

REFERENCE

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ศูนย์วิทยทรัพยากร
อุปกรณ์มหาวิทยาลัย

APPENDIX A



ศูนย์วิทยทรัพยากร
จุฬาลงกรณ์มหาวิทยาลัย

APPENDIX A

Equation for determining the mean velocity gradient

The author suggested that G value of these apparatus, the rapid mixing tank and the fluidized pellet-floc bed clarifier quite be around G value that evaluated by jar tester, maximum G value is generally about 100 /sec. So, in this investigation the author would like to use the same equation for determining the G value of rapid mixing tank and agitation of the clarifier.

Mechanical velocity gradient in mechanical agitation, paddle revolve on a horizontal or vertical shaft. In such systems the power input is a function of the drag force of the paddle, which expressed as

$$F_d = 1/2 C_d A p v^2$$

therefore P , the power input per unit column , will be

$$P = \text{force} \times \text{velocity}$$

$$\text{so } P = 1/2 C_d A p v^3$$

for mechanical velocity gradient

$$G = [P / (u V)]^{1/2}$$

$$\text{or } G = [C_d A p v^3 / (2 u V)]^{1/2}$$

in which

F_d = drag force (kg.m./s.²)

C_d = coefficient of drag

A = area of paddle (m.²)

ρ = density of water (kg./m.³)

v = velocity of the paddle relative to the water
(m./sec.) is about 0.75 of peripheral speed
of the paddle (v_p)

P = power input per unit volume (N.m./s.)

G = velocity gradient (1/sec.)

μ = dynamic viscosity (N.s./m.²)

V = volume of unit (m.³)

Calculation of mean velocity gradient value

From above equation G value at 25 degree Celsius can be calculated as follow:

C_d is 1.8

A is 7.2×10^{-4} m.² (for each paddle)

ρ is 997 kg./m.³

v_p is peripheral speed of the paddle

v is 75 % of v_p

then v^3 is 0.42 (v_p^3)

μ is 0.89×10^{-3} N.s./m.²

V is arbitrary volume of each paddle

therefore

$$G \text{ value is } (304.88 v_p^3 / V)^{1/2}$$

from above value could be determined the G value as following
table:

Paddle Speed (rpm.)	v_p^3 (m. ³ /s. ³)	Paddle Spacing (cm.)	V (m. ³)	G value (sec. ⁻¹)

Slow Mixing

5	1.53×10^{-6}	5	1.14×10^{-4}	2.02
5	1.53×10^{-6}	10	2.29×10^{-4}	1.43
10	1.22×10^{-5}	5	1.14×10^{-4}	5.70
10	1.22×10^{-5}	10	2.29×10^{-4}	4.03
15	4.13×10^{-5}	5	1.14×10^{-4}	10.49
15	4.13×10^{-5}	10	2.29×10^{-4}	7.42

Rapid Mixing

100	1.22×10^{-2}	10	2.29×10^{-4}	127.45

APPENDIX B

ศูนย์วิทยทรัพยากร
อุปกรณ์คอมพิวเตอร์

APPENDIX B

Exerimental results of each run

The experimental condition was consisted of the following parameters:

- a) Polyaluminum chloride dosages were 1, 2, 3, 4 mg./l.
- b) Anionic polymer dosages were 0.1, 0.2, 0.3 mg./l.
- c) Speeds of paddle agitation were 5, 10, 15 rpm.
- d) Upflow velocities were 30, 40 cm./min.

The experimental results of each run were shown as:

- Effluent turbidity with time;
- Pellet-floc settling velocity with time at various fluidized pellet-floc bed height;
- Pellet-floc diameter with time at various fluidized pellet-floc bed height.

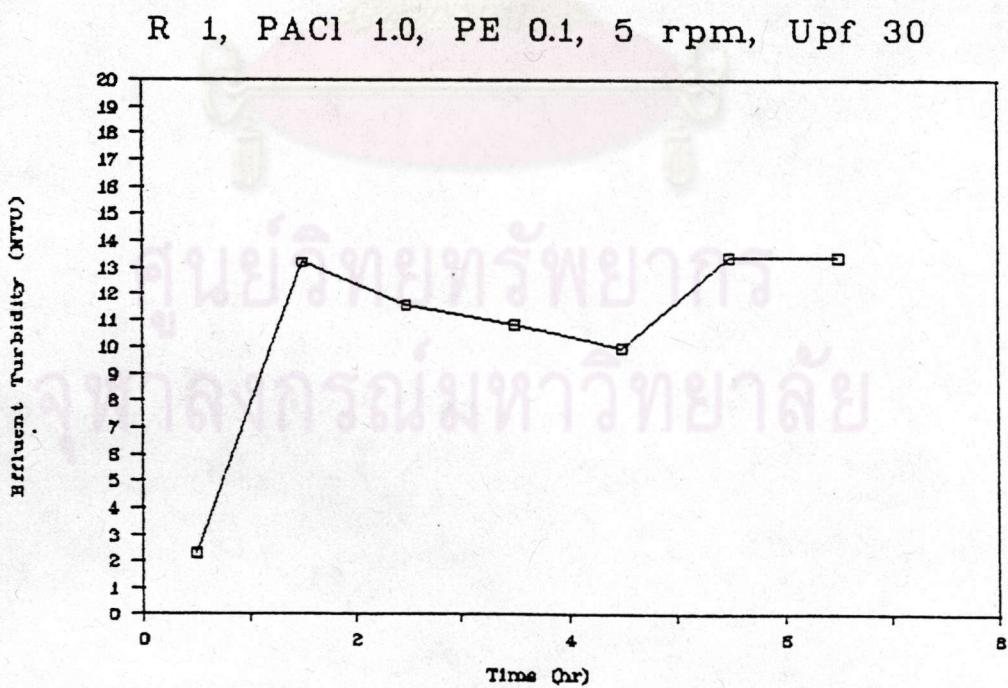
Thus detail of the experimental results of each run were shown as follow:

RUN NO. 1

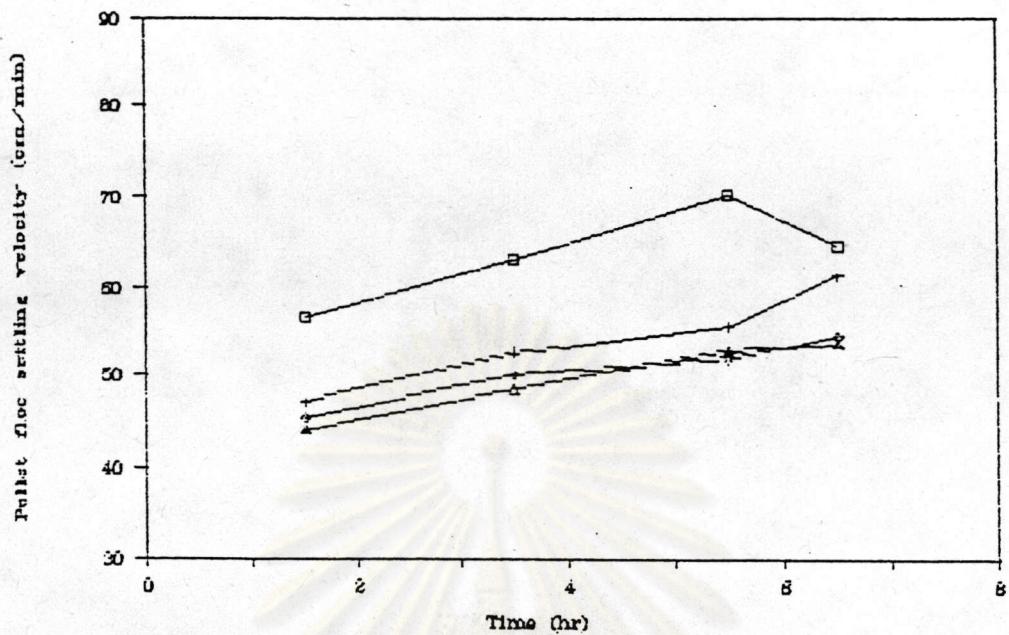
The experimental condition was consisted of the following parameters:

- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 30 cm./min.

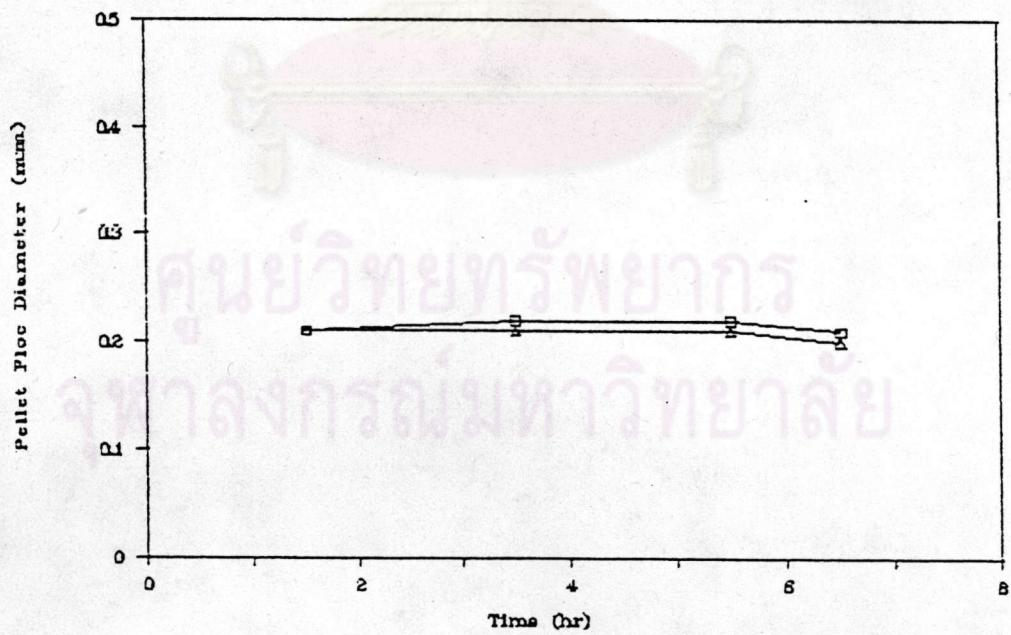
The experimental results of each run were shown in the following figures:



R 1, PACl 1.0, PE 0.1, 5 rpm, Upf 30



R 1, PACl 1.0, PE 0.1, 5 rpm, Upf 30



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

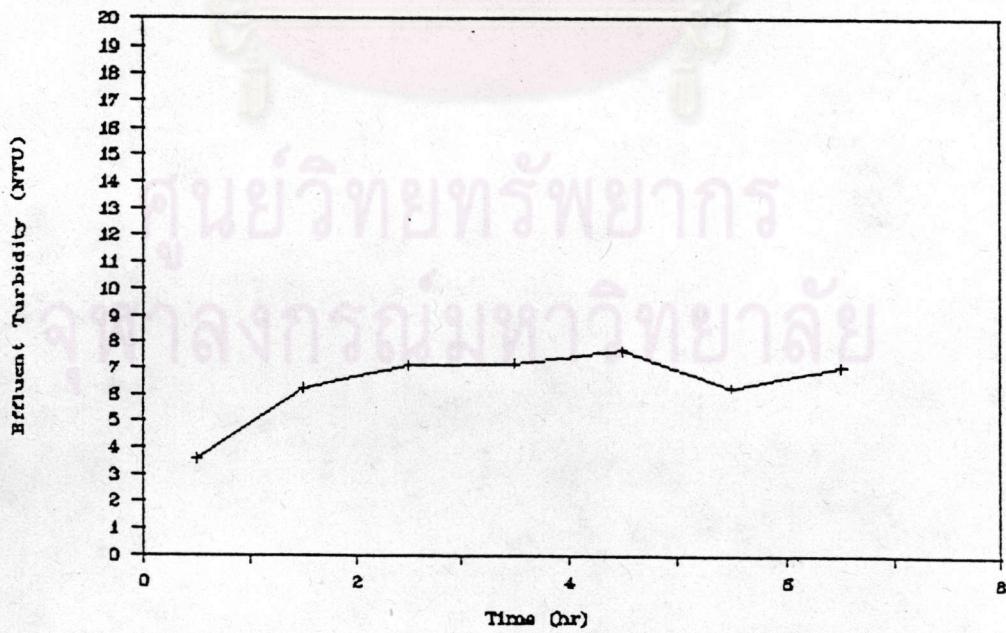
RUN NO. 2

The experimental condition was consisted of the following parameters:

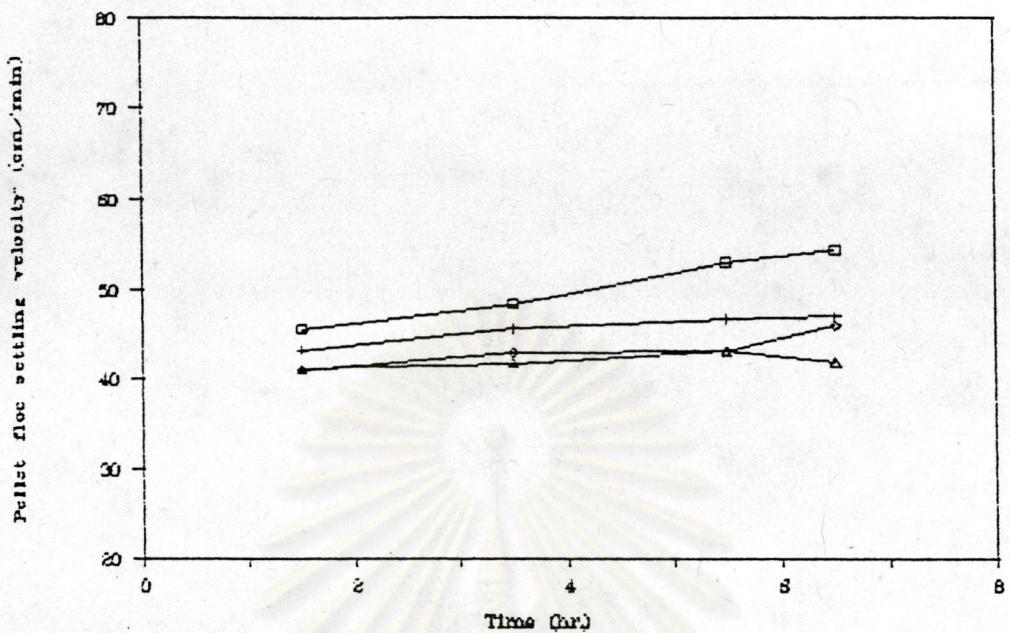
- a) Polyaluminum chloride dosage was 2 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

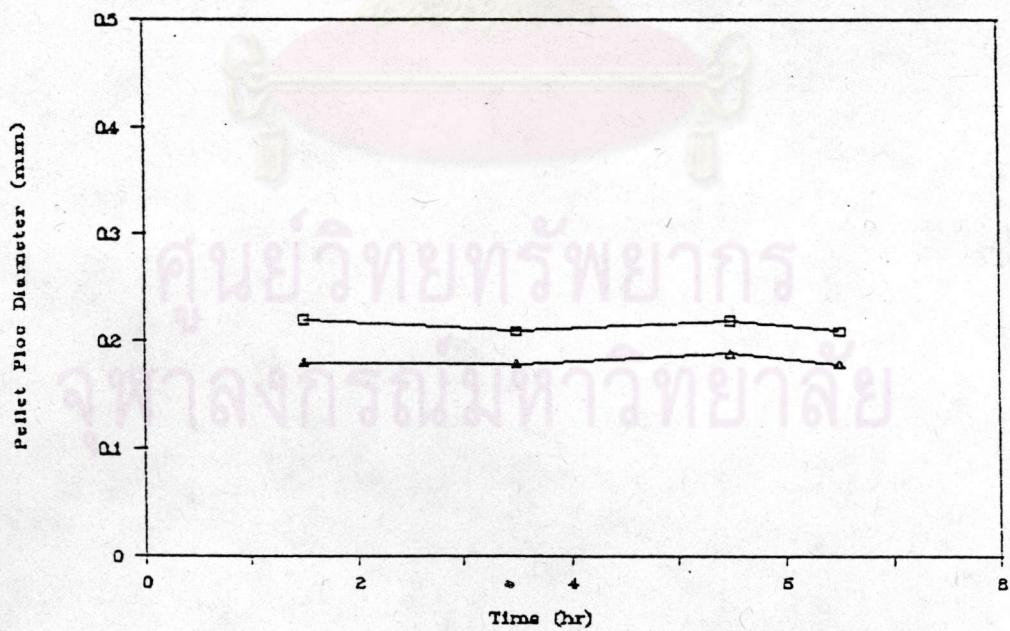
R 2, PACl 2.0, PE 0.1, 5 rpm, Upf 30



R 2, PACl 2.0, PE 0.1, 5 rpm, Upf 30



R 2, PACl 2.0, PE 0.1, 5 rpm, Upf 30



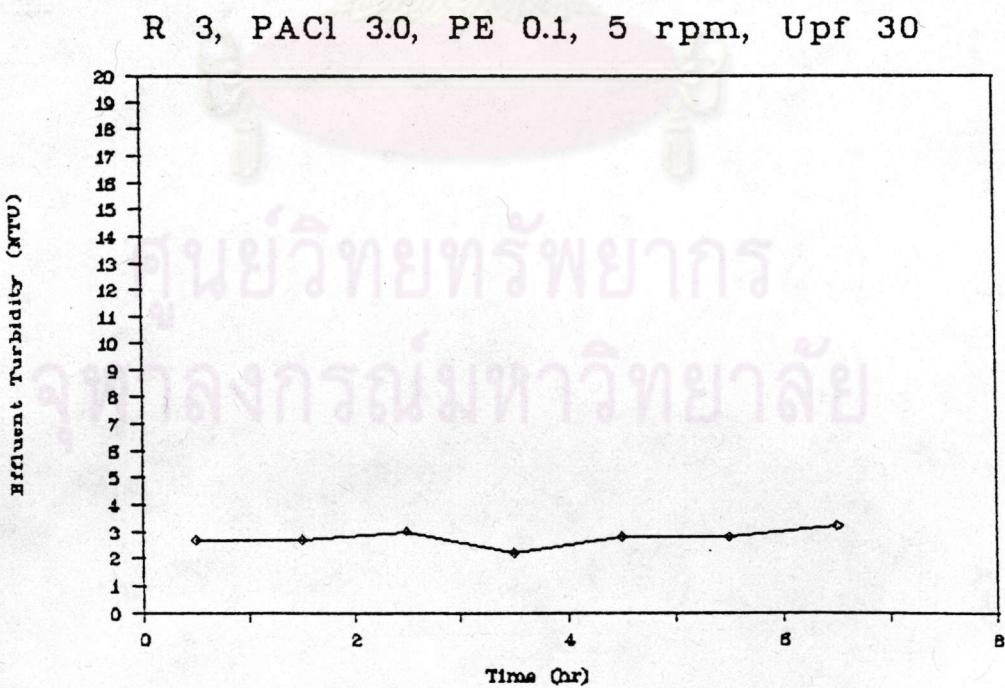
□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

RUN NO. 3

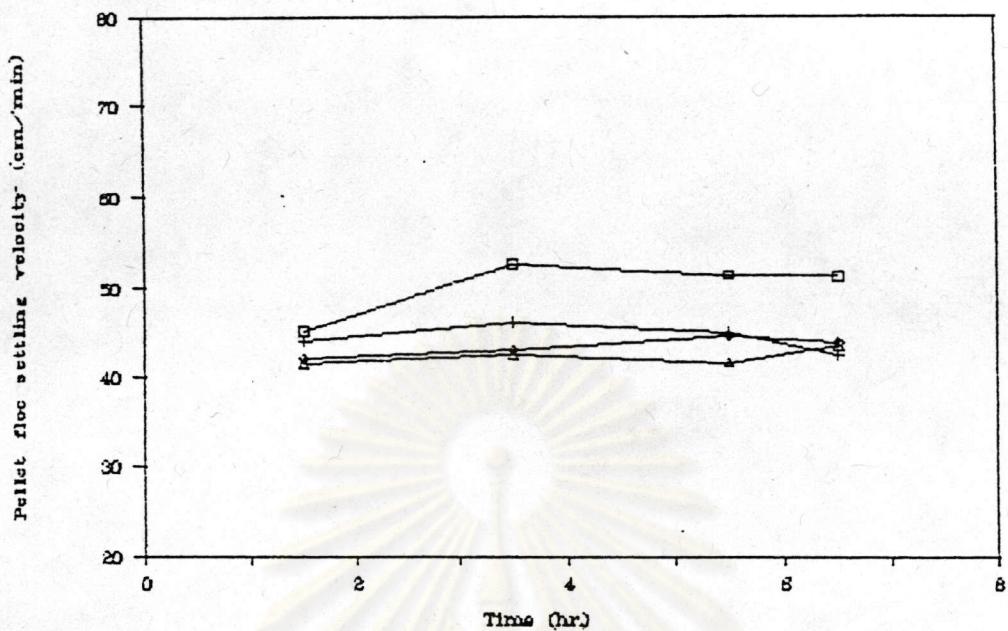
The experimental condition was consisted of the following parameters:

- a) Polyaluminum chloride dosage was 3 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 30 cm./min.

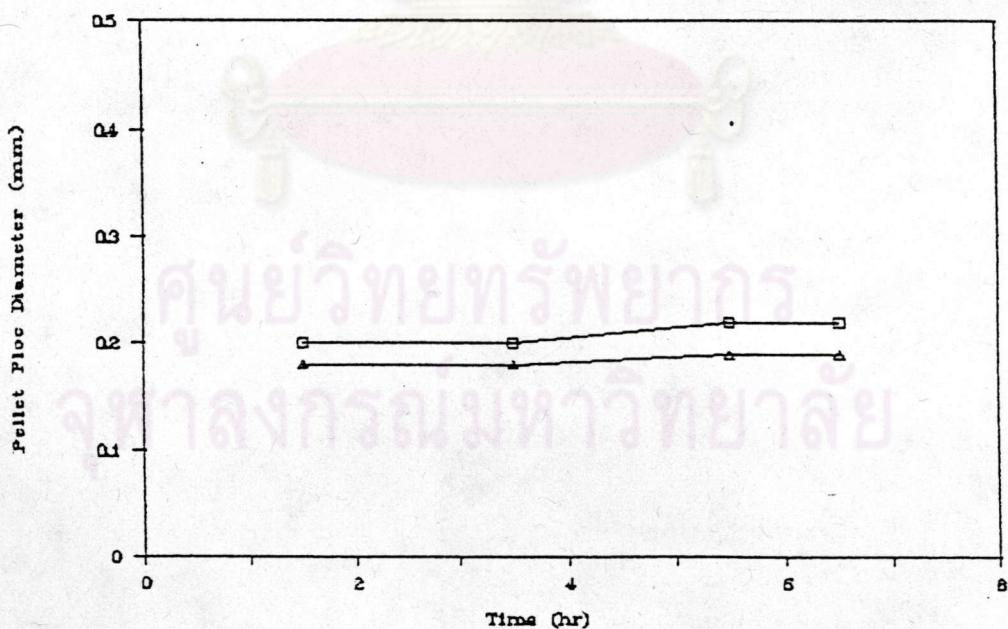
The experimental results of each run were shown in the following figures:



R 3, PACl 3.0, PE 0.1, 5 rpm, Upf 30



R 3, PACl 3.0, PE 0.1, 5 rpm, Upf 30



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

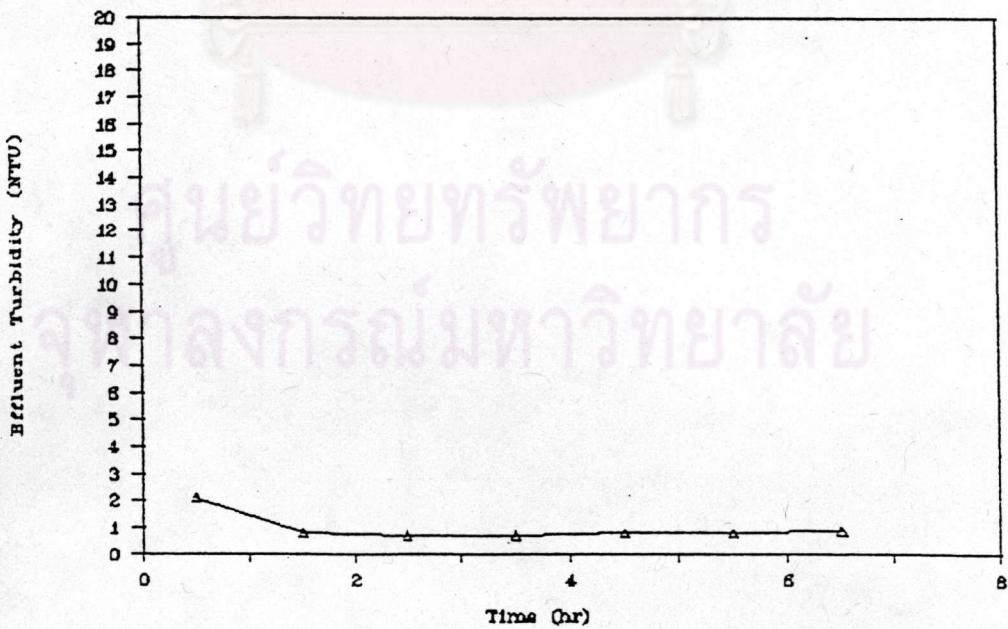
RUN NO. 4

The experimental condition was consisted of the following parameters:

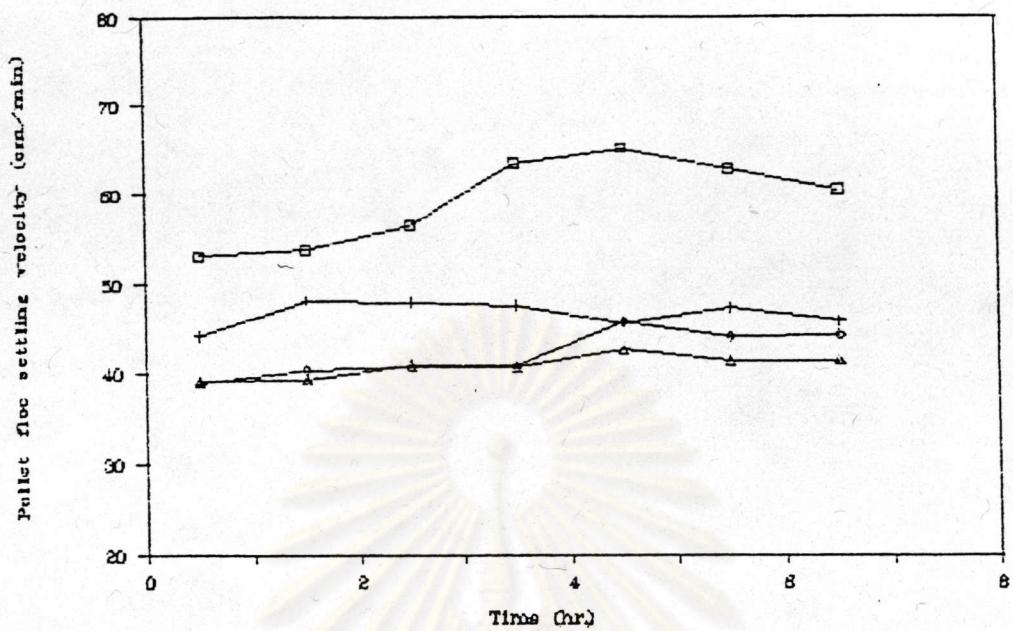
- a) Polyaluminum chloride dosage was 4 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

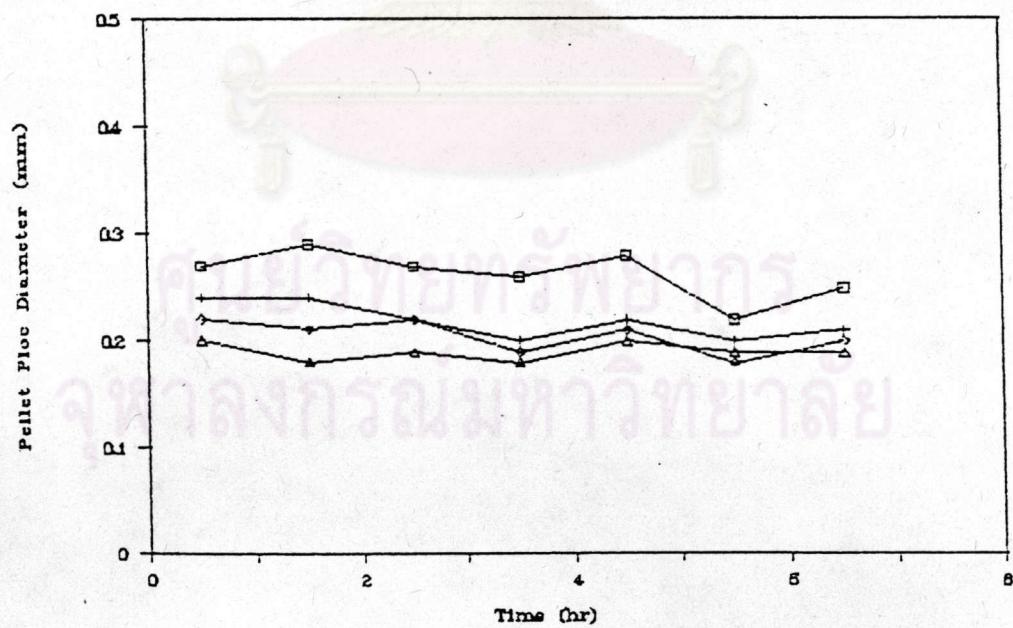
R 4, PACl 4.0, PE 0.1, 5 rpm, Upf 30



R 4, PACl 4.0, PE 0.1, 5 rpm, Upf 30



R 4, PACl 4.0, PE 0.1, 5 rpm, Upf 30



□ H 0 cm + H 60 cm ◆ H 120 cm △ H 150 cm

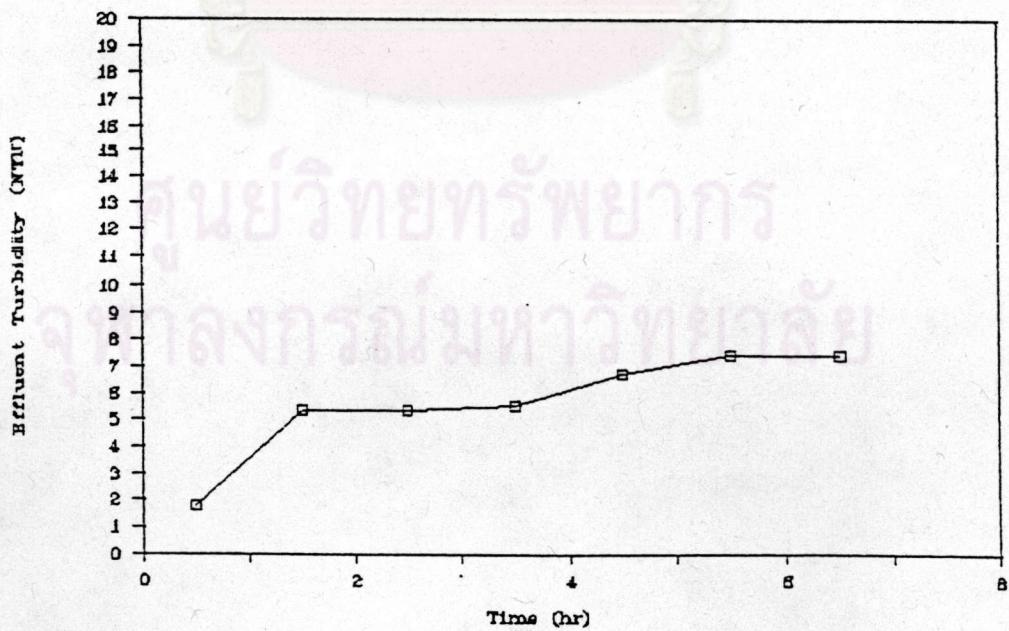
RUN NO. 5

The experimental condition was consisted of the following parameters:

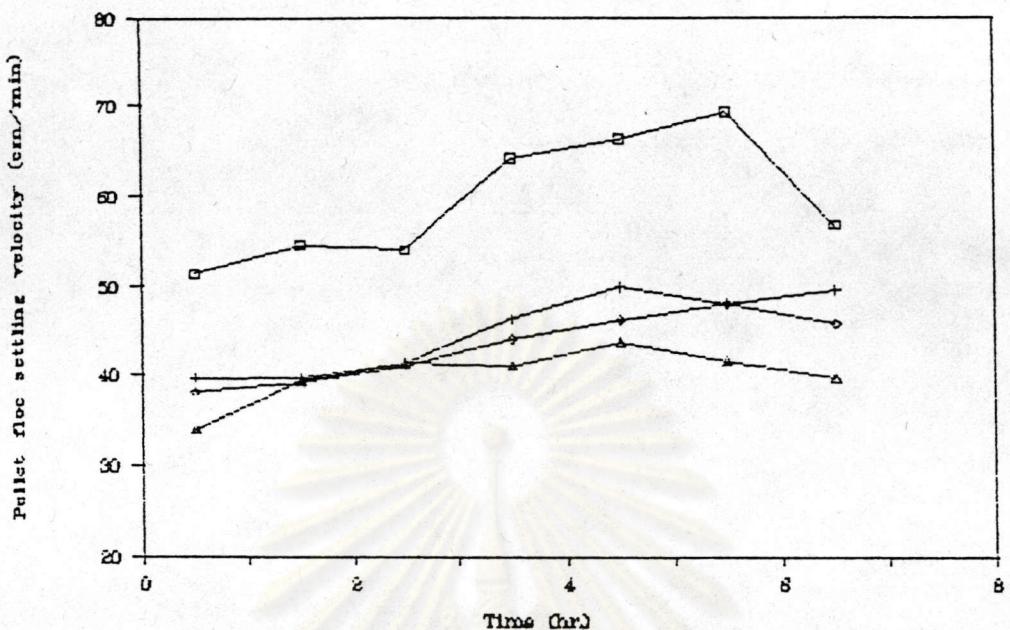
- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

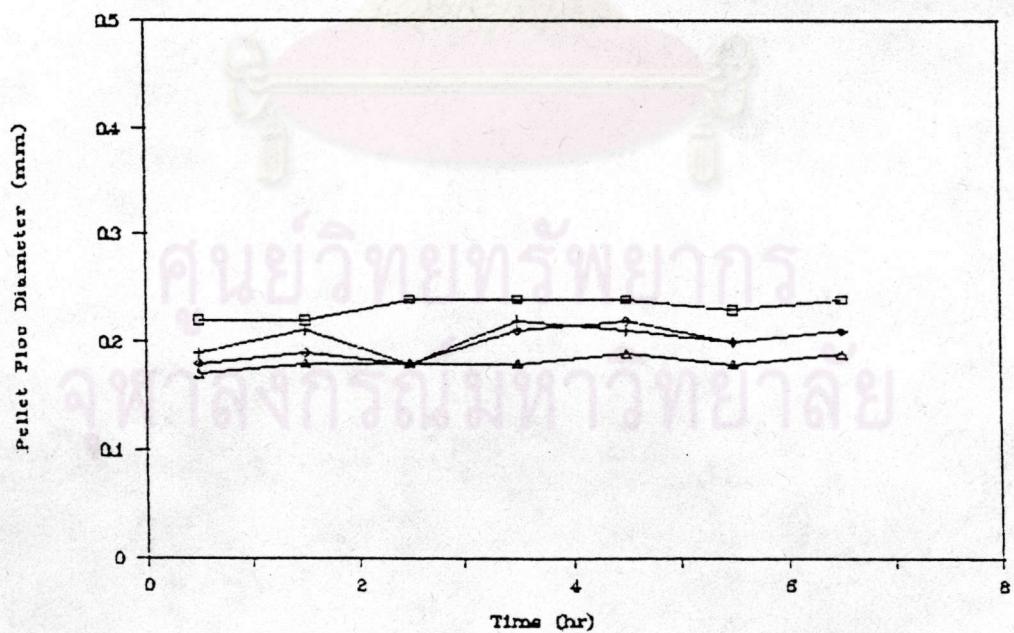
R 5, PACl 1.0, PE 0.2, 5 rpm, Upf 30



R 5, PACl 1.0, PE 0.2, 5 rpm, Upf 30



R 5, PACl 1.0, PE 0.2, 5 rpm, Upf 30



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

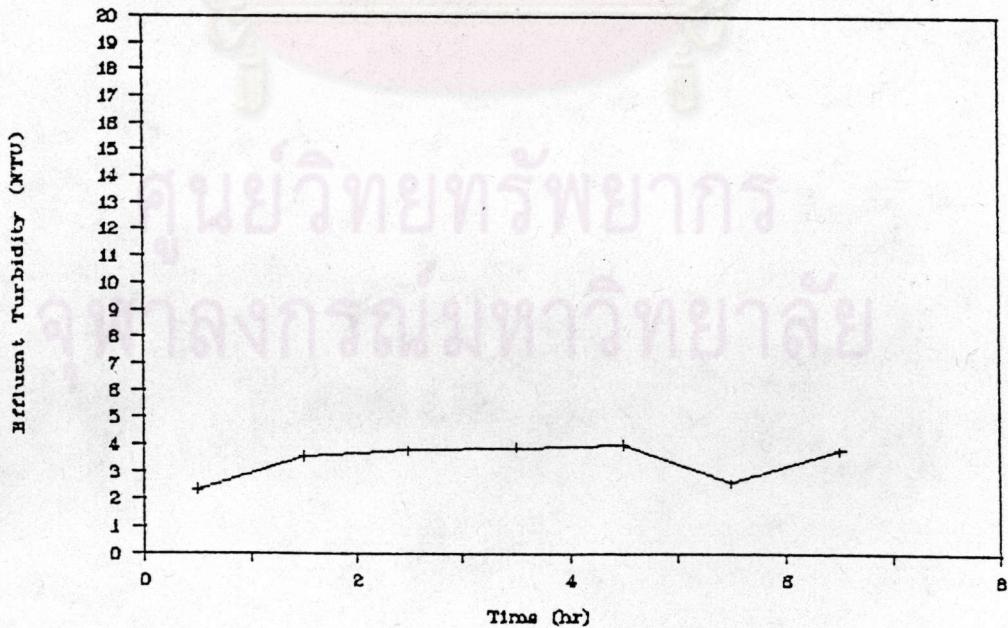
RUN NO. 6

The experimental condition was consisted of the following parameters:

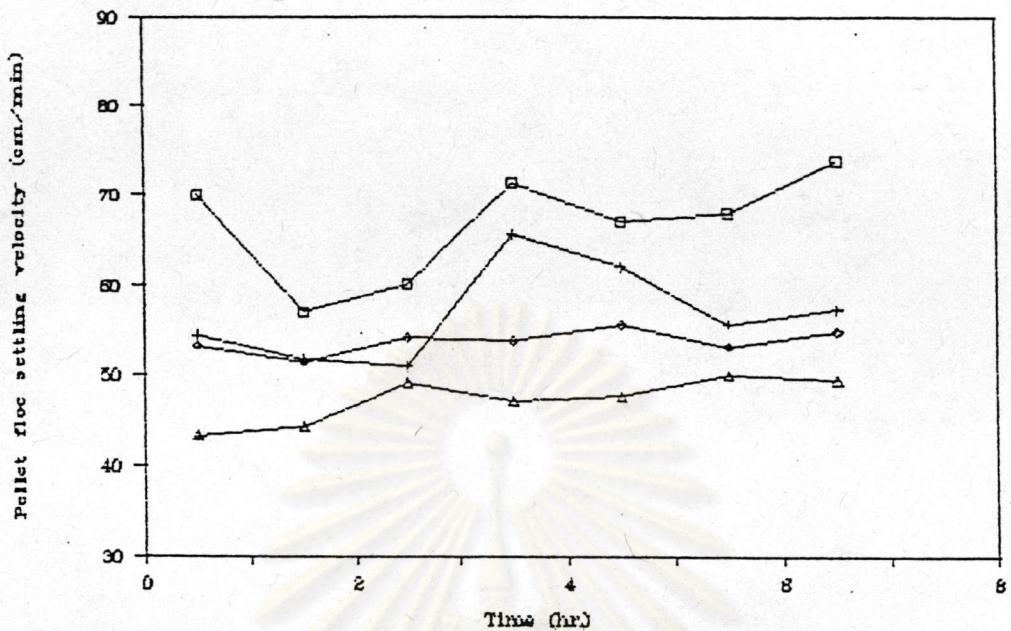
- a) Polyaluminum chloride dosage was 2 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

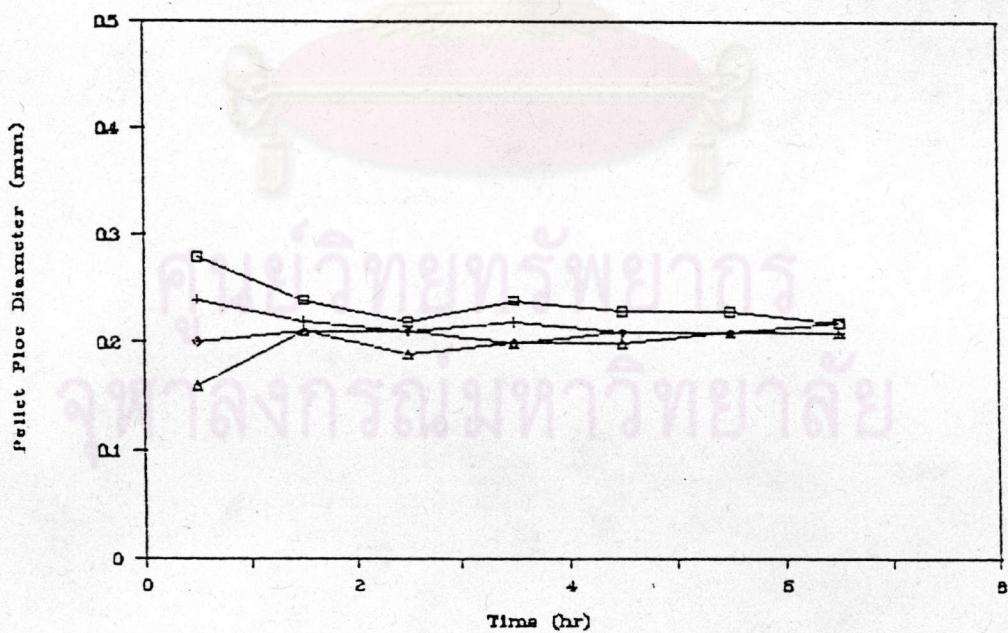
R 6, PACl 2.0, PE 0.2, 5 rpm, Upf 30



R 6, PACl 2.0, PE 0.2, 5 rpm, Upf 30



R 6, PACl 2.0, PE 0.2, 5 rpm, Upf 30



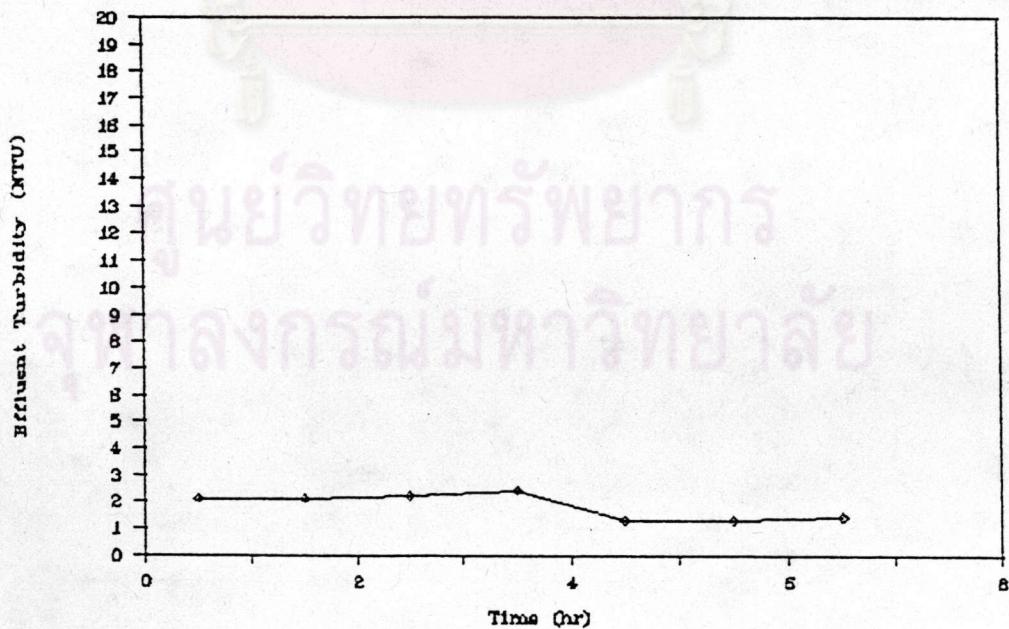
□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

The experimental condition was consisted of the following parameters:

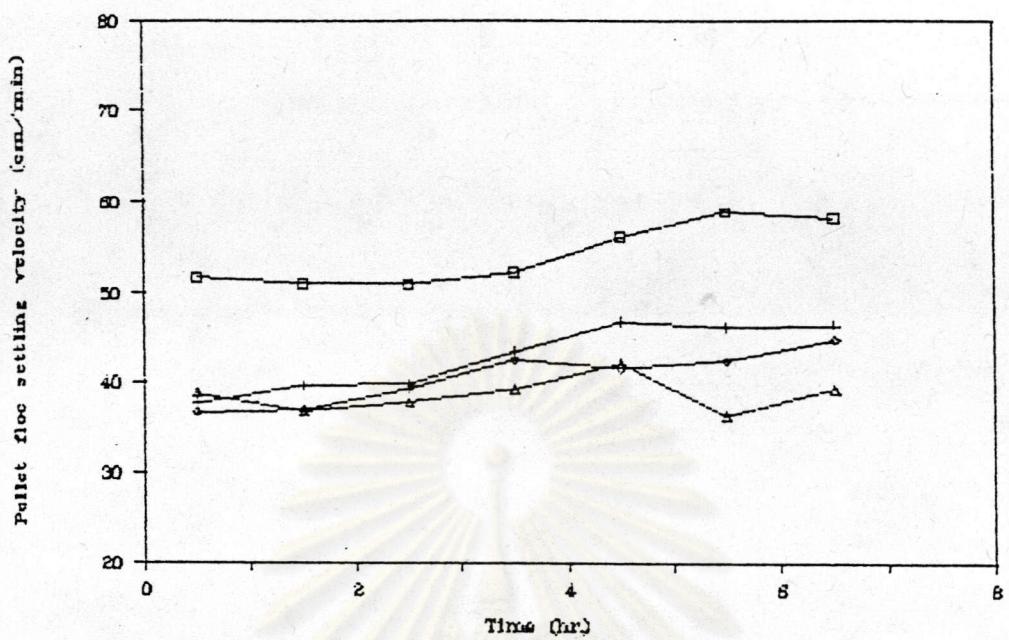
- a) Polyaluminum chloride dosage was 3 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

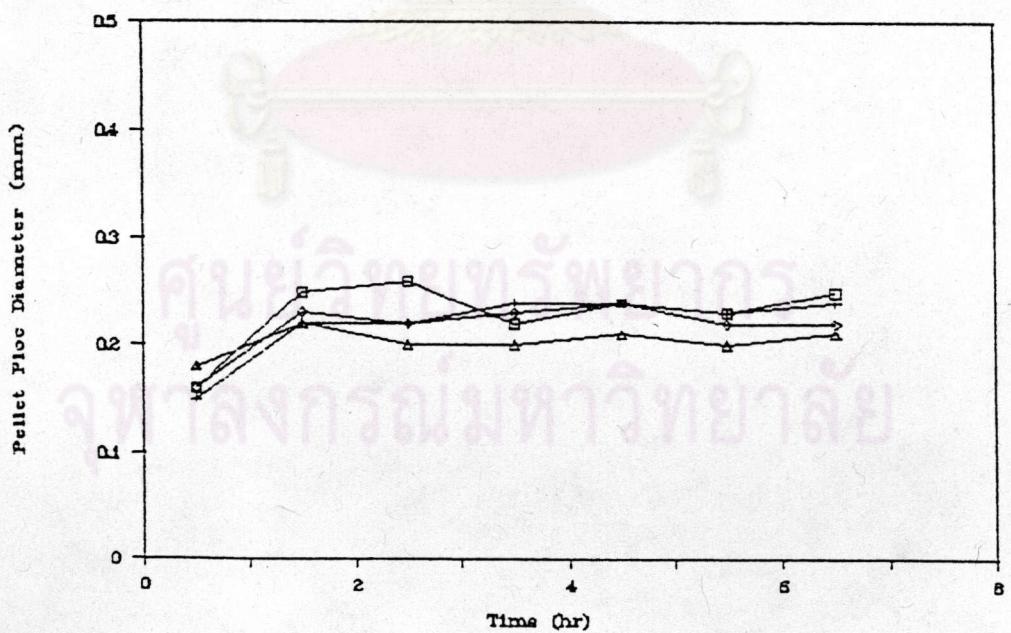
R 7, PACl 3.0, PE 0.2, 5 rpm, Upf 30



R 7, PACl 3.0, PE 0.2, 5 rpm, Upf 30



R 7, PACl 3.0, PE 0.2, 5 rpm, Upf 30



□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

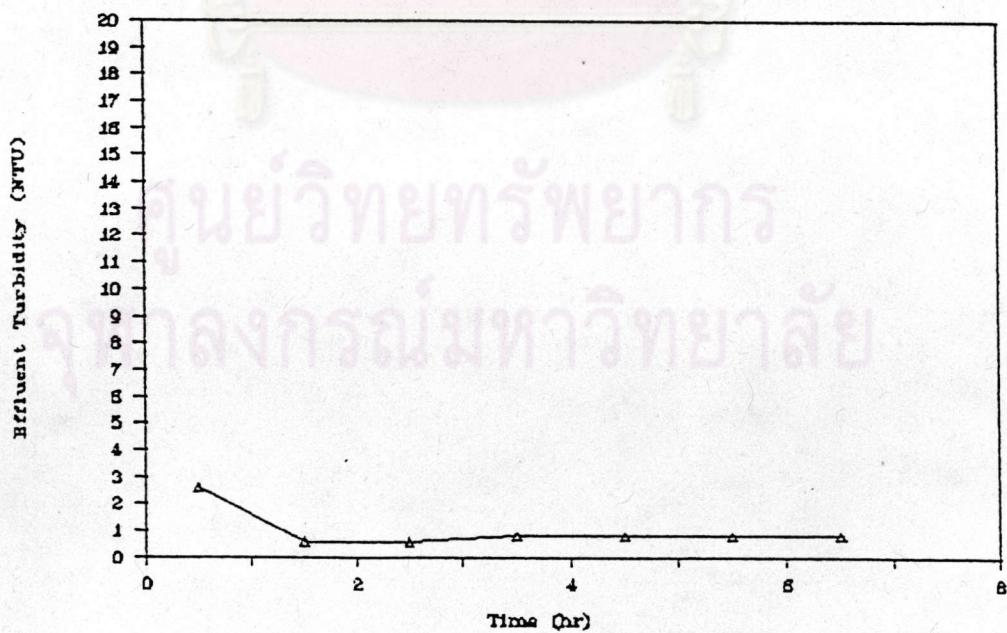
RUN NO. 8

The experimental condition was consisted of the following parameters:

