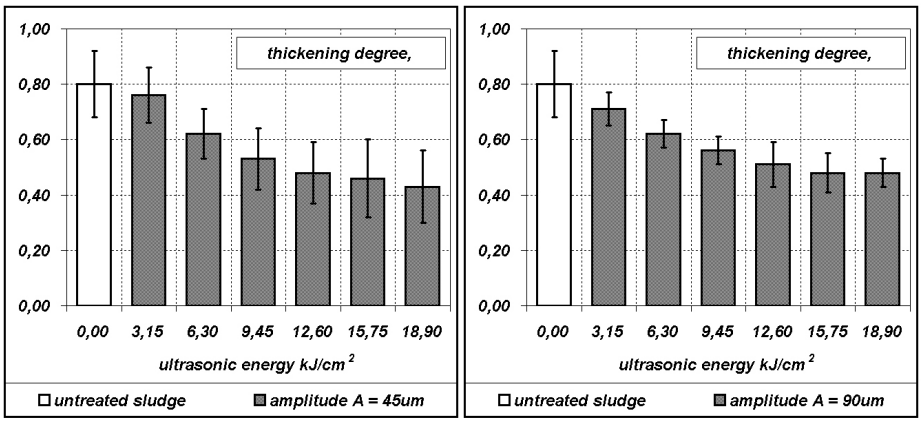

Fig. 4. Thickening degree of sonicated sludge

During investigating dewatering ability, two basic measurements were carried out: capillary suction time and dewatering on vacuum filter (figures 5, 6). Sonicated sludge after the thickening process released water from the floc structure with difficulty. The CST test showed that the method applied was not effective. Extending sonication time and amplitude lengthened capillary suction time. Moreover, it was observed that final hydration values increased with growing increase of ultrasonic frequency. Describing the importance of the parameters of the input energy, we noticed that different effects of preparation could be achieved at the same energy level, depending on the combination of sonication times and amplitudes. The parameter

values characteristic of dewatering process on vacuum filter confirmed that disintegration effects were more distinct at higher amplitude (A = 90 μm).

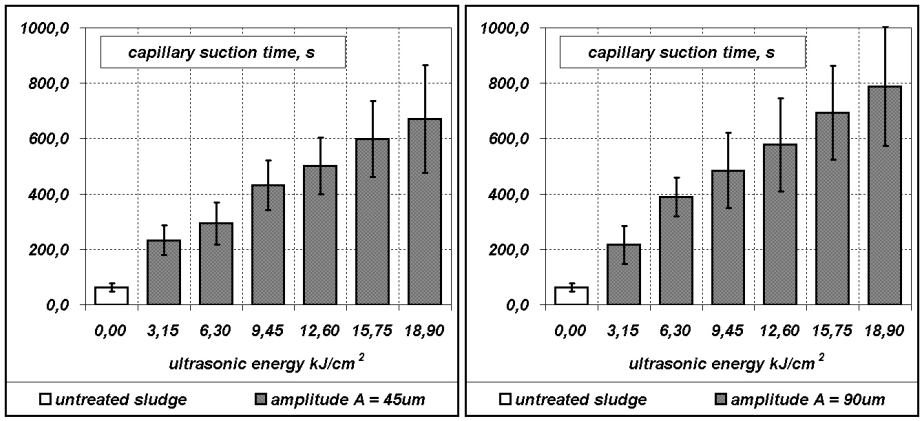

Fig. 5. Changes of CST values of thickened sludge

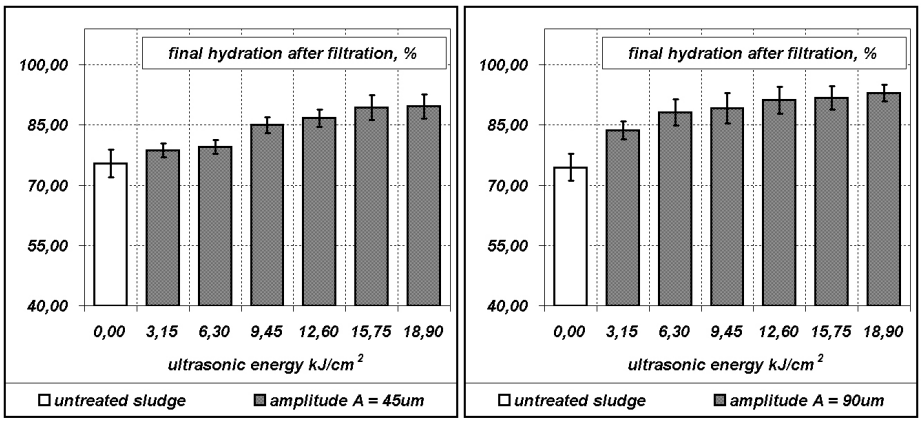

Fig. 6. Final hydration of filtration cake of sonicated sludge

4. FINAL OBSERVATIONS

Ultrasounds significantly changed the technological properties of prepared sludge. The sonication applied only once, at the beginning of technological sequence of sludge treatment, was critical for all processes. Pretreatment of sludge changed its settling properties, thickening ability and dewatering efficiency. Undoubtedly, the digestion process will also be modified. In the research conducted, the intensification of sedimentation and thickening by ultrasounds can be used in a limited range, par-

ticularly in the case of flotation and foaming of sludge. The possibility of intensifying the sludge dewatering by means of ultrasounds should be excluded. Suitable selection of sonication parameters and input energy of ultrasound play a key role in the process of preparation. Higher input energy intensified the changes, which became greater with the increase of ultrasound frequency. Preparation time and amplitude describe also an input energy of sonication, and the effect of ultrasonic treatment depends on ultrasound magnitude. It was noticed that the combination of wider amplitude and shorter sonication time were more destructive, hence may be treated as a better disintegration method. Changes of the technological properties of prepared sludge were definitely diminished with the application of narrower ultrasound amplitude. That confirms ultrasound application to be a useful method for solid–liquid separation, which does not change their chemical properties. Although sonication is still an expensive technique to be used on a large scale, these experiments considerably advanced the problems of preparation efficiency and ultrasonic energy expenditure.

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GRAWITACYJNA I MECHANICZNA SEPARACJA ZAWIESIEN OSADU CZYNNEGO, KTÓRY PODDANO DZIAŁANIU FALI ULTRADŹWIĘKOWEJ

Przedstawiono zmiany sprawności separacji grawitacyjnej i mechanicznej zawiesin osadu czynnego poddanego działaniu fali ultradźwiękowej. Efekty sonifikacji obserwowano w formie zmiennych procesu, tj. czasów i amplitud nadźwiękawiania oraz koncentracji osadów. Określono wybrane wskaźniki charakterystyczne dla procesu sedymentacji i zagęszczania oraz mechanicznego odwadniania. Korzystnym efektem propagacji fali ultradźwiękowej było m.in. przyspieszenie procesu separacji grawitacyjnej. Negatywne zmiany zaobserwowano podczas odwadniania osadów, co manifestuje się zwiększeniem oporu filtracji. Zjawiska te analizowano, opierając się na wielkości wniesionej energii sonifikacji, oznaczając tendencje występujące podczas propagacji fali ultradźwiękowej.