Chapter IV

EXPERIMENTAL INVESTIGATION

4.1 Chemical reagent used in the experiment

Chemical reagent used for promote particle agglomeartion when contact occurs. Polyaluminum chloride was used as coagulant to charge neutralization of colloidal suspension. And anionic polymer was used as flocculant to generate strength of floc in the system. Description of polyalumimun chloride and anionic polymer are shown as follow:

4.1.1 Polyaluminum chloride (PACl) coagulant

PACl coagulant is used for destabilization of colloidal particles, some informations of PACl are shown as:

4.1.1.1 General information of Polyaluminum chloride, using in Japan (Japan Water Work Association, 1978). PACl is a liquid that itself hydrolysed and polymerized, and it is widely used in Japan as a very effective coagulant. This reagent shows an excellent coagulation superior to that of alum, has a wide range of dosage and less reduction of alkalinity. Because of its easiness in treatment, this chemical has found steady use in water works in the cold regions and small-scale plants in recent years. Considering in technical and economic angles, use alum coagulant at normal time and PACl at the time of high turbidity or low temperature. When alum is used as coagulant, coagulant aid will be required. But when PACl is used, generally need no coagulant aid. From the standards of coagulants in Japan, shown that PACl in a solution of 10.0 to 11.0 percent concentration as Al_2O_3, specific gravity of PACl at 20 degree Celsius is more than 1.19, pH is 3.5 to 5 and basicity of PACl is 42 to 60 precent while alum itself do not have basicity. Reduction of Alkalinity by injection of coagulant 1 ppm., indicate that Polyaluminum chloride (10 percent as Al_2O_3, 50 percent basicity) have reduction effect of 0.15 ppm. of alkalinity which is slightly less alkalinity reduction than using alum as coagulant.

4.1.1.2 General information of polyaluminum chloride coagulant used in this research, was a Japanese powder product of Takei Chemical Co., that can be described as follow:

a) PACl is a special basic salt of aluminum chloride designed to give much stronger coagulatating and flocculating power than ordinary aluminum and iron salts. Its highly competitive merits over conventional coagulant chemicals in water treatment.

b) PACl is a polynuclear complex of polymerized aquo-aluminum ions, a kind of inorganic polymer with its molecular weight being several hundreds. It is generally formulated as " $Al_n(OH)_mCl_{3n-m}$ " combined with small amounts of other components.

4.1.1.3 Polyaluminum chloride coagulant used in this research is hygroscopic powder type, code name is PAC-250AD. The specification of PACl are shown in table 4.1 as follow:

Table 4.1 Specification of polyaluminum chloride used in this investigation.

Specification of Polyaluminum Chloride

Code name	PAC-250AD
Appearance	Hygroscopic powder
Al_2O_3 (%)	Min. 30.0
Fe (%)	Max. 0.03
As (ppm)	Max. 20
Mn (ppm)	Max. 75
Cd (ppm)	Max. 6
Pb (ppm)	Max. 30
Hg (ppm)	Max. 0.6
Basicity (%)	50.0 ± 5.0

4.1.1.4 Characteristic of PACl as coagulant are shown as:

a) Strong coagulating and flocculating power, to produce good flocs which settle down rapidly to form an easily filtrable sludge

b) Reduced or no consumption of alkali aids, coagulation with PACl do not much alkali aid needed as with other coagulants. So that pH value of water remains approximately neutral even if an overdosage of PACl take place

c) PACl dose not require any other coagulant aids

d) Effectiveness in wide range of pH, PACl works in a wider range of pH than alum and other coagulants, generally useful in pH 6-9 but in some cases it is also serviceable in a wider range of pH 5-10.

e) Rapid formation of flocs, PACl forms flocs more rapid than alum coagulant, also leading to shorten the rapid mixing time.

4.1.2 Anionic polymer flocculant

FLOERGER AN 910 PWG is an anionic polyacrylamide type flocculant, anionic polymer. This flocculant was a powder product of SNF, which was used as flocculant in this research. The specification of flocculant are shown in table 4.2 as follow:

Table 4.2 Specification of anionic polymer flocculant used in this investigation.

Specification of Anionic Polymer

Code name	FLOERGER AN 910 PWG
Mesh size (mm.)	1.25
Maximum concentration of dissolution (g./l.)	10
Stability of this solution (in days)	5

4.2 Experimental apparatus

Experimental apparatus in this research consisted of constant head tank, rapid mixing tank used for destabilization of colloidal suspension, fluidized pellet-floc bed clarifier used for pellet flocculation and sedimentation in the same unit. And sludge concentrator used for collecting and concentrating of excess pellet flocs which were drained from the clarifier.

