CHAPTER VI

EXPERIMENTAL INVESTIGATION

An experimental investigation is undertaken to provide experimental information on turbulent flows. Such information is essential to support the reliable theoretical model for flow predictions in the next chapter.

6.1 EXPERIMENTAL FACILITY AND PROCEDURE

The experimental facility consists of a smooth-plastic square duct approximately 7.8 m in length that is divided into five sections as 1.5 m for the inlet or the upstream-section , joints together with the test-section for 0.3 m long , and three downstream-sections for 2.4 m , 2.4 m and 1.2 m respectively. The distance between opposite walls of the duct was maintained at 0.15 m over the length of the duct. The duct inlet is preceded by a contraction (area ratio 9 : 1) and a settling chamber with screens (mesh 120 , 80 , 50) , honeycomb , screen (mesh 1 × 1 cm) , expansion and converter respectively. The air is supplied by two blowers through a mixed-joint (45 degree angle) and the flexible hose. See the schematic diagram of the wind tunnel in figure 6.1 and its photograph in figures 6.2.

The smooth-aluminium flat plate (approximately 0.5 mm thick) is installed inside the test-section with adjustable angle. The dimension of these flat plates depend on the type of the damper. All of them are the same in length , that is the diameter of the duct (D) which is equivalent to the hydraulic diameter (D_h) in section 3.3 , equals to 0.15 m. Their breadth are different as : (D) for 1-blade , (D / 2) for 2-blade and (D / 3) for 3-blade.

Furthermore , in order to make a dummy for reference , the empty test-section without any blade inside or *blank* is also used. The instruments of measuring are a Pitot-static tube (Ø = 1.5 mm for total-pressure hole and 0.5 mm for static-pressure holes) and a manometer (DWYER MODEL NO. 424 , inclined type , overall range : 0 to 250 mm of water with resolution 0.2 mm of water) and a digital thermometer (VAISALA MODEL HM 34 , overall range : -20 to +60 °C) for reading the reference temperature of the moving air.

For probe access , 5.0 mm holes are drilled along a centerline plane on the top-wall of the duct.

The purpose of an experimental investigation is separated for two parts :

The first is to measure on the mean-longitudinal-velocity at the centerline point of each cross-section over the length of the duct. A characteristic line is created for each initial condition. By using a fixed degree angle of the blade in the test-section and change the type of the damper from 1- , 2- and 3-blade also including a blank duct. Then , do the same way but alternate procedure. That is the number of blade is fixed or specified the type of the damper and vary its inclination ranging from 10 to 50 degree angle (steps up by 20).

The second is to measure on the mean-longitudinal-velocity along the vertical direction at the centerline plane of the duct for each cross-section. The velocity profiles are created for two different initial conditions which are the air flow past the obstacle and without it in the duct. However , the experimental results of this part are illustrated later as well as the appropriate discussion in section 7.1.

6.2 EXPERIMENTAL RESULTS

The collected data of the pressure difference is calculated to be the local mean velocity (V) from a relation as below

$$V\ [m/s] = \sqrt{\frac{2\ (P_{total} - P_{static})\ [N/m^2]}{\rho\ [kg/m^3]}} \qquad (6.1)$$

where ρ is the density of the air flow in the duct.

The inlet velocity is measured to be uniform and the measurements are made at Reynolds number approximately 4×10^4.

Figure 6.3 presents the local mean velocity along flow direction at the centerline of the duct versus the normalized term of the local distance (L) and the diameter of the duct (D). The velocity characteristic line of a blank case gradually change from the inlet to the outlet of the duct because there is no obstacle. When the damper is installed at the position of L / D = 10 behind the inlet of the duct. Each type of the damper (1- , 2- and 3-blade) is fixed its inclination at 30 degree angle. Their characteristic lines (see figures 6.4 , 6.5 and 6.6 respectively) , indicate that the flow can be disturbed by the single blade damper easier than the multi-blade damper due to the mean velocity fluctuations over the length of the duct are greater than 2- and 3-blade cases.

When the number of blade is fixed as the selected type : 3-blade damper , while the inclination is changed for 10 , 30 and 50 degree angle. The experimental results of these initial conditions as shown in figures 6.7 , 6.6 and 6.8 respectively , indicate that the flow can be disturbed by the large inclination (against the flow direction) of the blade easier than the small degree angle due to the mean velocity over the length of the duct for 50 degree angle case is most fluctuated. Such behavior is reduced when the inclination becomes 30 degree angle and being the least in case of 10 degree angle.