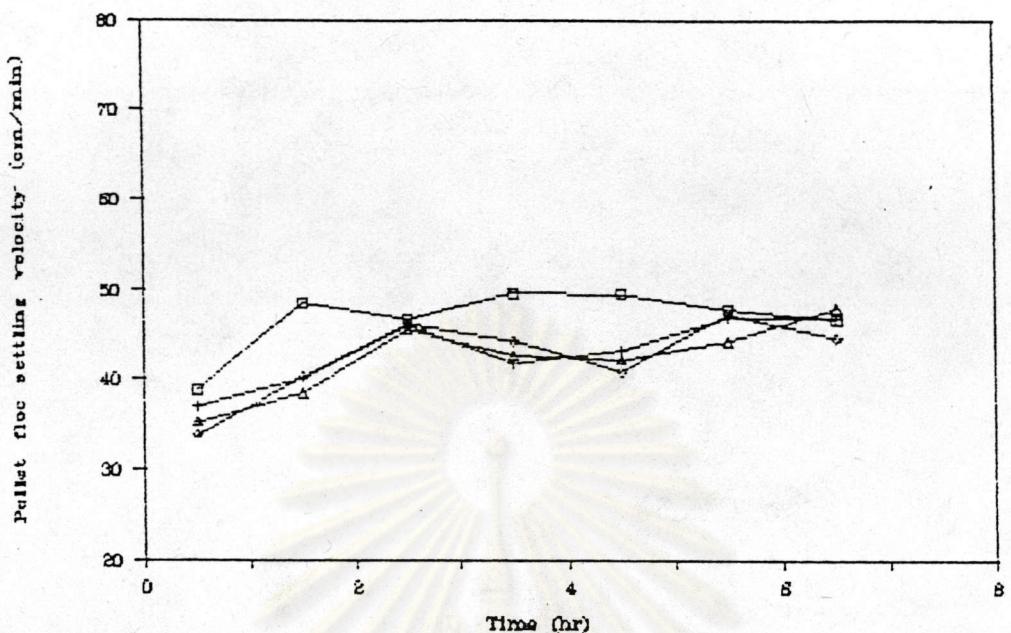
- a) Polyaluminum chloride dosage was 4 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

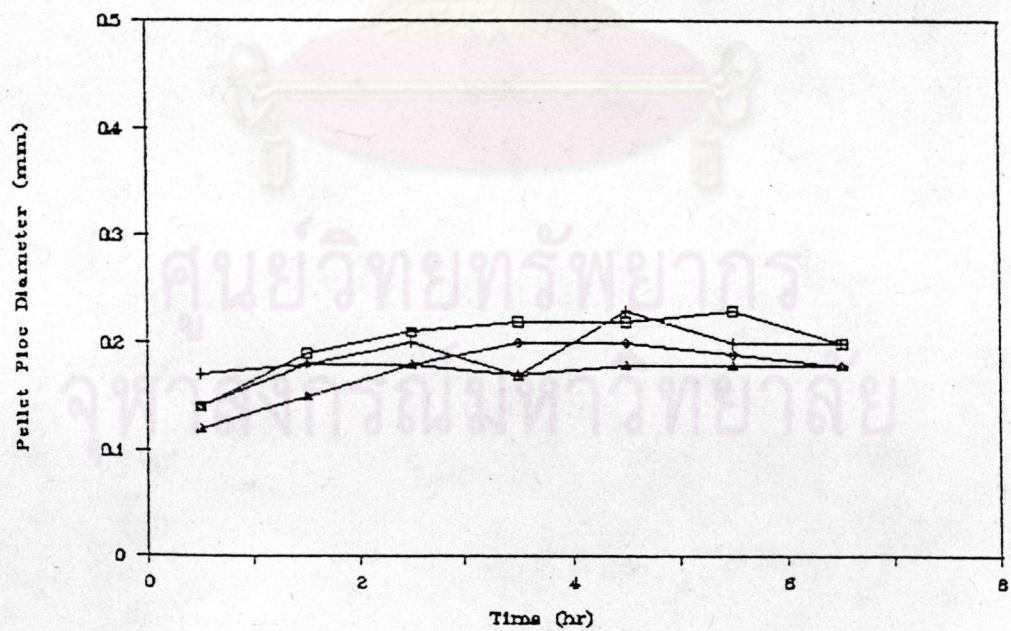
R 8, PACl 4.0, PE 0.2, 5 rpm, Upf 30



R 8, PACl 4.0, PE 0.2, 5 rpm, Upf 30



R 8, PACl 4.0, PE 0.2, 5 rpm, Upf 30



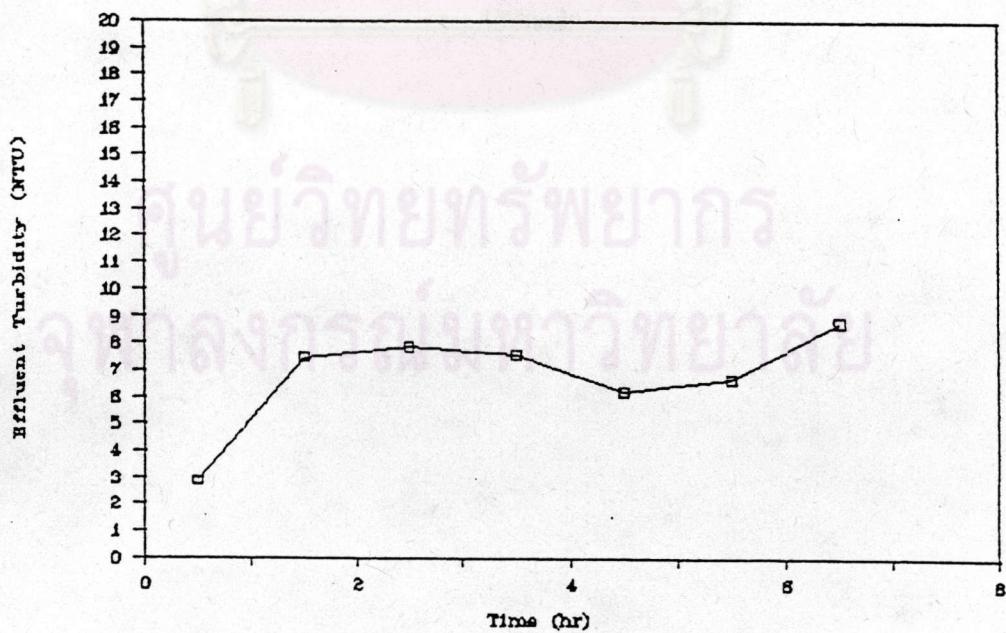
□ H 0 cm + H 60 cm ◆ H 120 cm △ H 150 cm

The experimental condition was consisted of the following parameters:

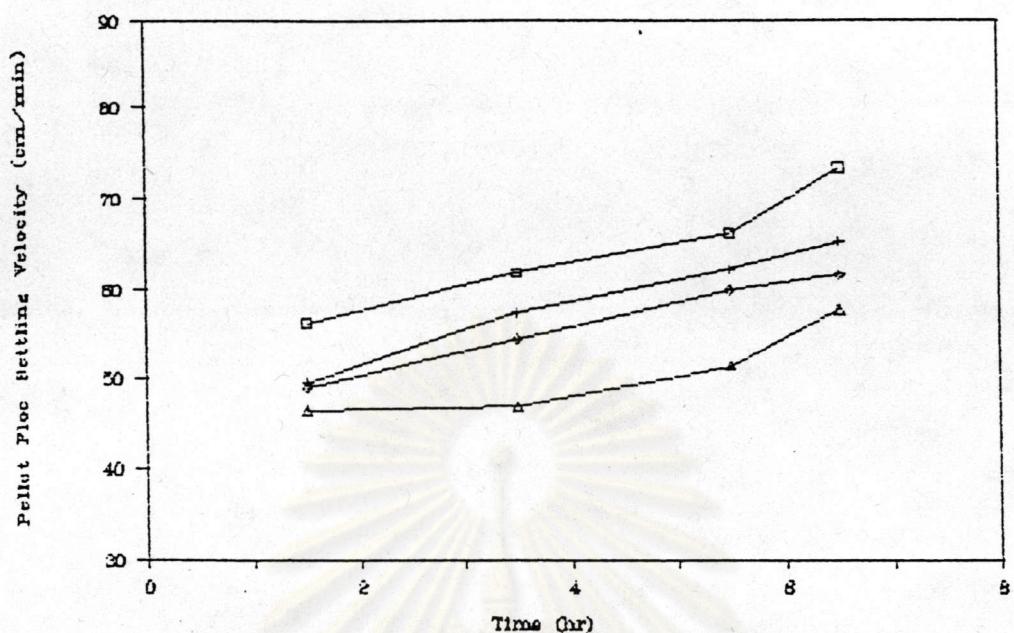
- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

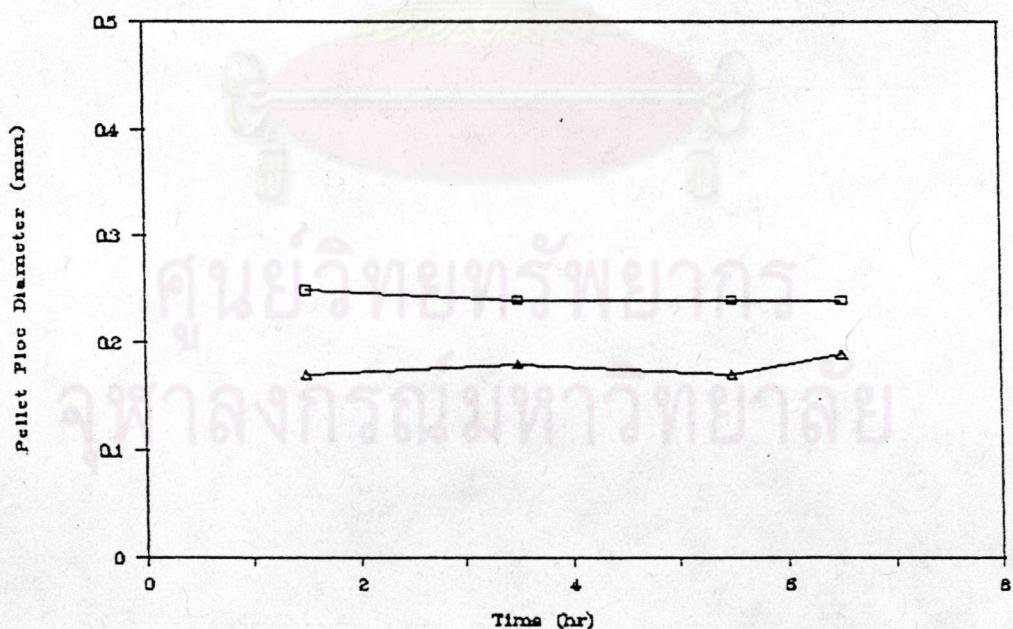
R 9, PACl 1.0, PE 0.3, 5 rpm, Upf 30



R 9, PACl 1.0, PE 0.3, 5 rpm, Upf 30



R 9, PACl 1.0, PE 0.3, 5 rpm, Upf 30



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

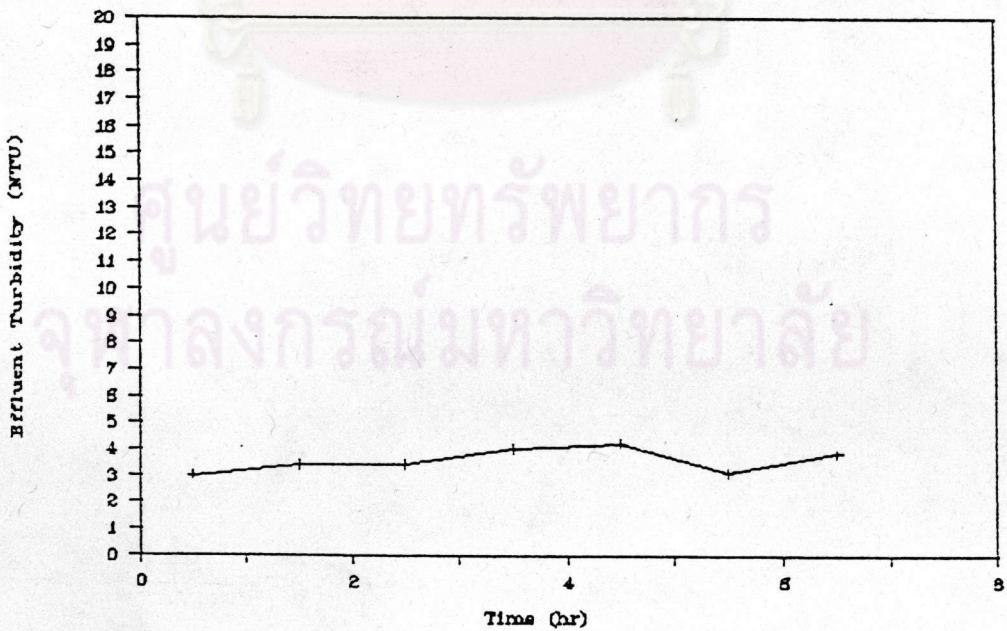
RUN NO. 10

The experimental condition was consisted of the following parameters:

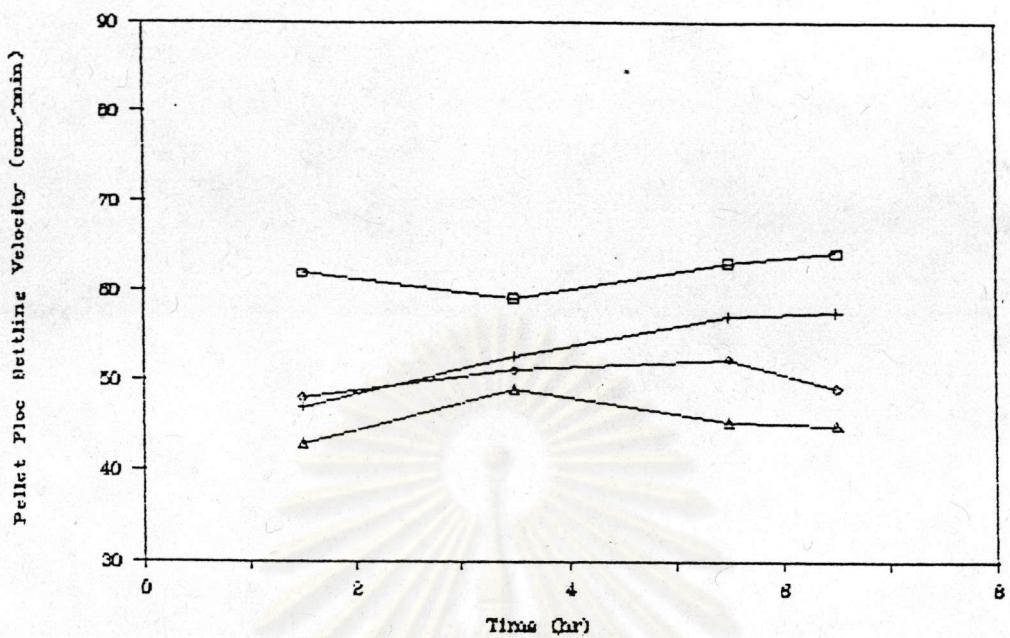
- a) Polyaluminum chloride dosage was 2 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

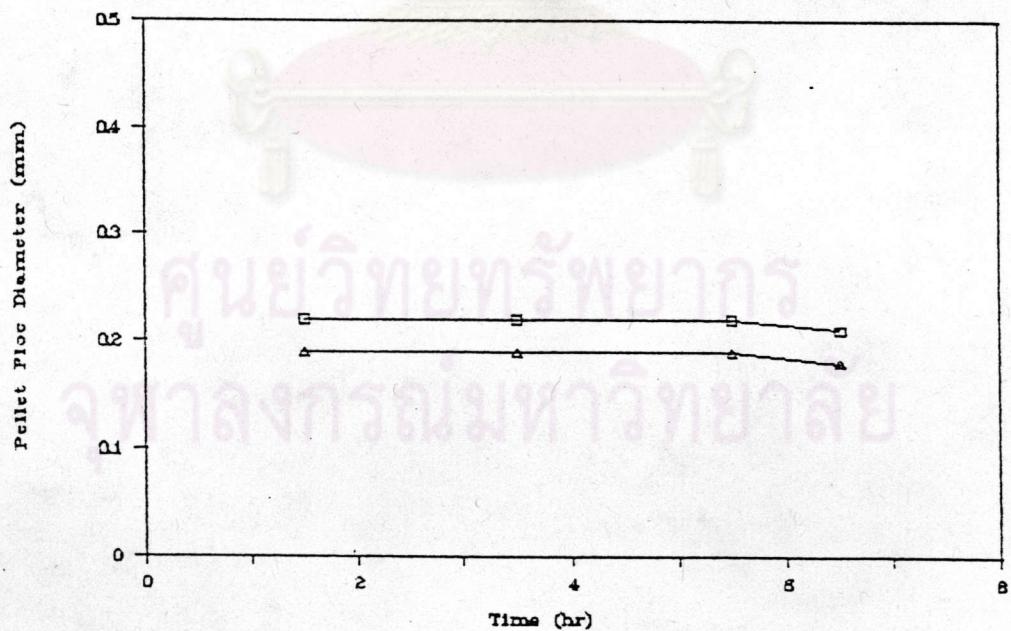
R 10, PACl 2.0, PE 0.3, 5 rpm, Upf 30



R10, PACl 2.0, PE 0.3, 5 rpm, Upf 30



R10, PACl 2.0, PE 0.3, 5 rpm, Upf 30



□ H 0 cm + H 60 cm ◆ H 120 cm △ H 150 cm

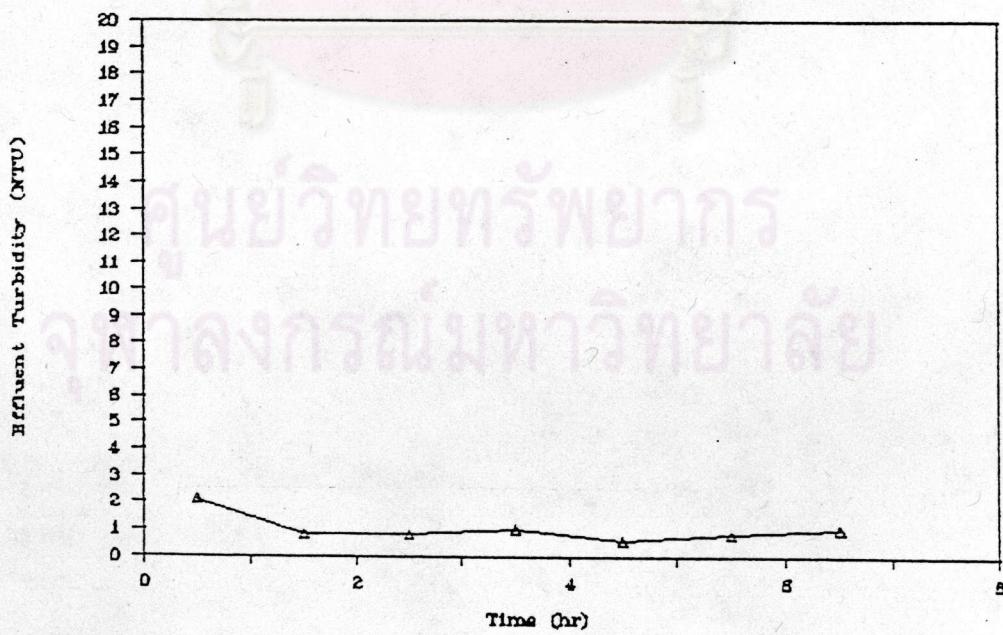
RUN NO. 12

The experimental condition was consisted of the following parameters:

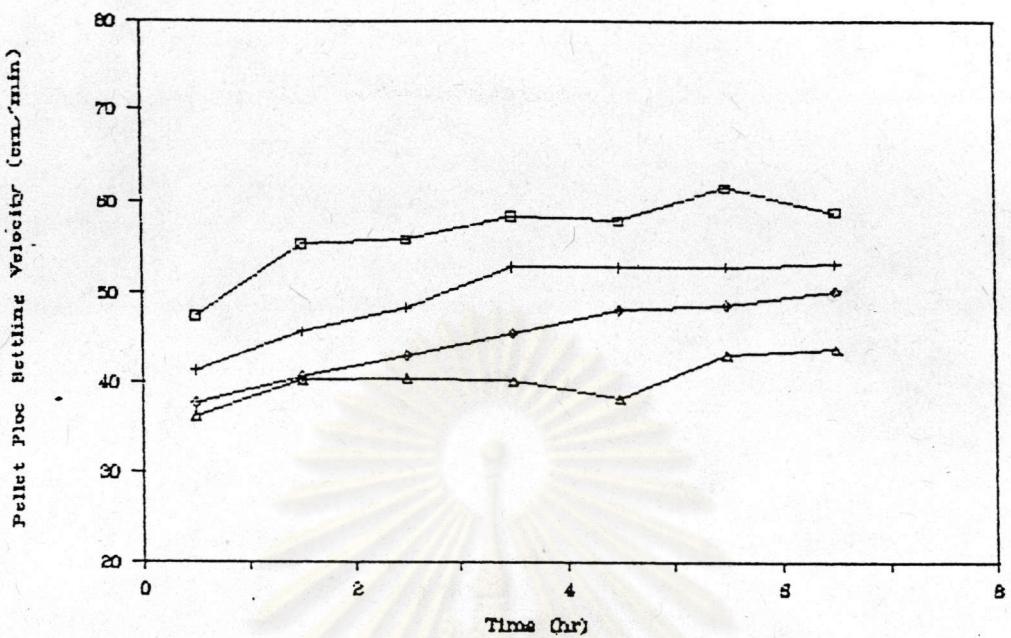
- a) Polyaluminum chloride dosage was 4 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

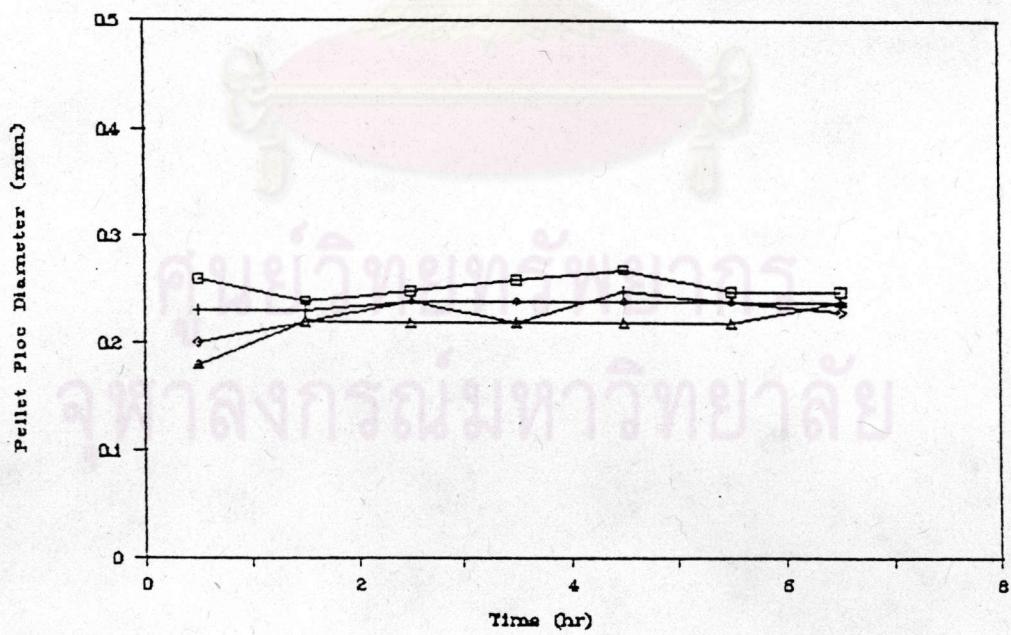
R 12, PACl 4.0, PE 0.3, 5 rpm, Upf 30



R12, PACl 4.0, PE 0.3, 5 rpm, Upf 30



R12, PACl 4.0, PE 0.3, 5 rpm, Upf 30



□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

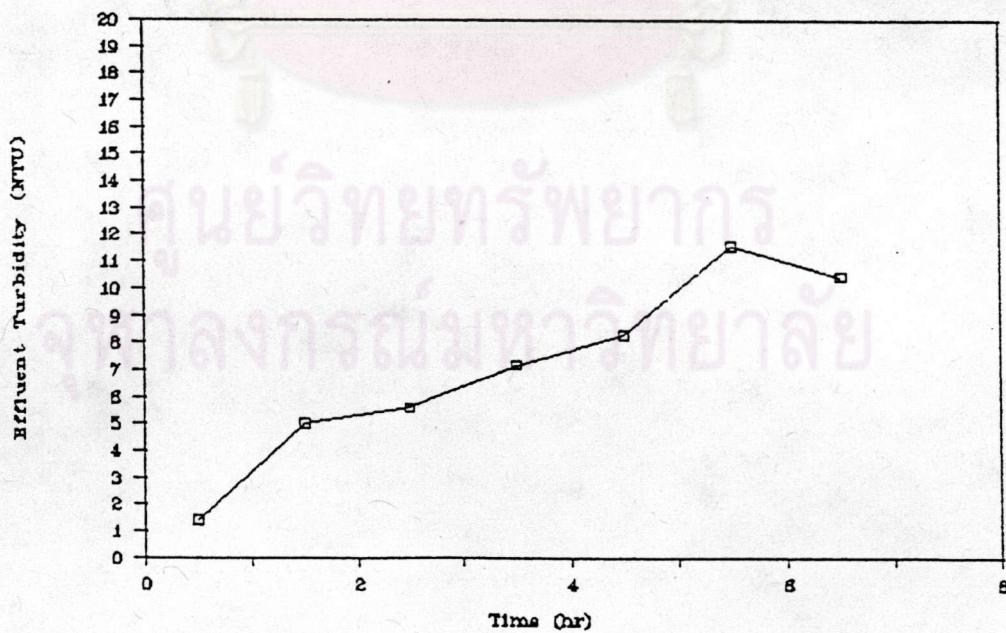
RUN NO. 13

The experimental condition was consisted of the following parameters:

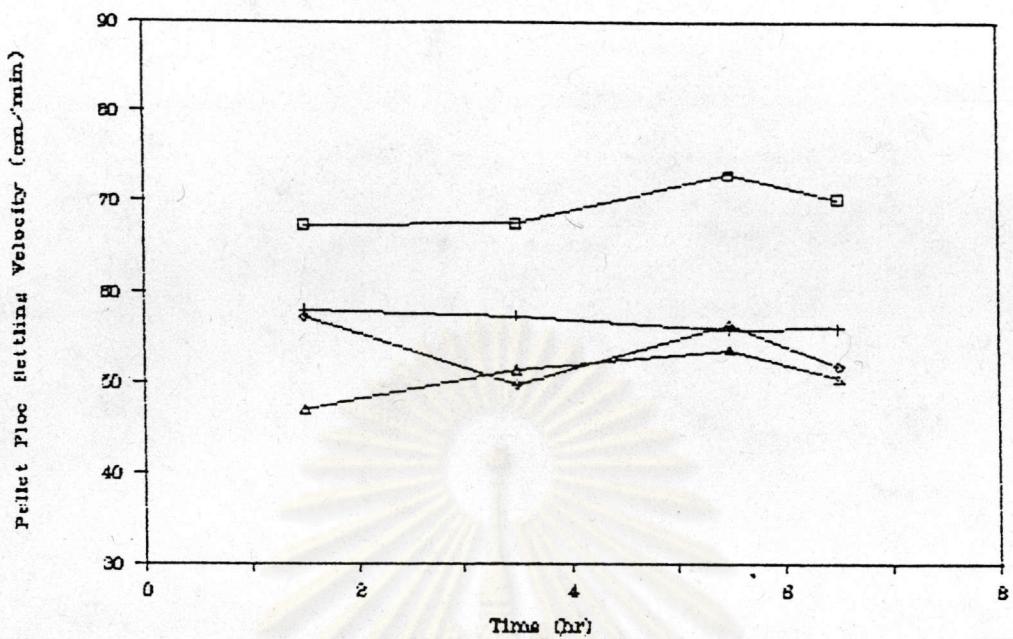
- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

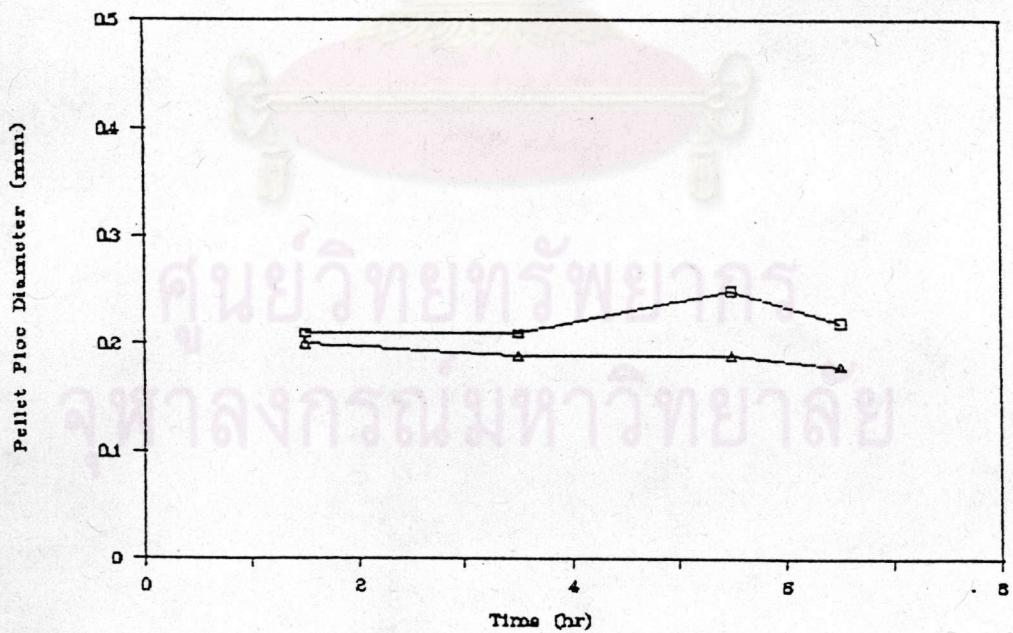
R 13, PACl 1.0, PE 0.1, 5 rpm, Upf 40



R13, PACl 1.0, PE 0.1, 5 rpm, Upf 40



R13, PACl 1.0, PE 0.1, 5 rpm, Upf 40



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

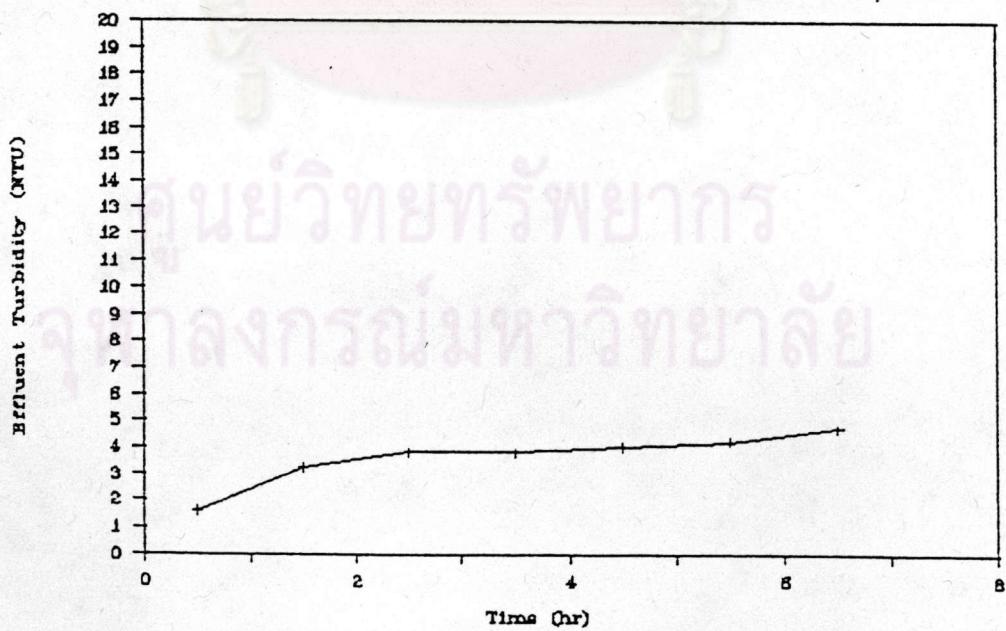
RUN NO. 14

The experimental condition was consisted of the following parameters:

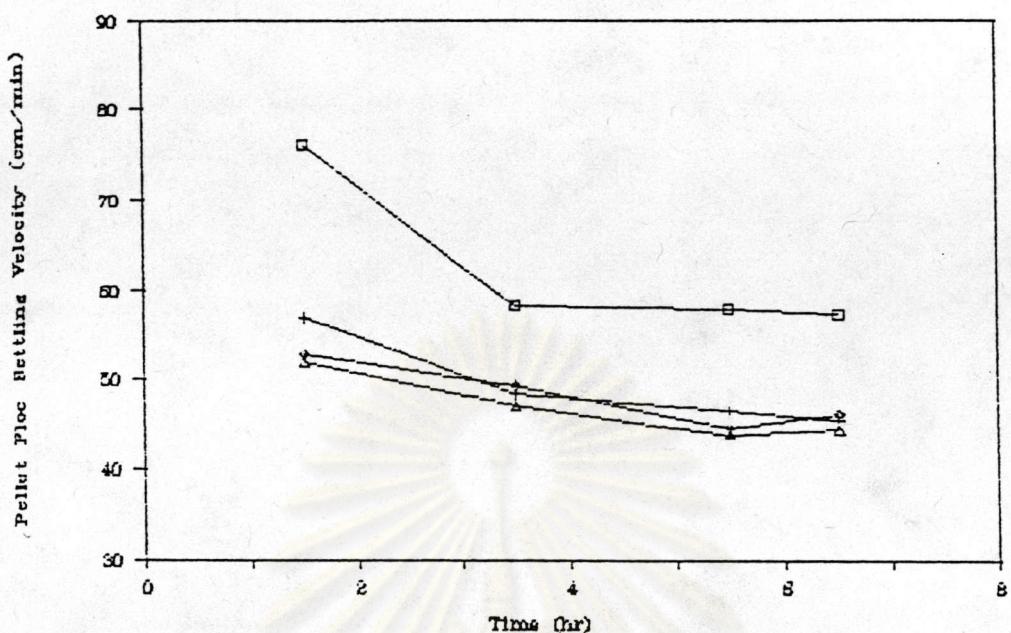
- a) Polyaluminum chloride dosage was 2 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

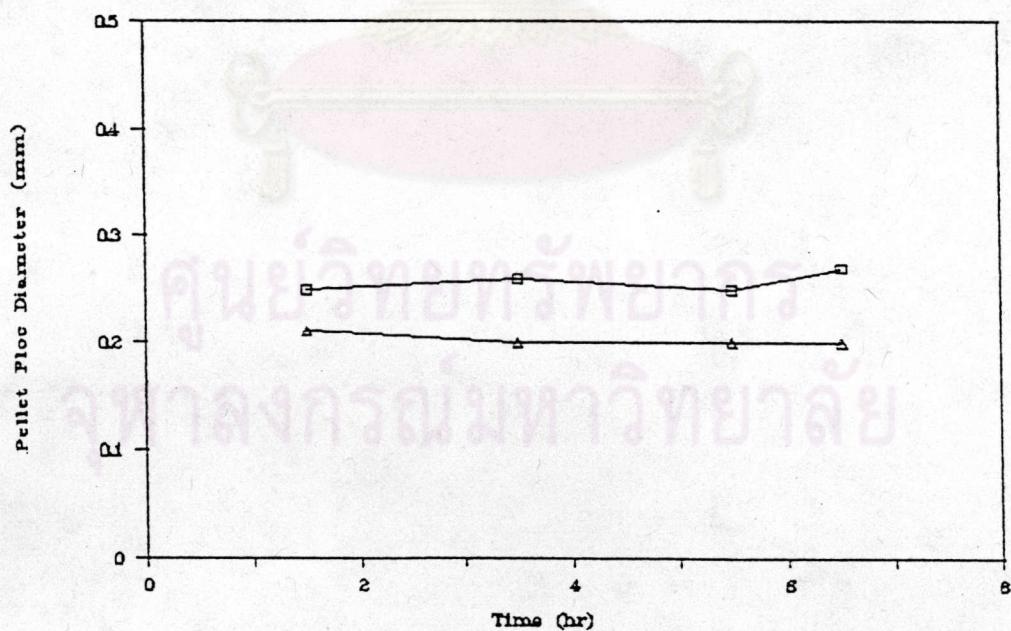
R 14, PACl 2.0, PE 0.1, 5 rpm, Upf 40



R14, PACl 2.0, PE 0.1, 5 rpm, Upf 40



R14, PACl 2.0, PE 0.1, 5 rpm, Upf 40



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

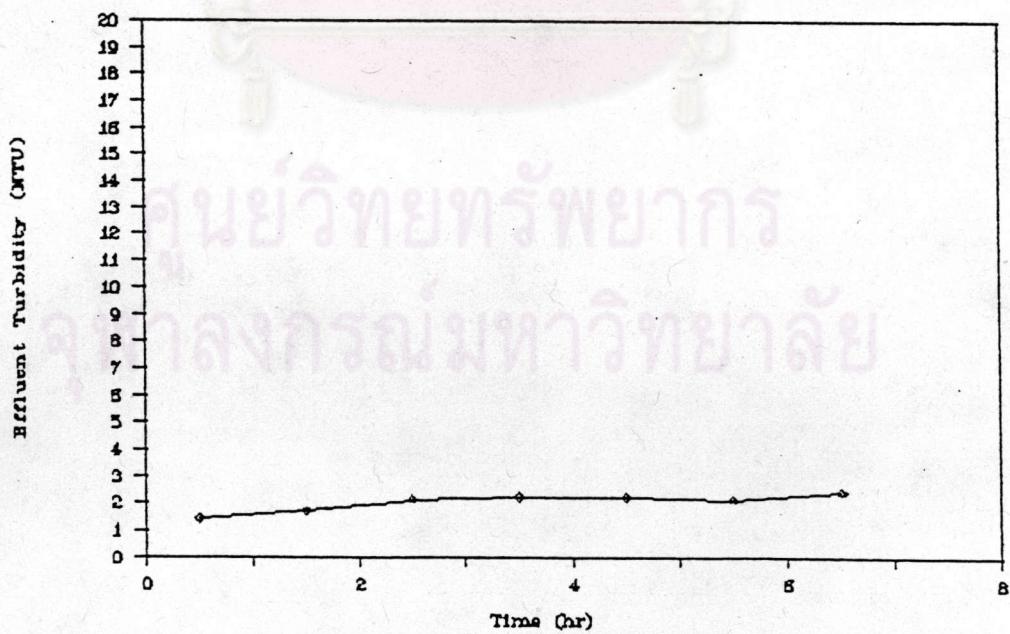
RUN NO. 15

The experimental condition was consisted of the following parameters:

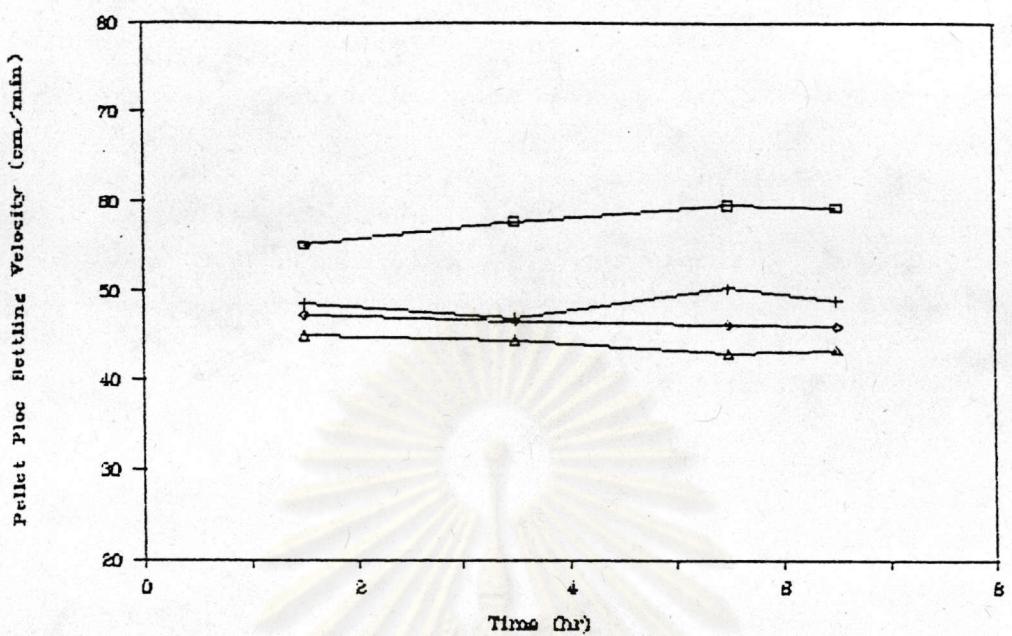
- a) Polyaluminum chloride dosage was 3 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

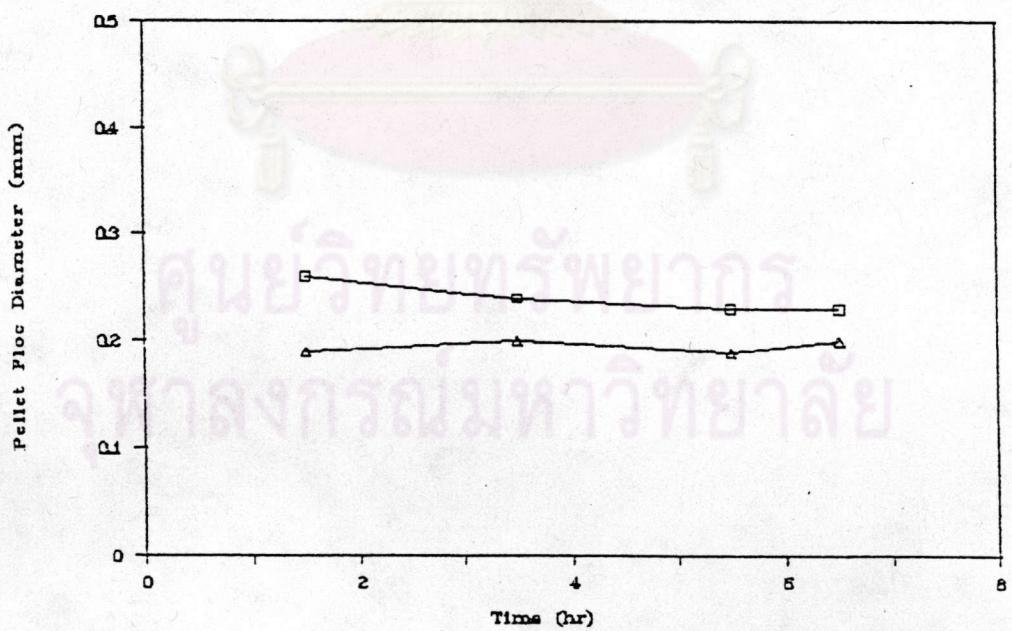
R 15, PACl 3.0, PE 0.1, 5 rpm, Upf 40



R15, PACl 3.0, PE 0.1, 5 rpm, Upf 40



R15, PACl 3.0, PE 0.1, 5 rpm, Upf 40



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

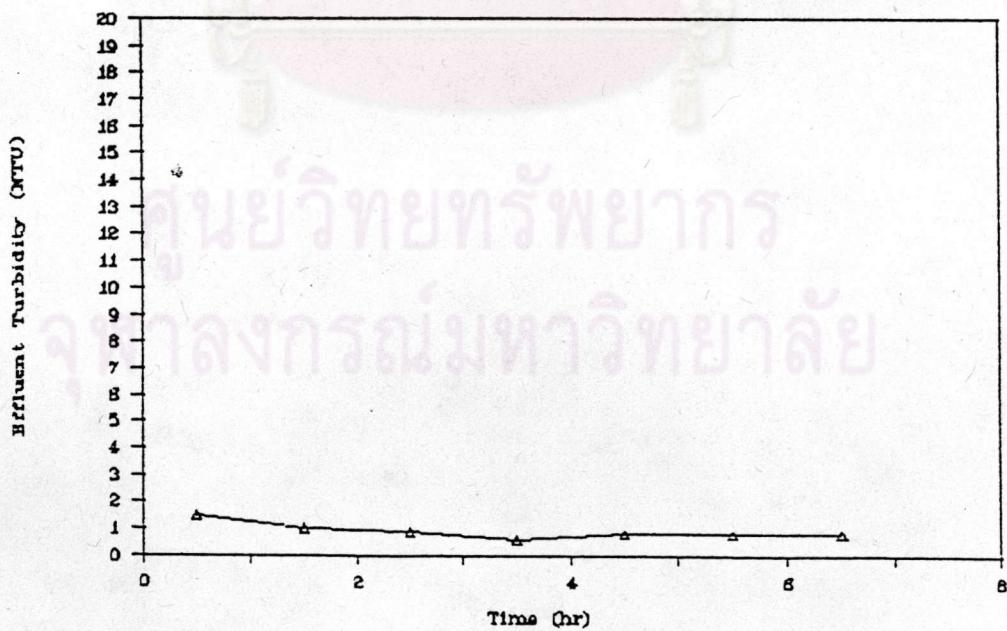
RUN NO. 16

The experimental condition was consisted of the following parameters:

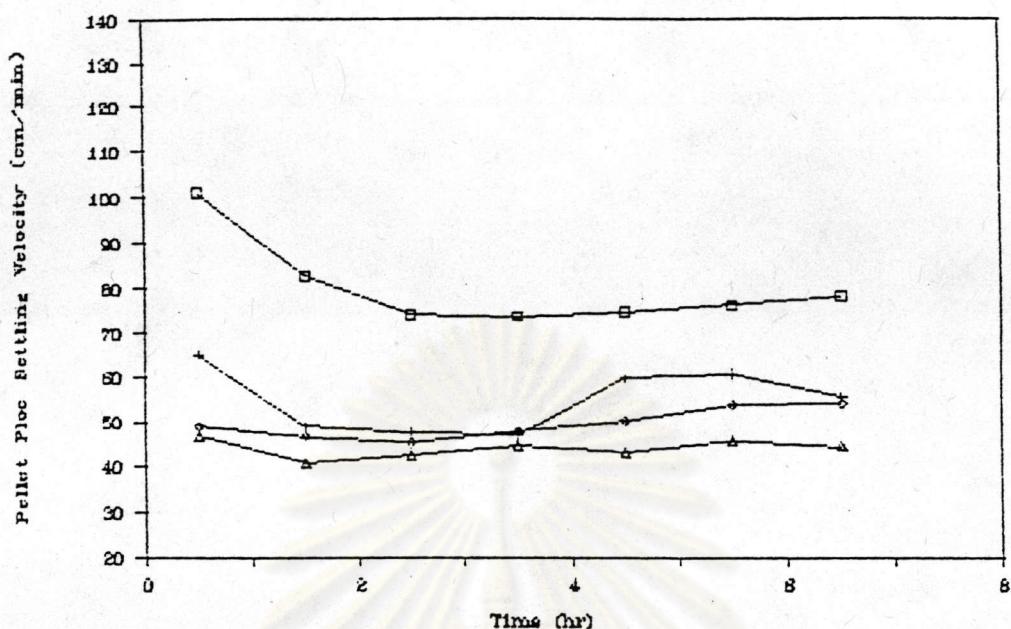
- a) Polyaluminum chloride dosage was 4 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

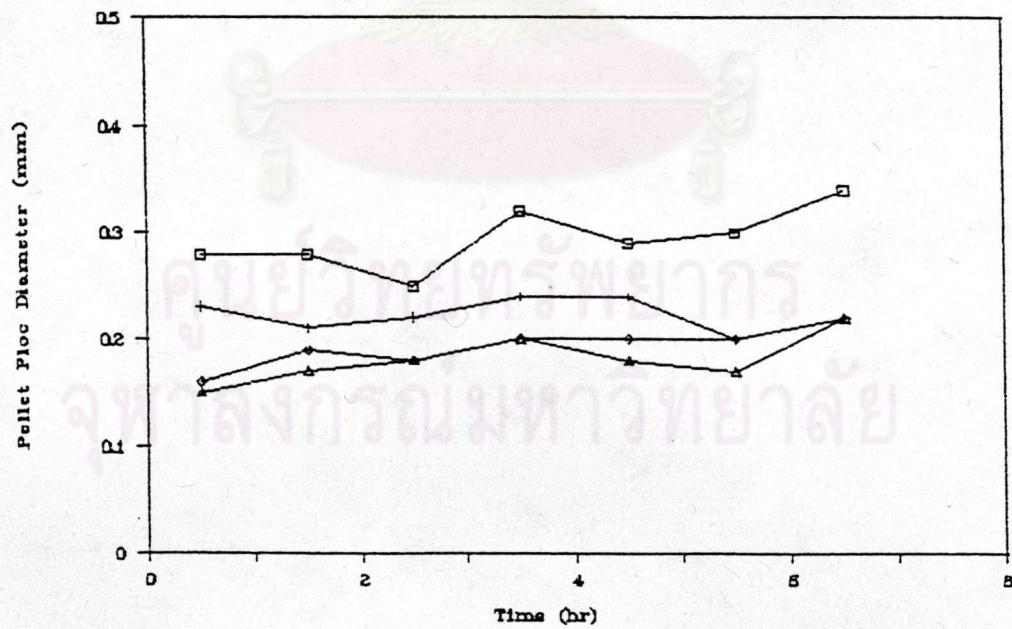
R 16, PACl 4.0, PE 0.1, 5 rpm, Upf 40



R16, PACl 4.0, PE 0.1, 5 rpm, Upf 40



R16, PACl 4.0, PE 0.1, 5 rpm, Upf 40



□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

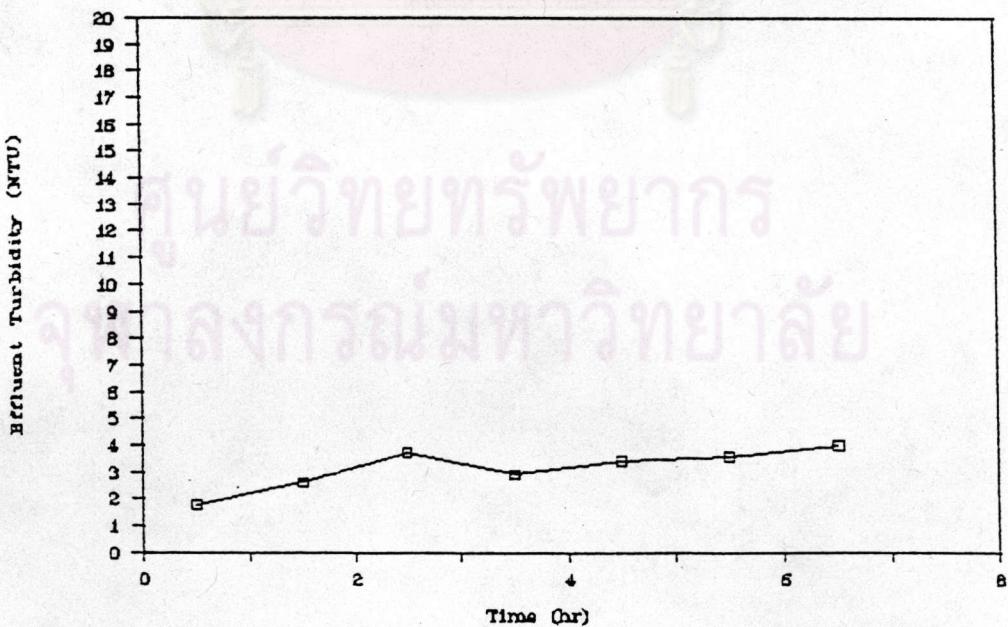
RUN NO. 17

The experimental condition was consisted of the following parameters:

