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DECAY LENGTH FOR 180° HELICOIDAL FLOW FLOCCULATOR

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ABSTRACT

The secondary flow in a helicoidal flow flocculator does not completely decay at the exit of the bend, but continues to a reasonable distance beyond the downstream end of the bend. This distance is called decay length. The paper aims at defining decay length on the basis of asymmetry of isovels and developing a relationship among the easily known parameters of straight channel and geometry of the curve. The proposed relationship is well comparable with the experimental values. The efficiency of flocculator have been tested in the laboratory and is found to be satisfactory.

INTRODUCTION

The flocculation plays an important role in water treatment plant to remove colloidal impurities. The concept of conventional flocculator has been modified to tapered flocculator in which velocity gradient decreases in the flow direction. The use of such concept assures good floc formation compared to conventional flocculator. Dhabadgaonkar (1994) stated a concept of helicoidal flow for flocculation process. Suresh Kumar (2003) stated a concept of tapered flocculation with hydraulic jets. The helicoidal flow is generated in the early reaches of the bend and continues on the downstream of bend (Chow 1951). In order to quantify the length to which it continues on downstream side, Nouh & Townsend (1979) suggested the length measured from the bend exit to a point on downstream side where residual circulation amounts to 10% of the initial intensity measured at the former. However, the present study states a definition of decay length on the basis of the degree of asymmetry, and a relationship for its calculations have been proposed. An experimental work has been carried out in the laboratory on 180° bend flocculator to study the effect of secondary circulation beyond the bend exit. The efficiency of flocculator has been tested in the laboratory and is found to be satisfactory.

The definition proposed for the decay length is the distance from the exit section of the curve to a section on downstream, where the degree of asymmetry is almost equal to the degree of asymmetry at upstream entrance section not affected by the curve. Degree of asymmetry a is defined as:

$$\alpha = \frac{\Sigma \text{Mean velocity} \times \text{Area between two isovels on outer half}}{\Sigma \text{Mean velocity} \times \text{Area between two isovels on inner half}}$$

The degree of asymmetry is calculated by plotting isovels at each section, 0.5 m. distance from bend exit. It was considered to establish a relationship between the decay length and parameters conveniently known, i.e., average velocity, depth of flow at the straight upstream, central radius of curve and central angle *q*. The relationship obtained is linear from which decay length can be calculated.

MATERIALS AND METHODS

The laboratory investigations were carried out on a 12 m long G.I. channel bend flocculator having a rectangular cross-section, 30 cm wide and 40 cm deep and painted from inside. The angle θ was kept equal to 180°. The straight upstream and downstream reach of channel was 3 m long. The channel curve was having $r_c/b = 3.5$. The general view of the arrangement is shown in Fig. 1. Flow entered a tank of 90 cm × 90 cm. Constant supply of water was provided. A gated control was provided at the downstream end of channel to regulate the depth of flow. Four runs were carried out with different discharges. The channel was divided into seven sections, each at 0.5 m on the downstream of the curve. The efficiency of flocculator was carried out by giving artificial turbidity to water. Fullers earth was used for this purpose. Turbidity was measured with help of a nephelometer.