According to above discussion , they are only analysis on the trend of the characteristic lines which acquire from the first part of an experimental investigation. Although these informations indicate some phenomena of the air flow in a square duct with various initial conditions but still be not sufficient to cover the whole domain of the flow field. Consequently , in order to support the reliable theoretical model for flow predictions , some additional informations are required by doing the second part of an experimental investigation.

Finally , there are some remarks on the experimental investigation as follows

1) The last step in the characteristic lines (approximately over L / D = 40) is resultant from the joint of two last sections of the duct which is not perfectly smooth. Their inside dimension are not exactly parallel , thus the pathway of the air flow across this joint , is like a step of the wall overlap. Such

behavior can easily disturb or even destroy the boundary-layer that be developing or fully developed. This leads the flow to begin to redevelop again , causing the observed results are shifted from the actual phenomena.

2) Due to behind the blade and nearby have a lot of swirl , thus the experimental information which is able to be analyzed , should be out off those influence (about L / D = 8 to 12). Otherwise , the accuracy of the Pitot-static tube will be greatly reduced.

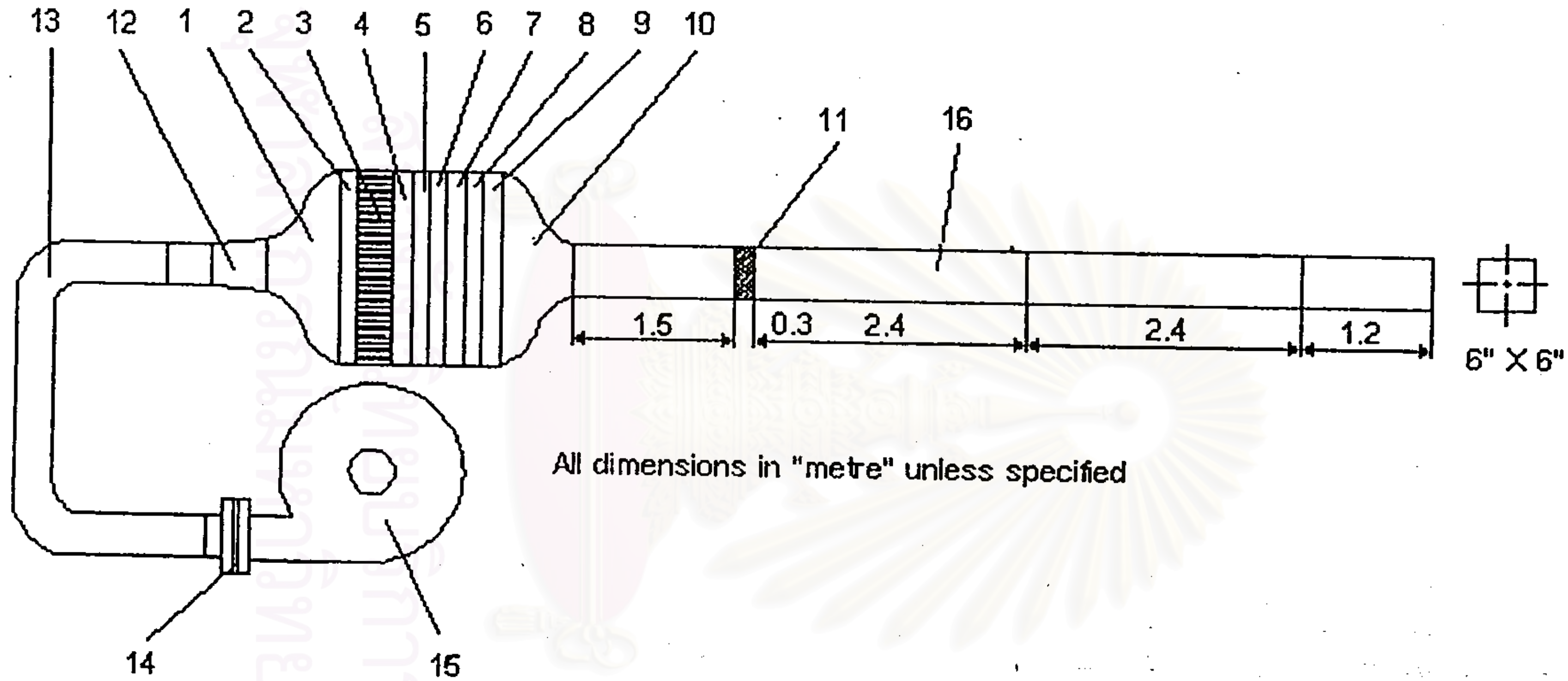

Figure 6.1 Schematic diagram of the wind tunnel.