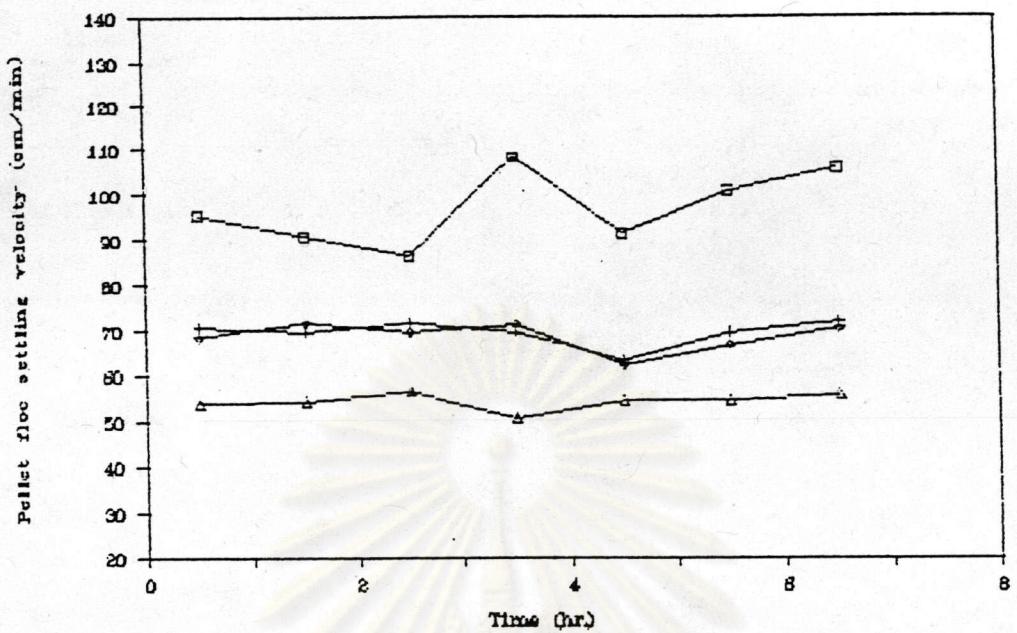
- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

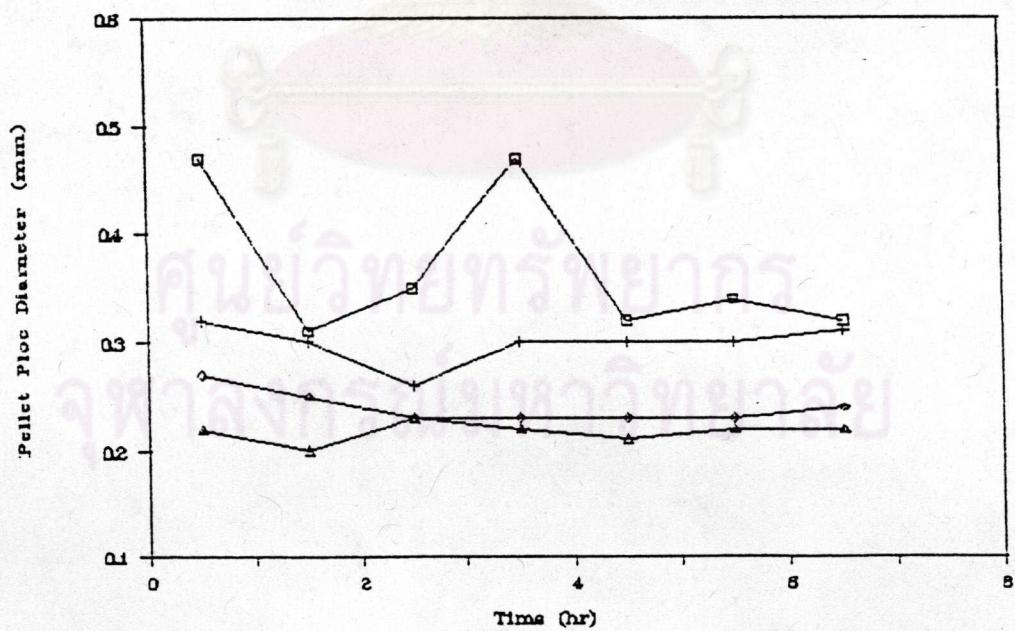
R 17, PACl 1.0, PE 0.2, 5 rpm, Upf 40



R17, PACl 1.0, PE 0.2, 5 rpm, Upf 40



R17, PACl 1.0, PE 0.2, 5 rpm, Upf 40



□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

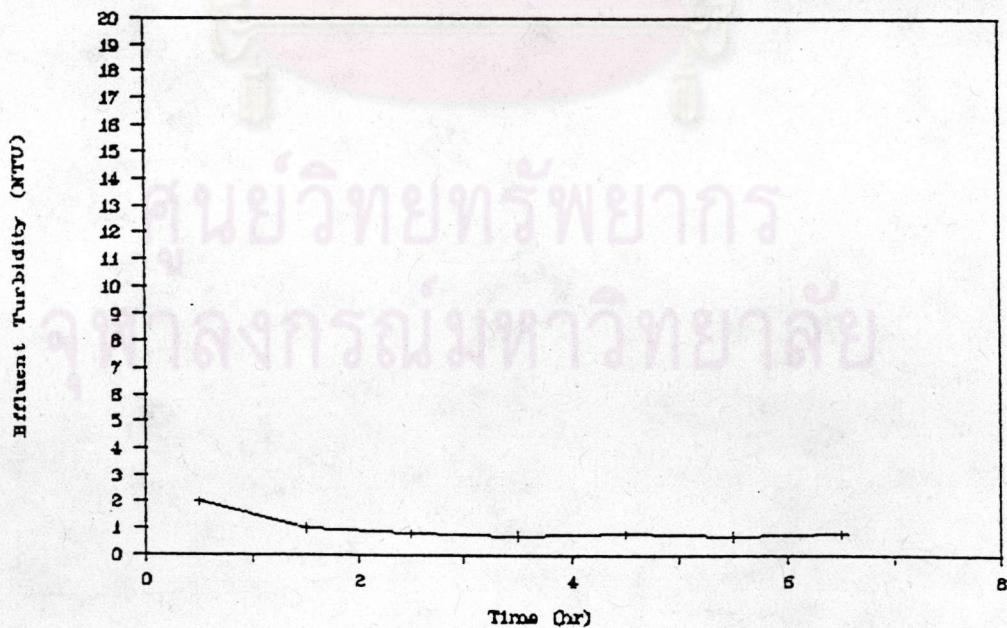
RUN NO. 18

The experimental condition was consisted of the following parameters:

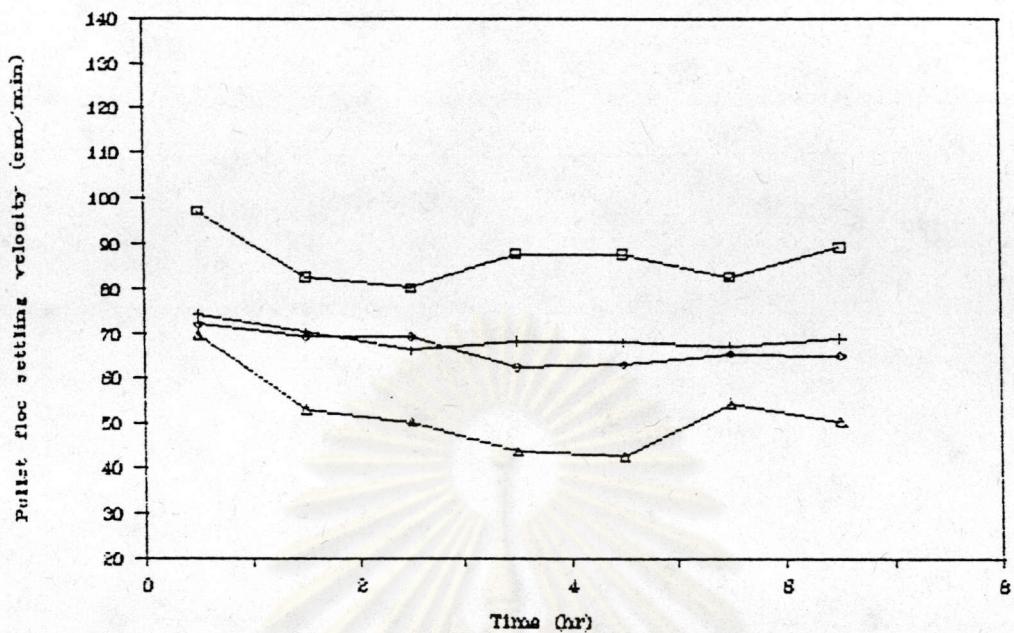
- a) Polyaluminum chloride dosage was 2 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

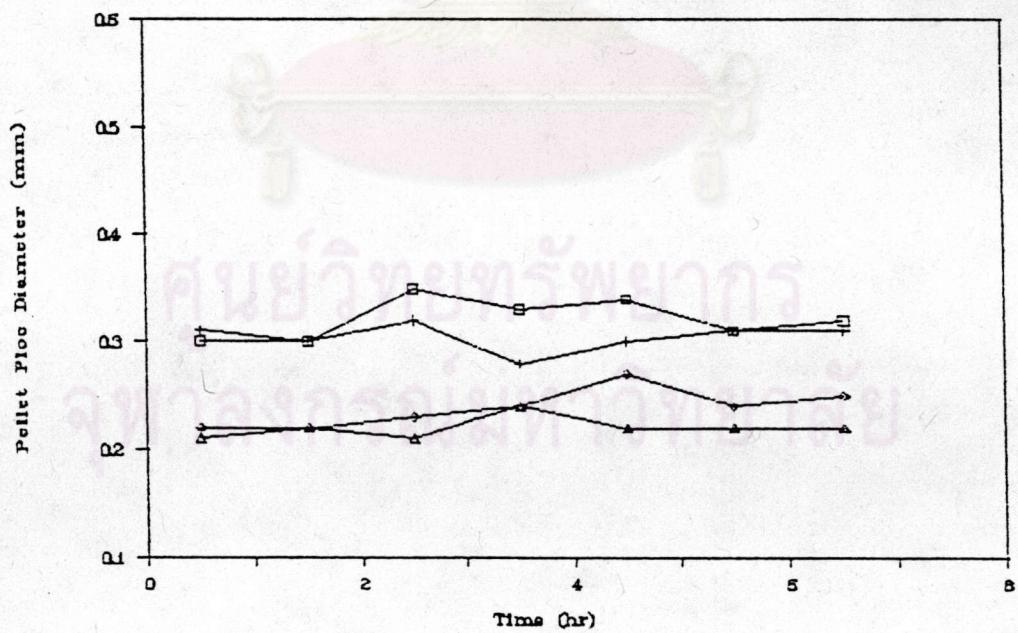
R 18, PACl 2.0, PE 0.2, 5 rpm, Upf 40



R18, PACl 2.0, PE 0.2, 5 rpm, Upf 40



R18, PACl 2.0, PE 0.2, 5 rpm, Upf 40



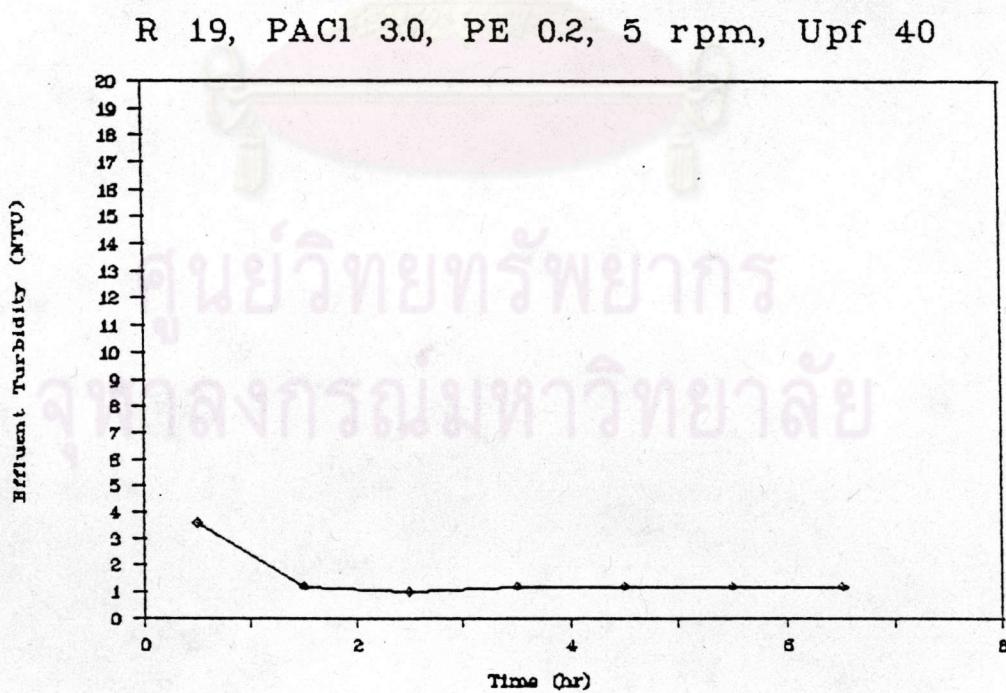
□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

RUN NO. 19

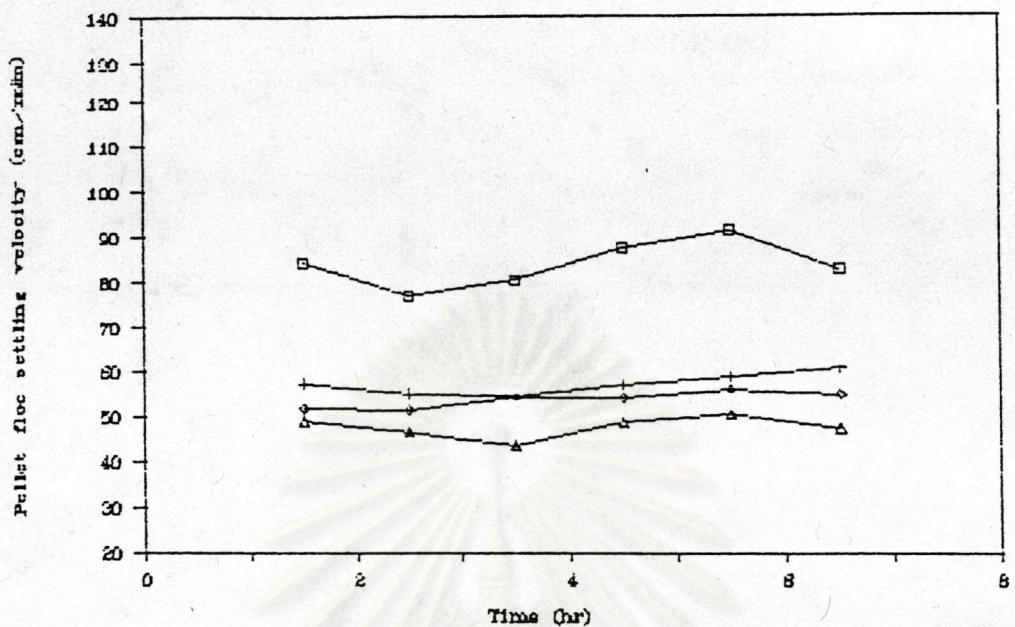
The experimental condition was consisted of the following parameters:

- a) Polyaluminum chloride dosage was 3 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 40 cm./min.

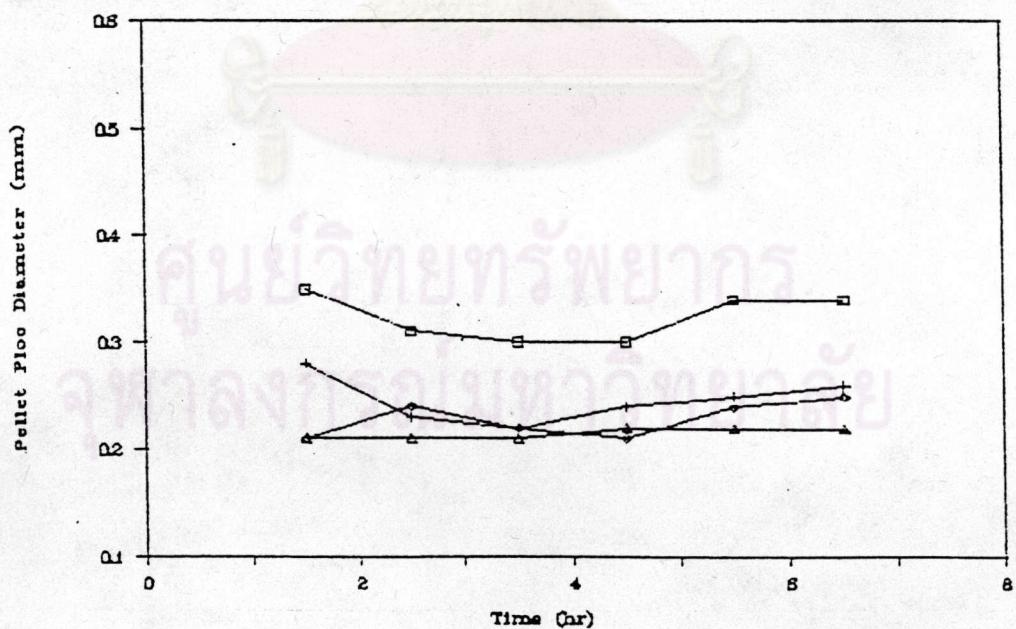
The experimental results of each run were shown in the following figures:



R19, PACl 3.0, PE 0.2, 5 rpm, Upf 40



R19, PACl 3.0, PE 0.2, 5 rpm, Upf 40



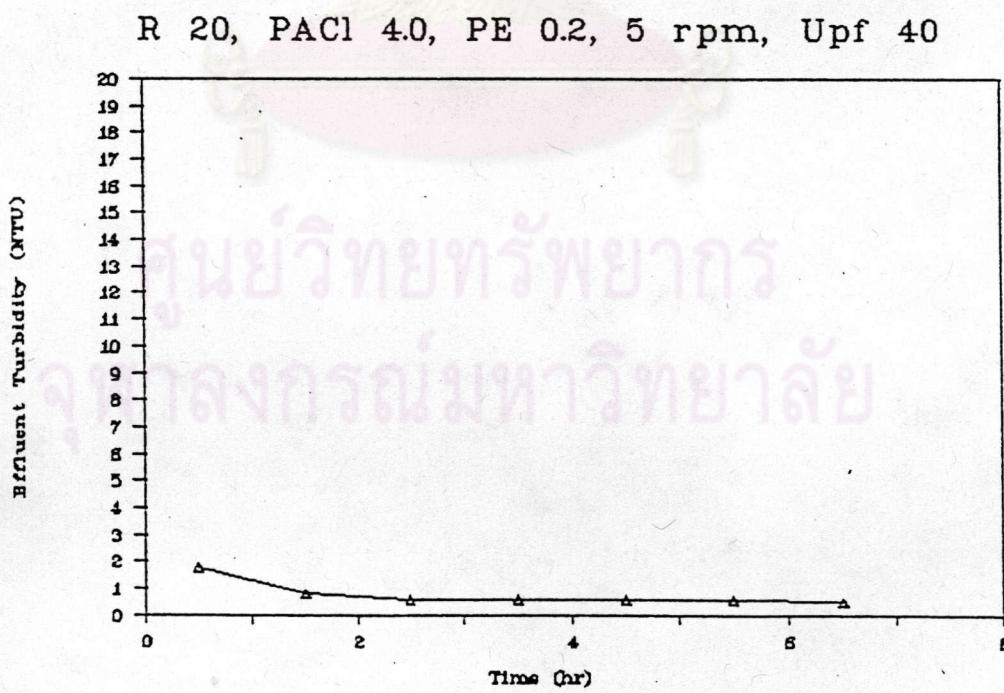
□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

RUN NO. 20

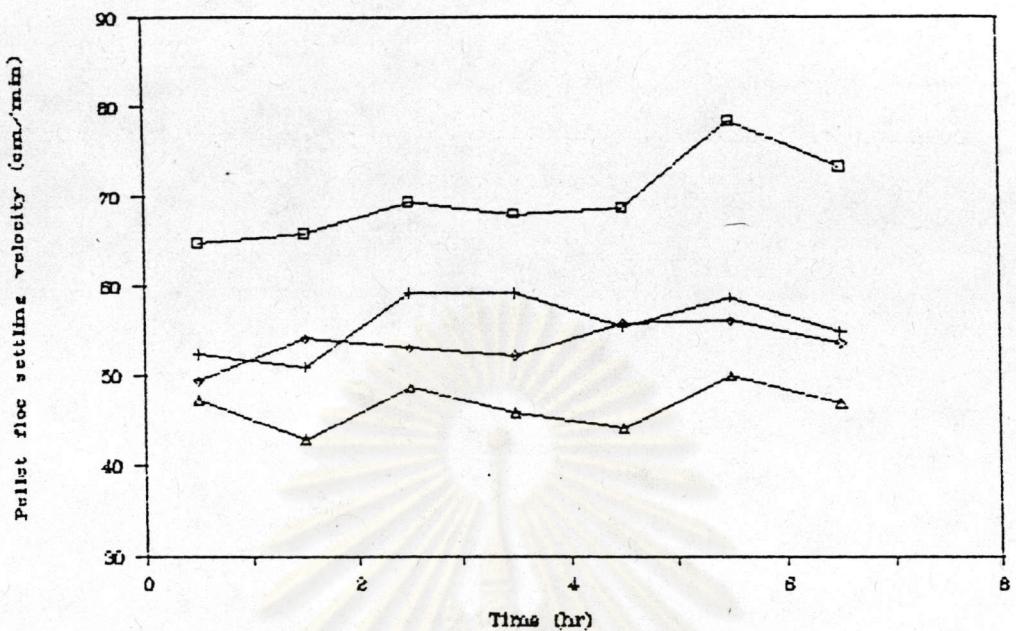
The experimental condition was consisted of the following parameters:

- a) Polyaluminum chloride dosage was 4 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 40 cm./min.

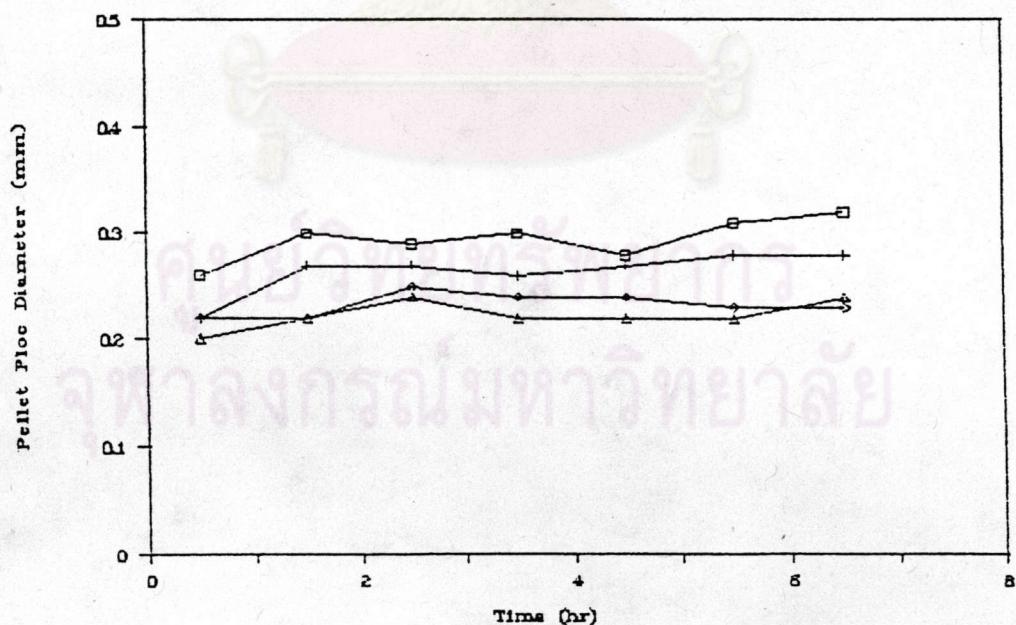
The experimental results of each run were shown in the following figures:



R20, PACl 4.0, PE 0.2, 5 rpm, Upf 40



R20, PACl 4.0, PE 0.2, 5 rpm, Upf 40



□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

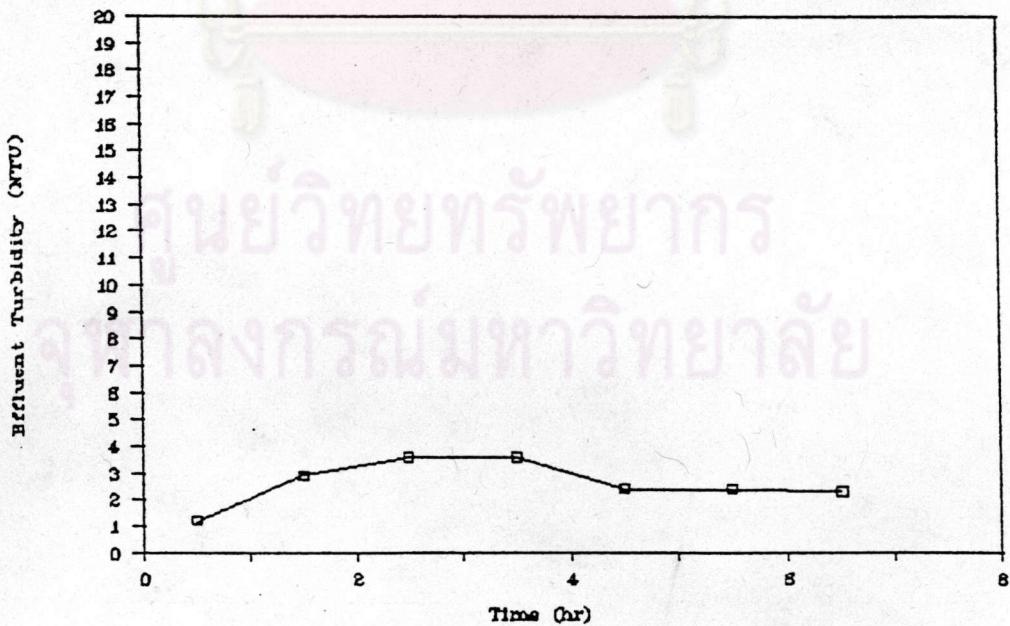
RUN NO. 21

The experimental condition was consisted of the following parameters:

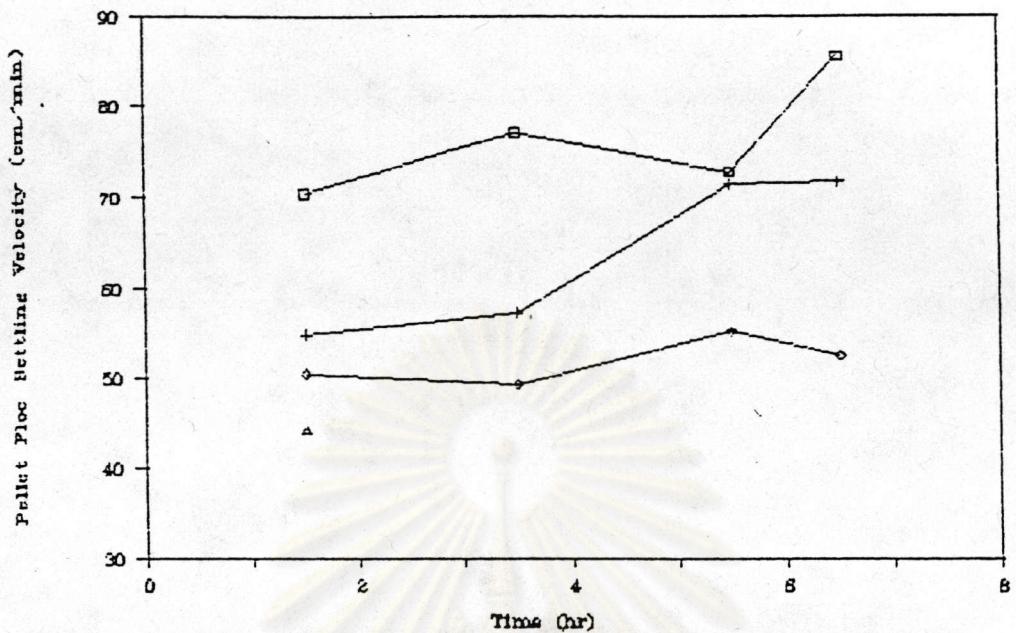
- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

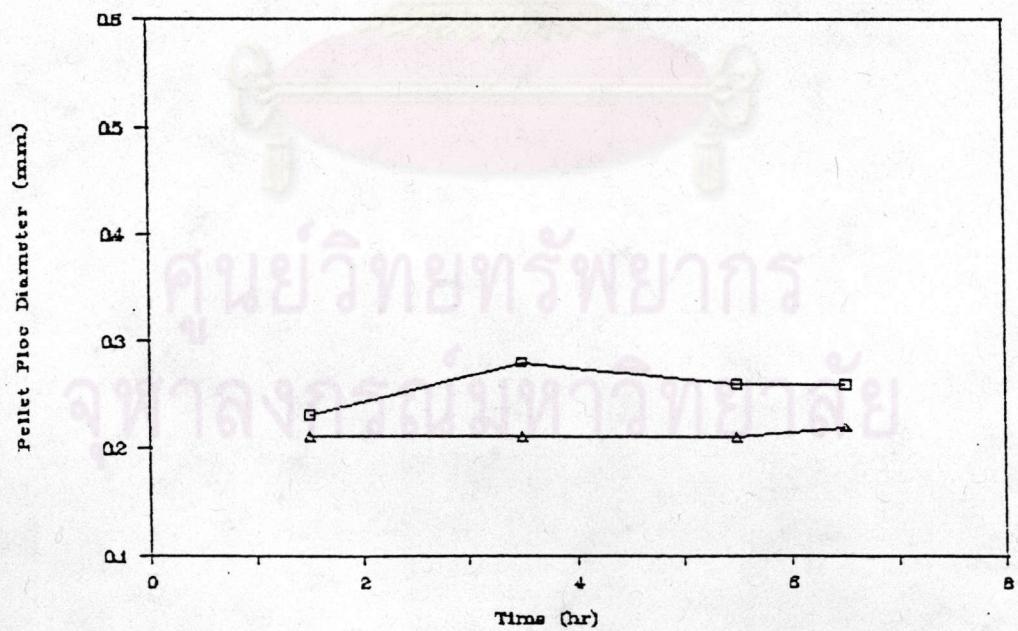
R 21, PACl 1.0, PE 0.3, 5 rpm, Upf 40



R21, PACl 1.0, PE 0.3, 5 rpm, Upf 40



R21, PACl 1.0, PE 0.3, 5 rpm, Upf 40



□ H 0 cm + H 60 cm ◆ H 120 cm △ H 150 cm

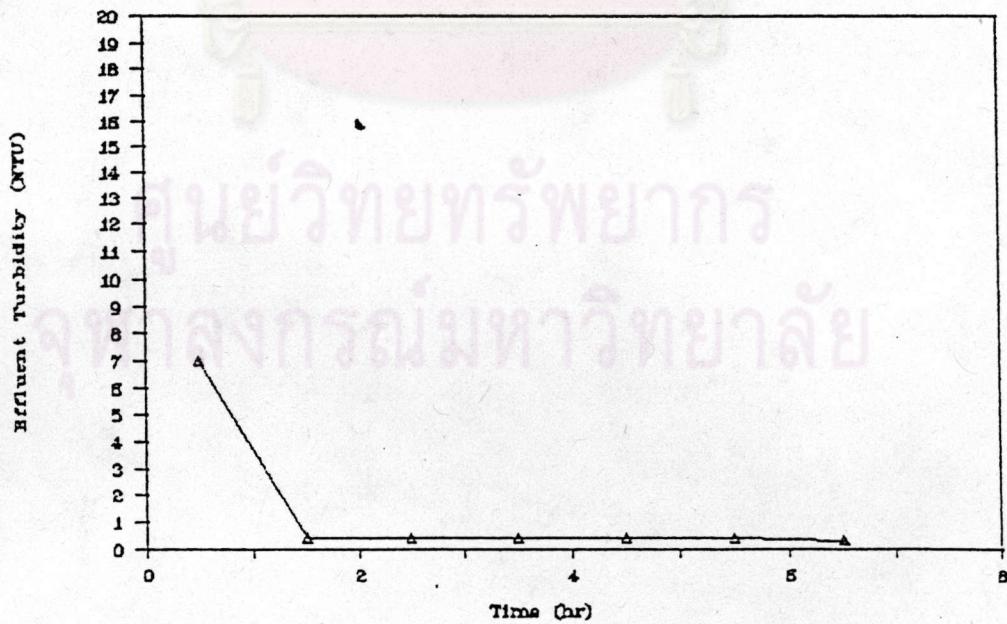
RUN NO. 24

The experimental condition was consisted of the following parameters:

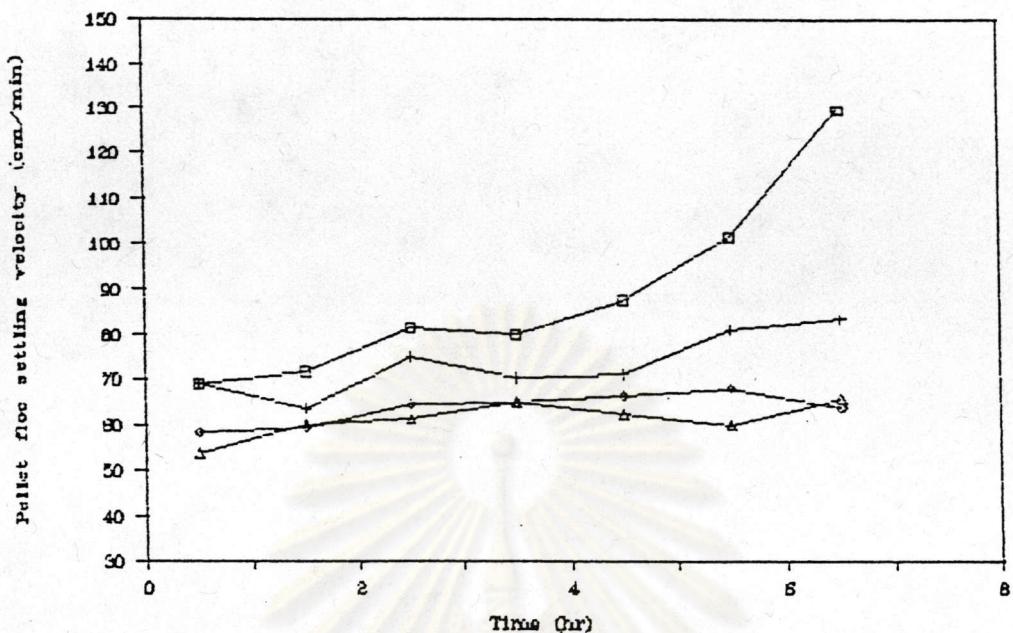
- a) Polyaluminum chloride dosage was 4 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 5 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

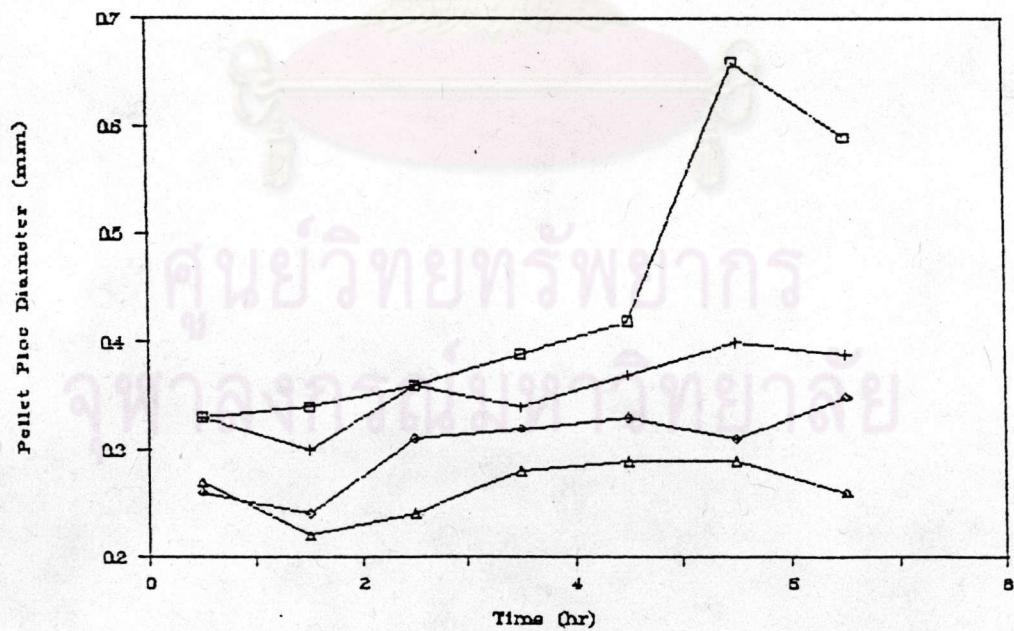
R 24, PACl 4.0, PE 0.3, 5 rpm, Upf 40



R24, PACl 4.0, PE 0.3, 5 rpm, Upf 40



R24, PACl 4.0, PE 0.3, 5 rpm, Upf 40



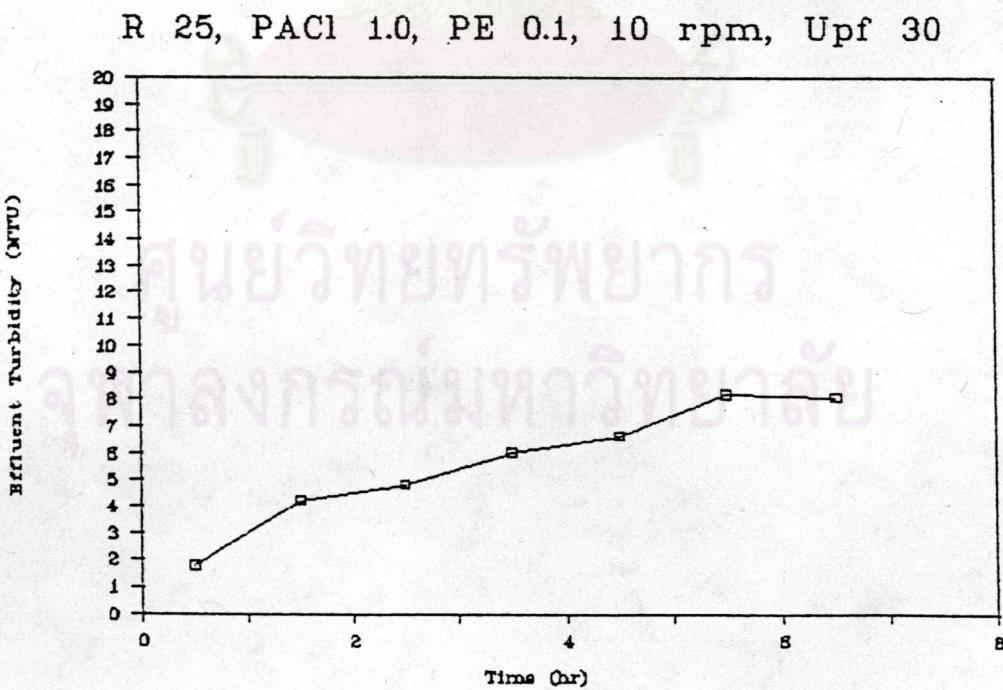
□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

RUN NO. 25

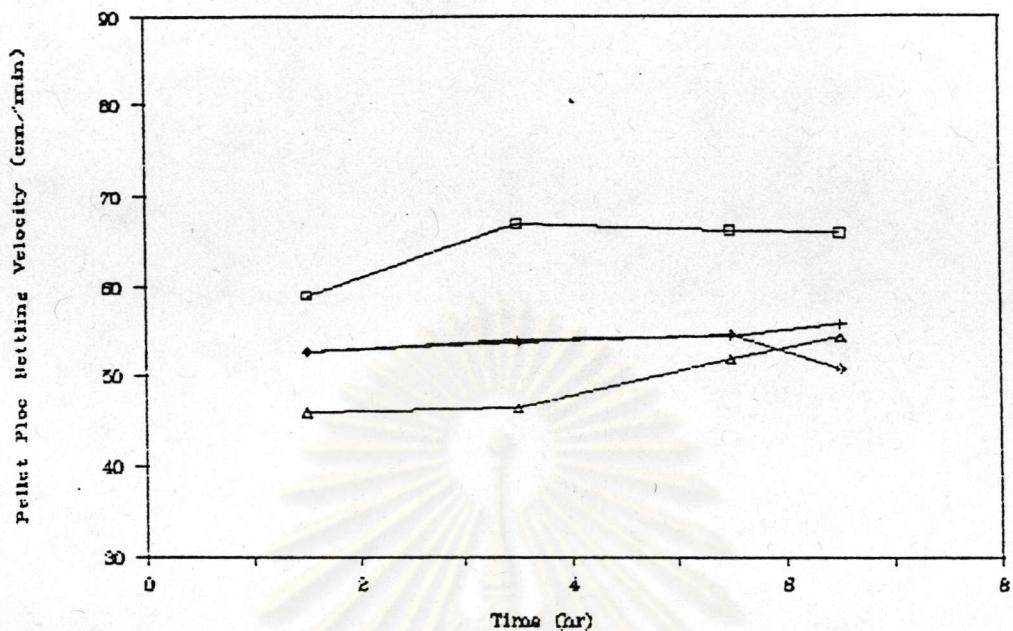
The experimental condition was consisted of the following parameters:

- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 30 cm./min.

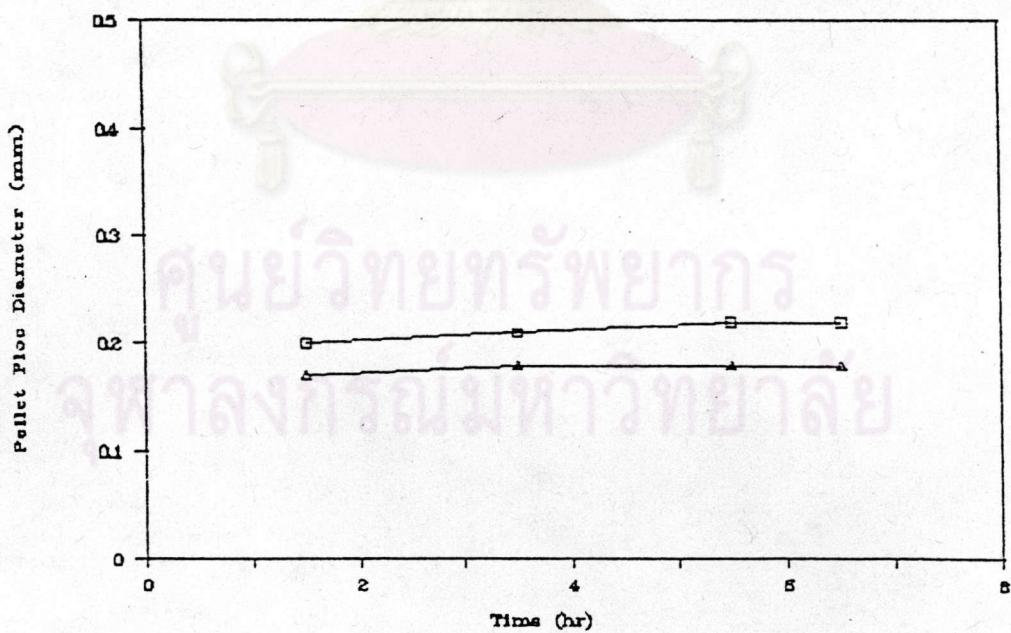
The experimental results of each run were shown in the following figures:



R25, PACl 1.0, PE 0.1, 10 rpm, Upf 30



R 25, PACl 1.0, PE 0.1, 10 rpm, Upf 30



□ H 0 cm + H 60 cm ◆ H 120 cm △ H 150 cm

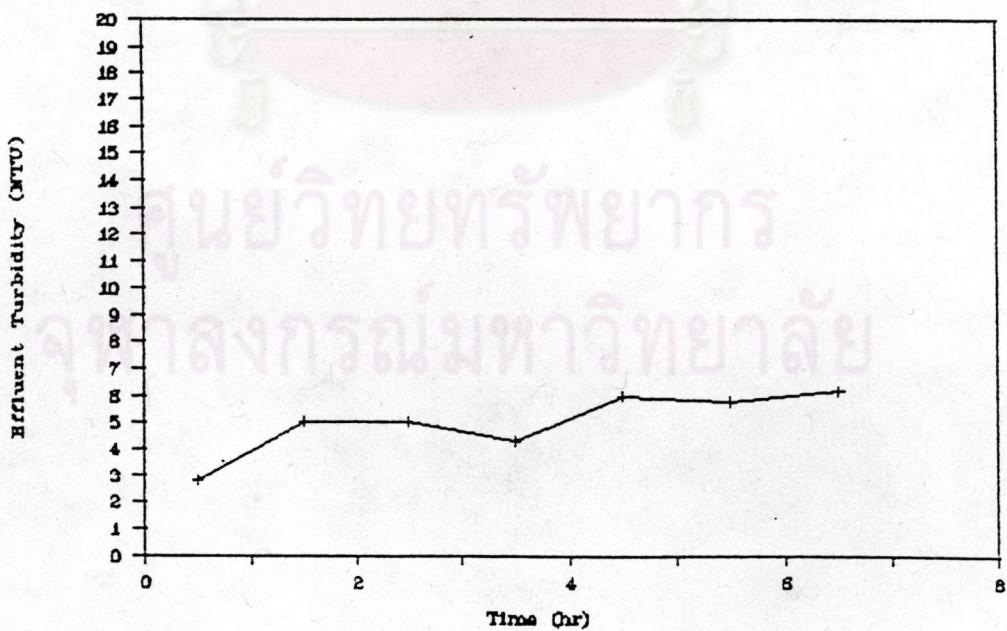
RUN NO. 26

The experimental condition was consisted of the following parameters:

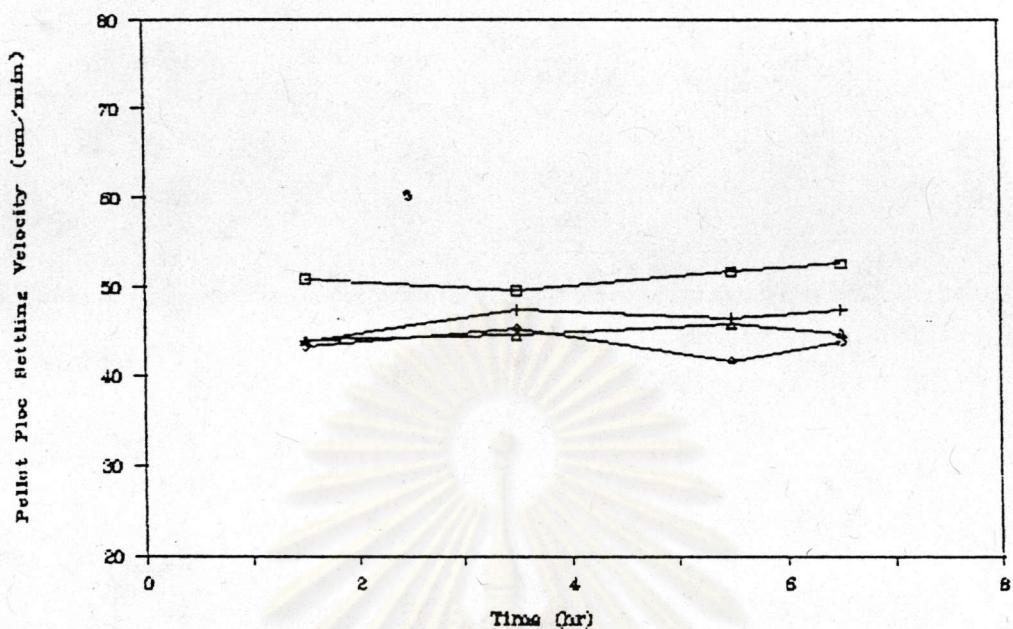
- a) Polyaluminum chloride dosage was 2 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