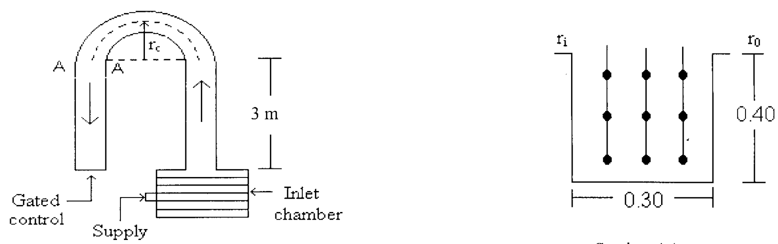

Fig. 1 : Flocculator

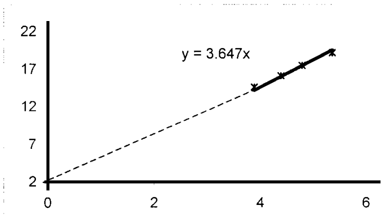

Fig. 2 : Relationship for decay length

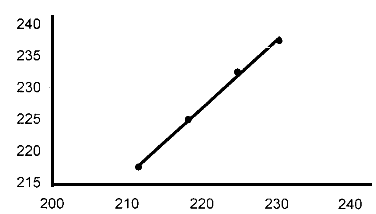

Fig. 4 : Calculated and observed values

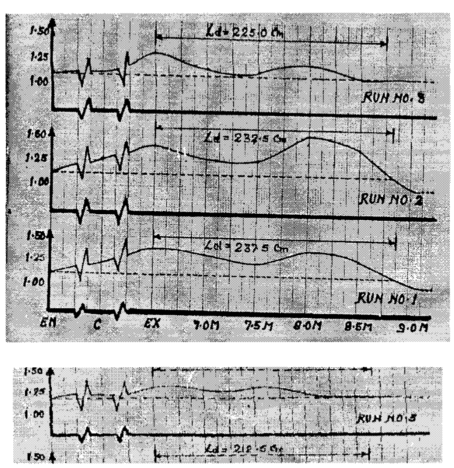

Fig. 3 : Degree of asymmetry

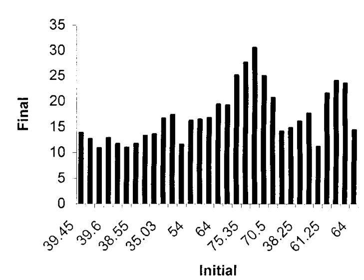

Fig. 5 : Efficiency

The optimum dose of alum solution was administered at the inlet of the bend. The results of efficiency have been presented in Fig. 5.

Analysis: A tool of dimensional analysis was used to obtain functional relationship as below.

$Ld = f(D_0, r_c, v_0, g, \theta)$

Carrying out dimensional analysis of the π terms,

$f_1 (\pi_1, \pi_2, \pi_3, \pi_4) = 0$

$$\mathbf{f_i}\left(\frac{\mathbf{L_d}}{\mathbf{D_0}}, \frac{\mathbf{r_c}}{\mathbf{D_0}}, \frac{\mathbf{V_0}}{(\mathbf{gD_0})^{1/2}}, \theta\right) = \mathbf{0}$$

Or,

$$\frac{\mathbf{L}}{\mathbf{D_0}} = \mathbf{f}\left[\frac{\mathbf{r_c}\theta}{\sqrt{\mathbf{g}}} \times \frac{\mathbf{V0}}{\mathbf{D_0^{3/2}}}\right]$$

The above relationship is linear and hence a curve was plotted as shown in Fig. 2 and the curve function can be defined as, y = 3.647x, i.e.,

$$\frac{\mathbf{L_d}}{\mathbf{D_0}} = \mathbf{3.647}\frac{\mathbf{V_0}}{\mathbf{D_0^{3/2}}} \cdot \frac{\mathbf{r_c}\theta}{\sqrt{\mathbf{g}}}$$

RESULTS

The degree of asymmetry at each section was calculated. For all the downstream sections starting from the exit of curve. A graph was plotted between degree of asymmetry along *y* axis and the distance of each section along *x* axis. A horizontal line was drawn from degree of asymmetry value at the reference section and wherever this intersects the curve in the downstream ridge; this point was considered to be a point where secondary circulation ends (Fig. 3). This is decay length calculated from degree of asymmetry. Fig. 4 shows the observed and calculated values of decay length for all runs. The efficiency of flocculator has been tested in the laboratory. The efficiency is found to be increased with increase in turbidity. This fact was also observed by Armal (1996).

CONCLUSIONS

1. The effect of secondary flow continues further on the downstream side of flocculator. This helps to build the floc further even on the downstream side.
2. The relationship to calculate decay length is simple.
3. The results of efficiency are found to be satisfactory.

NOTATIONS

b = Width of channel

r_c = Central radius of bend

θ = Total angle of bend.

g = Acceleration due to gravity

D_0 = Water depth on u/s of bend

V_0 = Average velocity in straight u/s of bend

L_d = Decay length

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