1. Expansion
2. Screen M 1 × 1 cm .
3. Honeycomb
4. Screen M50
5. Screen M80
6. Screen M80
7. Screen M120
8. Screen M120
9. Screen M120
10. Contraction
11. Test section (damper)
12. Converter
13. Flexible hose
14. Flange
15. Blower
16. Plastic square duct

Figure 6.1 (continued).

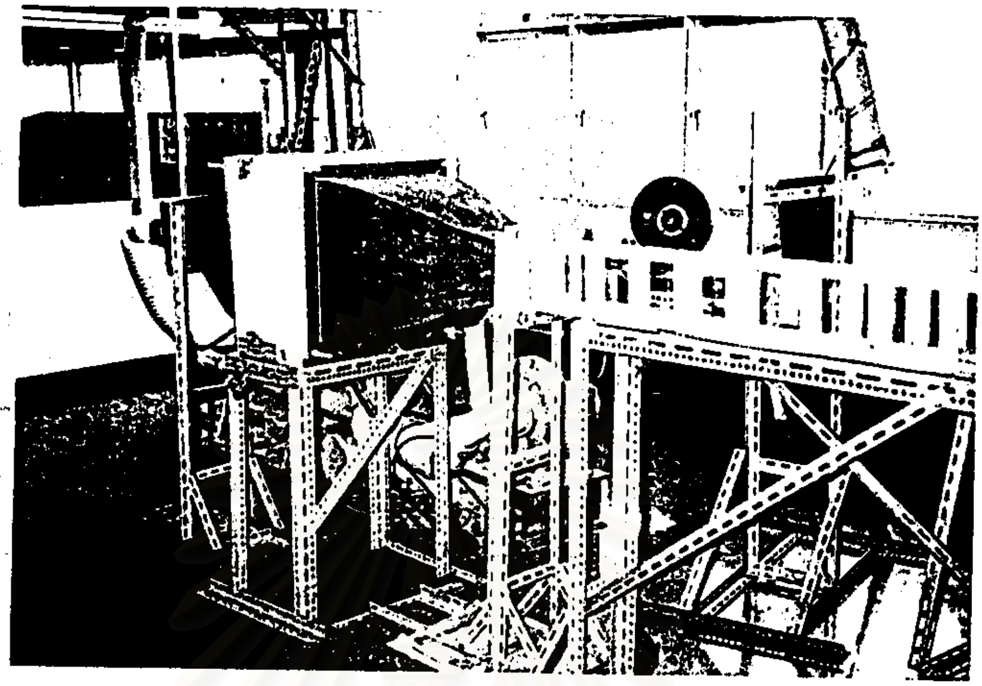

Figure 6.2(a) The wind tunnel (upstream-section).