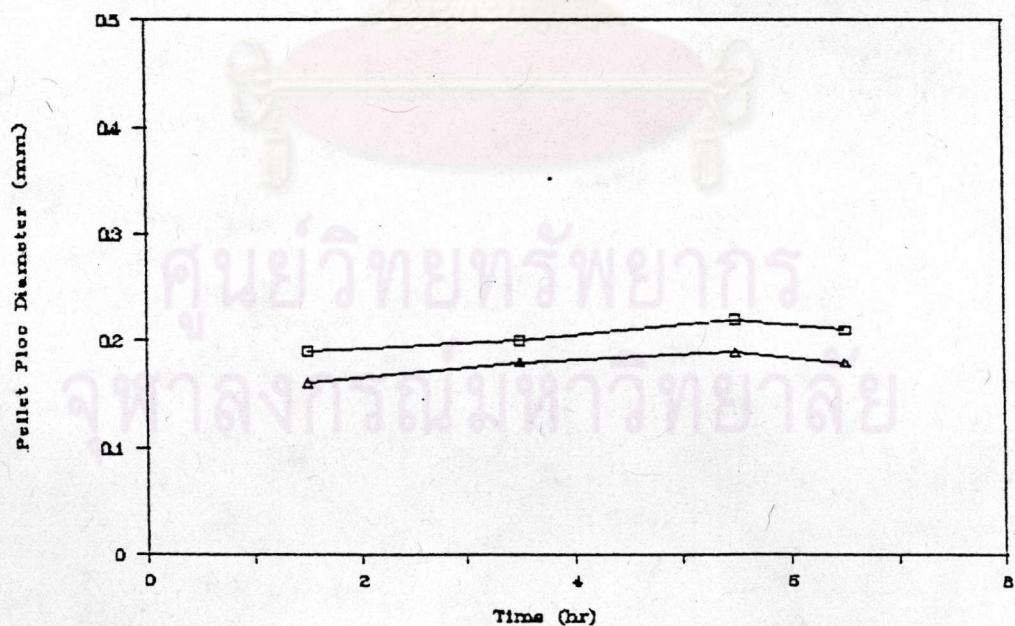
R 26, PACl 2.0, PE 0.1, 10 rpm, Upf 30



R26, PACl 2.0, PE 0.1, 10 rpm, Upf 30



R 26, PACl 2.0, PE 0.1, 10 rpm, Upf 30



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

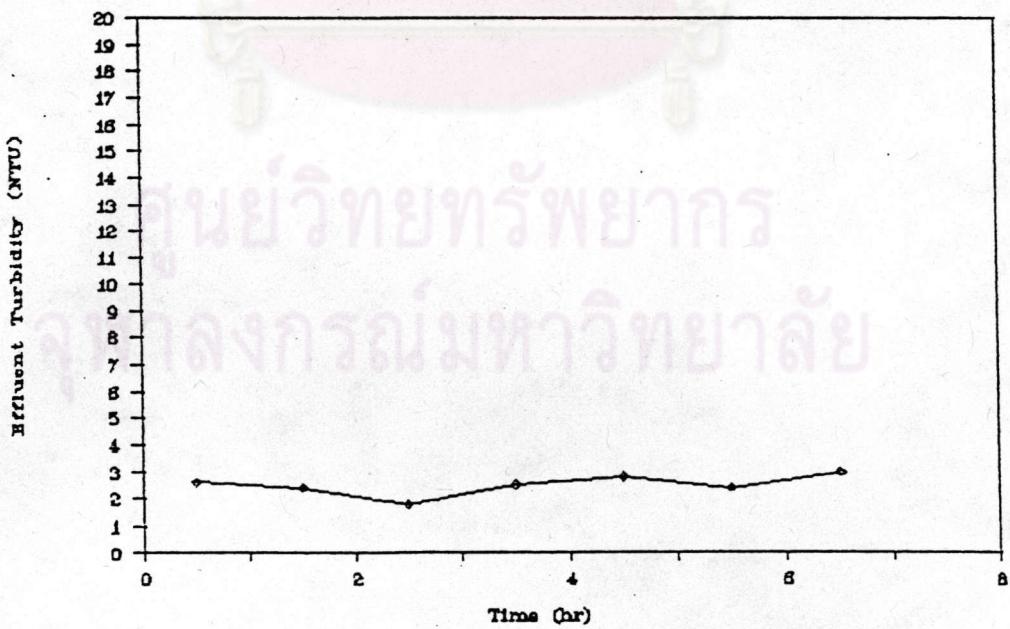
RUN NO. 27

The experimental condition was consisted of the following parameters:

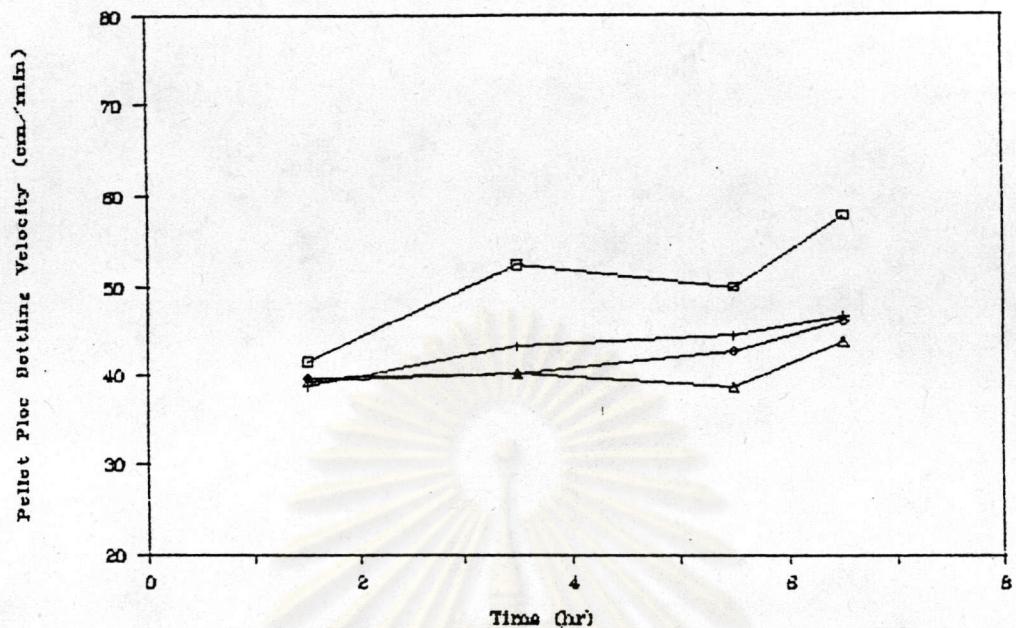
- a) Polyaluminum chloride dosage was 3 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

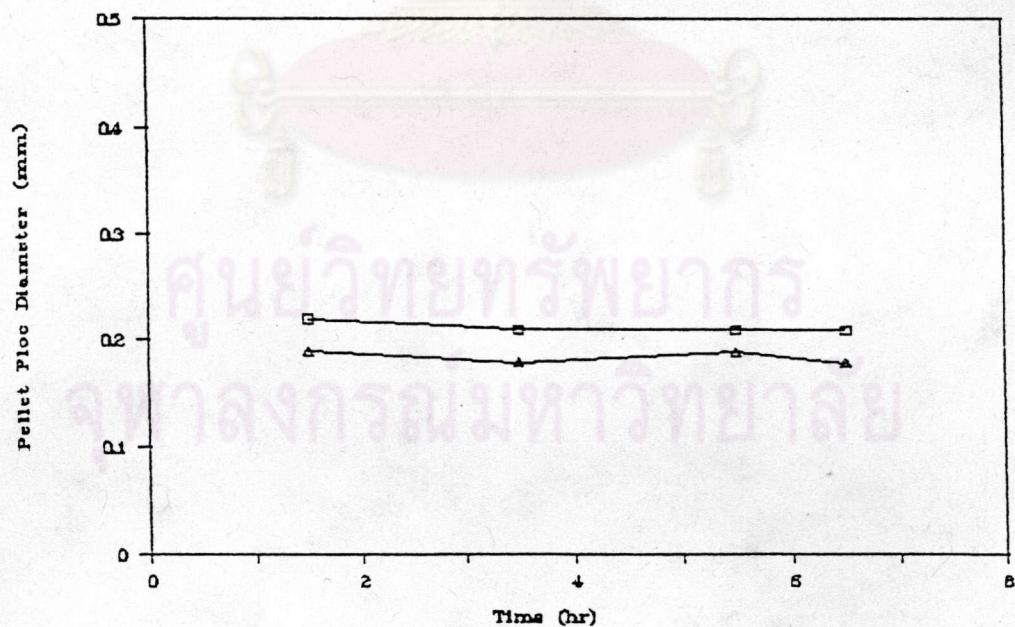
R 27, PACl 3.0, PE 0.1, 10 rpm, Upf 30



R27, PACl 3.0, PE 0.1, 10 rpm, Upf 30



R 27, PACl 3.0, PE 0.1, 10 rpm, Upf 30



□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

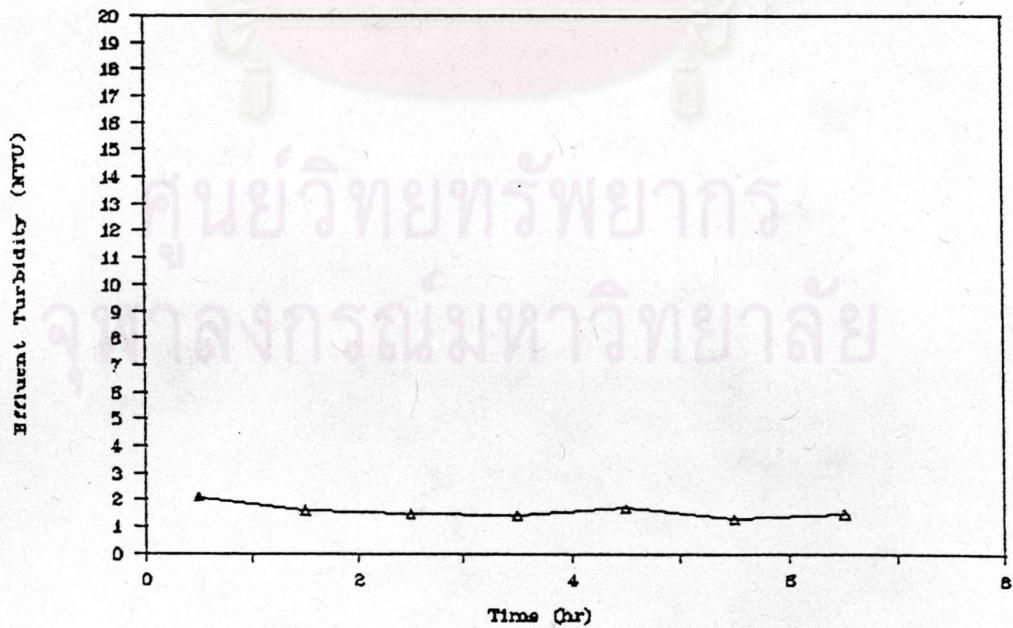
RUN NO. 28

The experimental condition was consisted of the following parameters:

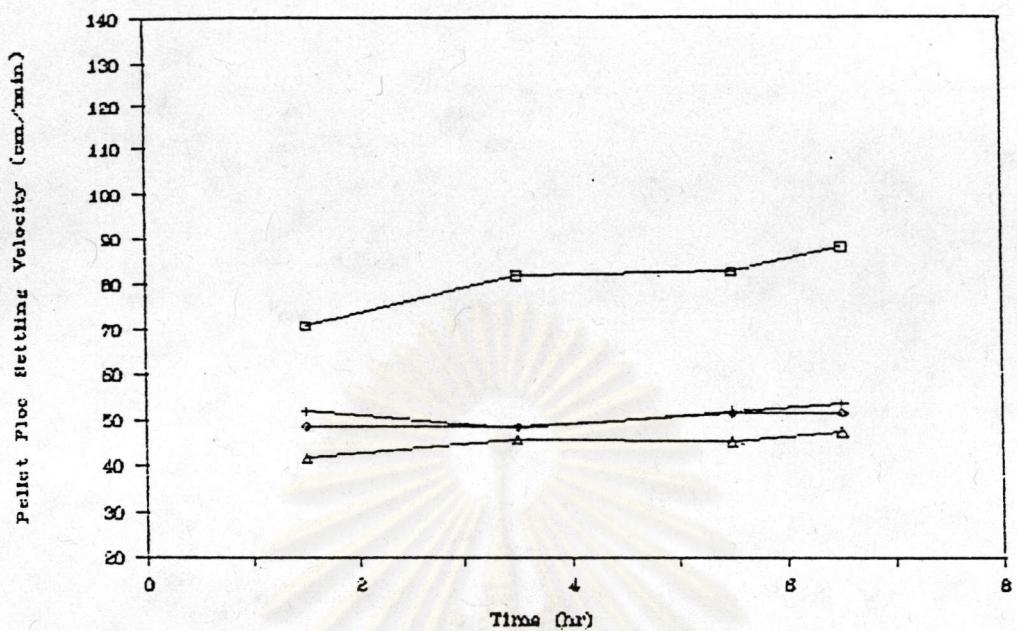
- a) Polyaluminum chloride dosage was 4 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

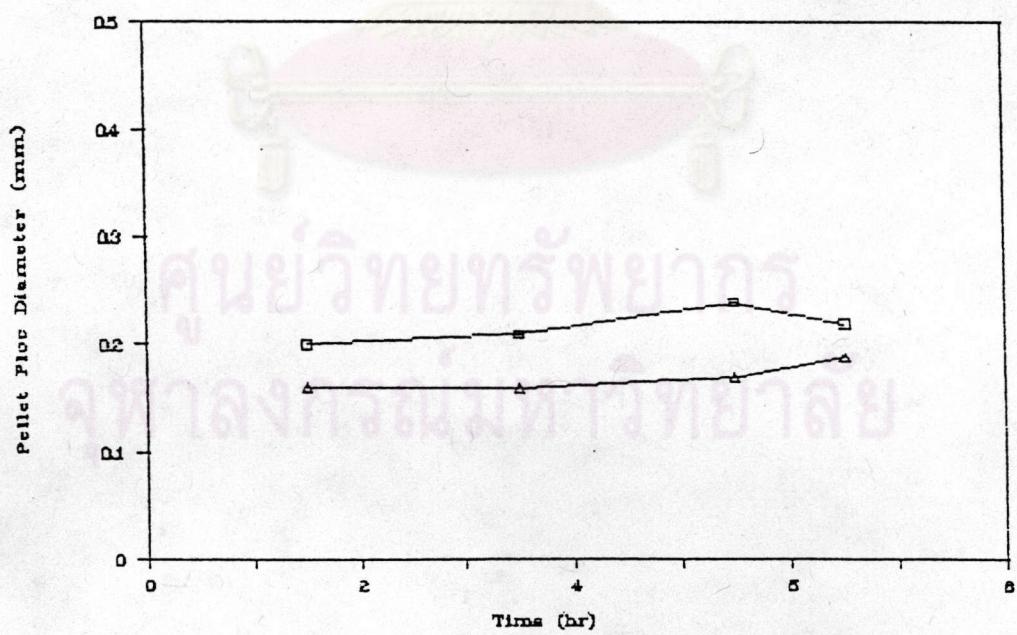
R 28, PACl 4.0, PE 0.1, 10 rpm, Upf 30



R28, PACl 4.0, PE 0.1, 10 rpm, Upf 30



R 28, PACl 4.0, PE 0.1, 10 rpm, Upf 30



□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

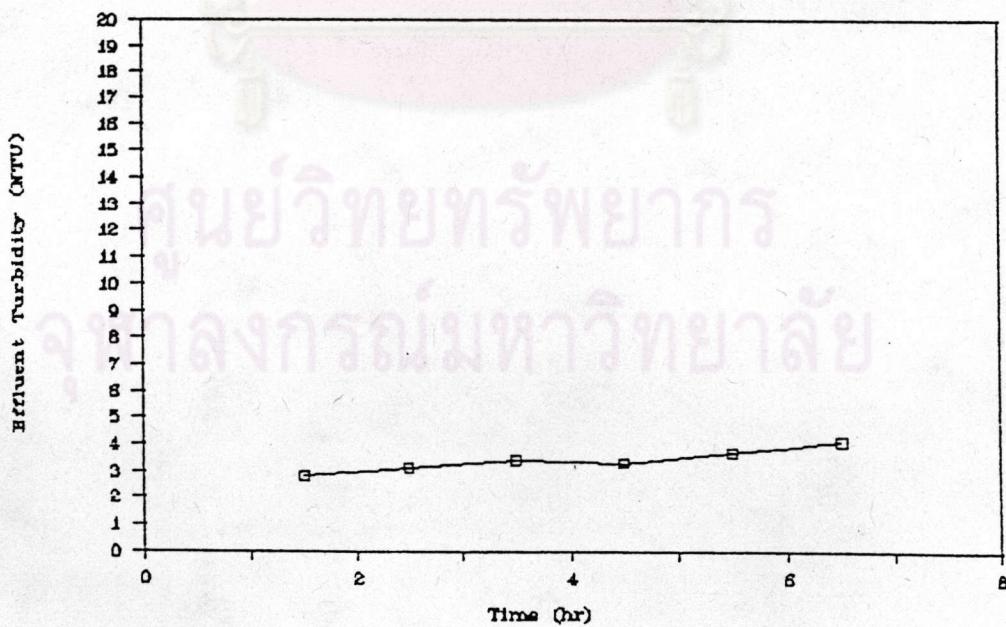
RUN NO. 29

The experimental condition was consisted of the following parameters:

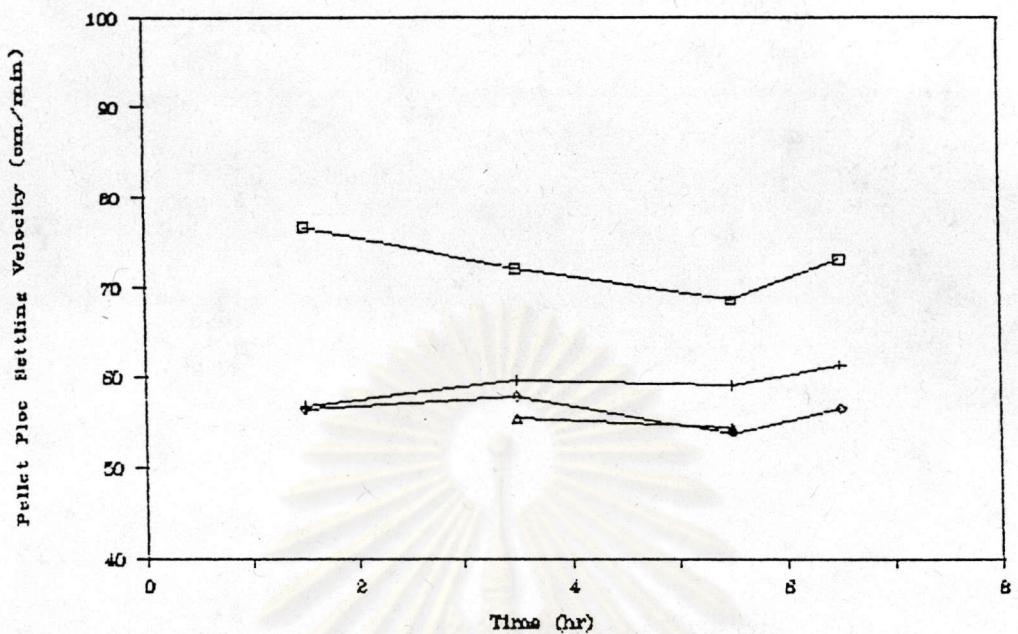
- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

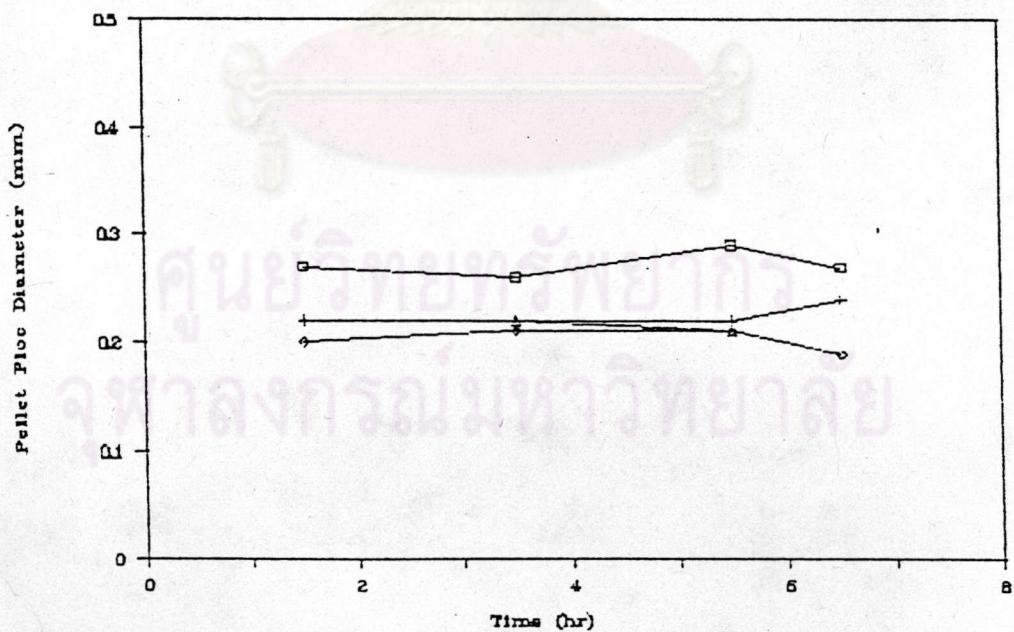
R 29, PACl 1.0, PE 0.2, 10 rpm, Upf 30



R29, PACl 1.0, PE 0.2, 10 rpm, Upf 30



R 29, PACl 1.0, PE 0.2, 10 rpm, Upf 30



□ H 0 cm + H 60 cm ♦ H 120 cm Δ H 150 cm

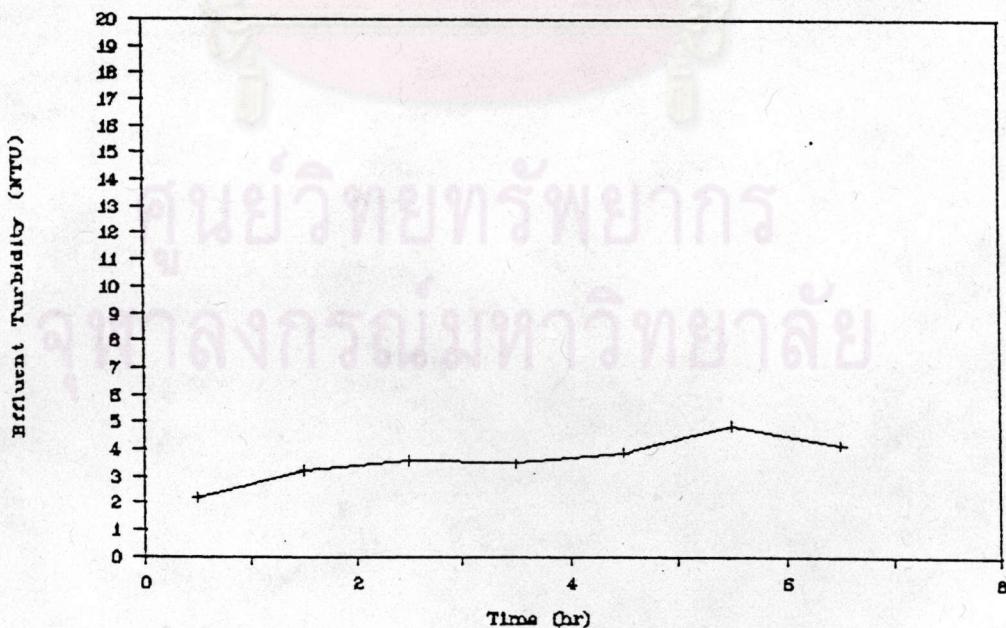
RUN NO. 30

The experimental condition was consisted of the following parameters:

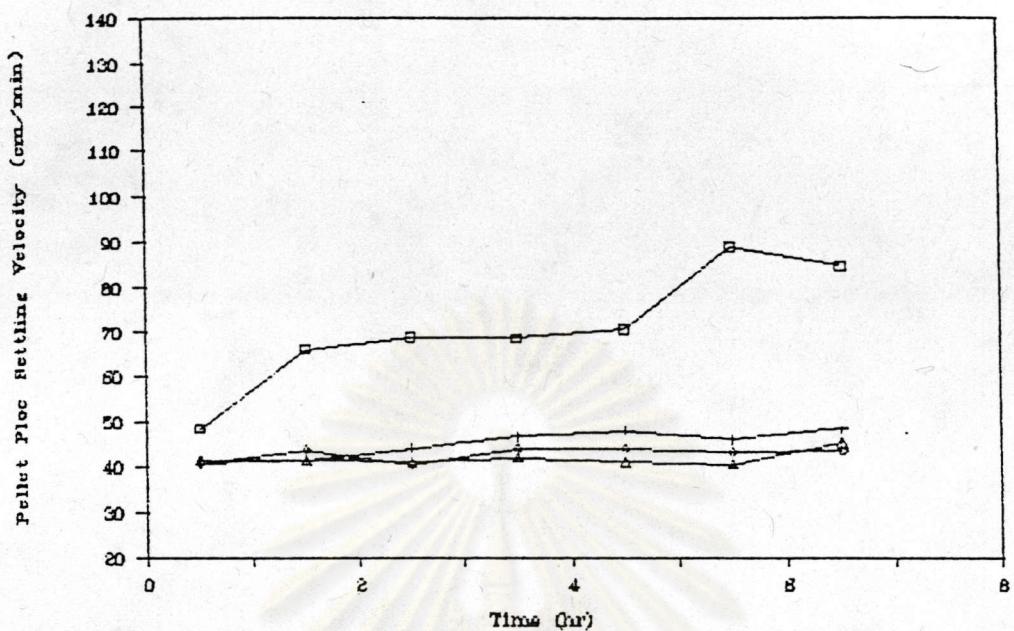
- a) Polyaluminum chloride dosage was 2 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

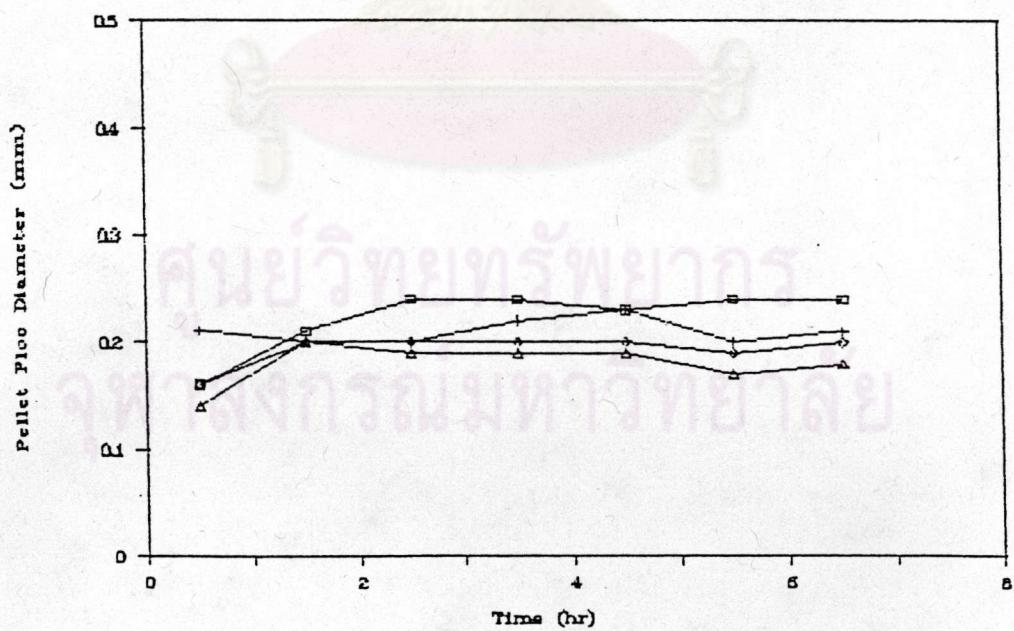
R 30, PACl 2.0, PE 0.2, 10 rpm, Upf 30



R30, PACl 2.0, PE 0.2, 10 rpm, Upf 30



R30, PACl 2.0, PE 0.2, 10 rpm, Upf 30



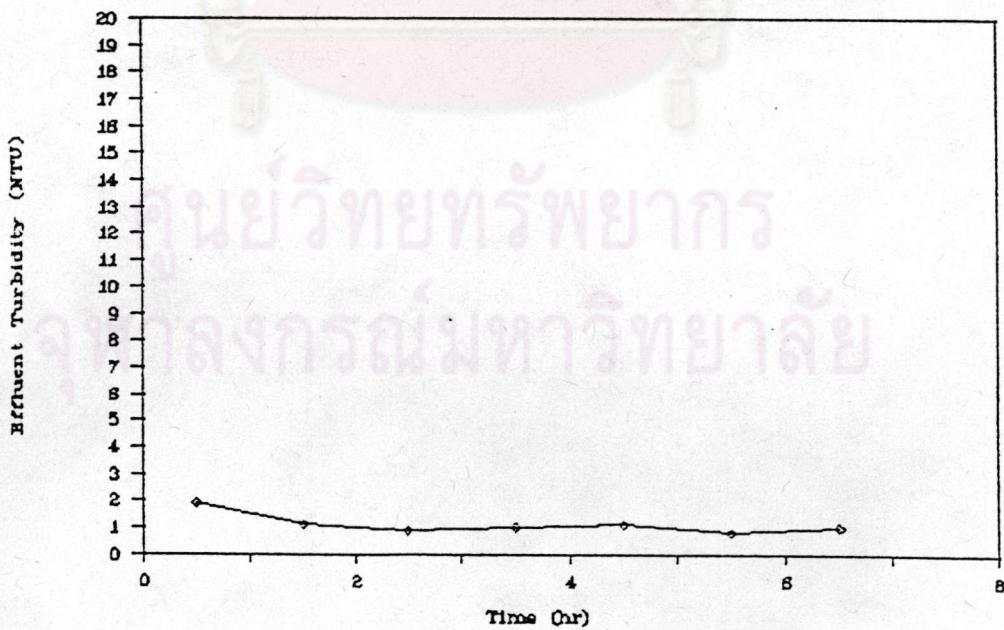
□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

The experimental condition was consisted of the following parameters:

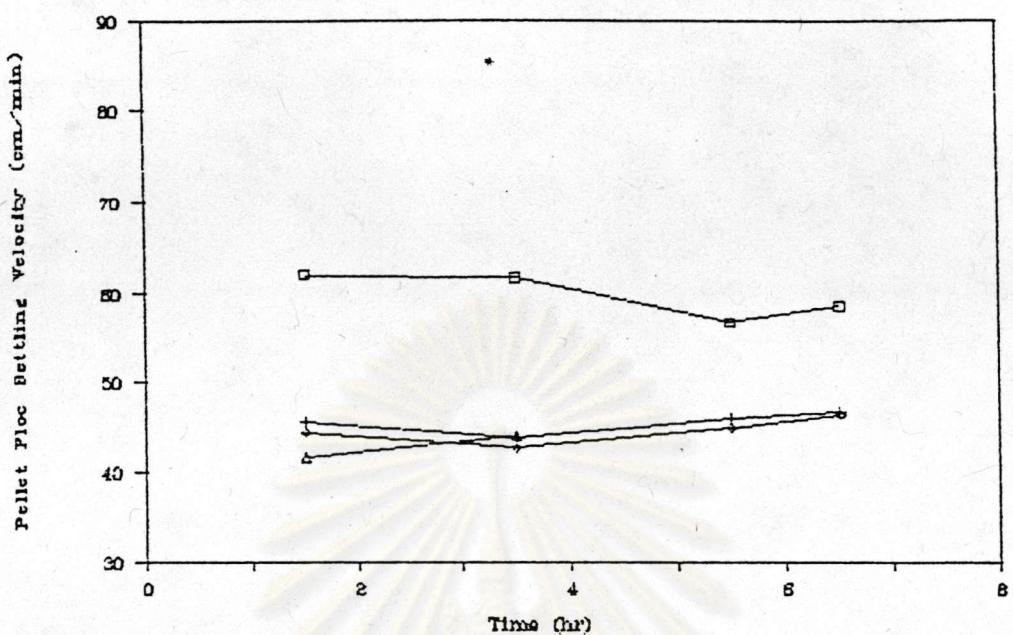
- a) Polyaluminum chloride dosage was 3 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

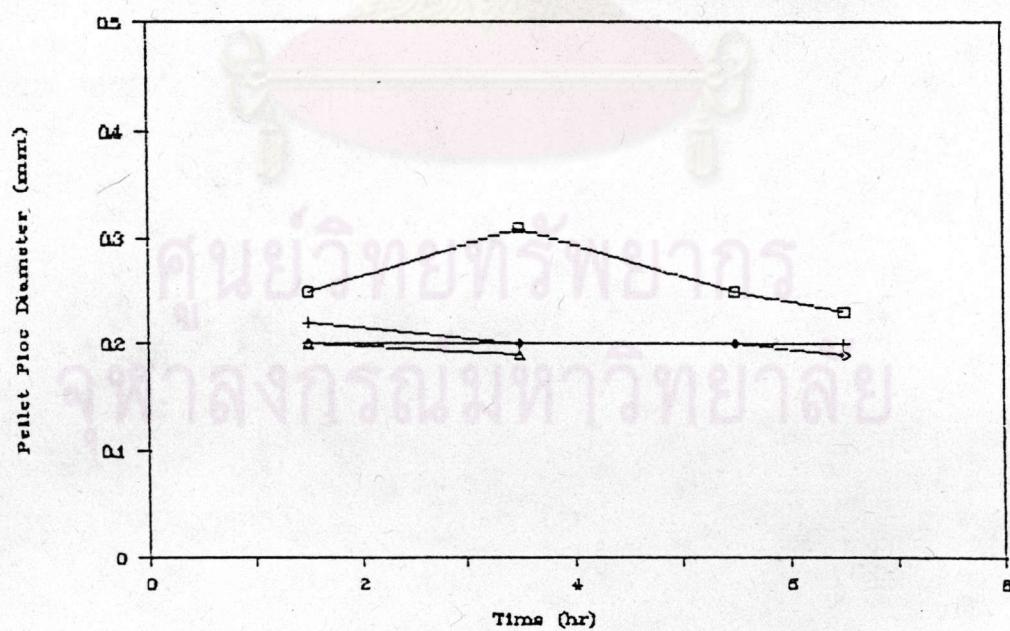
R 31, PAC1 3.0, PE 0.2, 10 rpm, Upf 30



R 31, PACl 3.0, PE 0.2, 10 rpm, Upf 30



R31, PACl 3.0, PE 0.2, 10 rpm, Upf 30



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

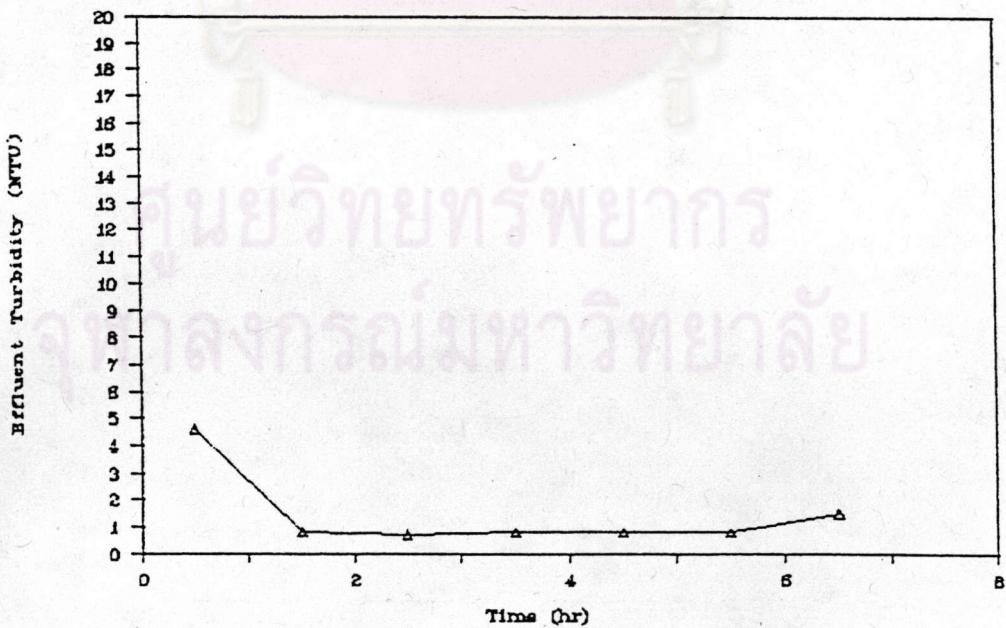
RUN NO. 32

The experimental condition was consisted of the following parameters:

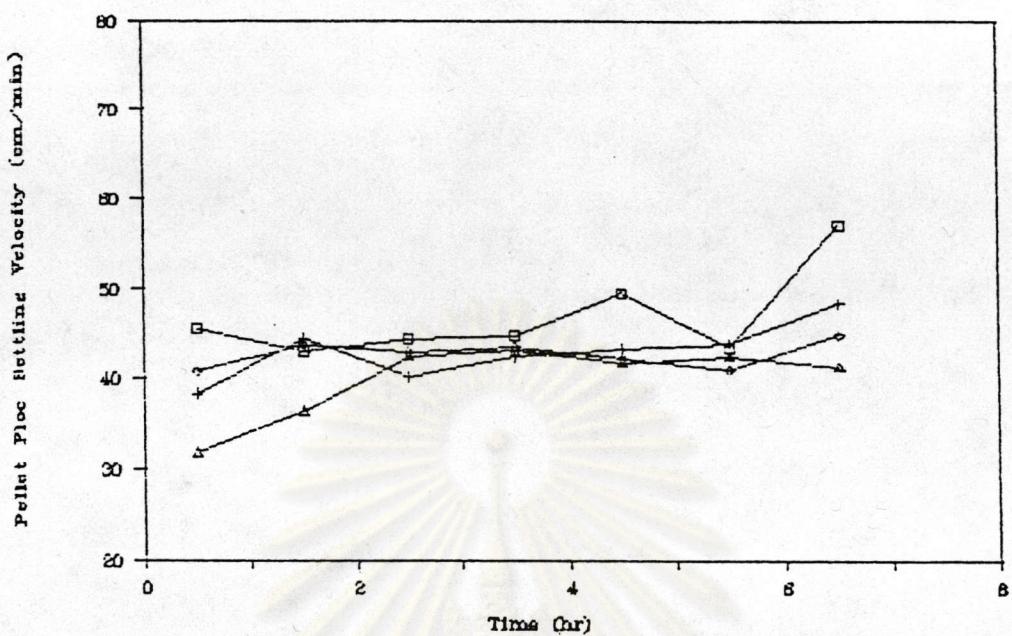
- a) Polyaluminum chloride dosage was 4 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

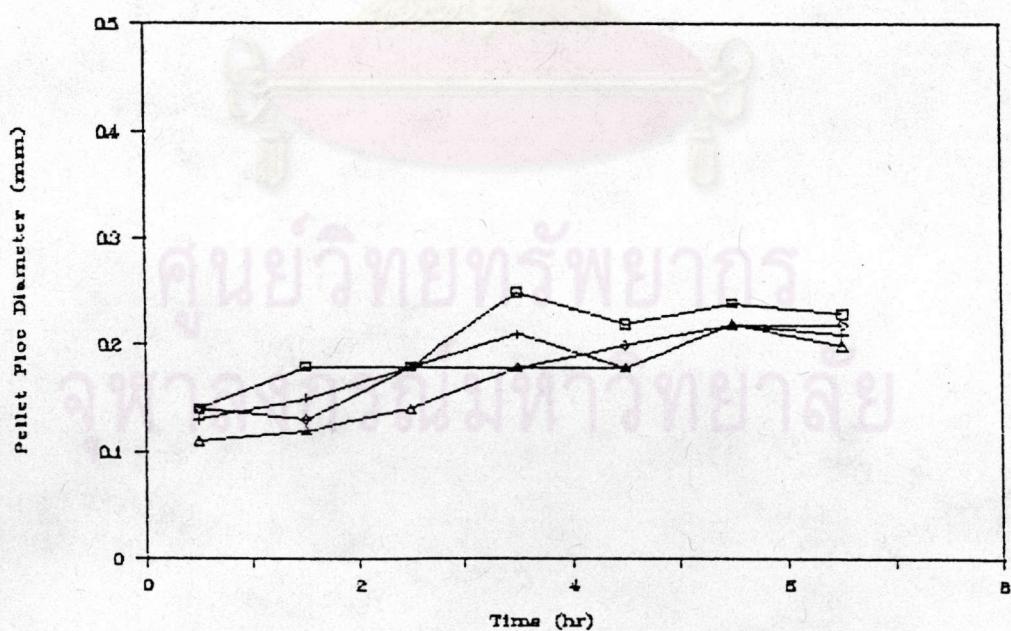
R 32, PACl 4.0, PE 0.2, 10 rpm, Upf 30



R32, PACl 4.0, PE 0.2, 5 rpm, Upf 30



R32, PACl 4.0, PE 0.2, 5 rpm, Upf 30



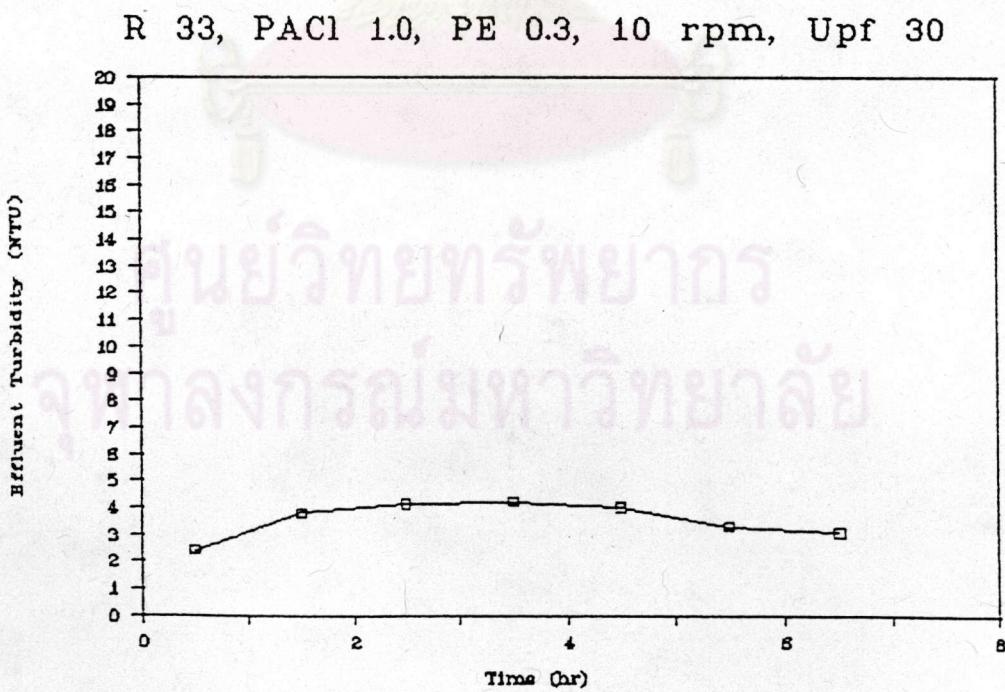
□ H 0 cm + H 60 cm ◇ H 120 cm △ H 150 cm

RUN NO. 33

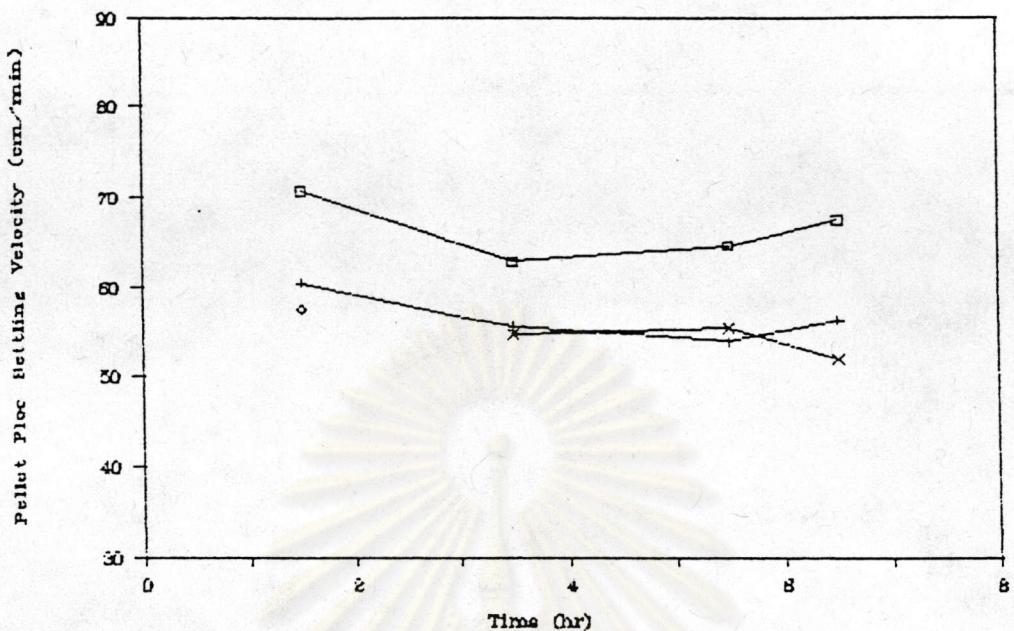
The experimental condition was consisted of the following parameters:

- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 30 cm./min.

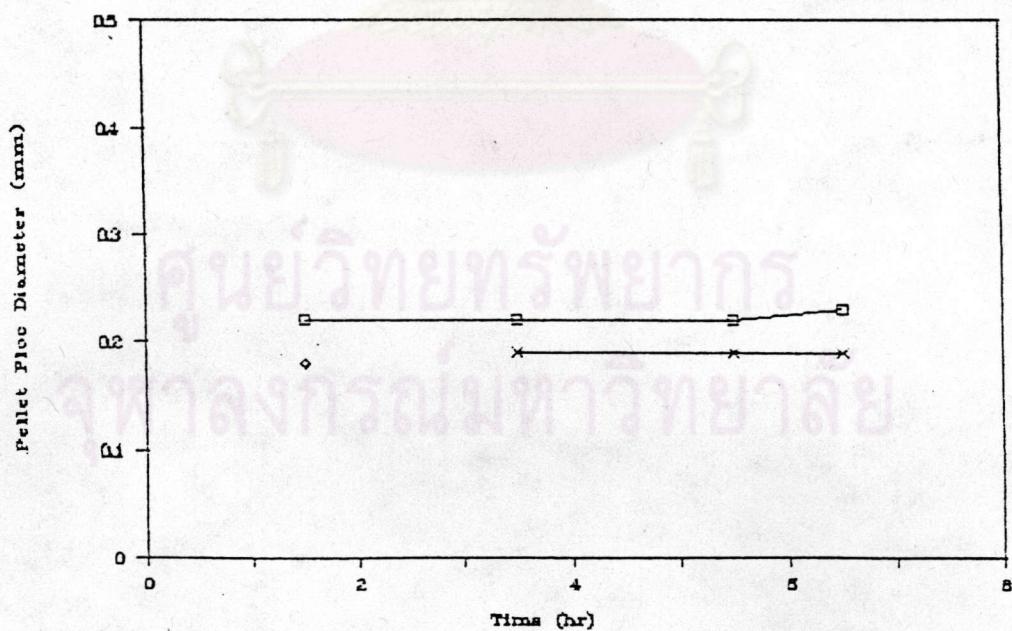
The experimental results of each run were shown in the following figures:



R 33, PACl 1.0, PE 0.3, 10 rpm, Upf 30



R33, PACl 1.0, PE 0.3, 10 rpm, Upf 30



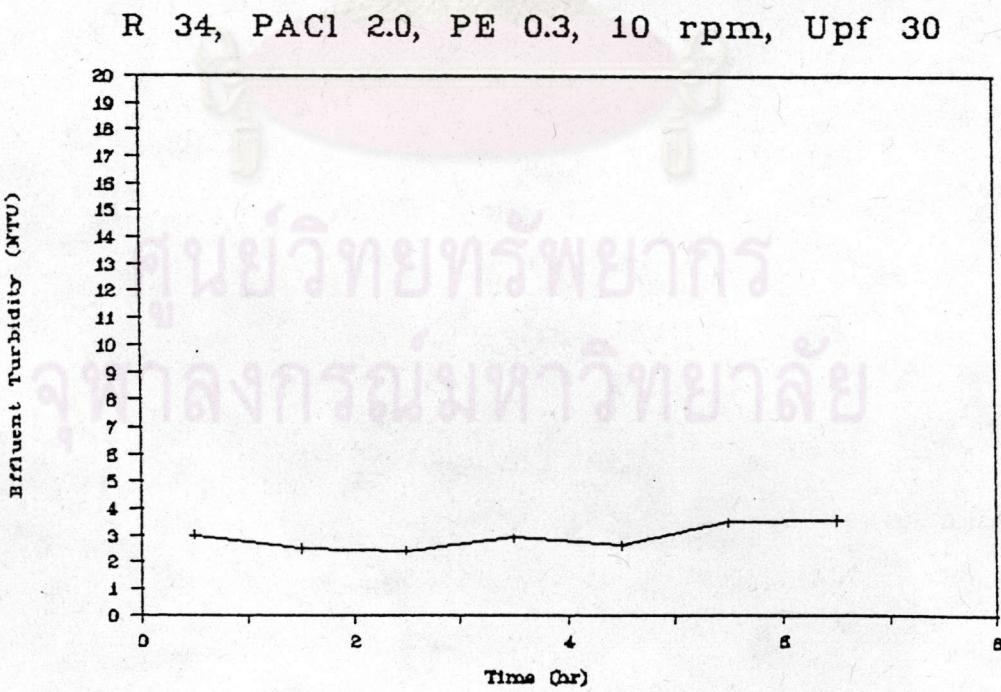
□ H 0 cm + H 60 cm × H 90 cm ◊ H 120 cm △ H 150 cm

RUN NO. 34

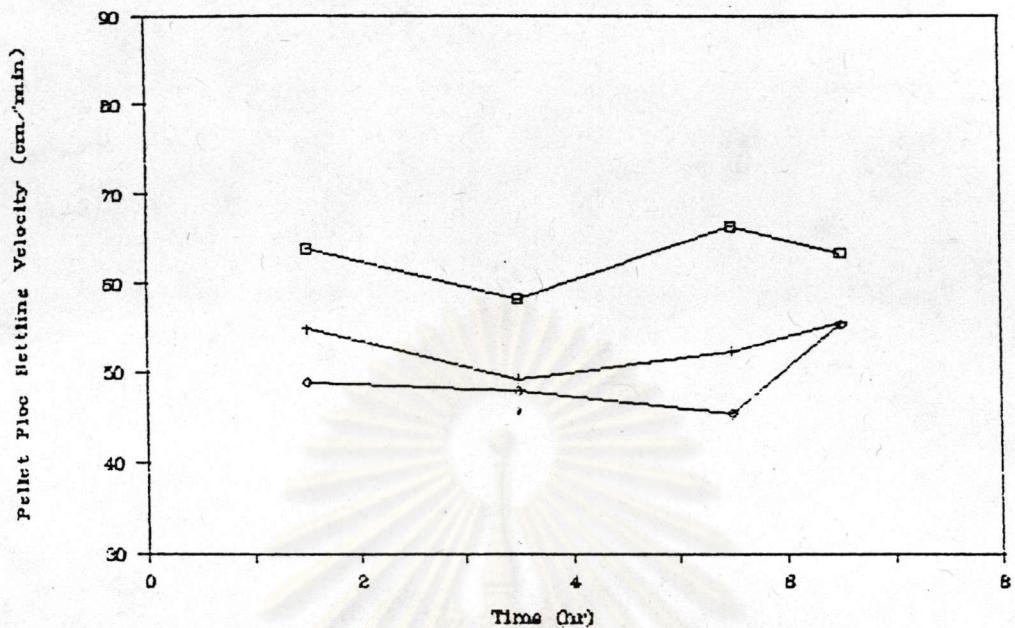
The experimental condition was consisted of the following parameters:

- a) Polyaluminum chloride dosage was 2 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 30 cm./min.