Two main parts of the experimental apparatus were shown as follow:

4.2.1 Rapid mixing tank

The rapid mixing tank was a mechanically mixed tank, back-mixed unit type, cylindrical shape basin with 5.4 cm. of the inner diameter. The turbid water was fed at the bottom of the basin and PACl coagulant was fed into the mixing tank near the bottom part and under the lowest paddle agitator for charge neutralized of the suspension. The speed of paddle agitation was fixed at 100 rpm. When upflow velocity of 30 cm./min. was used, the coagualated water flew through the two-stage paddles agitator and overflew at 20.6 cm. height of the basin. Thus the detention time was about 41 seconds. When upflow velocity of 40 cm./min. was used, the coagulated water flew through the three-stage paddles agitator and overflew at 30.2 cm. height of the mixing collumn. So that, the detention time was about 45 seconds. The mixing collumn, rapid-mix tank was shown in the figure 4.1.

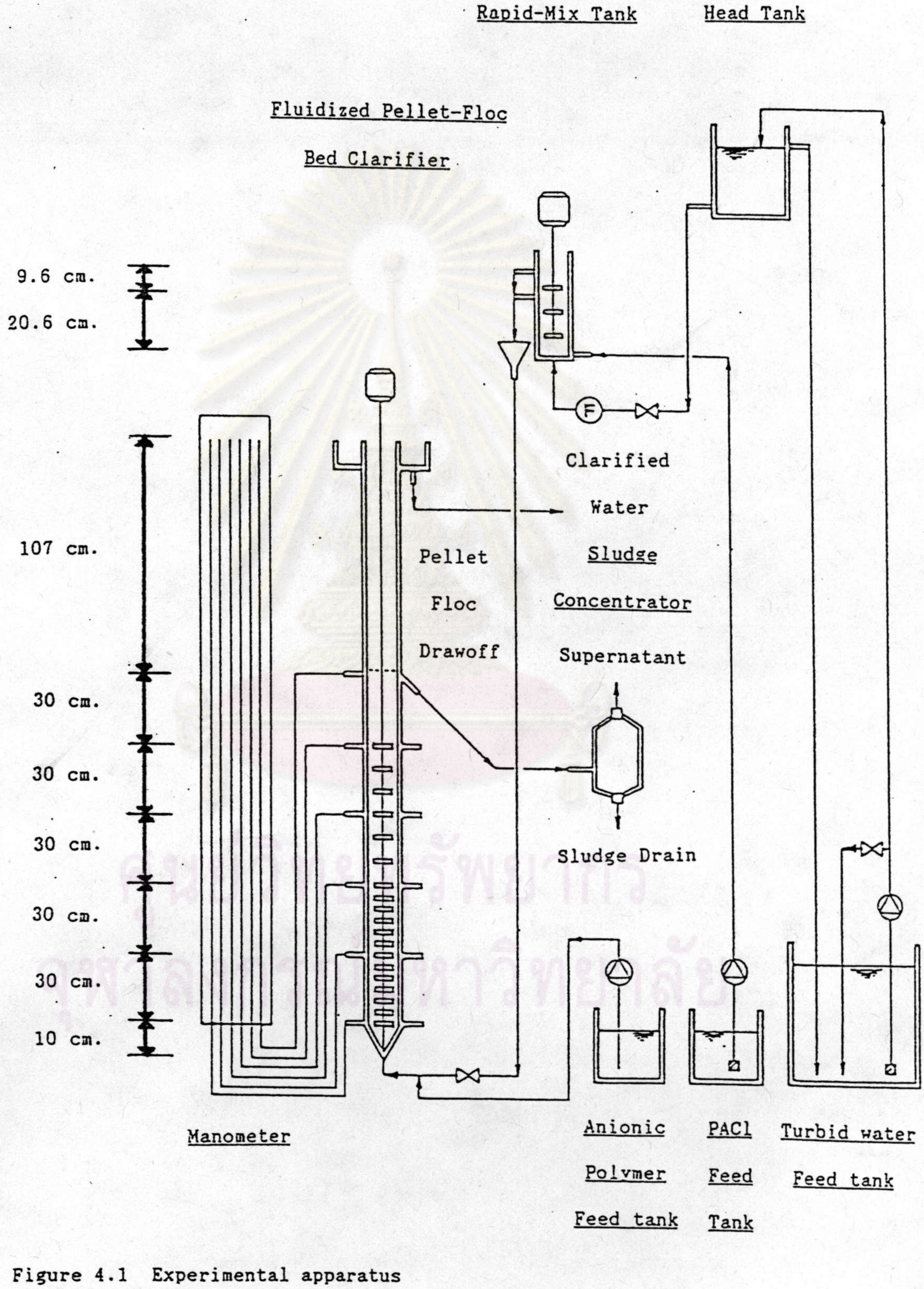

Figure 4.1 Experimental apparatus

4.2.2 Fluidized pellet-floc bed clarifier

The inner diameter of the fluidized pellet-floc bed clarifer was 5.4 cm., made of plastic glass collumn. The clarifier consisted of 10 cm. height of conical inlet bottom part and 257 cm. height of cylindrical upper part. This clarifier consisted of multiple-stage paddles along 120 cm. of the cylindrical height of the clarifier. The fluidized pellet-floc bed height was fixed at around 150 cm., along the cylindrical upper part. The excess flocs were continuously drewoff at the 150 cm. height of the cylindrical part of the clarifier into sludge concentrator. Clarified water passed through the fluidized bed and overflew at the top of the clarifier. The fluidized pellet-floc bed clarifier was shown in figure 4.1.