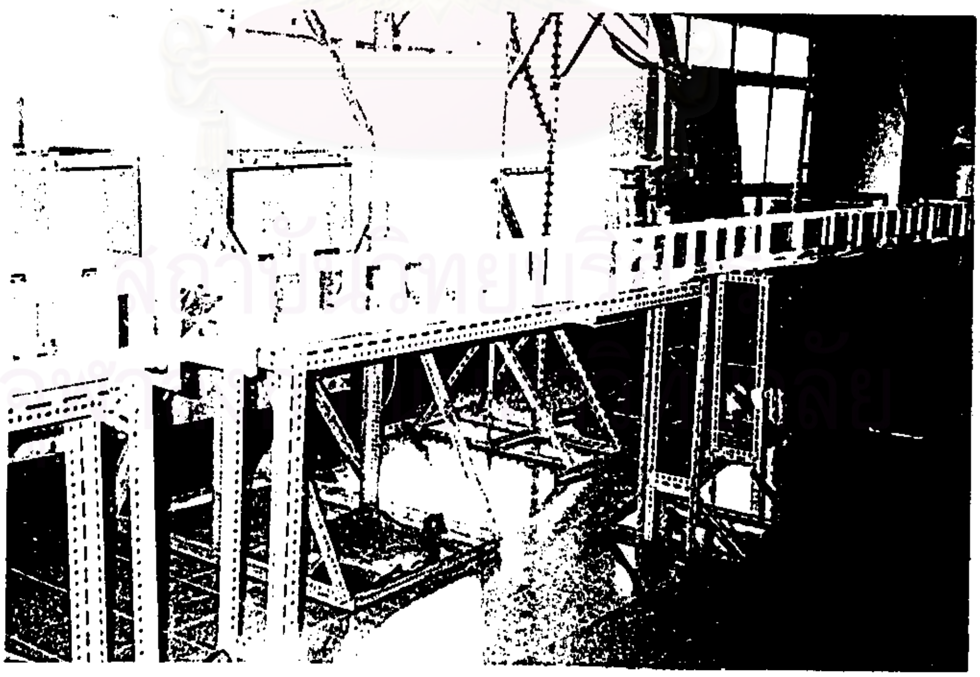

Figure 6.2(b) The wind tunnel (test- and downstream-section).