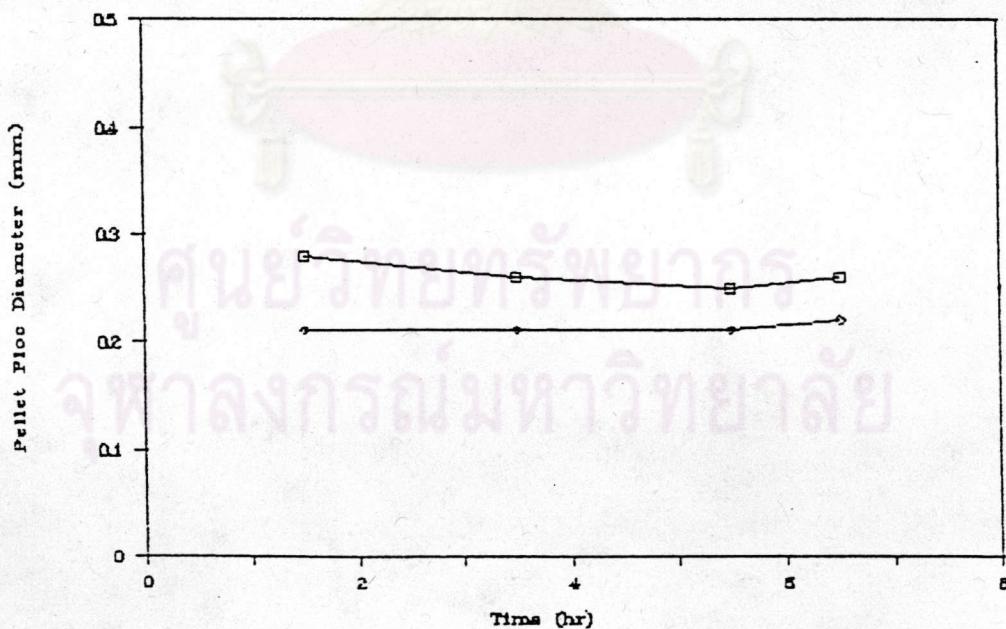
The experimental results of each run were shown in the following figures:



R34, PACl 2.0, PE 0.3, 10 rpm, Upf 30



R34, PACl 2.0, PE 0.3, 10 rpm, Upf 30



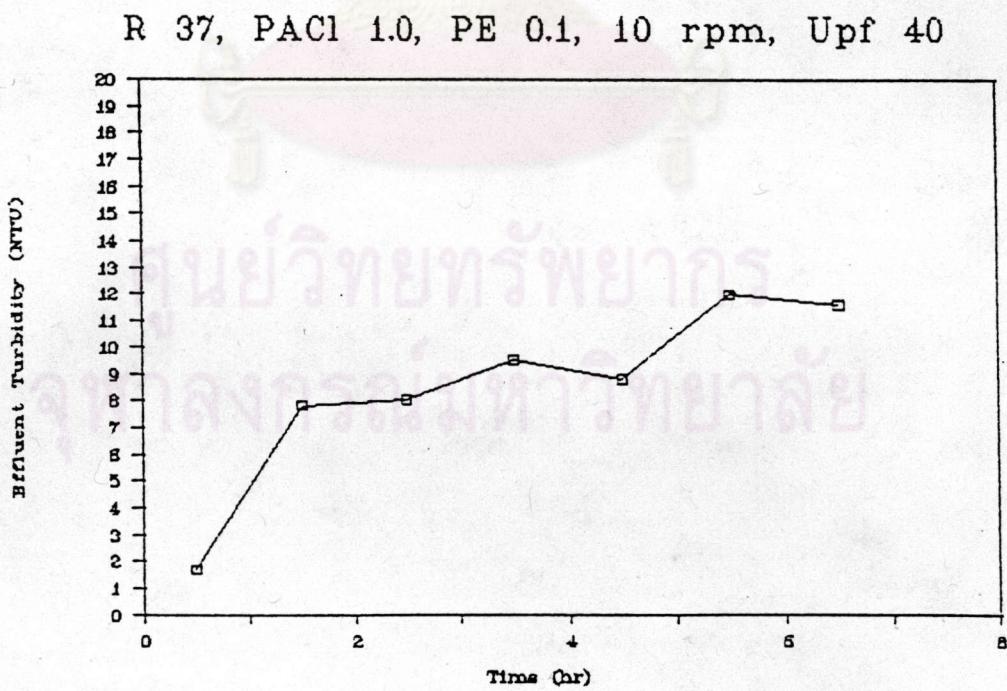
□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

RUN NO. 37

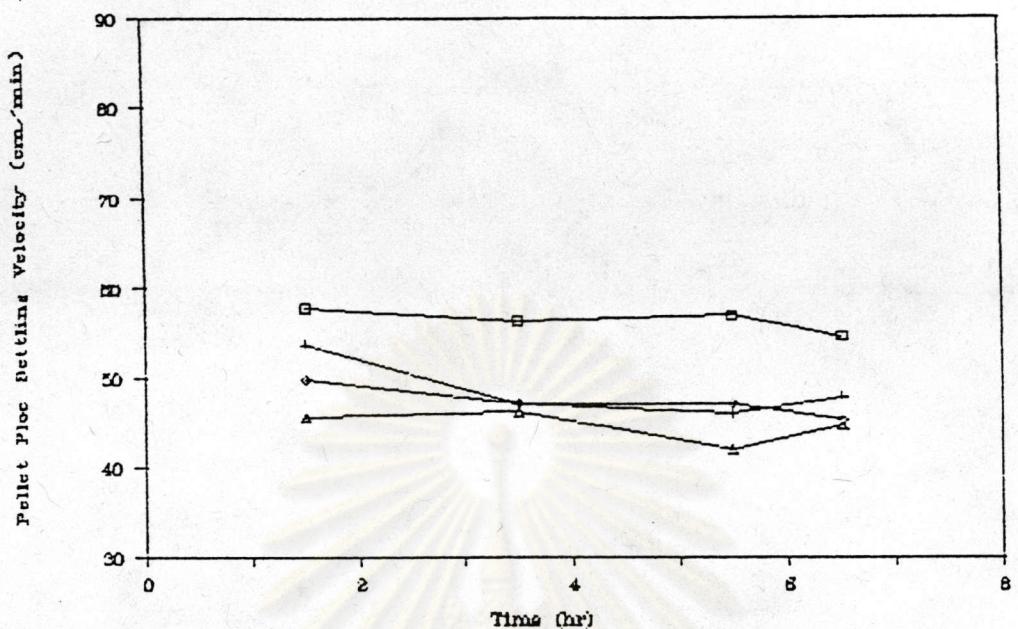
The experimental condition was consisted of the following parameters:

- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 40 cm./min.

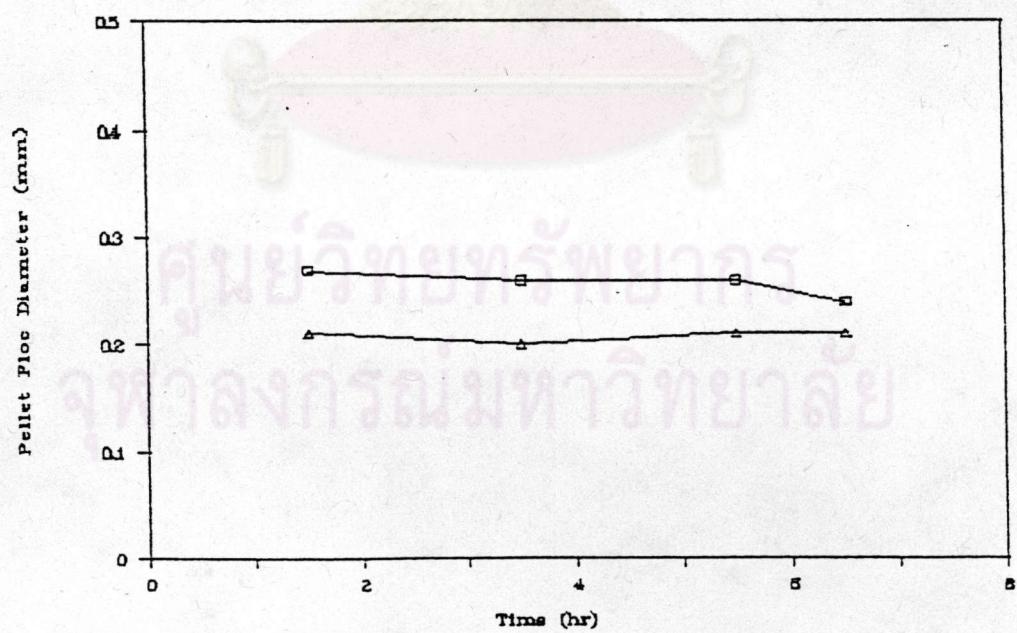
The experimental results of each run were shown in the following figures:



R37, PACl 1.0, PE 0.1, 10 rpm, Upf 40



R37, PACl 1.0, PE 0.1, 10 rpm, Upf 40



□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

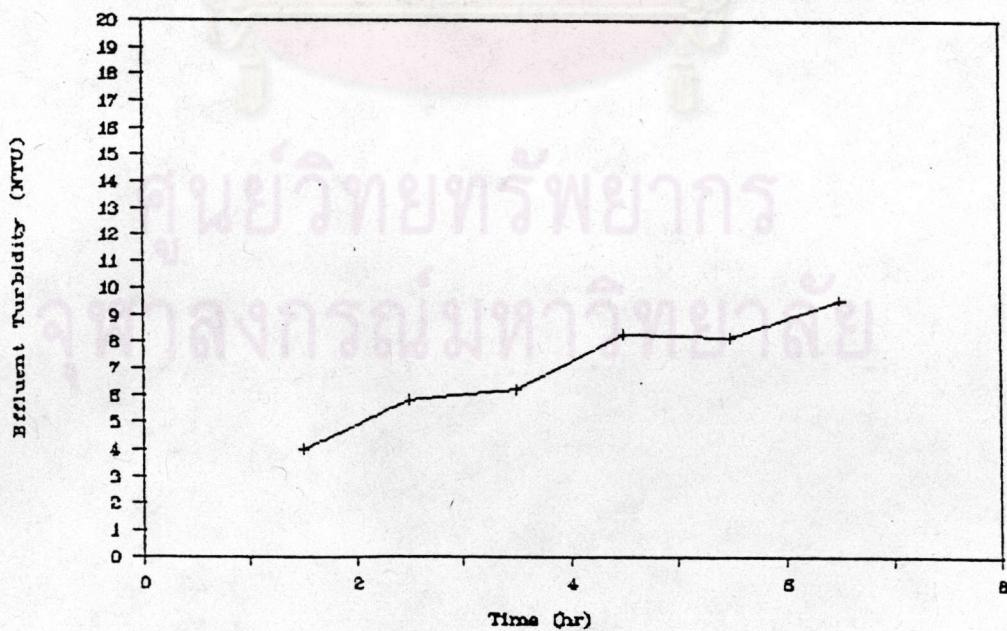
RUN NO. 38

The experimental condition was consisted of the following parameters:

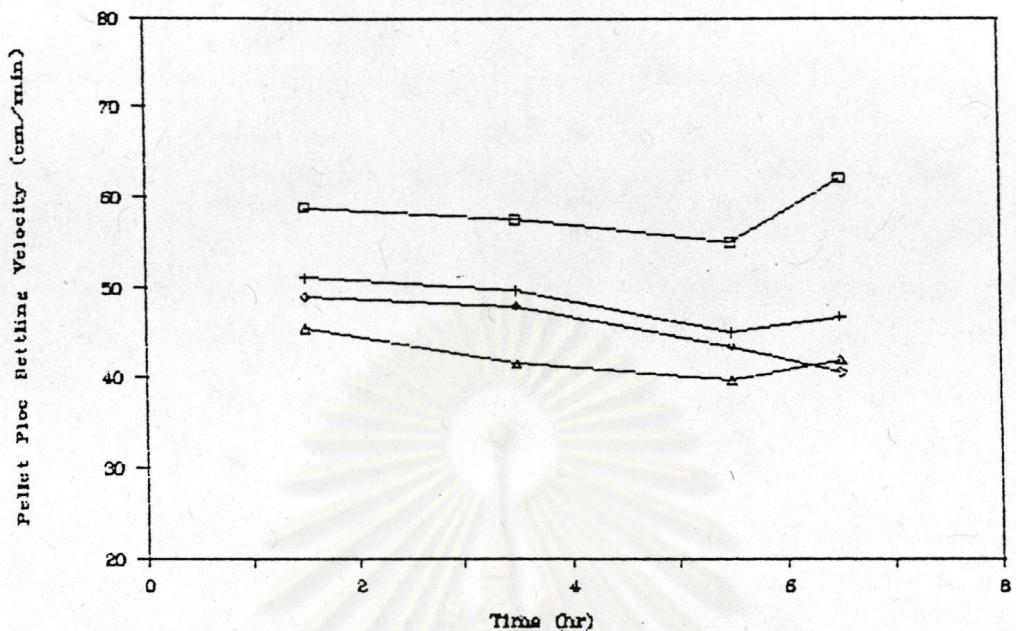
- a) Polyaluminum chloride dosage was 2 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

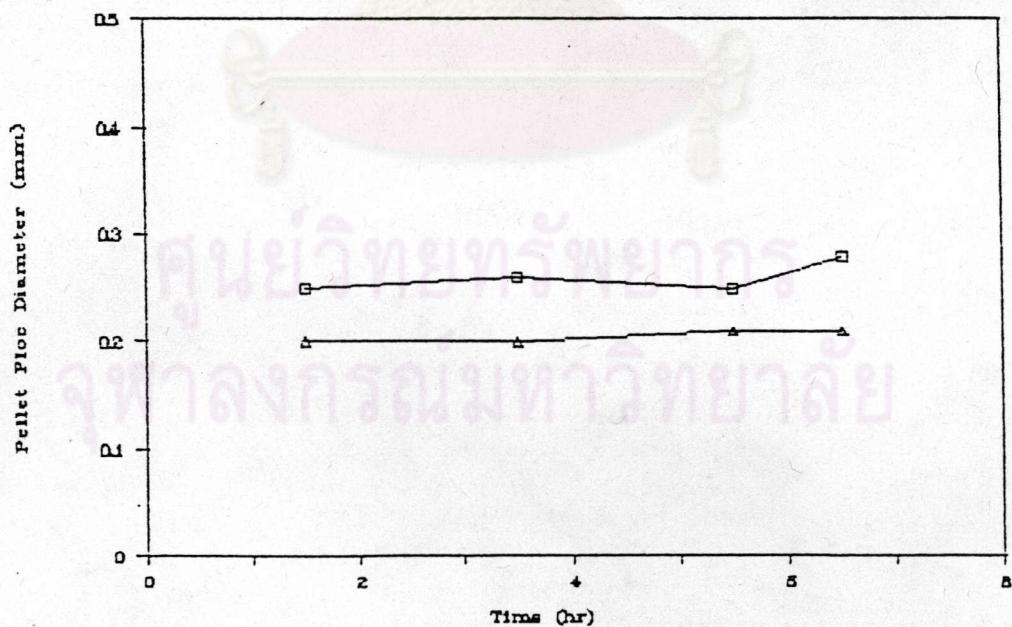
R 38, PACl 2.0, PE 0.1, 10 rpm, Upf 40



R38, PACl 2.0, PE 0.1, 10 rpm, Upf 40



R38, PACl 2.0, PE 0.1, 10 rpm, Upf 40



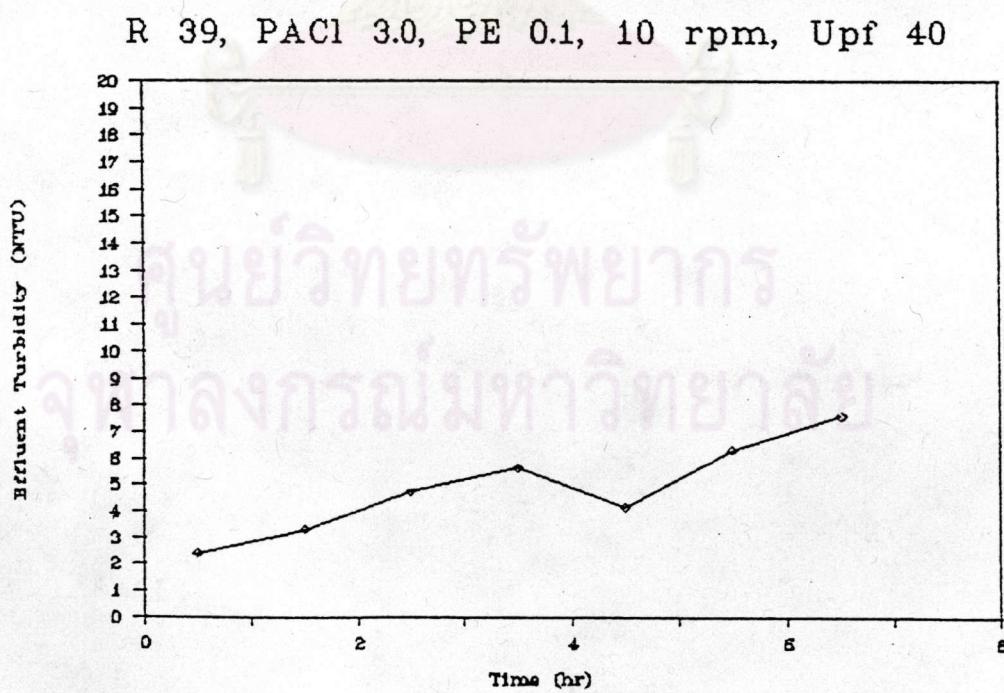
□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

RUN NO. 39

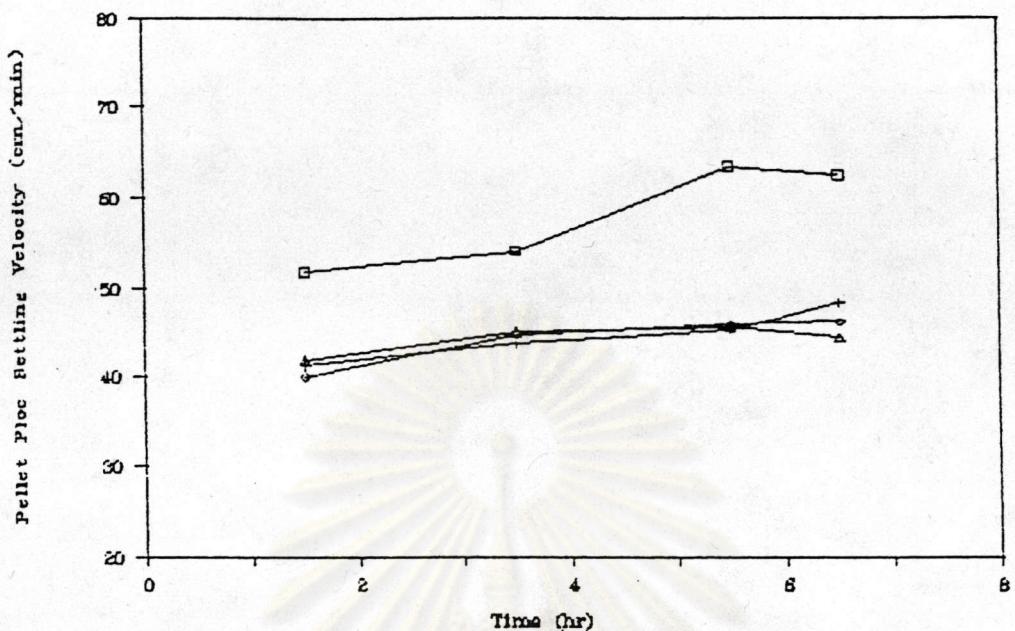
The experimental condition was consisted of the following parameters:

- a) Polyaluminum chloride dosage was 3 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 40 cm./min.

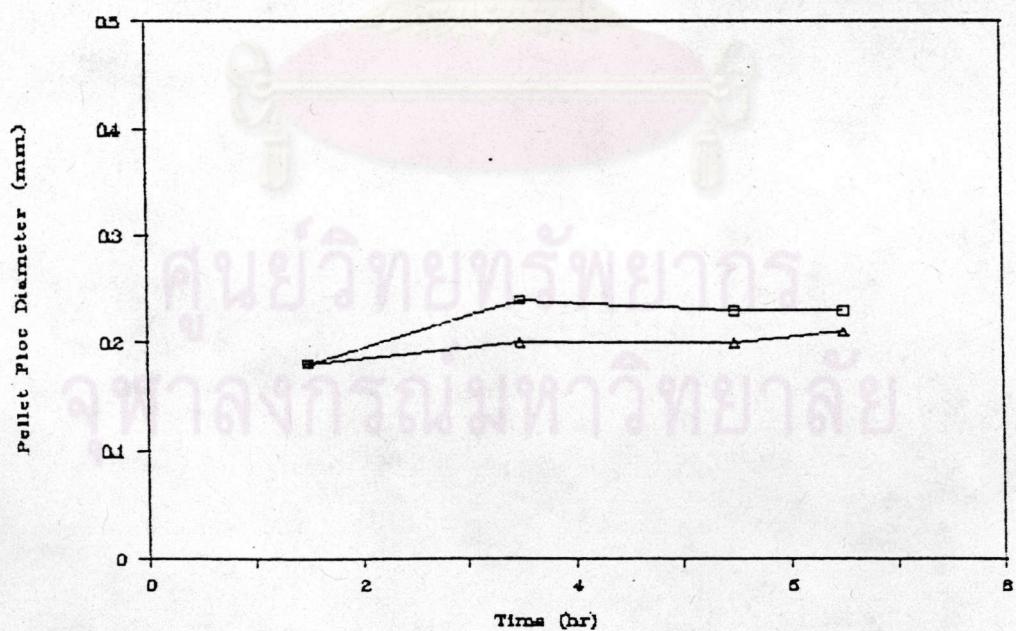
The experimental results of each run were shown in the following figures:



R39, PACl 3.0, PE 0.1, 10 rpm, Upf 40



R39, PACl 3.0, PE 0.1, 10 rpm, Upf 40



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

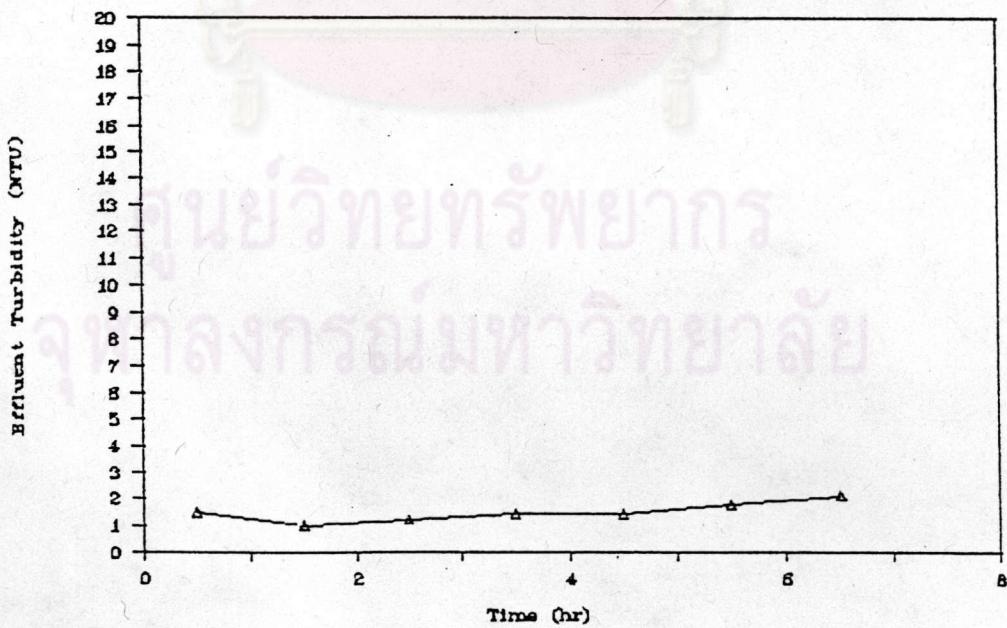
RUN NO. 40

The experimental condition was consisted of the following parameters:

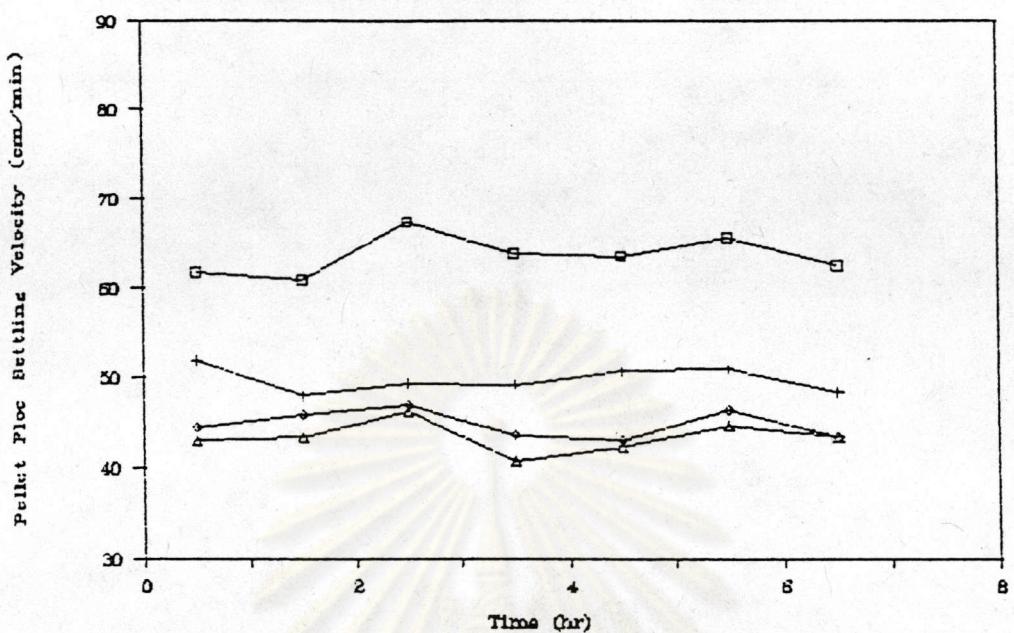
- a) Polyaluminum chloride dosage was 4 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

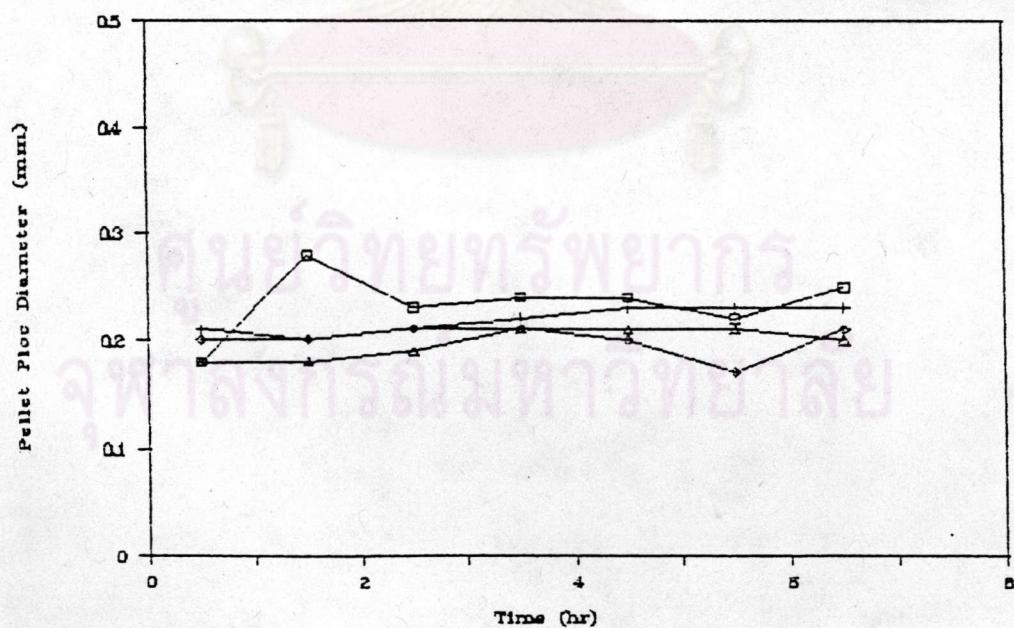
R 40, PACl 4.0, PE 0.1, 10 rpm, Upf 40



R 40, PACl 4.0, PE 0.1, 10 rpm, Upf 40



R40, PACl 4.0, PE 0.1, 10 rpm, Upf 40



□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

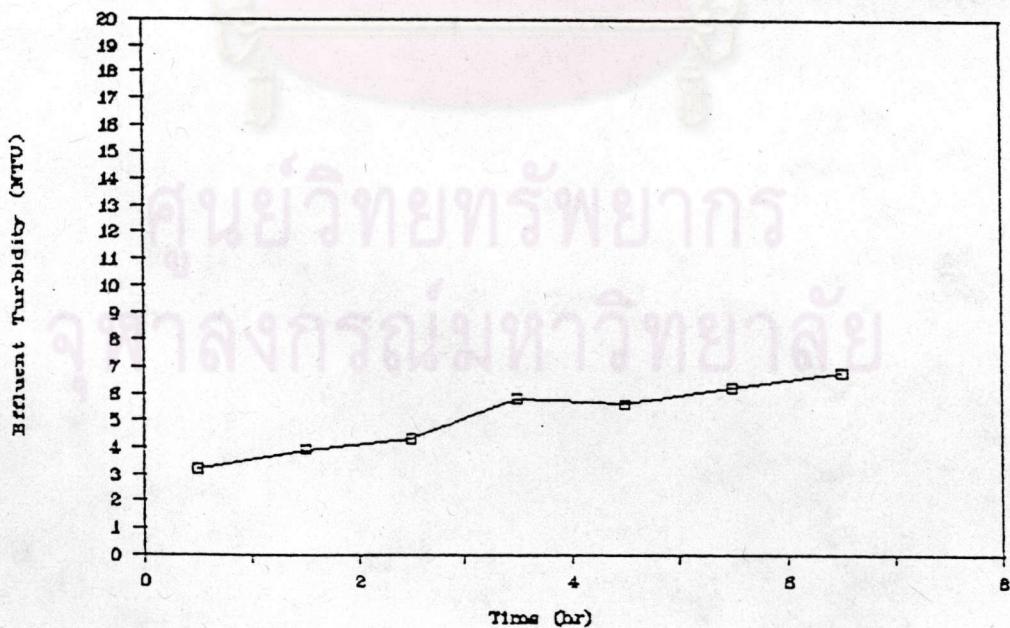
RUN NO. 41

The experimental condition was consisted of the following parameters:

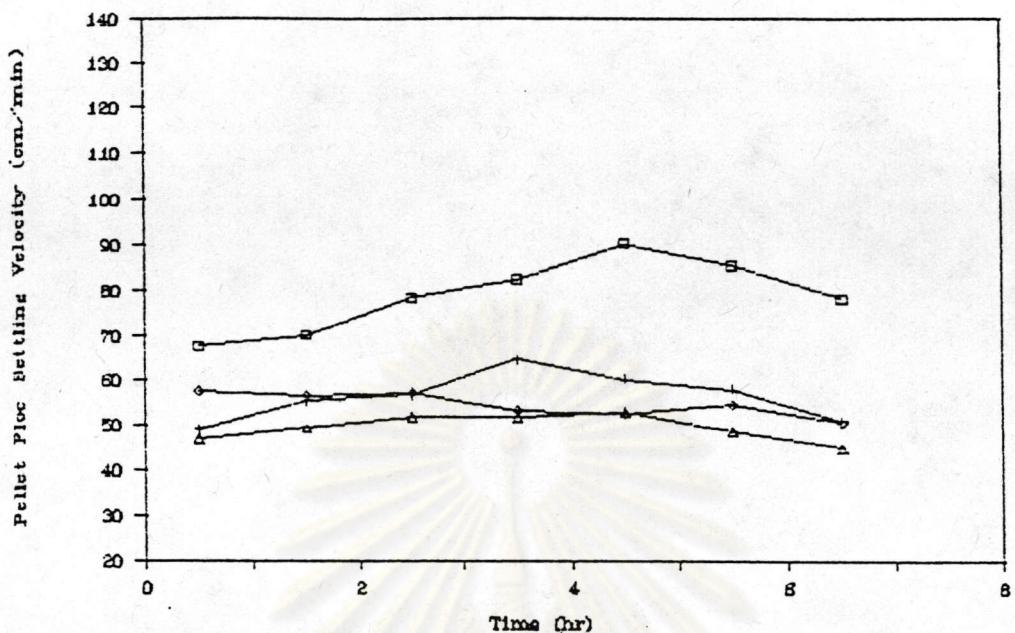
- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

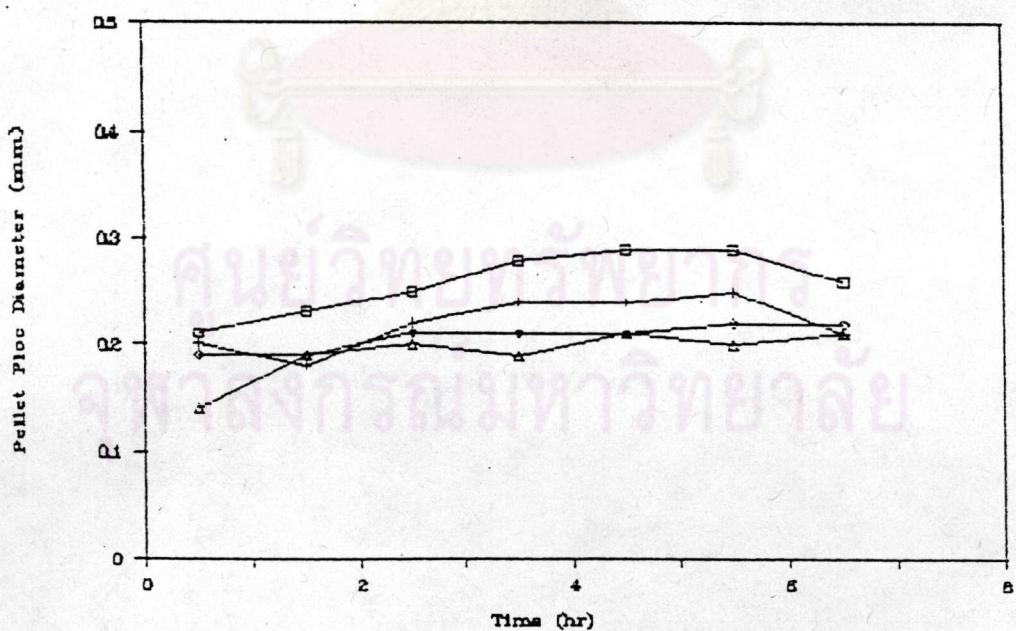
R 41, PACl 1.0, PE 0.2, 10 rpm, Upf 40



R41, PACl 1.0, PE 0.2, 10 rpm, Upf 40



R41, PACl 1.0, PE 0.2, 10 rpm, Upf 40



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

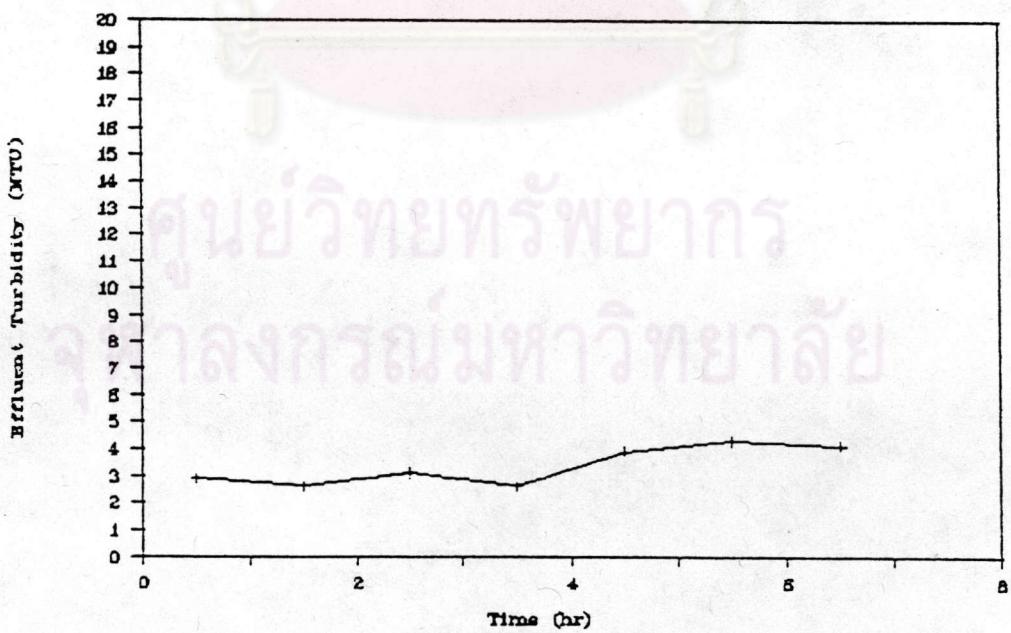
RUN NO. 42

The experimental condition was consisted of the following parameters:

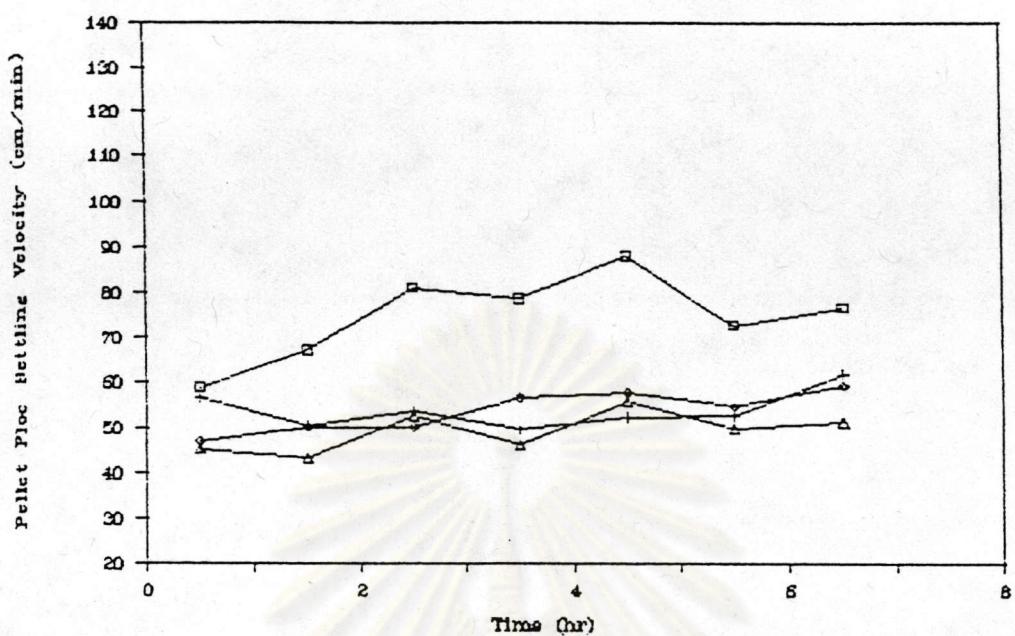
- a) Polyaluminum chloride dosage was 2 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

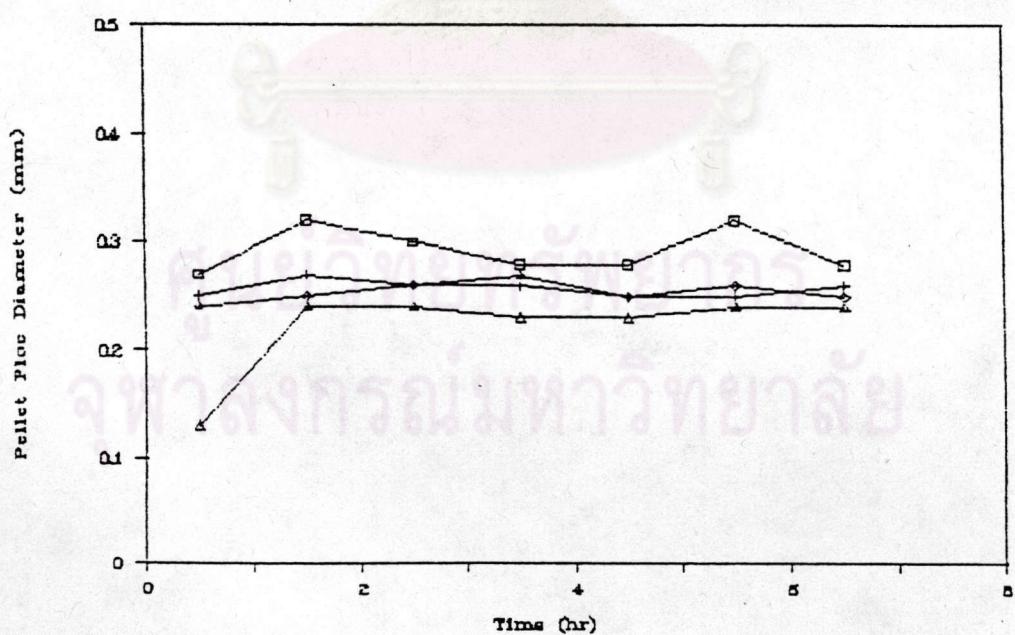
R 42, PACl 2.0, PE 0.2, 10 rpm, Upf 40



R42, PACl 2.0, PE 0.2, 10 rpm, Upf 40



R42, PACl 2.0, PE 0.2, 10 rpm, Upf 40



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

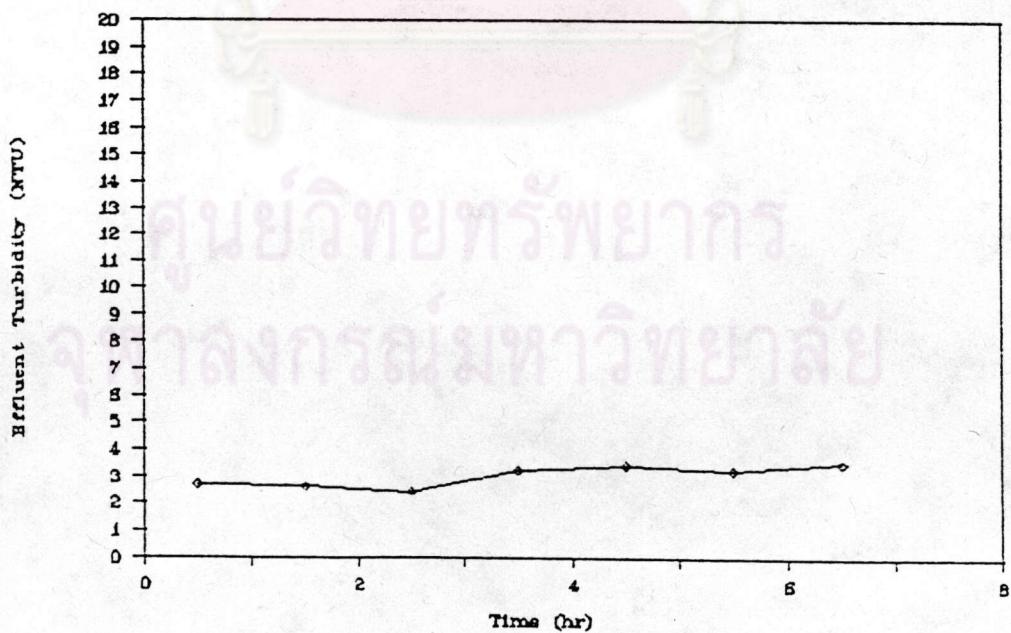
RUN NO. 43

The experimental condition was consisted of the following parameters:

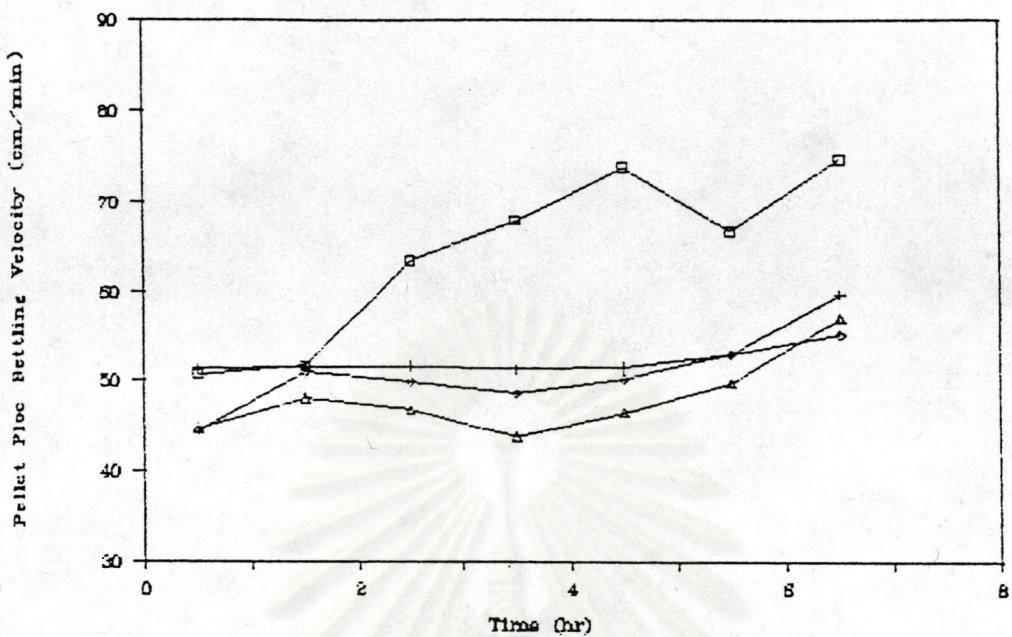
- a) Polyaluminum chloride dosage was 3 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

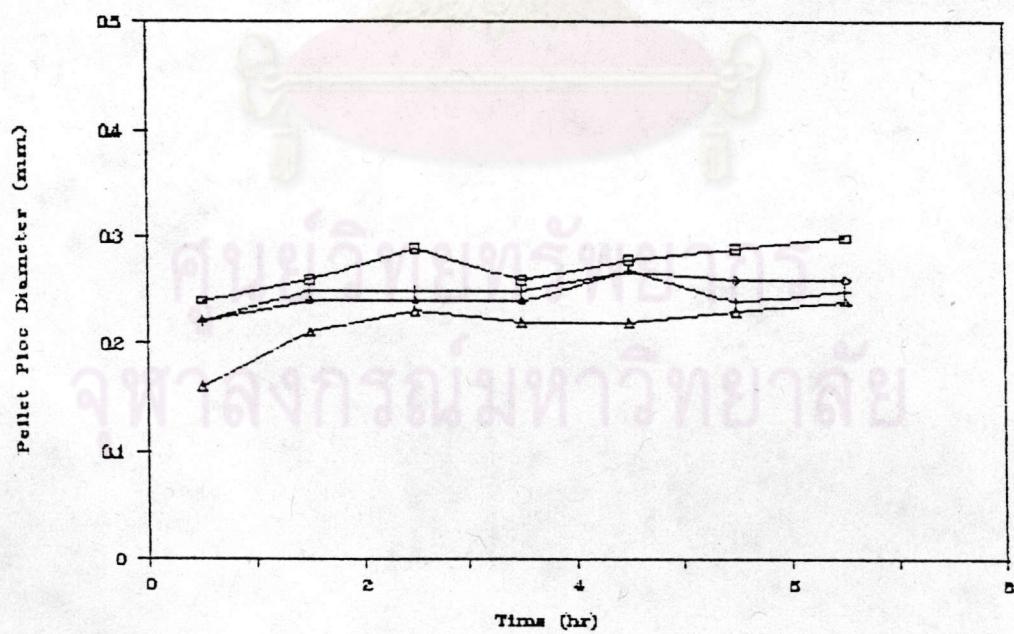
R 43, PACl 3.0, PE 0.2, 10 rpm, Upf 40



R43, PACl 3.0, PE 0.2, 10 rpm, Upf 40



R43, PACl 3.0, PE 0.2, 10 rpm, Upf 40



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

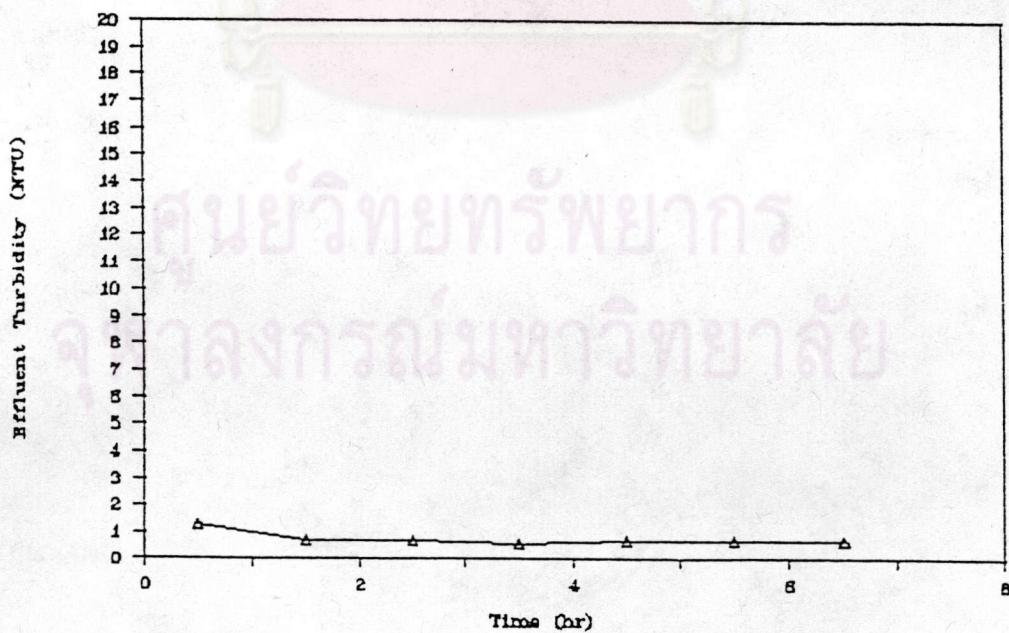
RUN NO. 44

The experimental condition was consisted of the following parameters:

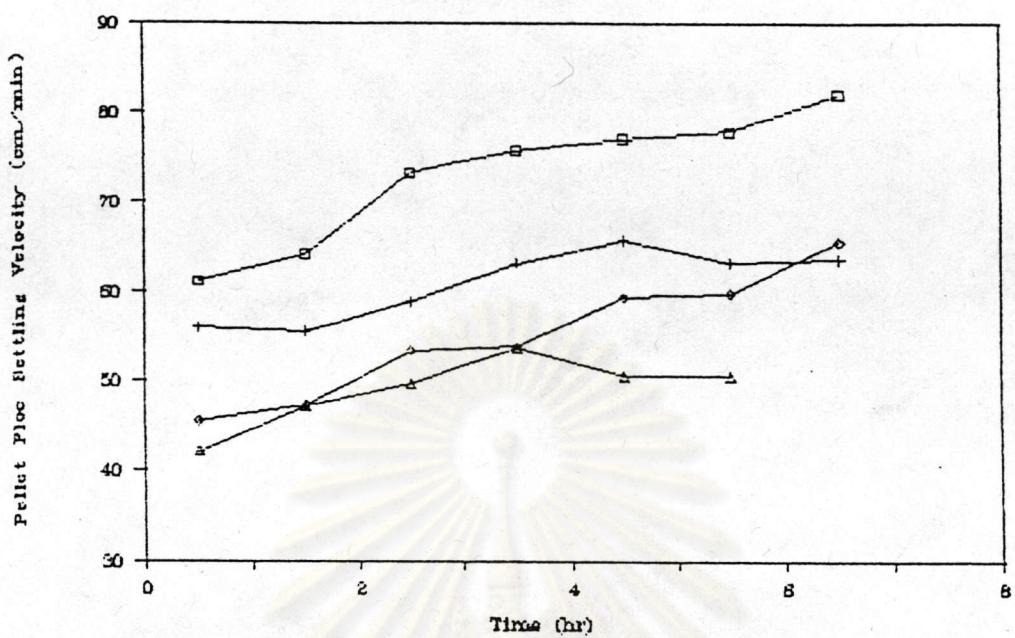
- a) Polyaluminum chloride dosage was 4 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