4.3 Experimental procedure

A 50 NTU turbid water was sent into the clarifier for water purification process. The 50 NTU turbid water was prepared by dilution of highly turbid water, of about 3000 mg./l. of kaolinite suspension, with tap water. Therefore removing of low-concentration suspension was carried out by using a fluidized pellet-floc bed clarifier. Pellet flocculation in 50 NTU turbid water treatment step was described as following procedure:

Polyaluminum chloride coagulant was added at neutral pH to charge neutralization of 50 NTU clay suspension by using rapid mixing tank to generate microflocs. The rapid mixing condition was agitating the water with paddle rotating speed of 100 rpm. And the detention time was about 40 seconds were proposed in the rapid mixing tank.

Under the bottom inlet part of the fluidized pellet-floc bed clarifier, anionic polymer flocculant was added directly to the coagulated particles or microflocs to give strong binding forces of flocs. The microflocs which was attached to the anionic polymer behave as the elementary particles in following process reaction.

The elementary particles were sent into the fluidized pellet-floc bed. And agglomerated onto the pellet flocs and the other elementary particles in the pellet-floc bed.

After that, the clarified water which passed through the fluidized pellet-floc bed would overflow at the top of the fluidized pellet-floc bed clarifier. Thus in very high upflow velocity condition, the treated water from the clarifier was very clear.

At the point of 150 cm. of cylindrical height of the clarifier, excess pellet flocs were continuously drawnoff to sludge concentrator in order to kept constant height of the fluidized pellet-floc bed and get rid of excess flocs carry over from the process. The rate of excess drawoff was kept constant at about 15 % of the inflow rate in this investigation.

Above mentioned experimental procedures were repeated with different combination of various experimental conditions with respected to following parameters:

a) Various coagulant dosages, polyaluminum chloride dosages were 1, 2, 3, 4 mg./l.

b) Various flocculant dosages, anionic polymer dosages were 0.1, 0.2, 0.3 mg./l.

c) Various paddle agitating speed in the fluidized pellet-floc bed clarifier were 5, 10, 15 rpm.

d) Various upflow velocity in the fluidzed floc bed clarifier were 30, 40 cm./min.

The experimental results were presented as follow:

a) The clarified water turbidity was presented in Nephelometric turbidity unit (NTU).

b) Nature of generated pellet flocs such as settling velocity of pellet flocs were presented in cm./min. and diameters of pellet flocs were indicated in mm.

4.4 Experimental analysis method

Experimental analysis method consisted of floc-sampling method, flocs settling velocity determining, sizing of flocs using microscope and clarified water turbidity measurement.

4.4.1 Floc-sampling method

Sampling flocs by suction device, that designed for this experiment. Flocs from the fluidized pellet-floc bed were sampled by gently suction into 6 mm. of inner diameter tube that one end was connected to the syringe. After that the flocs were kept in the cylindrical container. By free settling of flocs under the surface of clarified water, in the cylindrical container. Before using for diameter sizing and settling velocity determining of the pellet flocs.

4.4.2 Flocs settling velocity determining

In this investigation the experimental method in which the settling velocity of a discrete floc was measured in a quiescent water collumn. Flocs were introduced into the quiescent settling collumn with 6 cm. of inner diameter. And a discrete floc was followed for 5 cm. distance through the two makred lines. The time required to settle 5 cm. distance were measured. Thus, the floc settling velocity could be calculated.

4.4.3 Sizing of flocs using microscope

Particle sizing by microscope with a 4X or 10X objective lenses and 10X occulars or eyepieces, including with microscale in eyepiece lense. Arbitary technique was used to sizing flocs by microscopy. For spherical flocs, the diameter was the appropriate measurement. For irregular flocs, projected area employed in this experiment, in which projected area diameter was the diameter of a circle having an area equal to the projected area of the floc.

4.4.4 Turbidity measurement

Turbidity of treated water was measured with a Hach 2100 A turbidimeter using latex solution standards which turbidity measurements with an accuracy of 0.01 NTU could be made. Gently mixing of treated-water sample before turbidity measurement, the clarified water turbidity was expressed in Nephelometric turbidity unit (NTU).