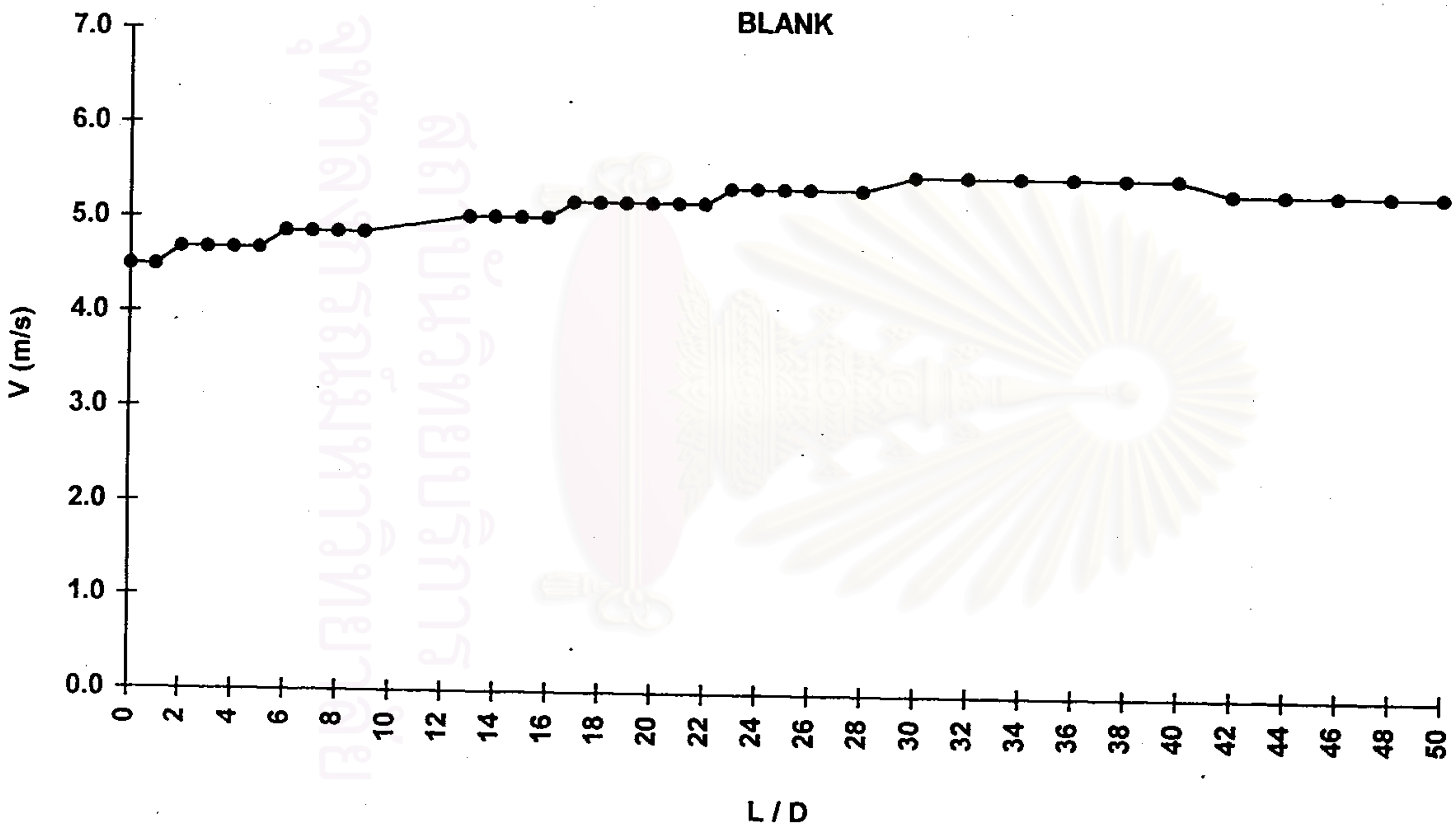

Figure 6.3 Centerline mean-longitudinal-velocity distribution in a blank duct.

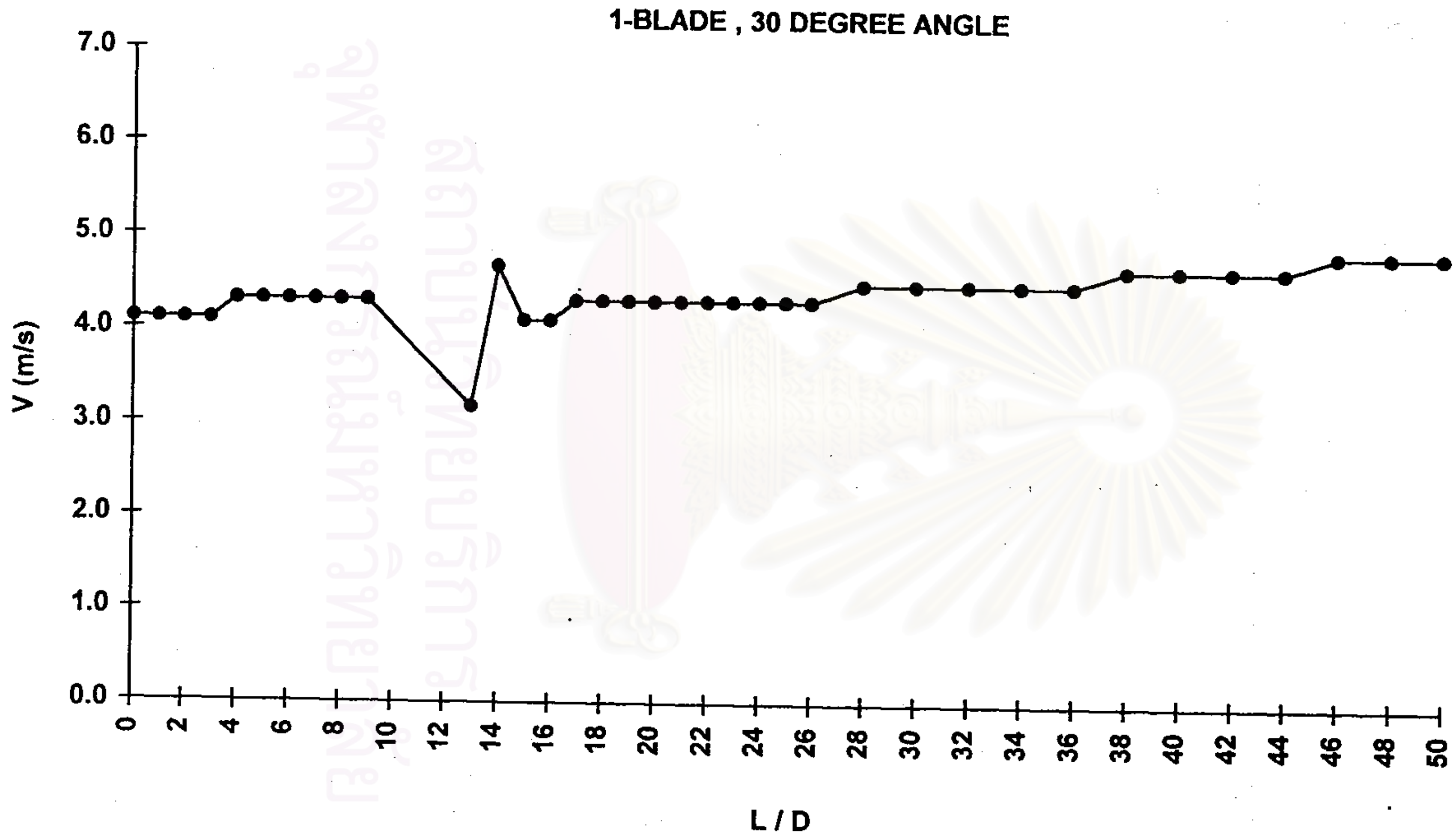

Figure 6.4 Centerline mean-longitudinal-velocity distribution of 1-blade damper with 30 degree angle.