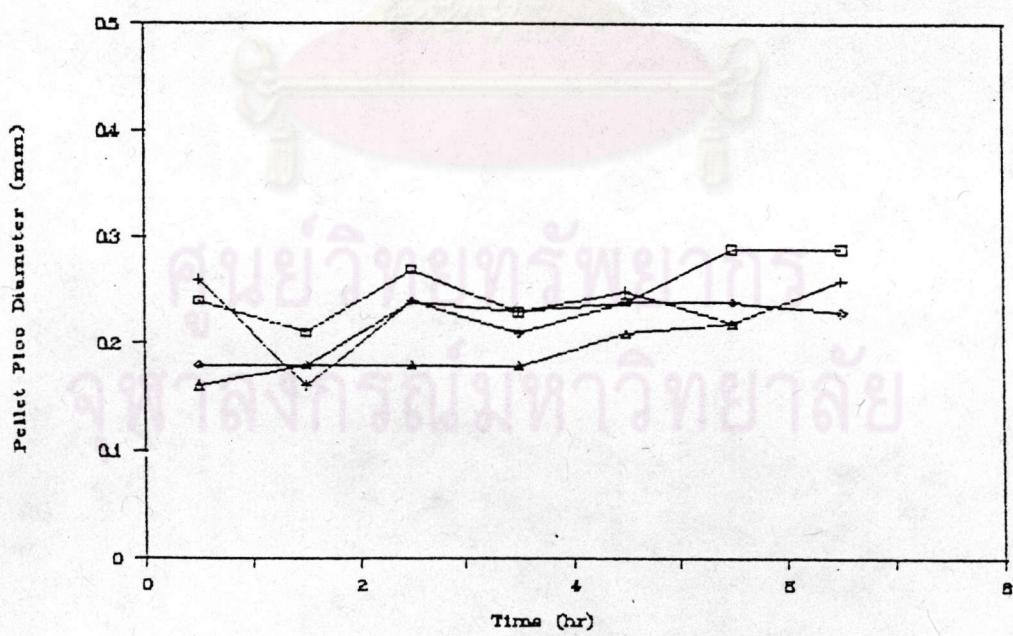
R 44, PACl 4.0, PE 0.2, 10 rpm, Upf 40



R44, PACl 4.0, PE 0.2, 10 rpm, Upf 40



R44, PACl 4.0, PE 0.2, 10 rpm, Upf 40



□ H 0 cm + H 60 cm ◆ H 120 cm △ H 150 cm

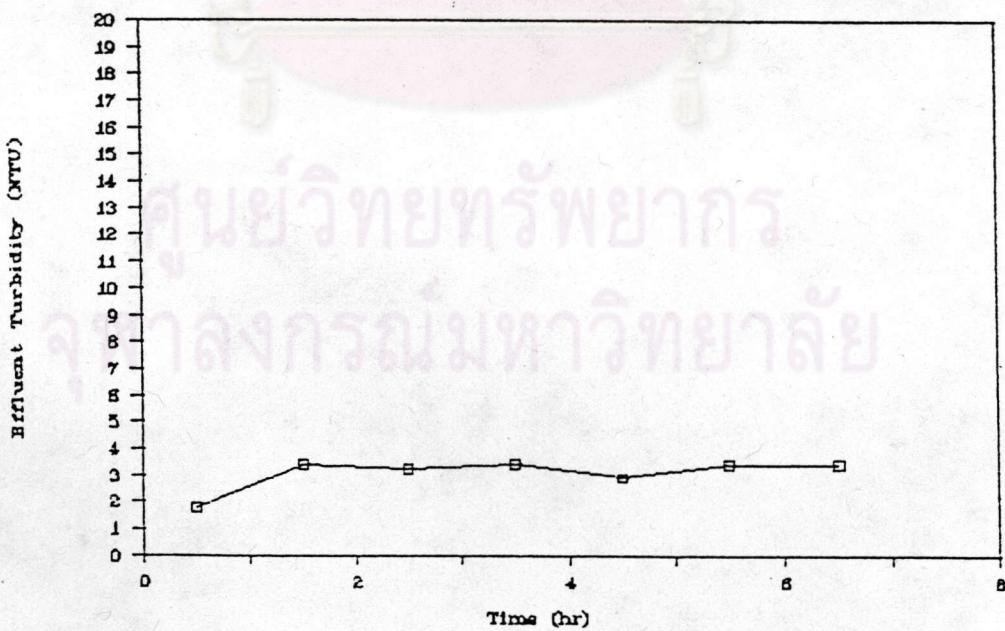
RUN NO. 45

The experimental condition was consisted of the following parameters:

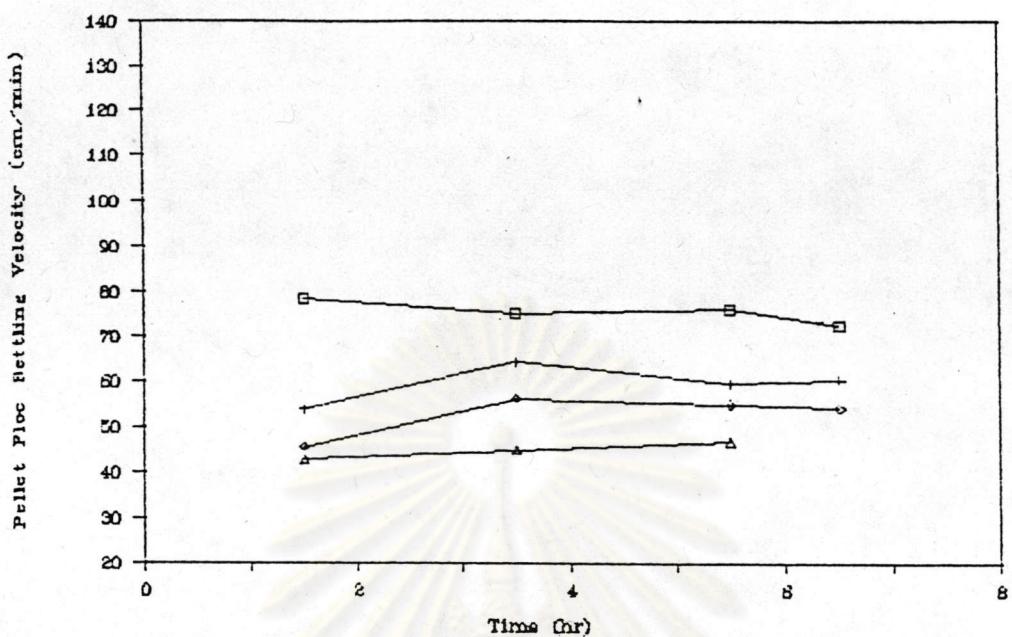
- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

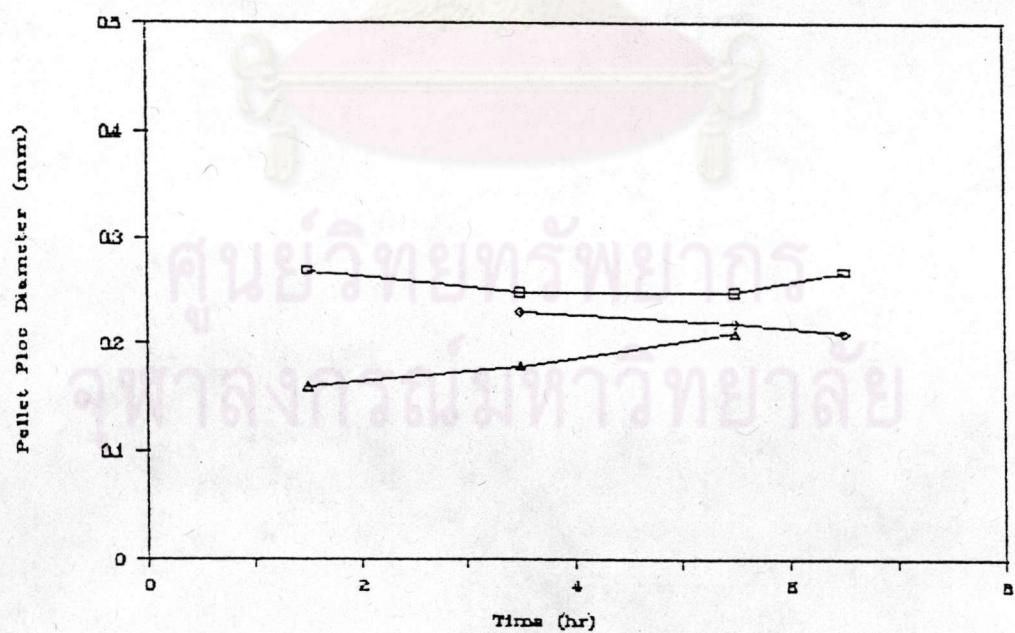
R 45, PACl 1.0, PE 0.3, 10 rpm, Upf 40



R45, PACl 1.0, PE 0.3, 10 rpm, Upf 40



R45, PACl 1.0, PE 0.3, 10 rpm, Upf 40



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

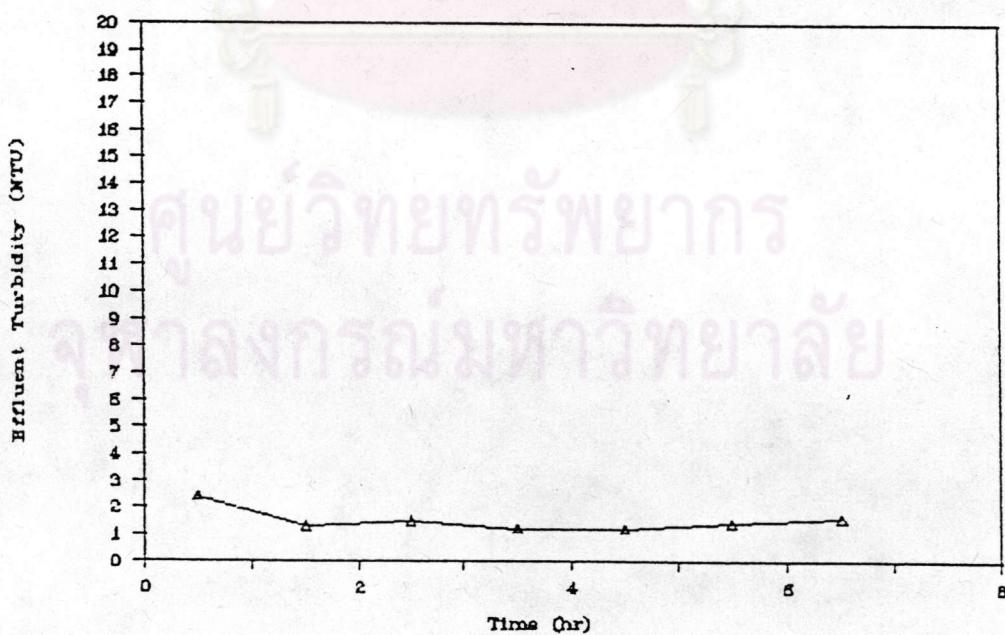
RUN NO. 48

The experimental condition was consisted of the following parameters:

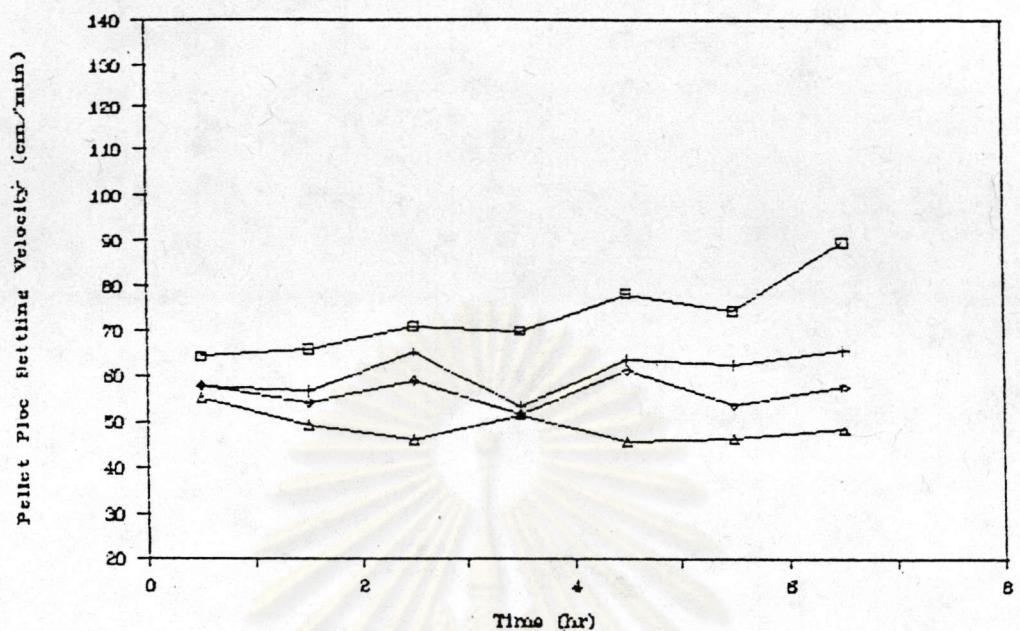
- a) Polyaluminum chloride dosage was 4 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 10 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

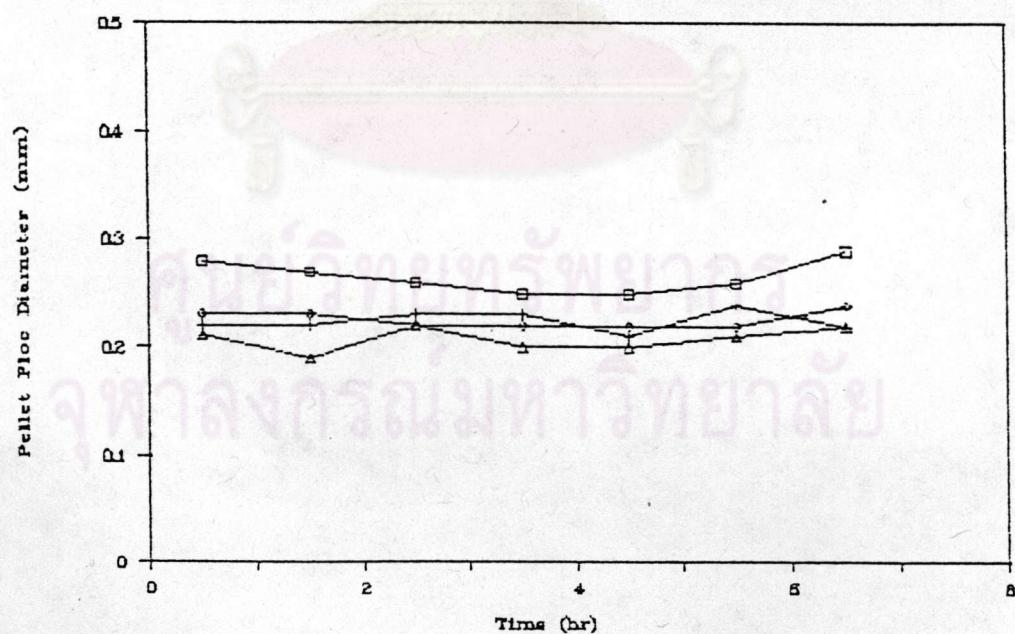
R 48, PACl 4.0, PE 0.3, 10 rpm, Upf 40



R48, PACl 4.0, PE 0.3, 10 rpm, Upf 40



R48, PACl 4.0, PE 0.3, 10 rpm, Upf 40



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

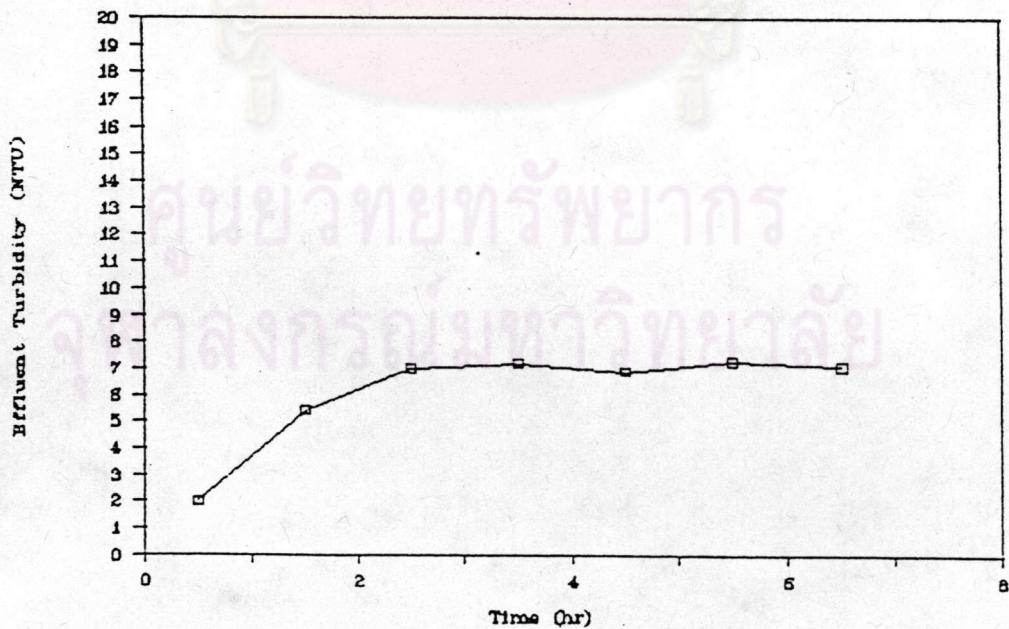
RUN NO. 49

The experimental condition was consisted of the following parameters:

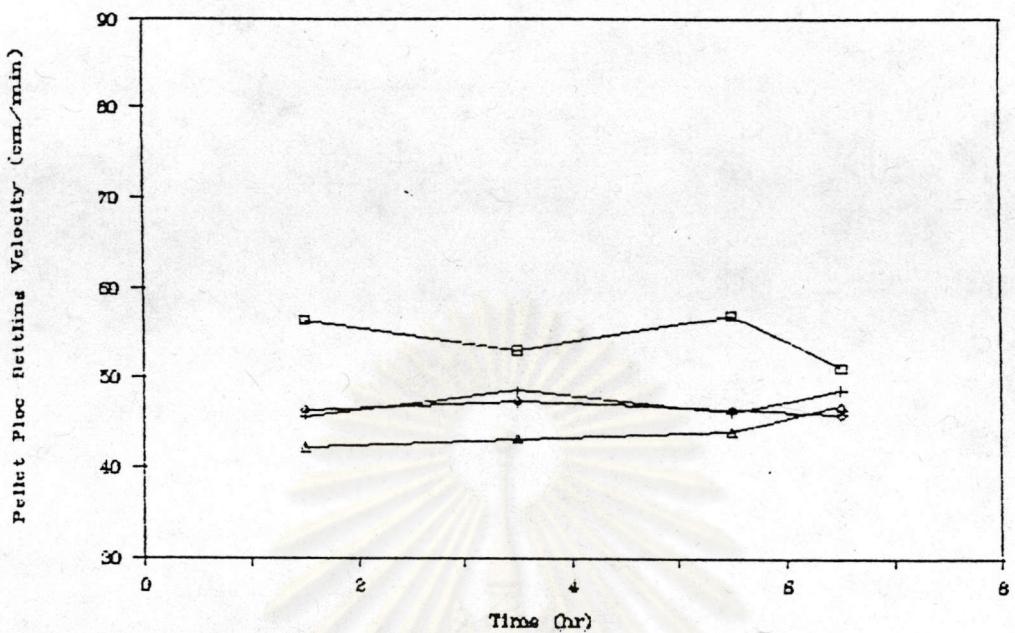
- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

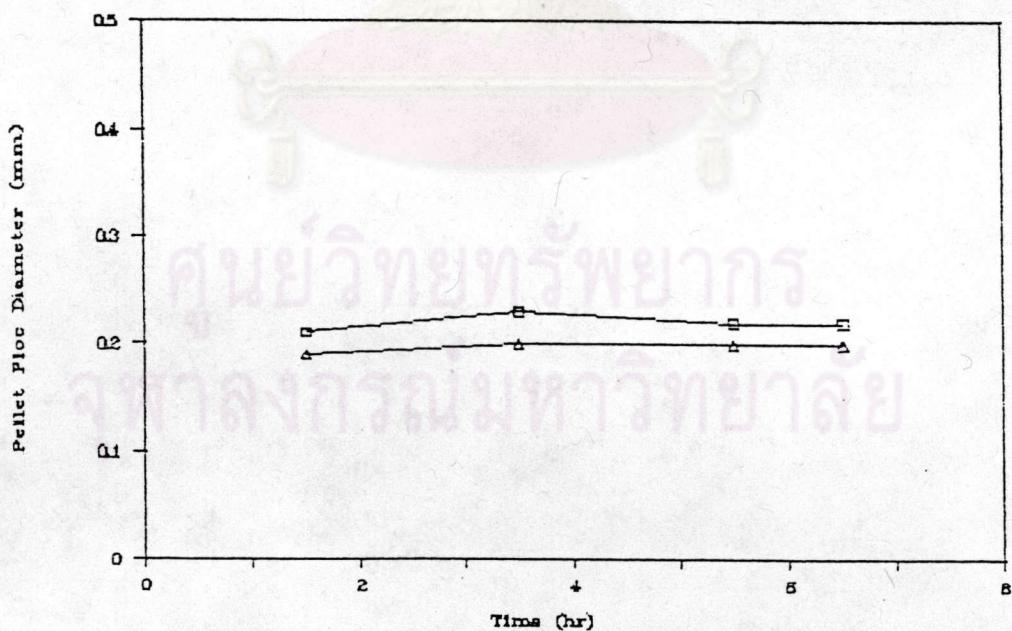
R 49, PACl 1.0, PE 0.1, 15 rpm, Upf 30



R49, PACl 1.0, PE 0.1, 15 rpm, Upf 30



R49, PACl 1.0, PE 0.1, 15 rpm, Upf 30



□ H 0 cm + H 50 cm ◆ H 120 cm △ H 150 cm

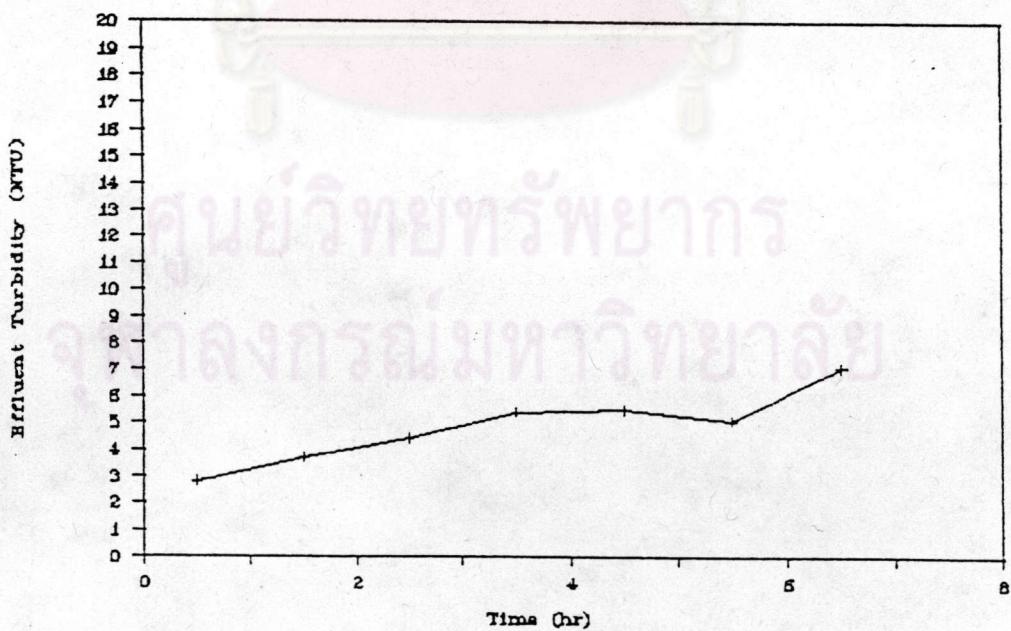
RUN NO. 50

The experimental condition was consisted of the following parameters:

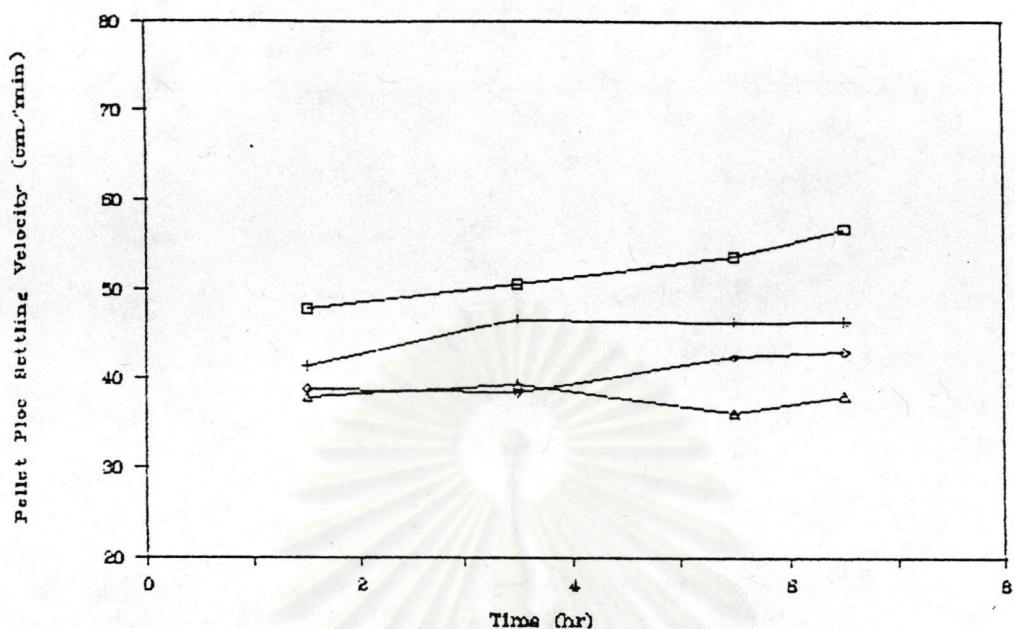
- a) Polyaluminum chloride dosage was 2 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

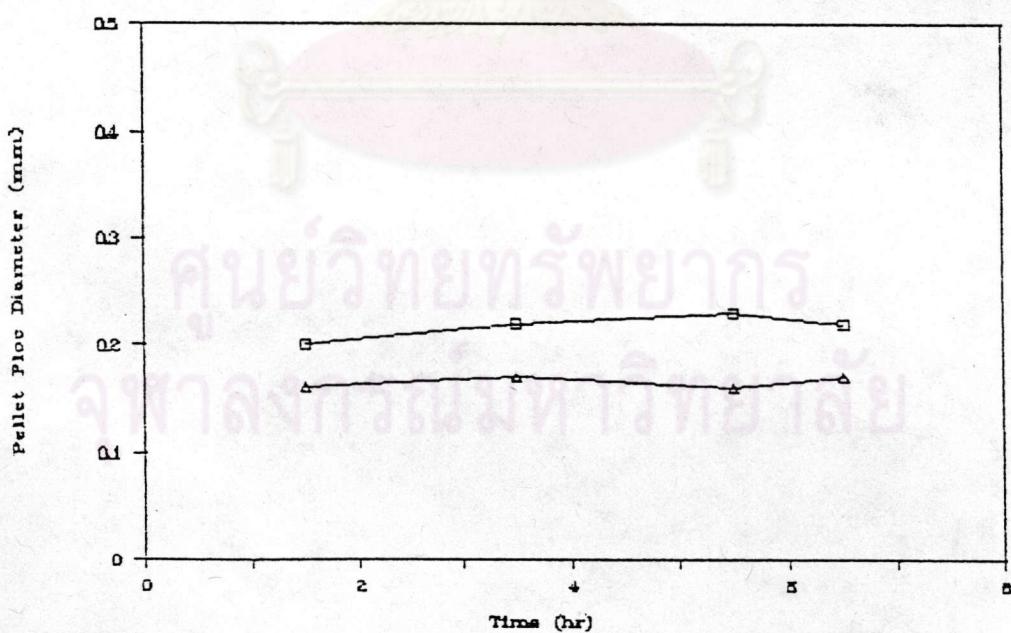
R 50, PACl 2.0, PE 0.1, 15 rpm, Upf 30



R50, PACl 2.0, PE 0.1, 15 rpm, Upf 30



R50, PACl 2.0, PE 0.1, 15 rpm, Upf 30



□ H 0 cm + H 50 cm ◊ H 120 cm △ H 150 cm

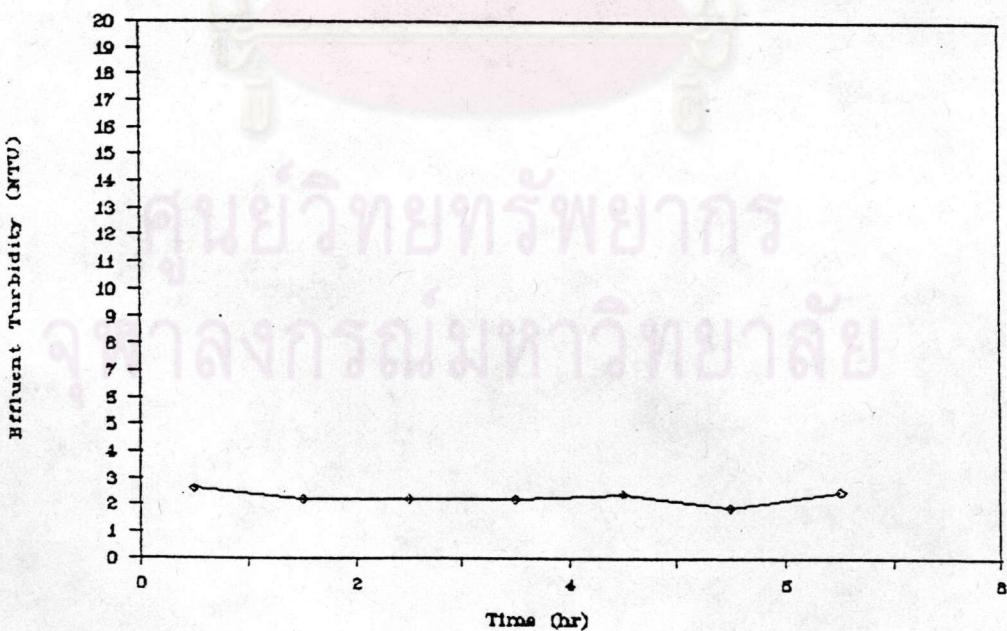
RUN NO. 51

The experimental condition was consisted of the following parameters:

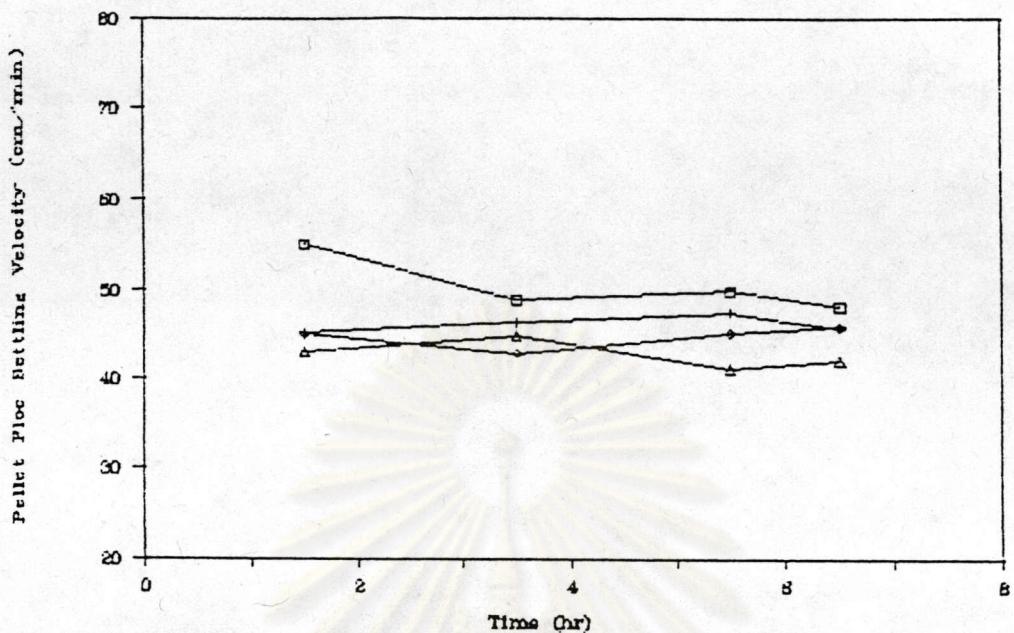
- a) Polyaluminum chloride dosage was 3 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

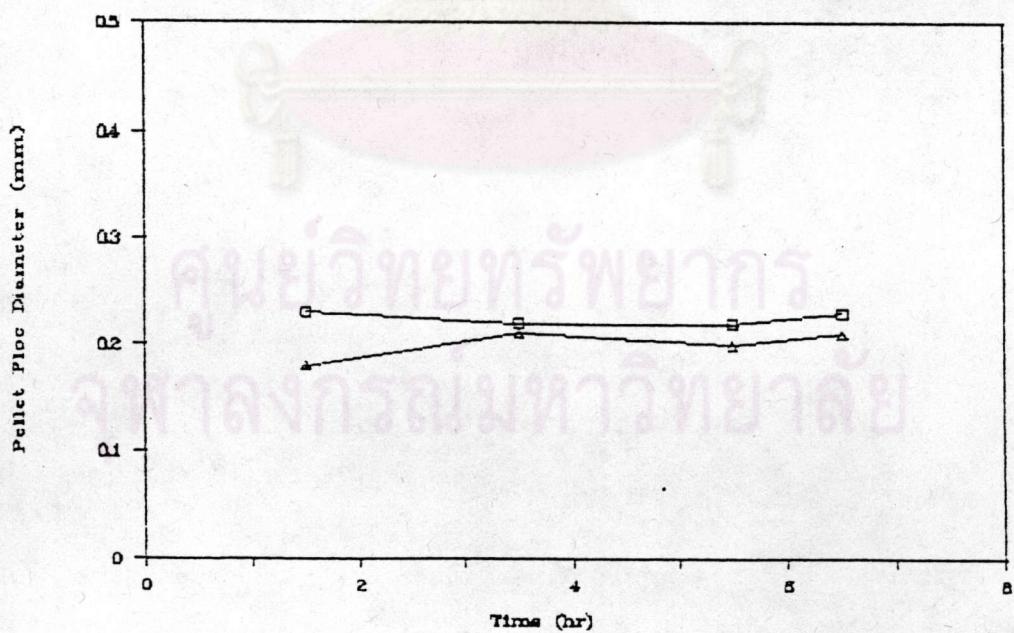
R 51, PACl 3.0, PE 0.1, 15 rpm, Upf 30



R51, PAC1 3.0, PE 0.1, 15 rpm, Upf 30



R51, PAC1 3.0, PE 0.1, 15 rpm, Upf 30



□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

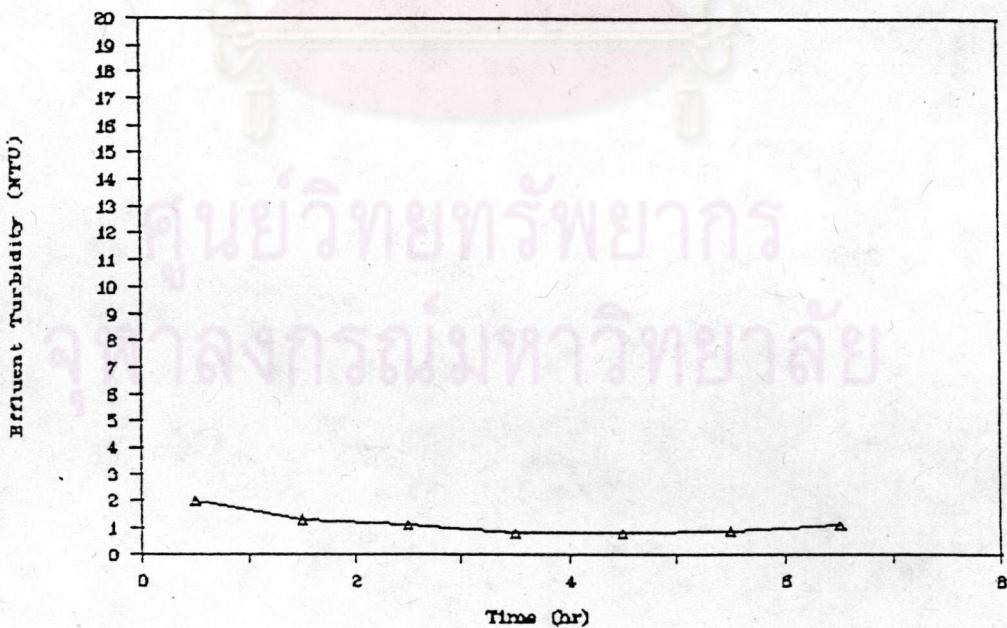
RUN NO. 52

The experimental condition was consisted of the following parameters:

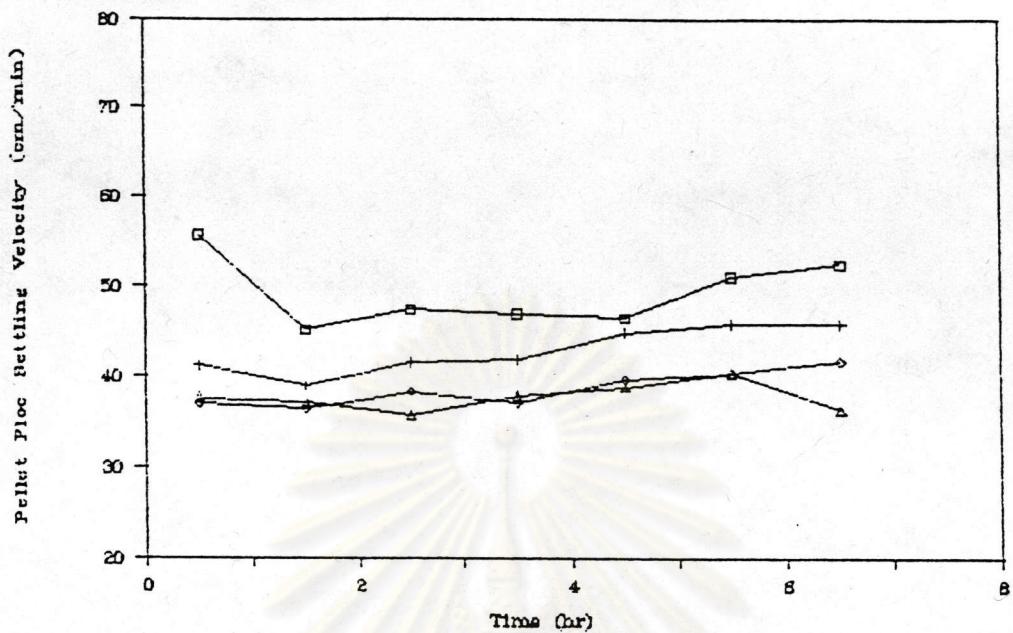
- a) Polyaluminum chloride dosage was 4 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

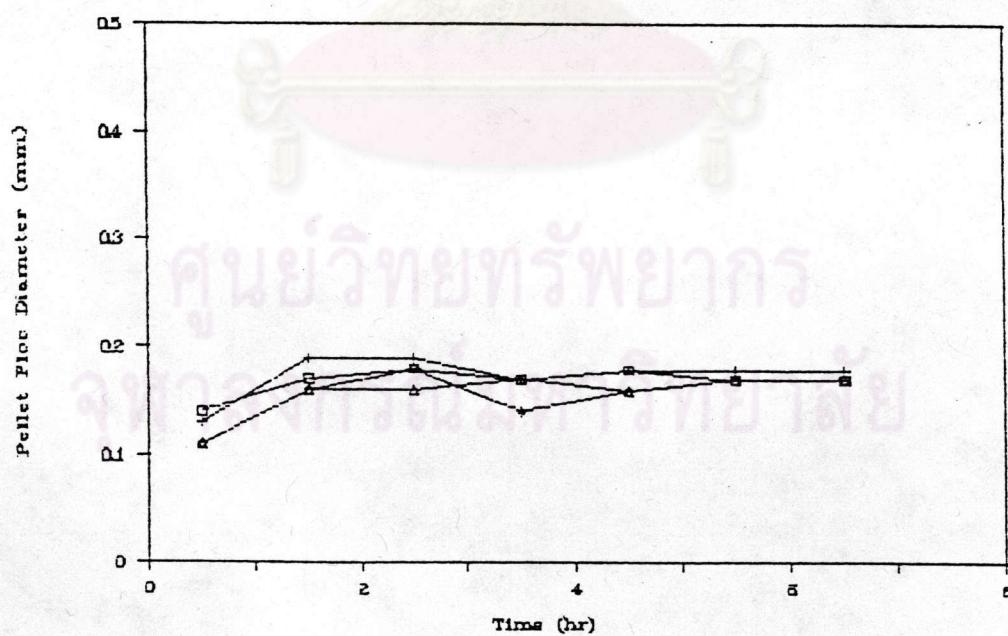
R 52, PACl 4.0, PE 0.1, 15 rpm, Upf 30



R52, PACl 4.0, PE 0.1, 15 rpm, Upf 30



R52, PACl 4.0, PE 0.1, 15 rpm, Upf 30



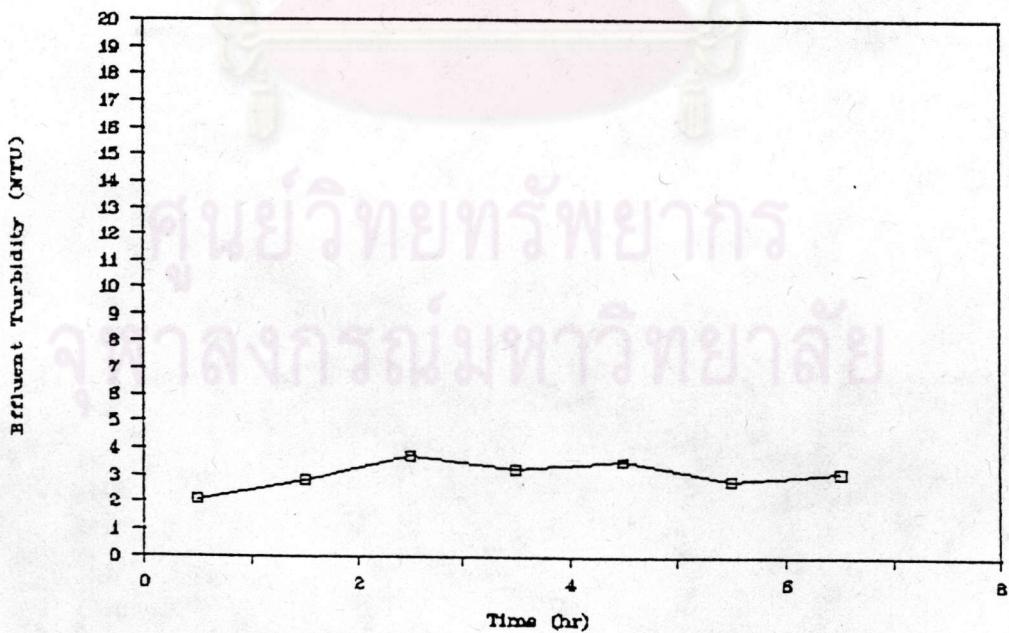
□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

The experimental condition was consisted of the following parameters:

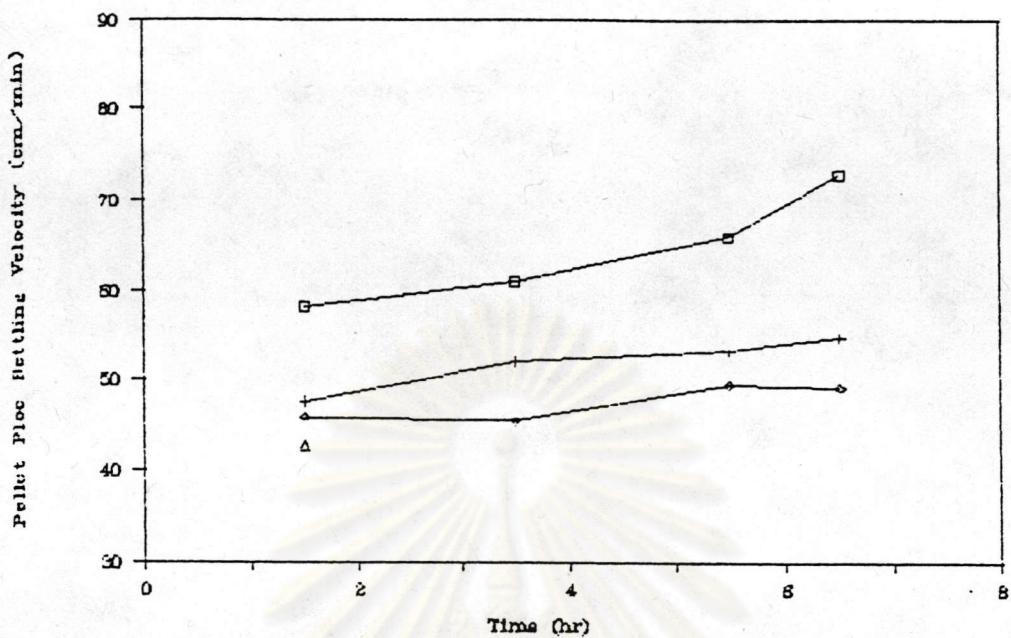
- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

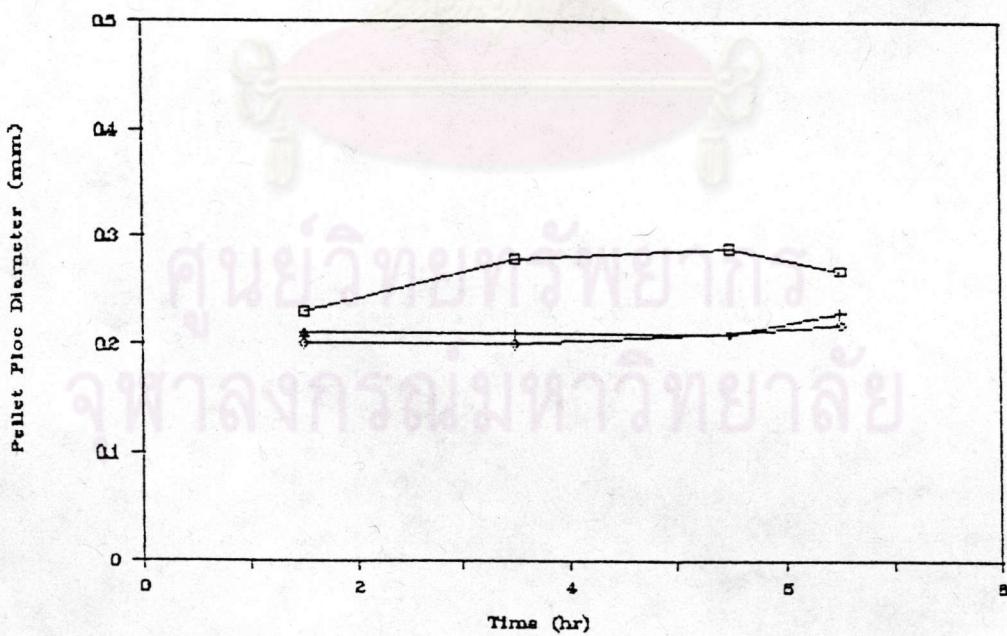
R 53, PACl 1.0, PE 0.2, 15 rpm, Upf 30



R 53, PACl 1.0, PE 0.2, 15 rpm, Upf 30



R53, PACl 1.0, PE 0.2, 15 rpm, Upf 30



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

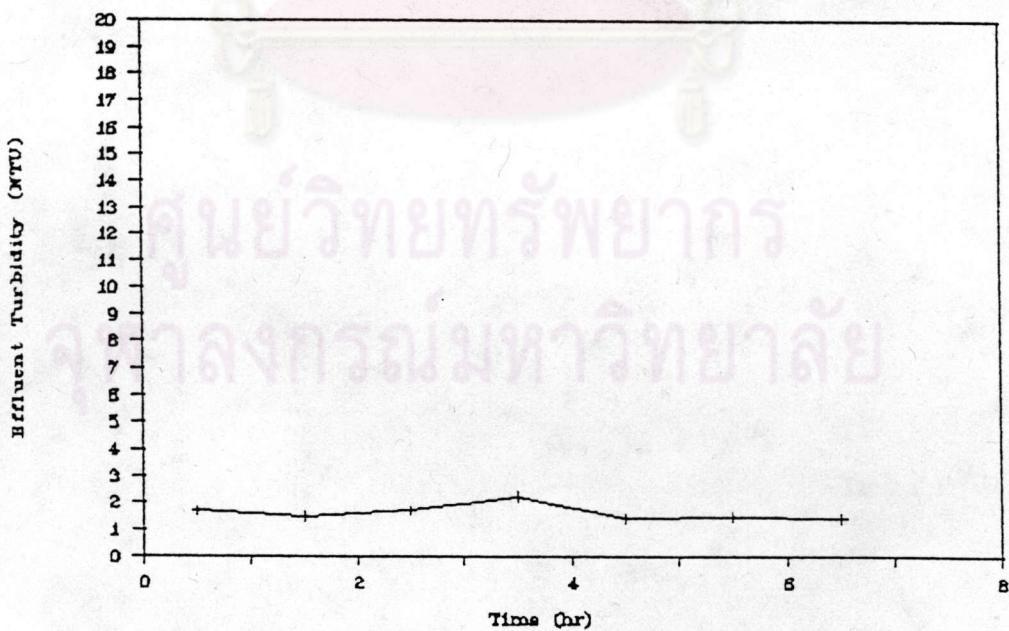
RUN NO. 54

The experimental condition was consisted of the following parameters:

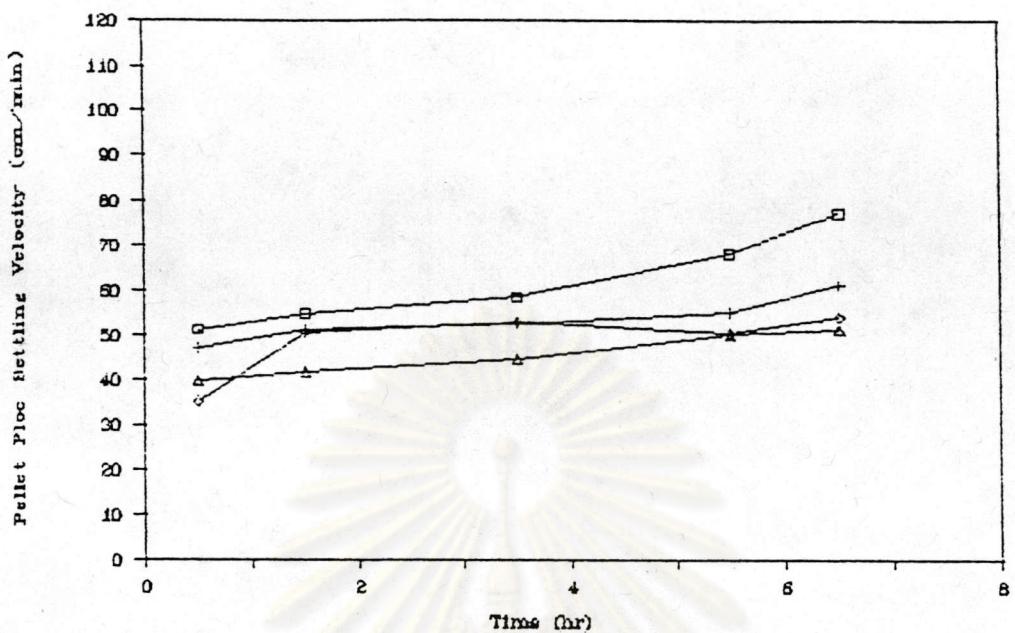
- a) Polyaluminum chloride dosage was 2 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

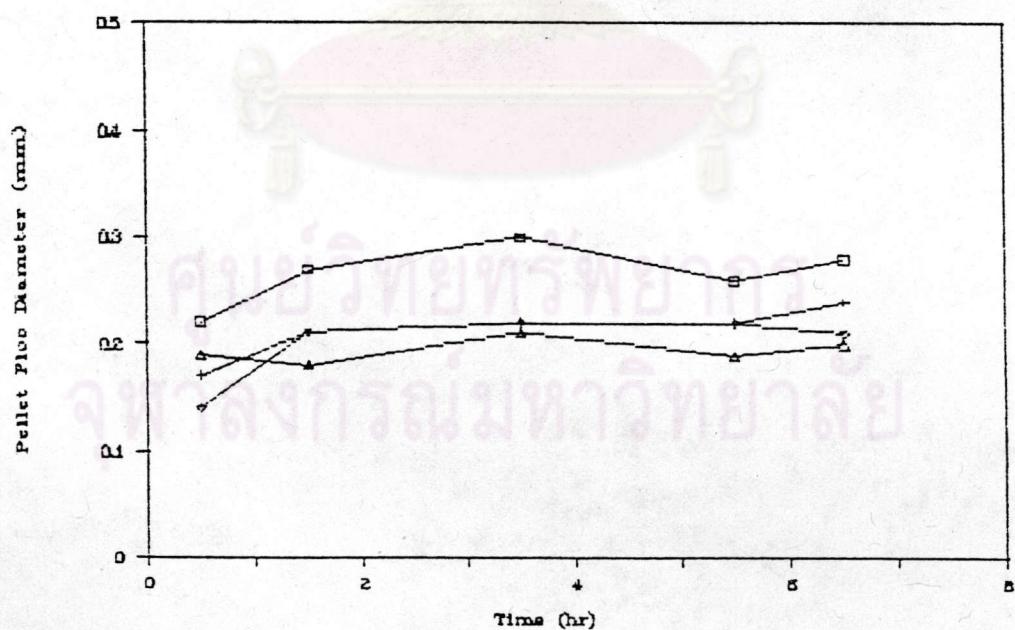
R 54, PACl 2.0, PE 0.2, 15 rpm, Upf 30



R 54, PACl 2.0, PE 0.2, 15 rpm, Upf 30



R54, PACl 2.0, PE 0.2, 15 rpm, Upf 30



□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

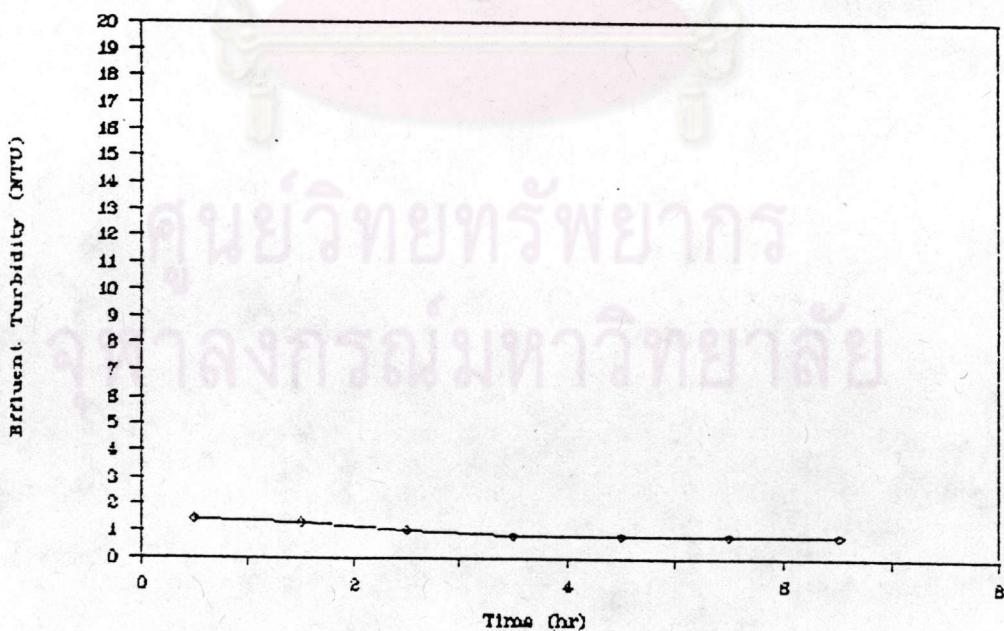
RUN NO. 55

The experimental condition was consisted of the following parameters:

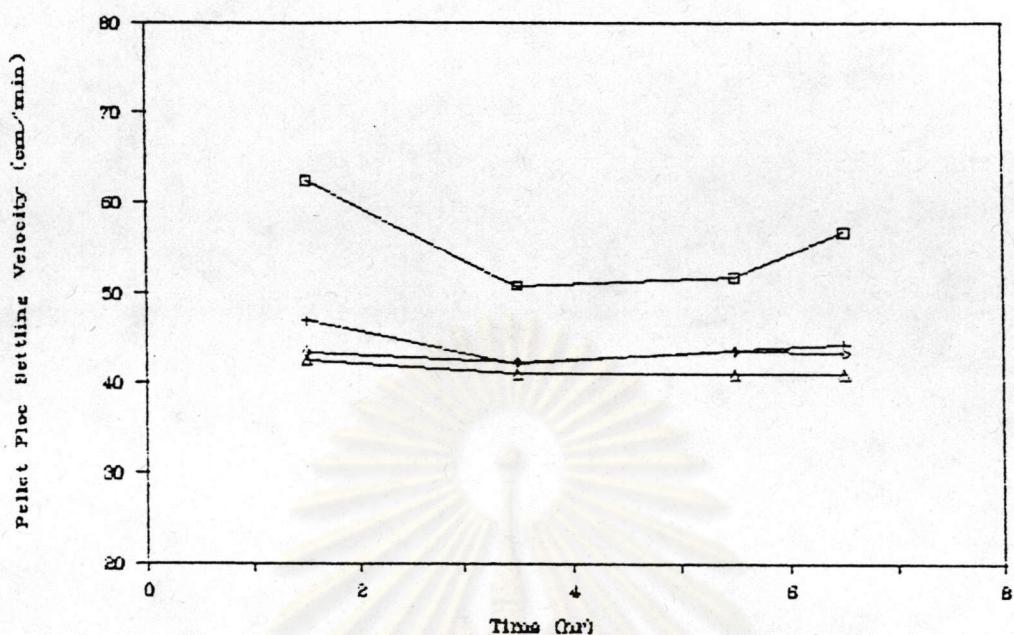
- a) Polyaluminum chloride dosage was 3 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

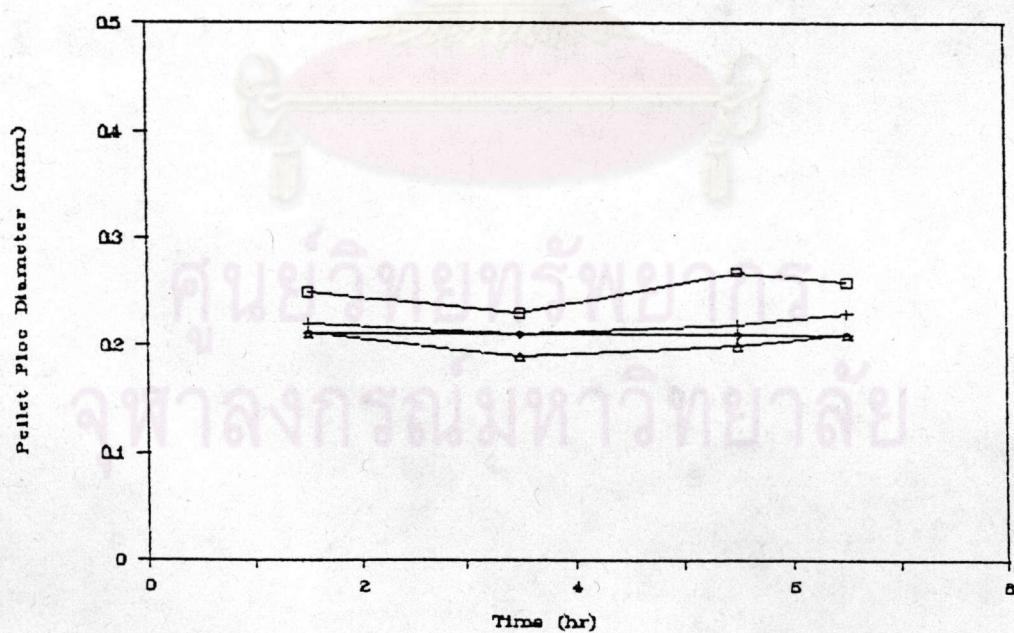
R 55, PACl 3.0, PE 0.2, 15 rpm, Upf 30



R 55, PAC1 3.0, PE 0.2, 15 rpm, Upf 30



R55, PAC1 3.0, PE 0.2, 15 rpm, Upf 30



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

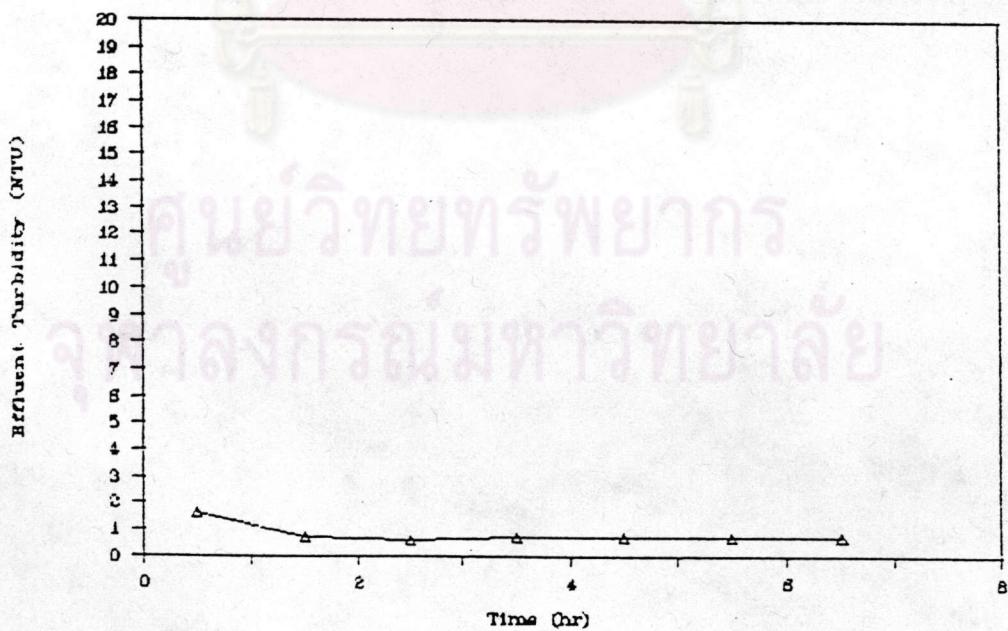
RUN NO. 56

The experimental condition was consisted of the following parameters:

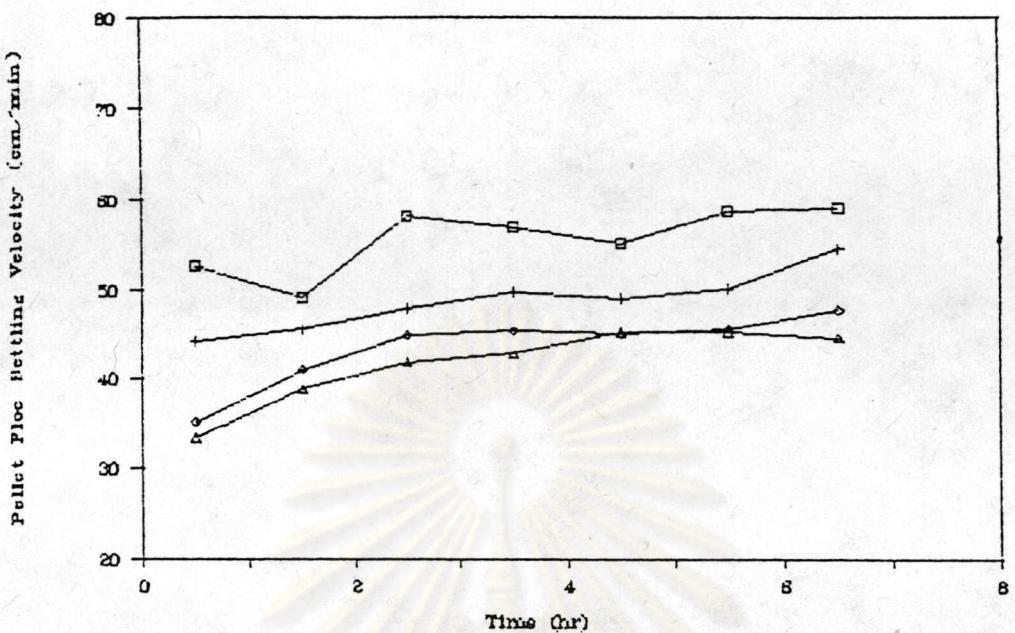
- a) Polyaluminum chloride dosage was 4 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

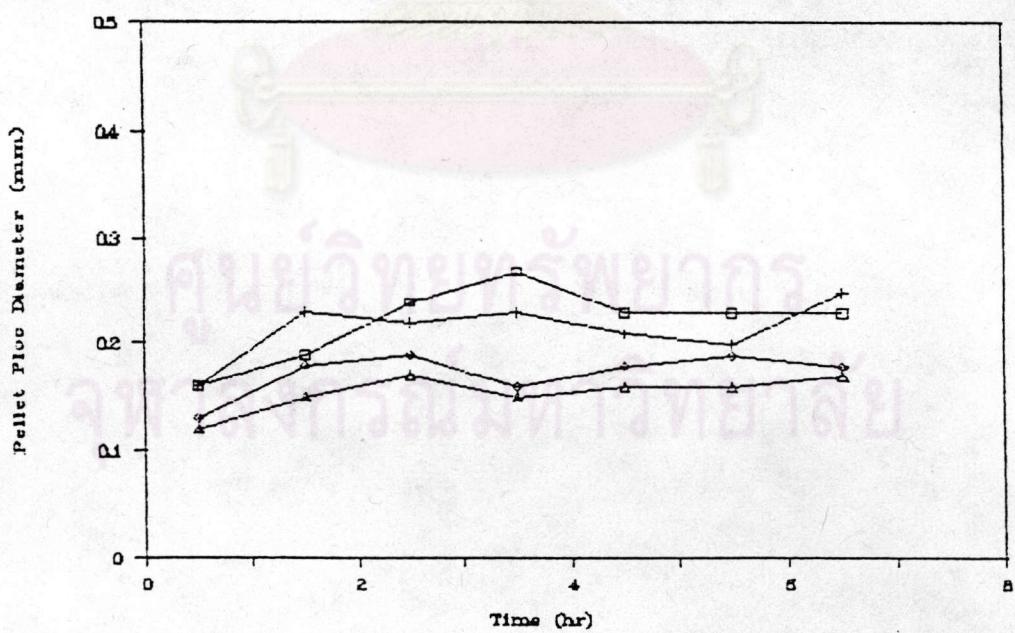
R 56, PACl 4.0, PE 0.2, 15 rpm, Upf 30



R 56, PACl 4.0, PE 0.2, 15 rpm, Upf 30



R56, PACl 4.0, PE 0.2, 15 rpm, Upf 30



□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

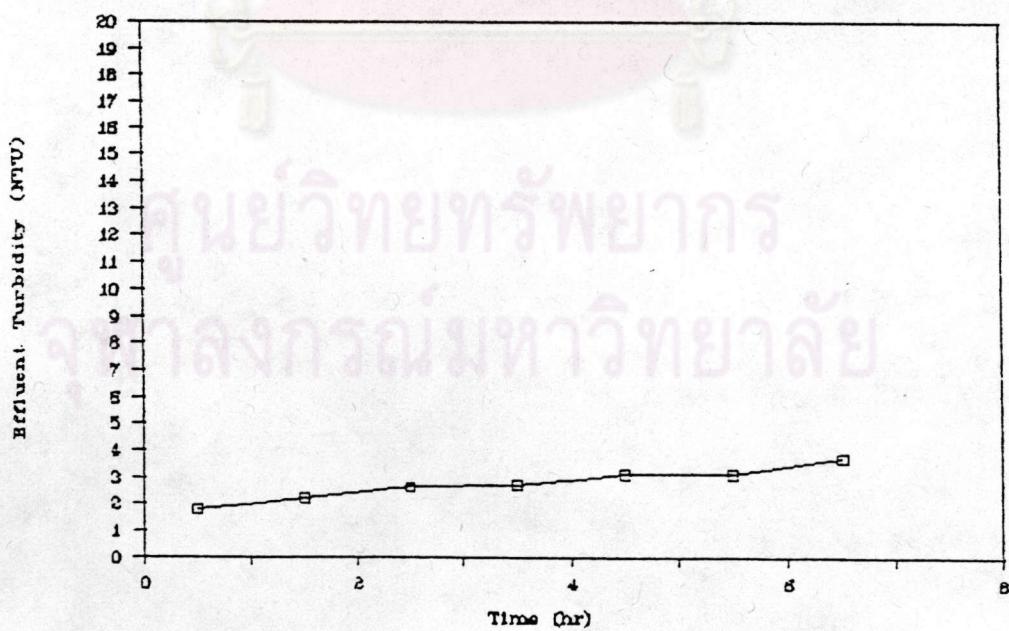
RUN NO. 57

The experimental condition was consisted of the following parameters:

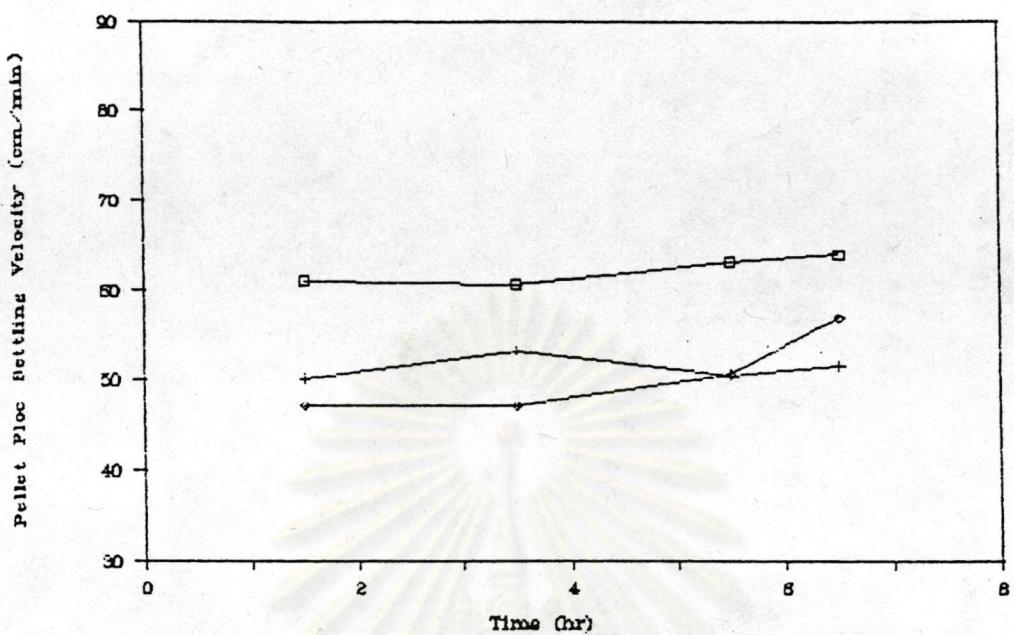
- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

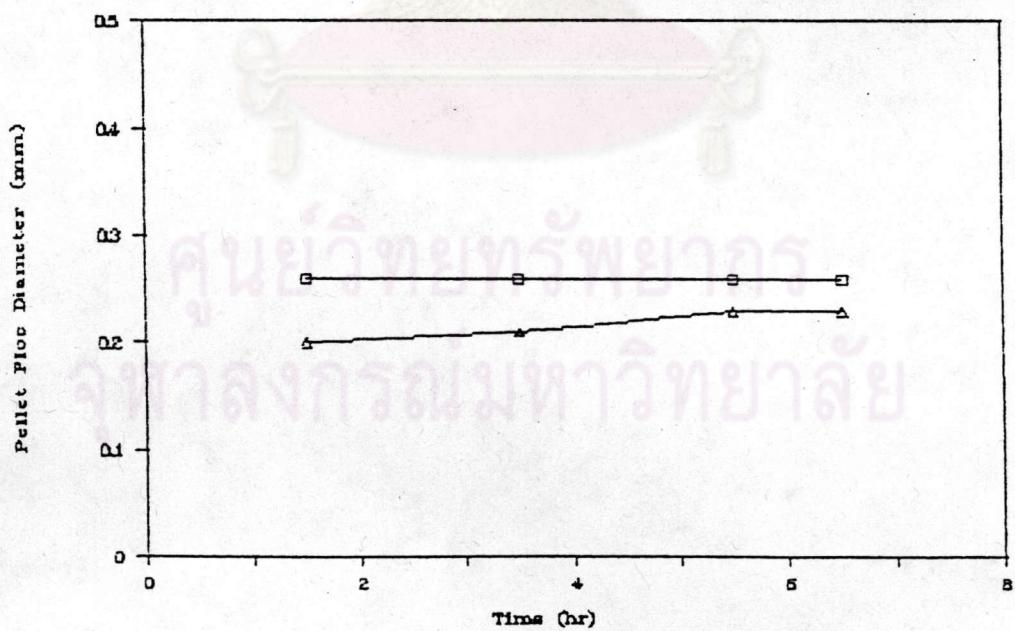
R 57, PACl 1.0, PE 0.3, 15 rpm, Upf 30



R57, PACl 1.0, PE 0.3, 15 rpm, Upf 30



R57, PACl 1.0, PE 0.3, 15 rpm, Upf 30



□ H 0 cm + H 60 cm . ◊ H 120 cm △ H 150 cm

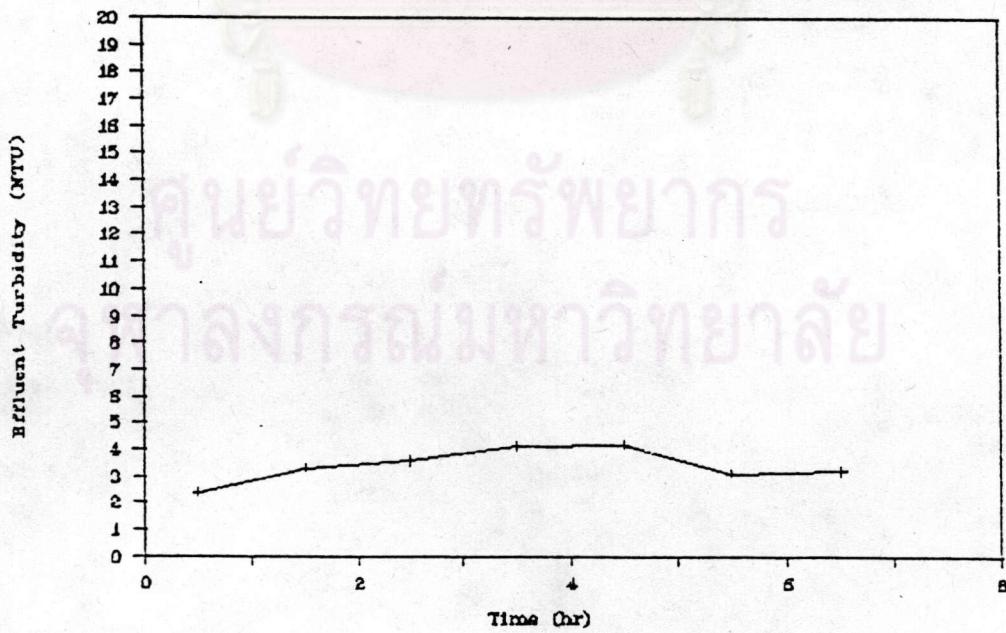
RUN NO. 58

The experimental condition was consisted of the following parameters:

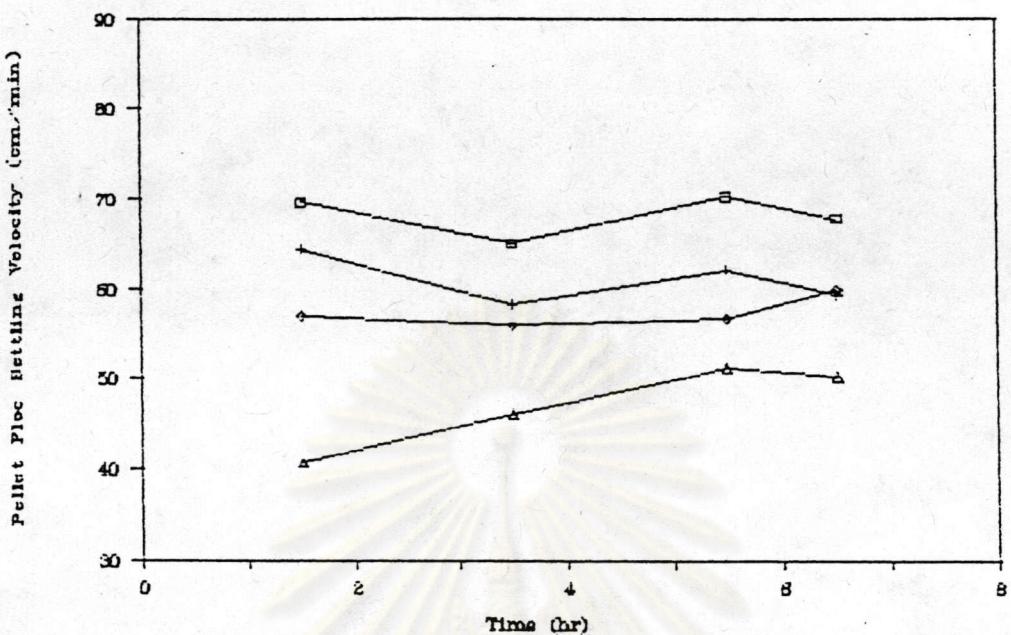
- a) Polyaluminum chloride dosage was 2 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 30 cm./min.

The experimental results of each run were shown in the following figures:

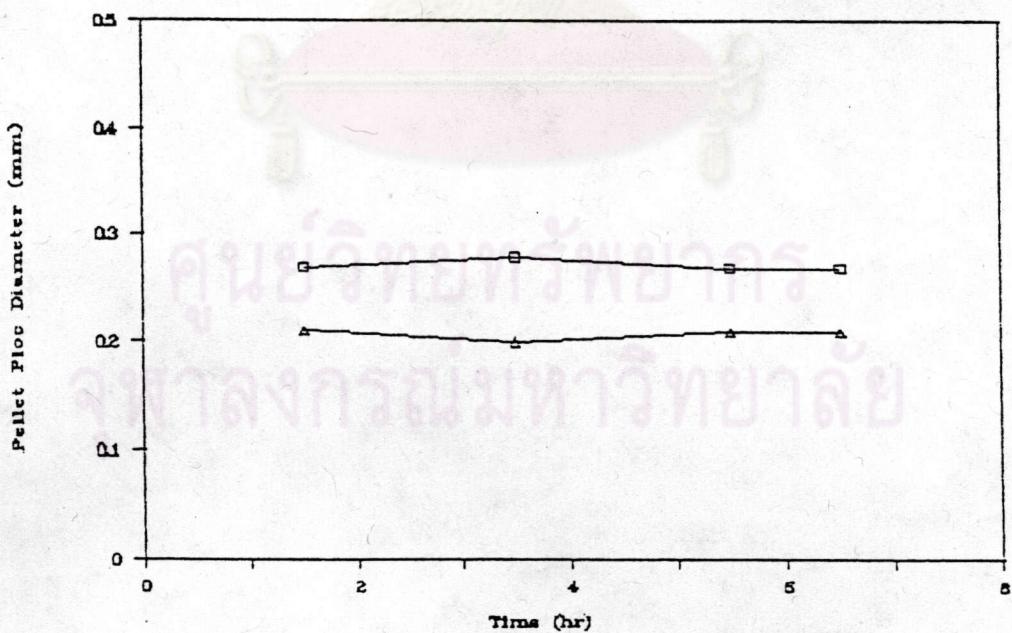
R 58, PACl 2.0, PE 0.3, 15 rpm, Upf 30



R58, PACl 2.0, PE 0.3, 15 rpm, Upf 30



R58, PACl 2.0, PE 0.3, 15 rpm, Upf 30



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

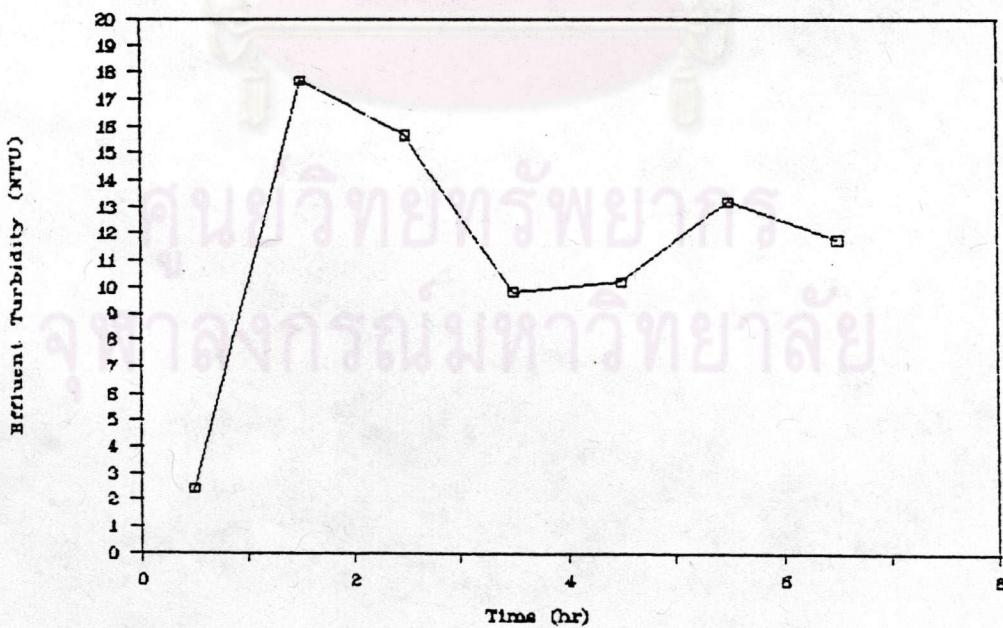
RUN NO. 61

The experimental condition was consisted of the following parameters:

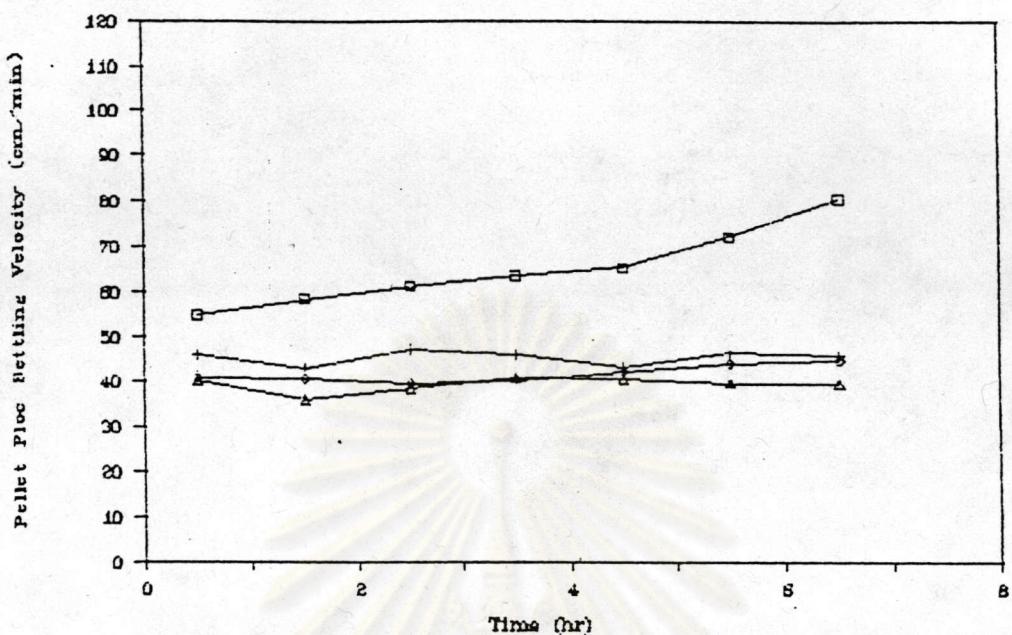
- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

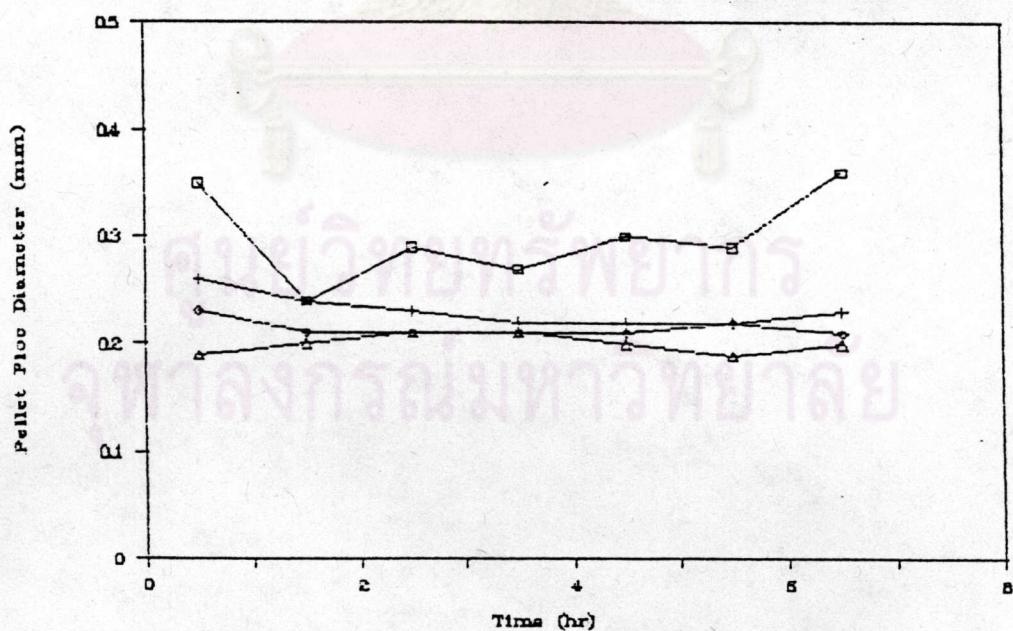
R 61, PACl 1.0, PE 0.1, 15 rpm, Upf 40



R61, PACl 1.0, PE 0.1, 15 rpm, Upf 40



R61, PACl 1.0, PE 0.1, 15 rpm, Upf 40



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

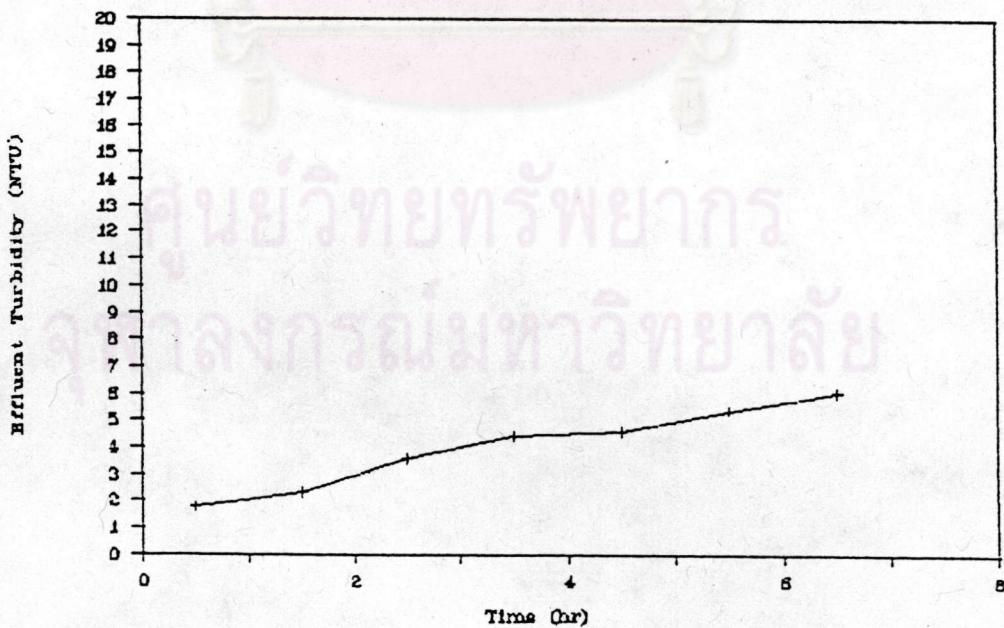
RUN NO. 62

The experimental condition was consisted of the following parameters:

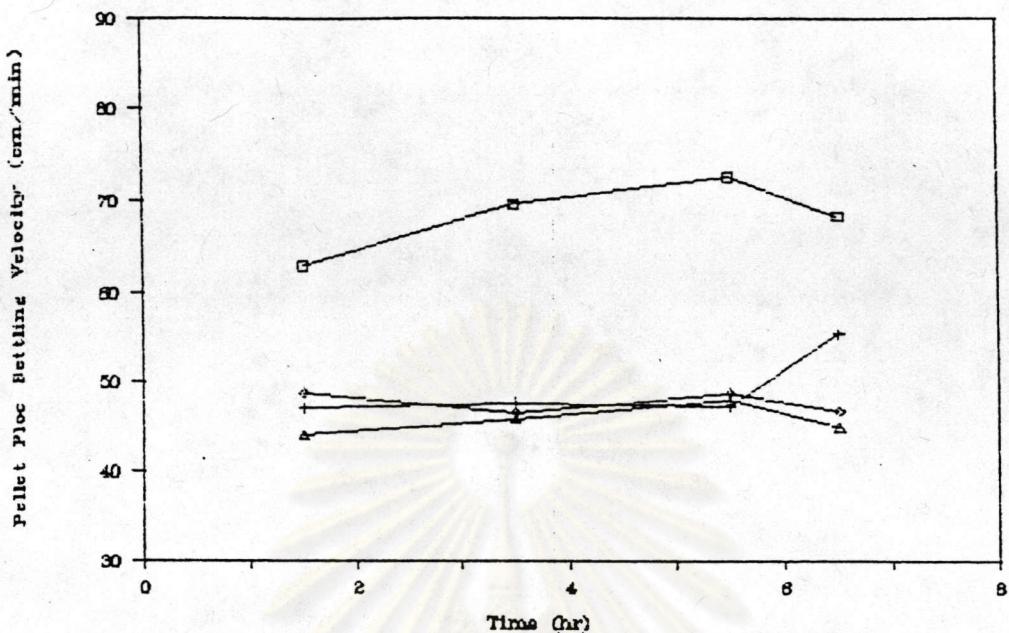
- a) Polyaluminum chloride dosage was 2 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

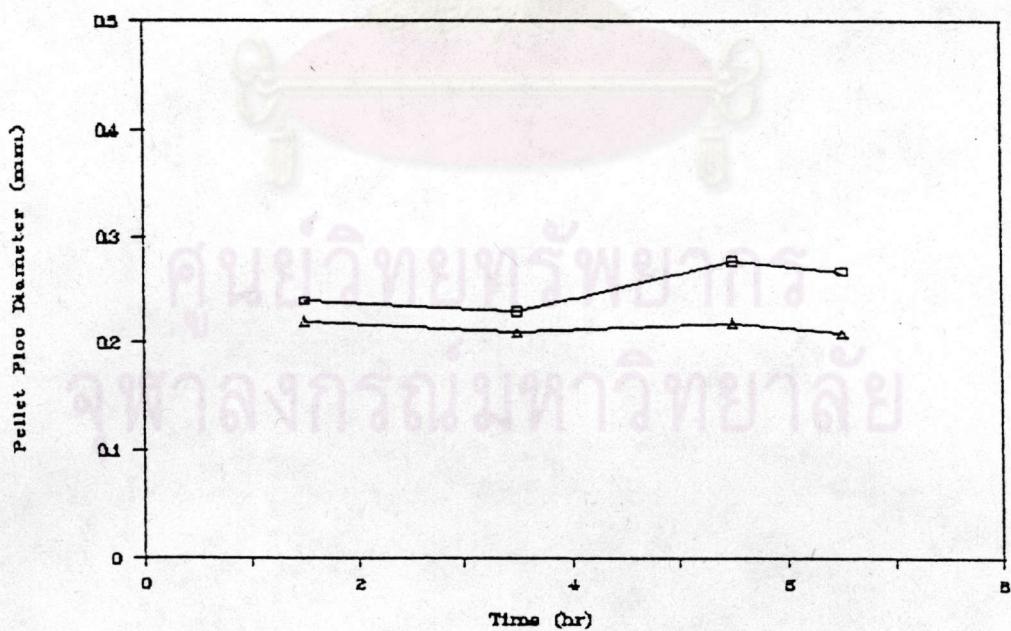
R 62, PACl 2.0, PE 0.1, 15 rpm, Upf 40



R62, PACl 2.0, PE 0.1, 15 rpm, Upf 40



R62, PACl 2.0, PE 0.1, 15 rpm, Upf 40



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

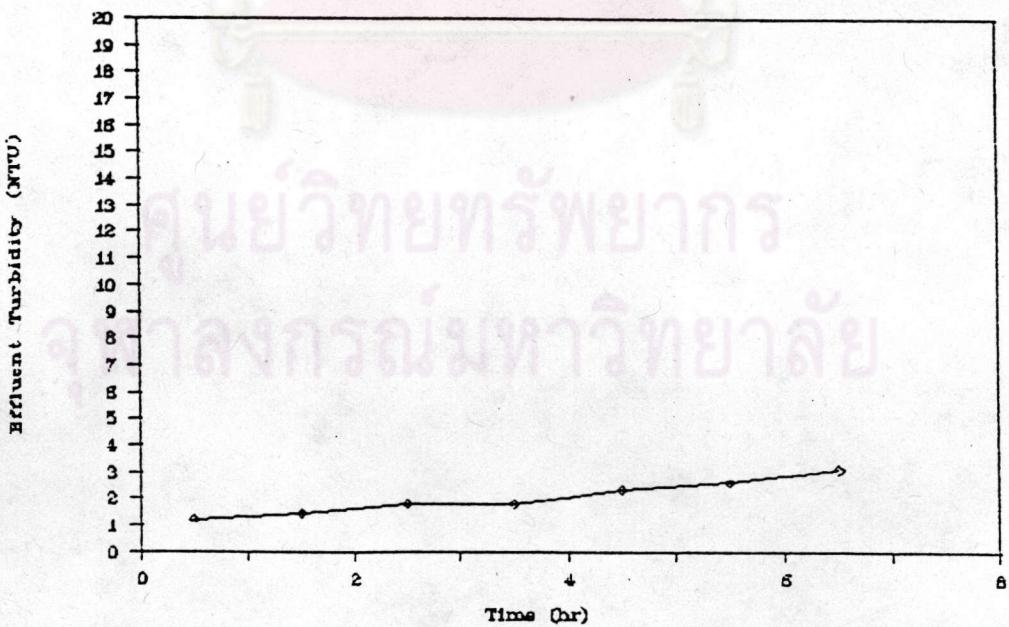
RUN NO. 63

The experimental condition was consisted of the following parameters:

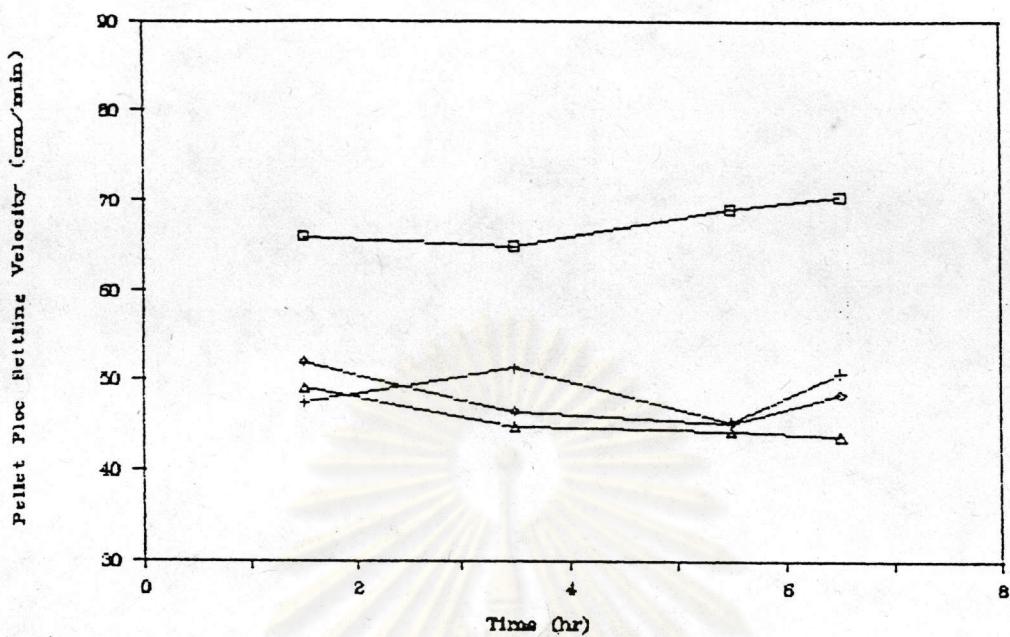
- a) Polyaluminum chloride dosage was 3 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

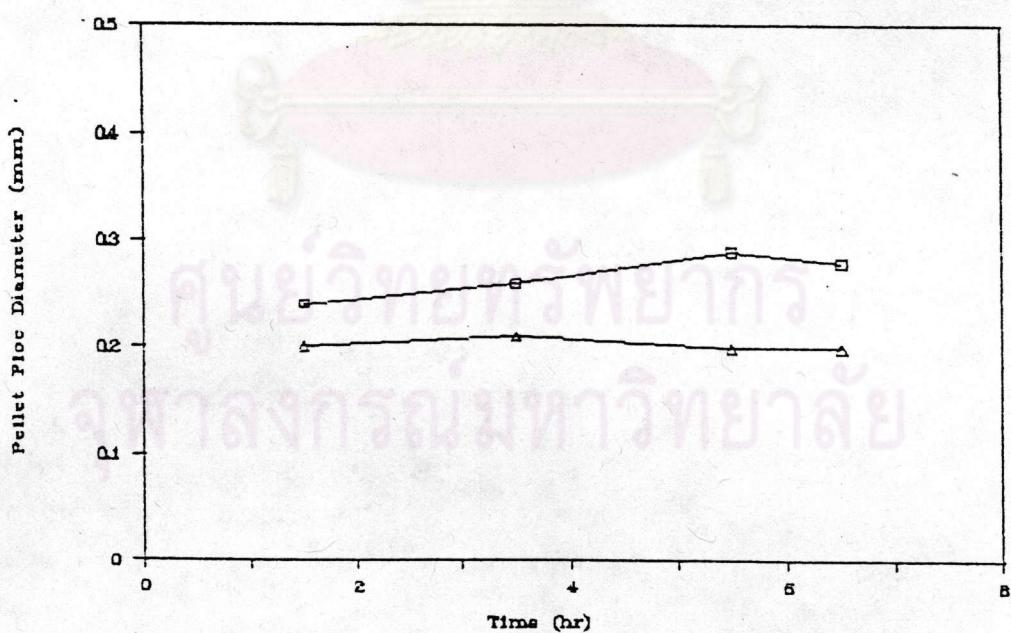
R 63, PACl 3.0, PE 0.1, 15 rpm, Upf 40



R63, PACl 3.0, PE 0.1, 15 rpm, Upf 40



R63, PACl 3.0, PE 0.1, 15 rpm, Upf 40



□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

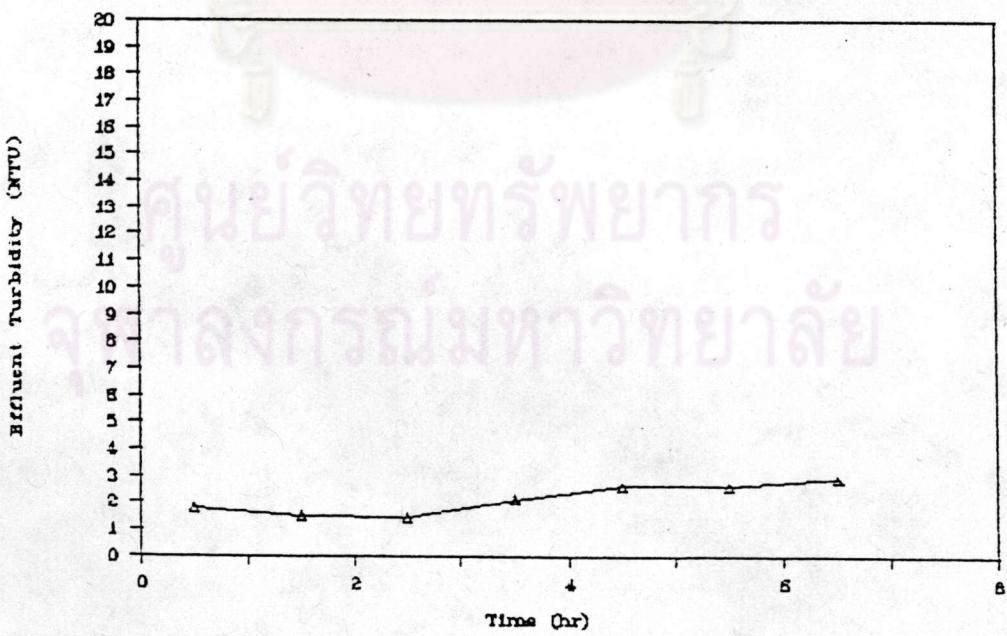
RUN NO. 64

The experimental condition was consisted of the following parameters:

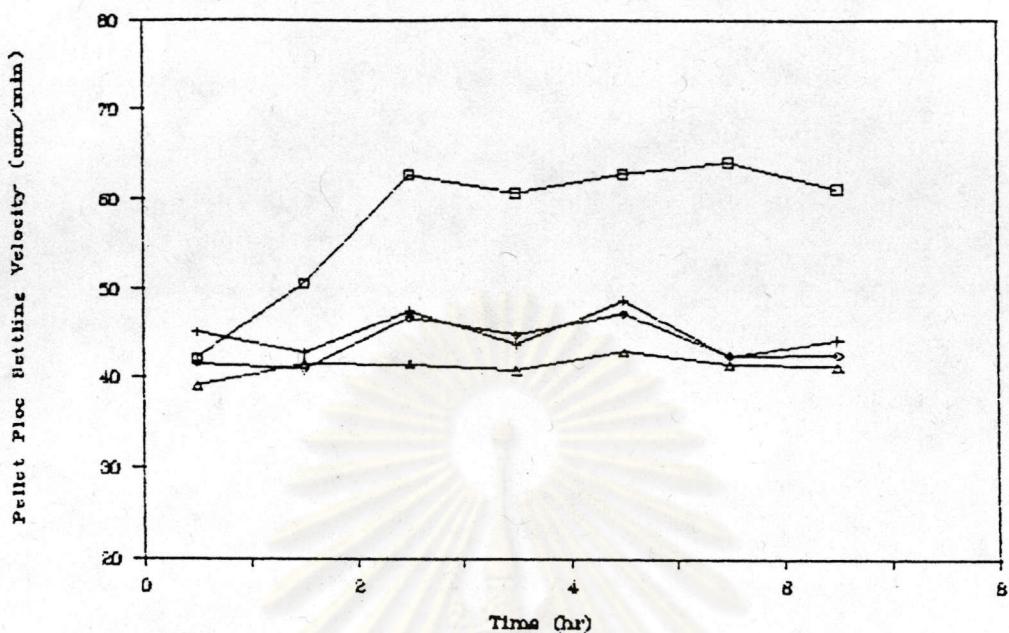
- a) Polyaluminum chloride dosage was 4 mg./l.
- b) Anionic polymer dosage was 0.1 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

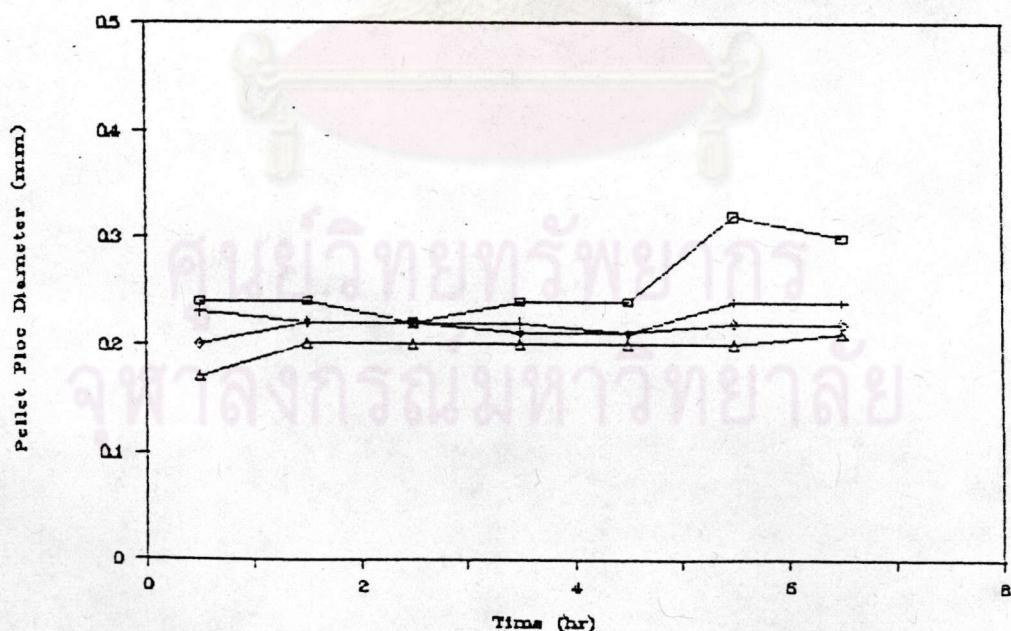
R 64, PACl 4.0, PE 0.1, 15 rpm, Upf 40



R64, PACl 4.0, PE 0.1, 15 rpm, Upf 40



R64, PACl 4.0, PE 0.1, 15 rpm, Upf 40



□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

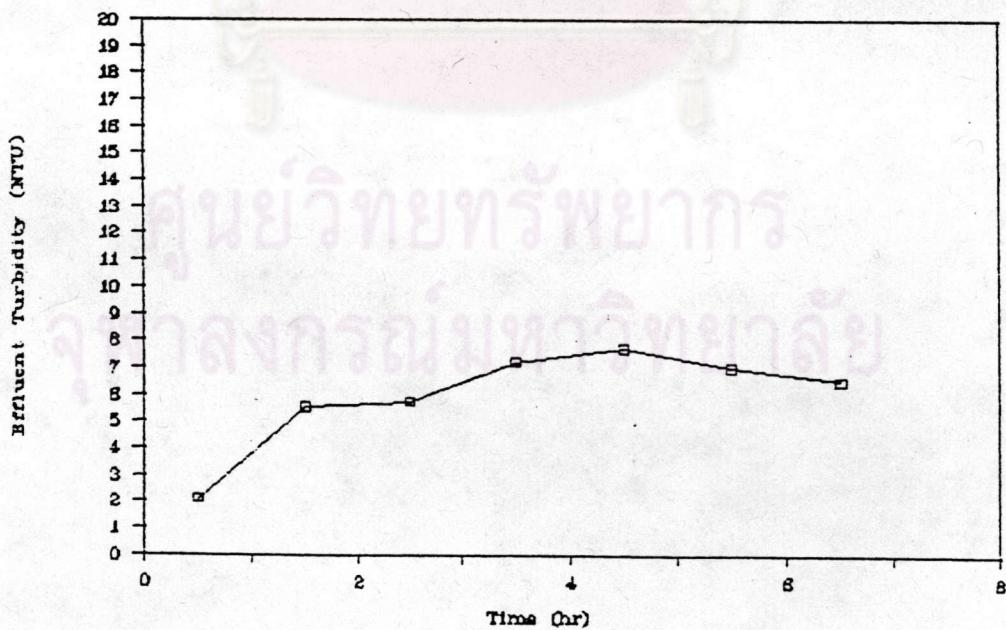
RUN NO. 65

The experimental condition was consisted of the following parameters:

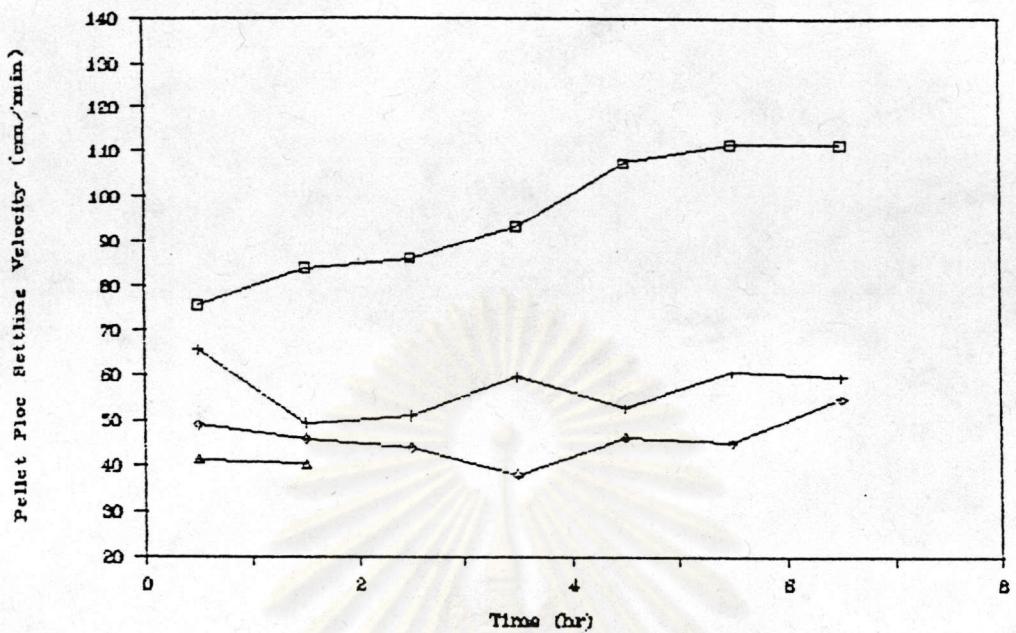
- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

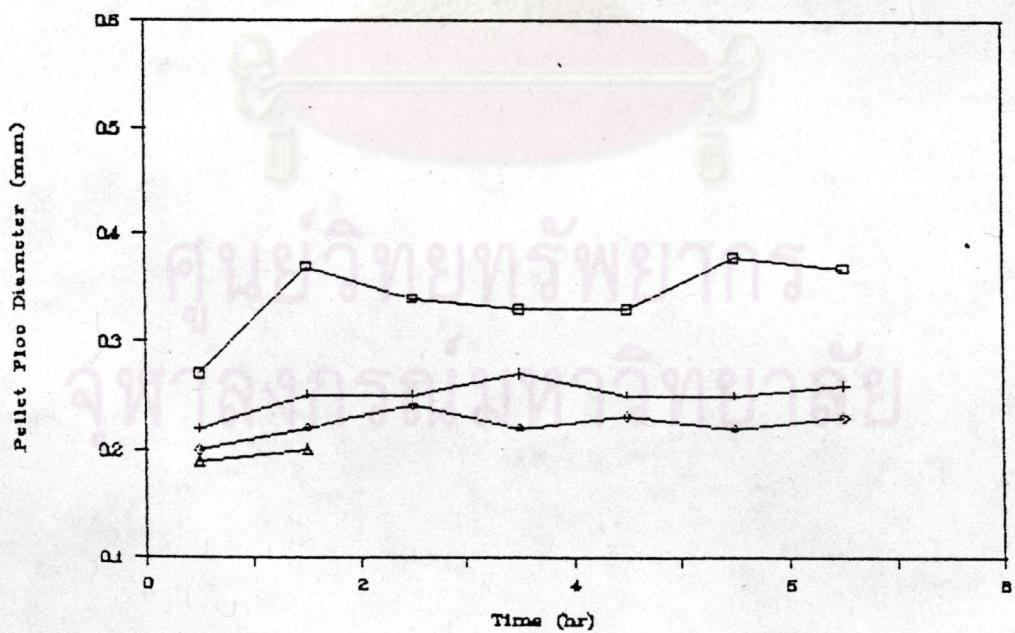
R 65, PACl 1.0, PE 0.2, 15 rpm, Upf 40



R65, PACl 1.0, PE 0.2, 15 rpm, Upf 40



R65, PACl 1.0, PE 0.2, 15 rpm, Upf 40



□ H 0 cm + H 60 cm ◆ H 120 cm △ H 150 cm

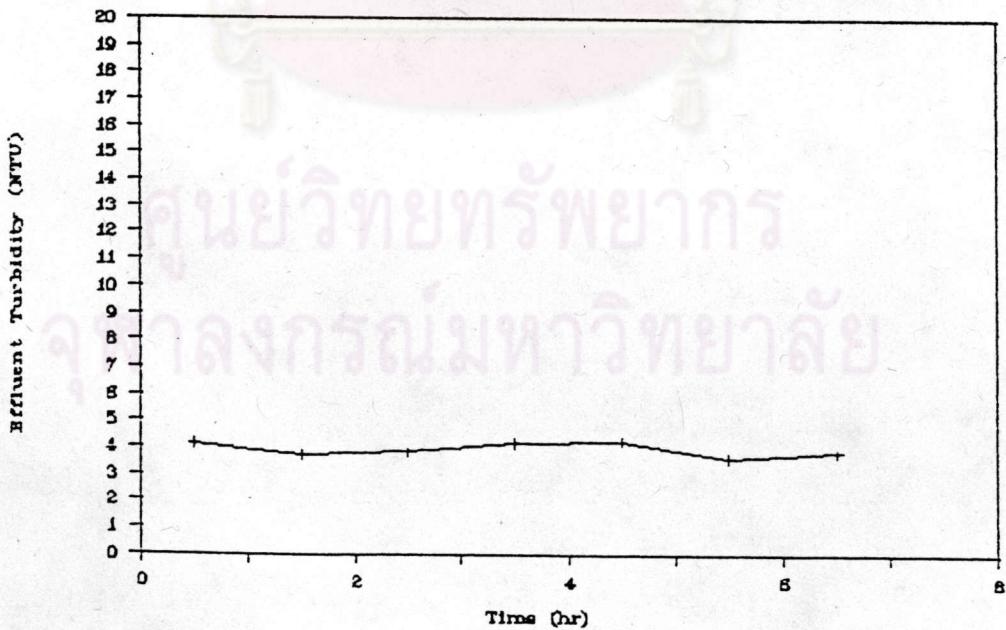
RUN NO. 66

The experimental condition was consisted of the following parameters:

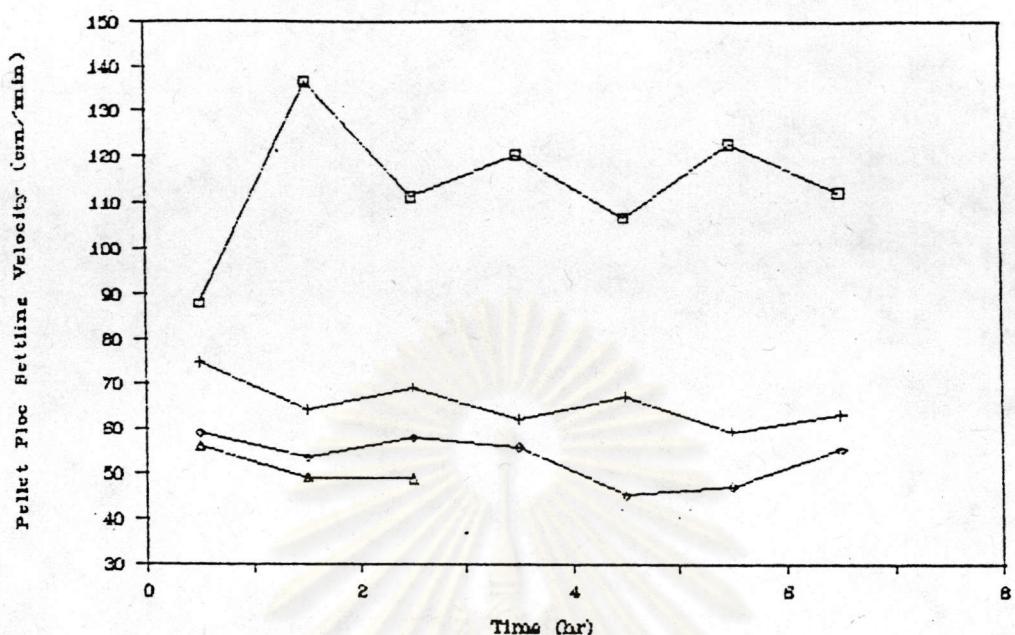
- a) Polyaluminum chloride dosage was 2 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

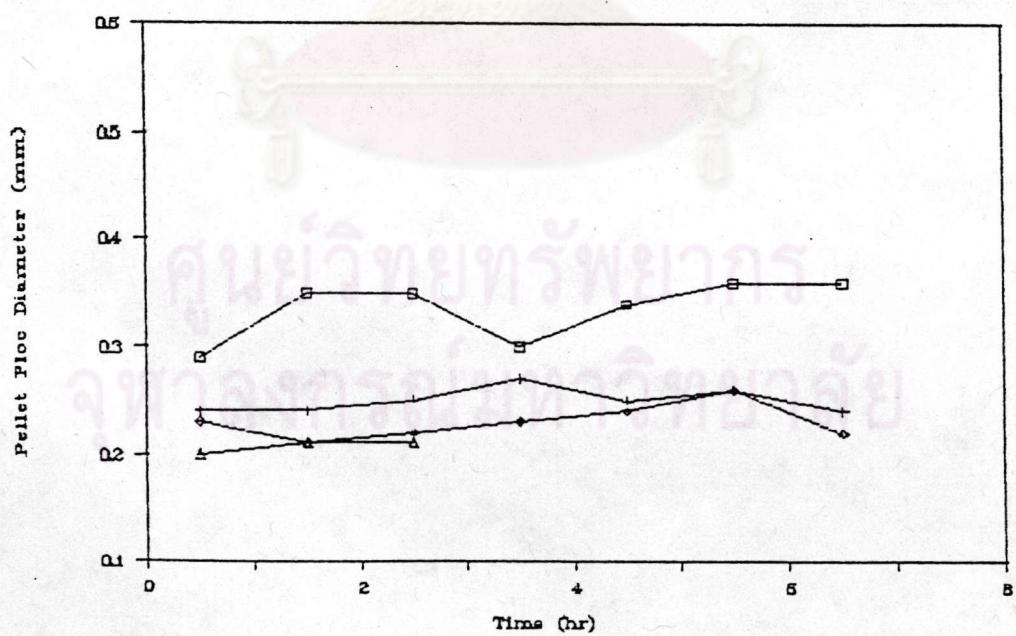
R 66, PACl 2.0, PE 0.2, 15 rpm, Upf 40



R66, PACl 2.0, PE 0.2, 15 rpm, Upf 40



R66, PACl 2.0, PE 0.2, 15 rpm, Upf 40



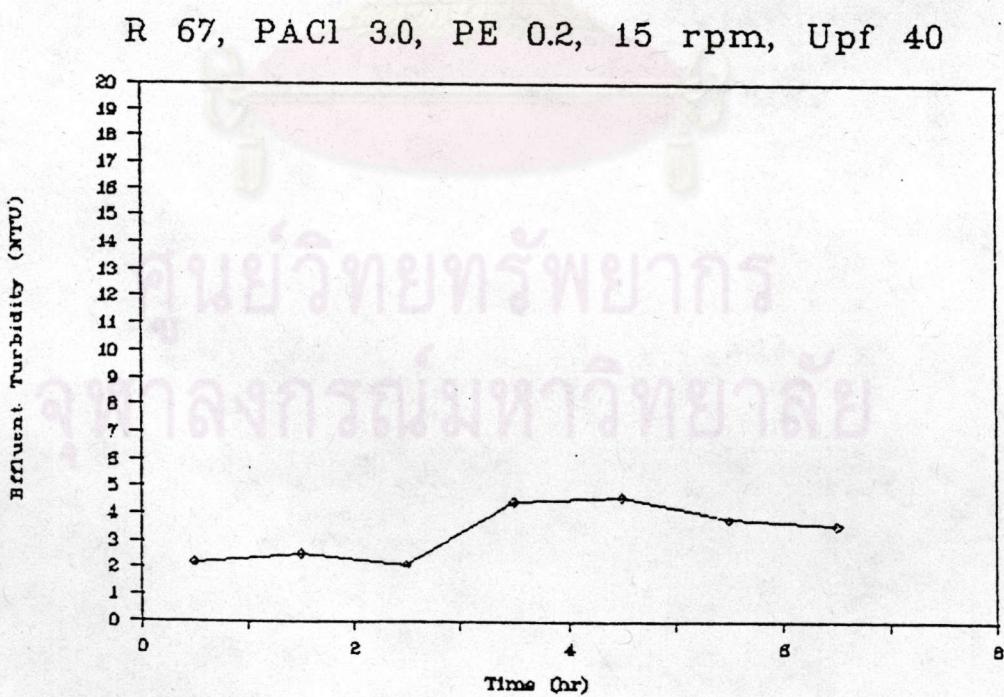
□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

RUN NO. 67

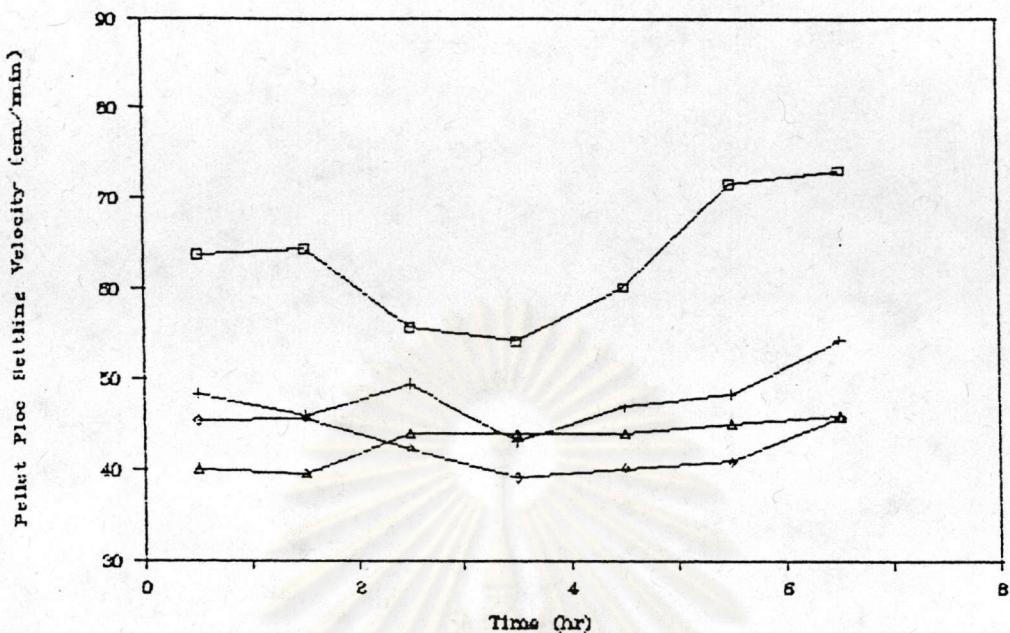
The experimental condition was consisted of the following parameters:

- a) Polyaluminum chloride dosage was 3 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 40 cm./min.

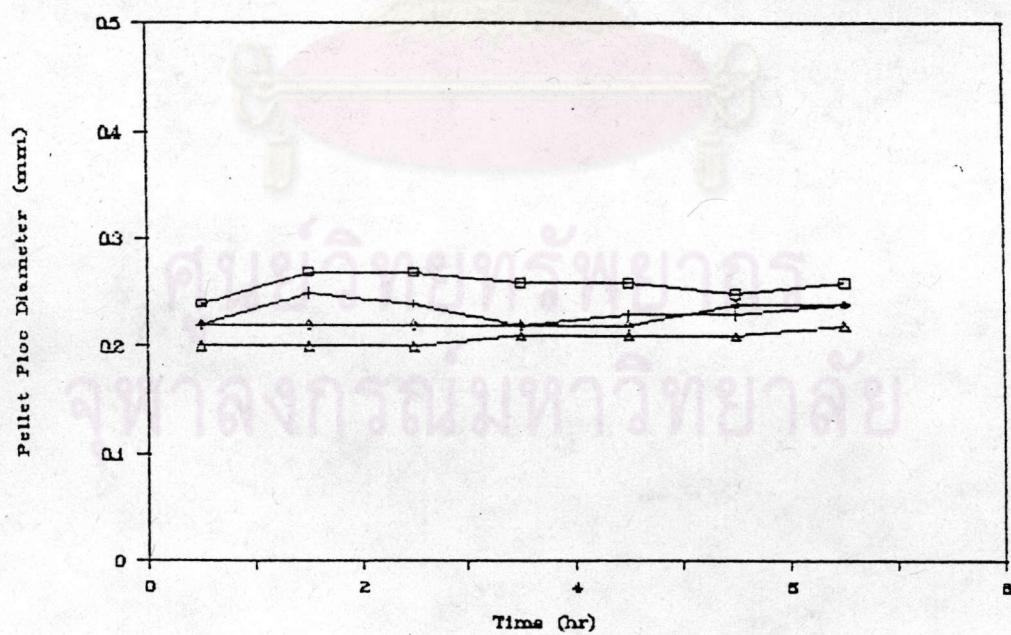
The experimental results of each run were shown in the following figures:



R67, PACl 3.0, PE 0.2, 15 rpm, Upf 40



R67, PACl 3.0, PE 0.2, 15 rpm, Upf 40



□ H 0 cm + H 60 cm ◊ H 120 cm △ H 150 cm

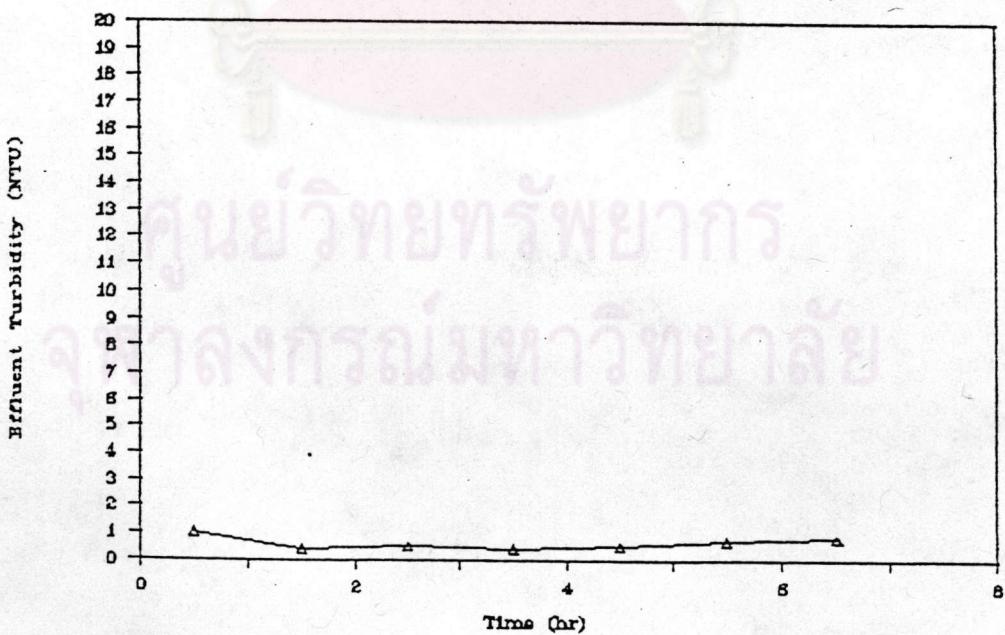
RUN NO. 68

The experimental condition was consisted of the following parameters:

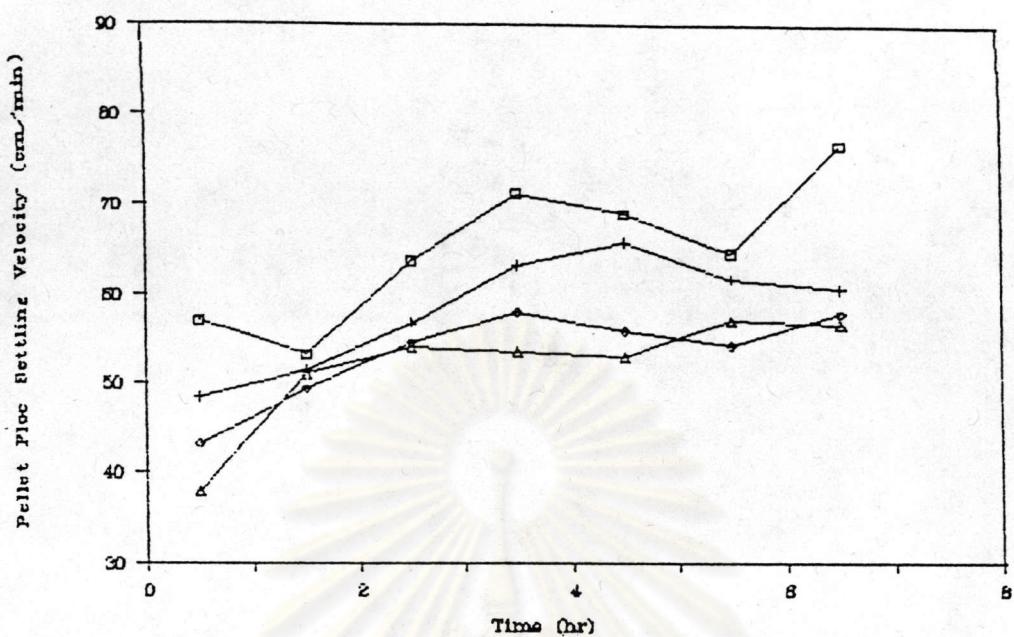
- a) Polyaluminum chloride dosage was 4 mg./l.
- b) Anionic polymer dosage was 0.2 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

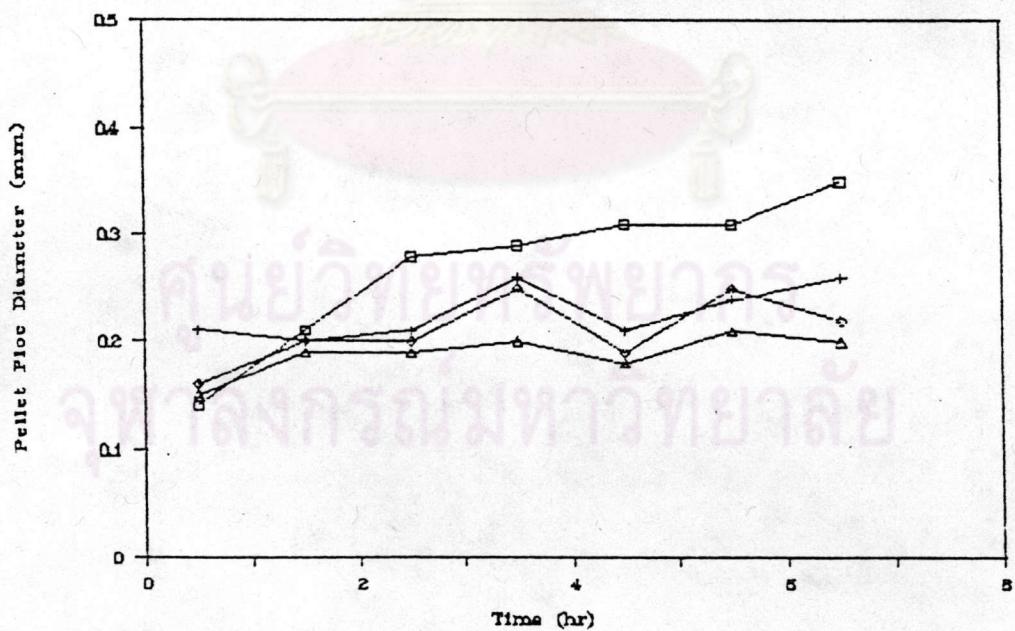
R 68, PACl 4.0, PE 0.2, 15 rpm, Upf 40



R68, PACl 4.0, PE 0.2, 15 rpm, Upf 40



R68, PACl 4.0, PE 0.2, 15 rpm, Upf 40



□ H 0 cm + H 60 cm ♦ H 120 cm Δ H 150 cm

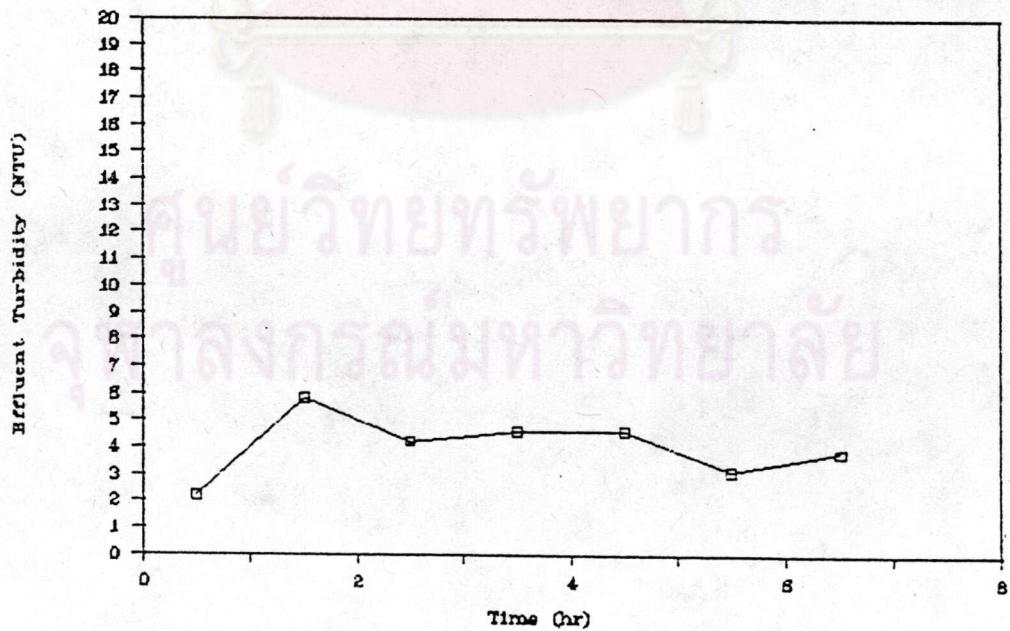
RUN NO. 69

The experimental condition was consisted of the following parameters:

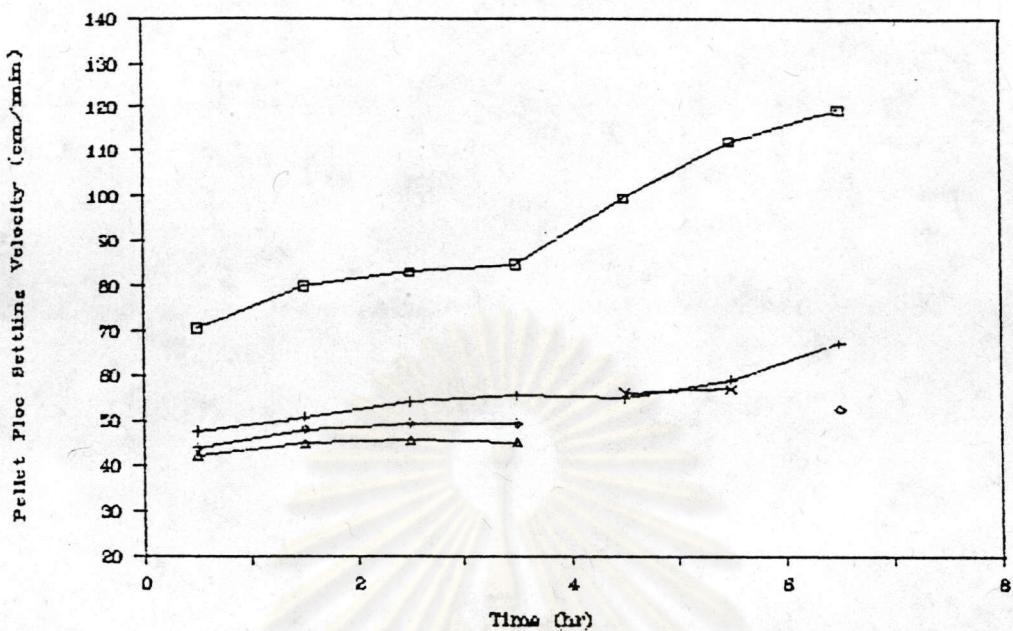
- a) Polyaluminum chloride dosage was 1 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

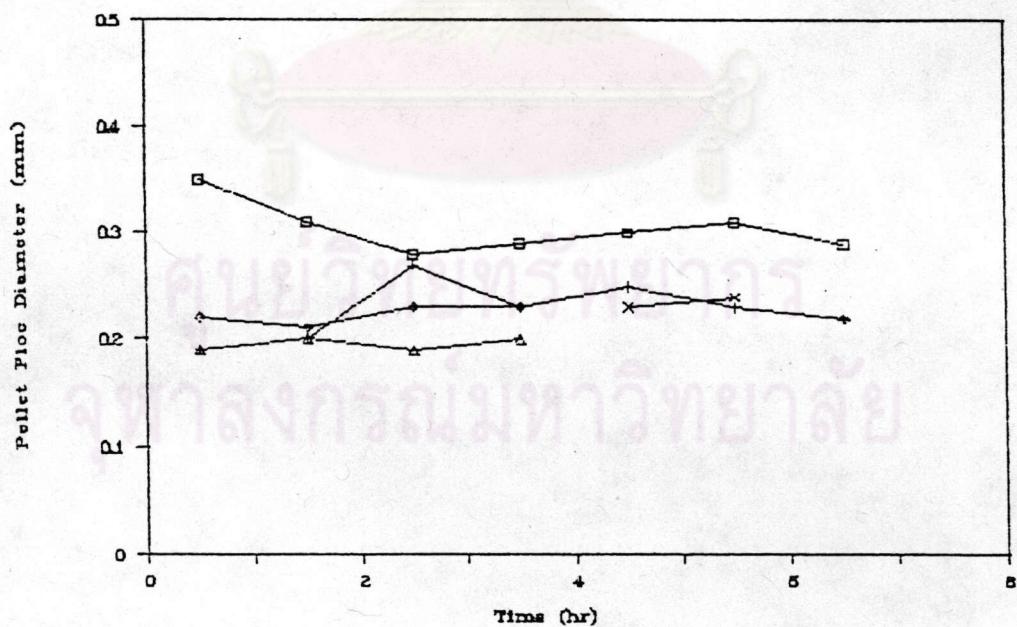
R 69, PACl 1.0, PE 0.3, 15 rpm, Upf 40



R69, PACl 1.0, PE 0.3, 15 rpm, Upf 40



R69, PACl 1.0, PE 0.3, 15 rpm, Upf 40



□ H 0 cm + H 60 cm X H 90 cm ◊ H 120 cm △ H 150 cm

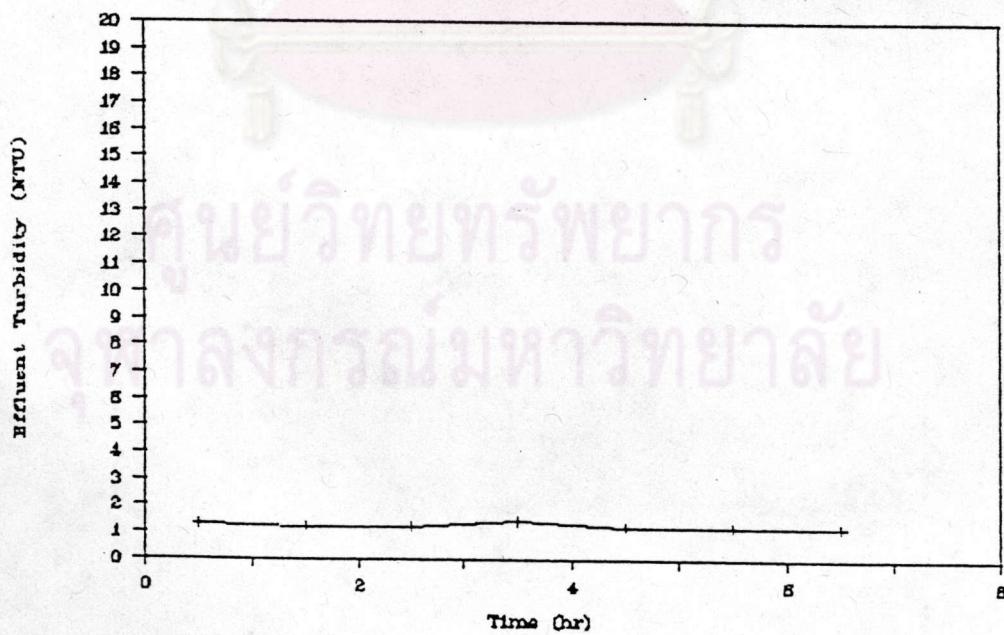
RUN NO. 70

The experimental condition was consisted of the following parameters:

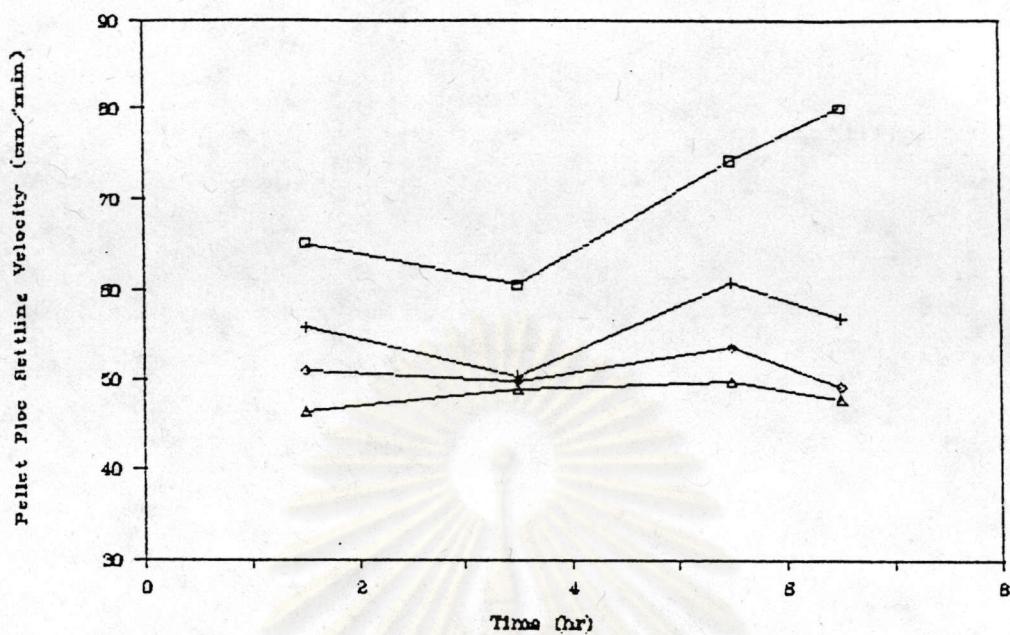
- a) Polyaluminum chloride dosage was 2 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

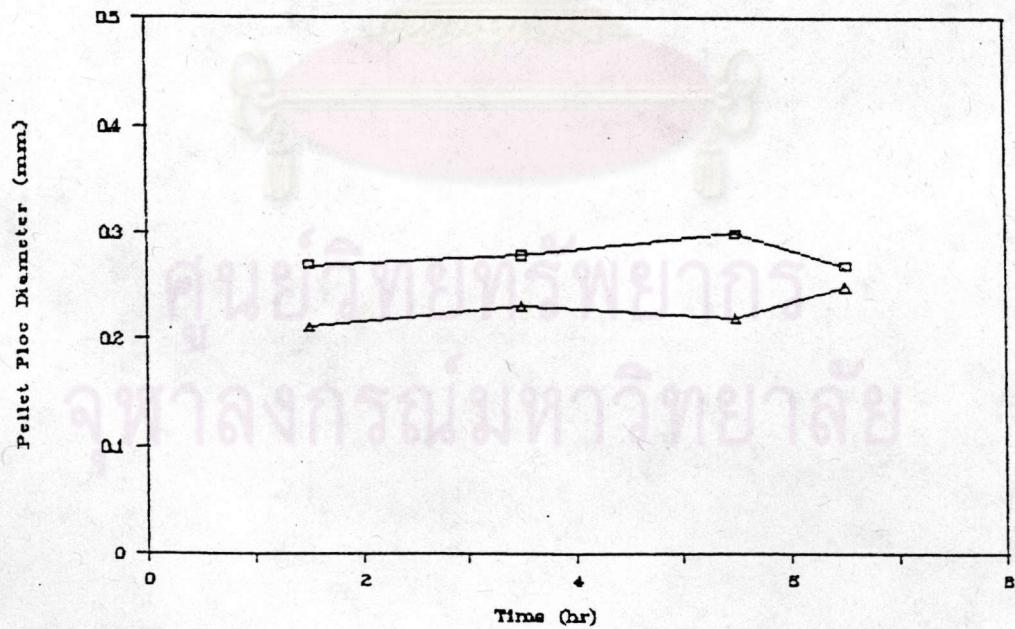
R 70, PACl 2.0, PE 0.3, 15 rpm, Upf 40



R70, PACl 2.0, PE 0.3, 15 rpm, Upf 40



R70, PACl 2.0, PE 0.3, 15 rpm, Upf 40



□ H 0 cm + H 60 cm ♦ H 120 cm △ H 150 cm

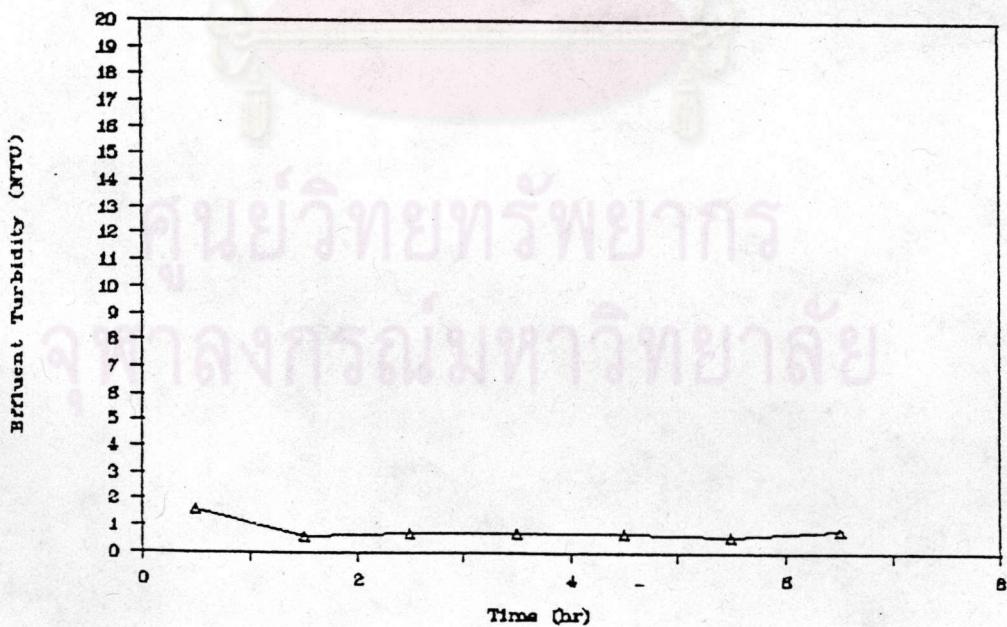
RUN NO. 72

The experimental condition was consisted of the following parameters:

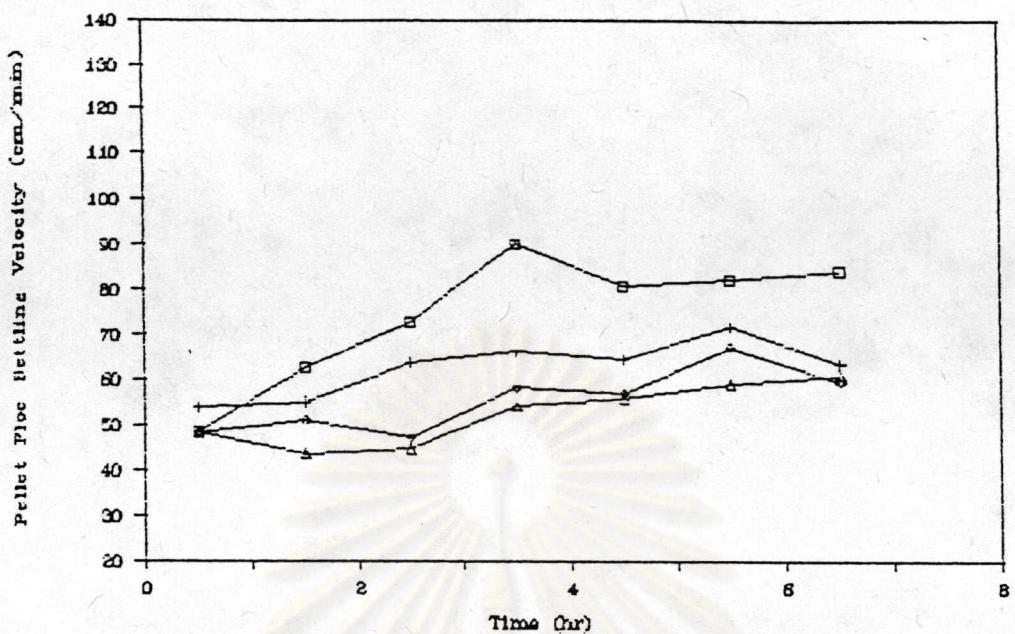
- a) Polyaluminum chloride dosage was 4 mg./l.
- b) Anionic polymer dosage was 0.3 mg./l.
- c) Speed of paddle agitation was 15 rpm.
- d) Upflow velocity was 40 cm./min.

The experimental results of each run were shown in the following figures:

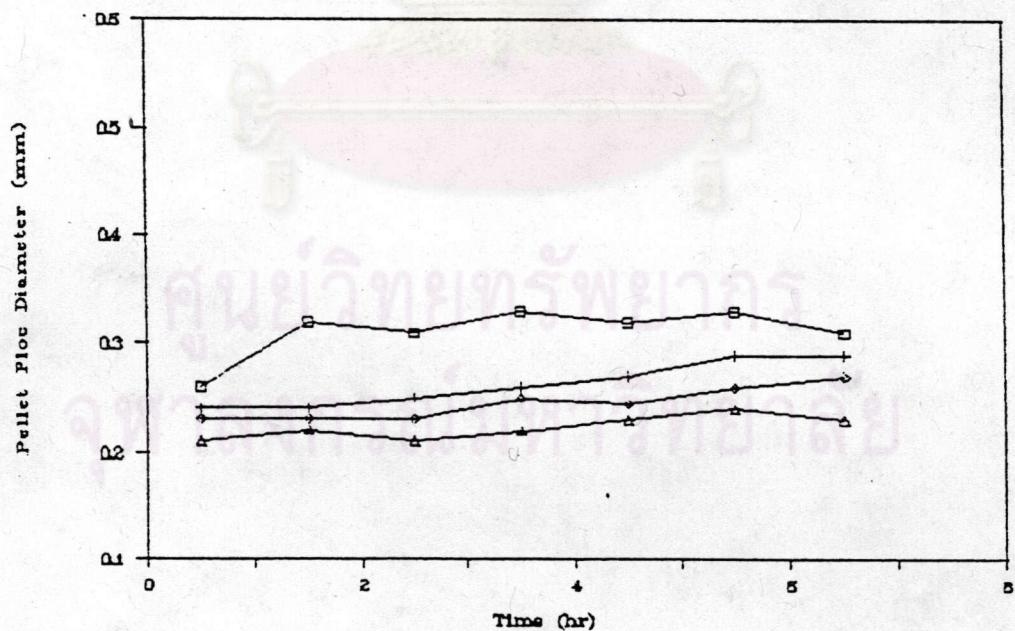
R 72, PACl 4.0, PE 0.3, 15 rpm, Upf 40



R72, PACl 4.0, PE 0.3, 15 rpm, Upf 40



R72, PACl 4.0, PE 0.3, 15 rpm, Upf 40



□ H 0 cm + H 60 cm ◆ H 120 cm △ H 150 cm

VITA

The author, Mr. Bundit Channarong, was born on August 11, 1963 in Sukhothai province, Thailand. He received bachelor of Science, major in Sanitary Science, Faculty of Public Health from Mahidol University.

At Department of Environmental Engineering, the first investigation of pellet flocculation was started by the author on October 1989, finished on March 1991. And during the time writting of this investigation, his advisor and he received an inventive hardware kit award: High-Efficiency Water Supply System from Chulalongkorn University on September 1991.



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