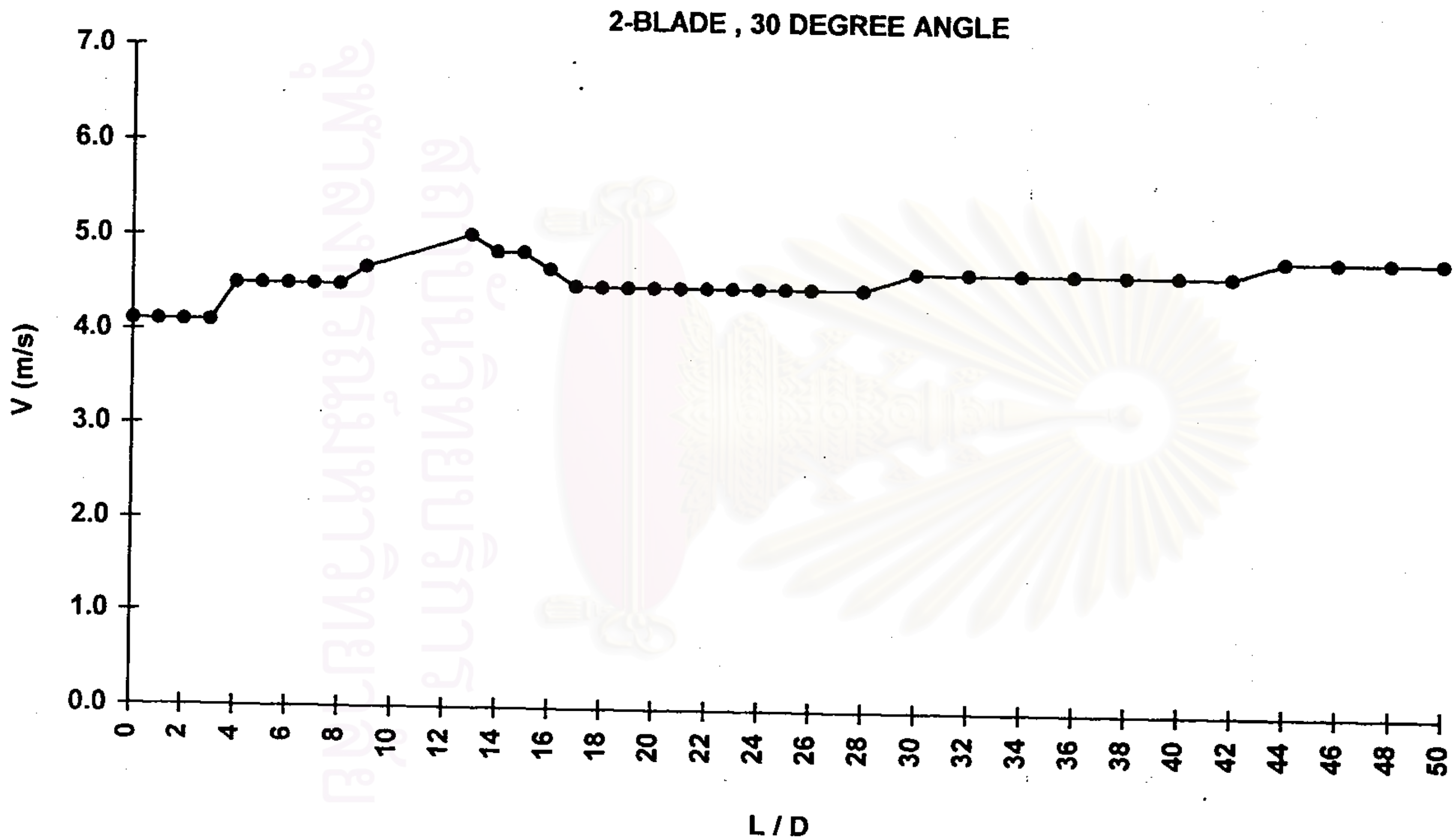

Figure 6.5 Centerline mean-longitudinal-velocity distribution of 2-blade damper with 30 degree angle.

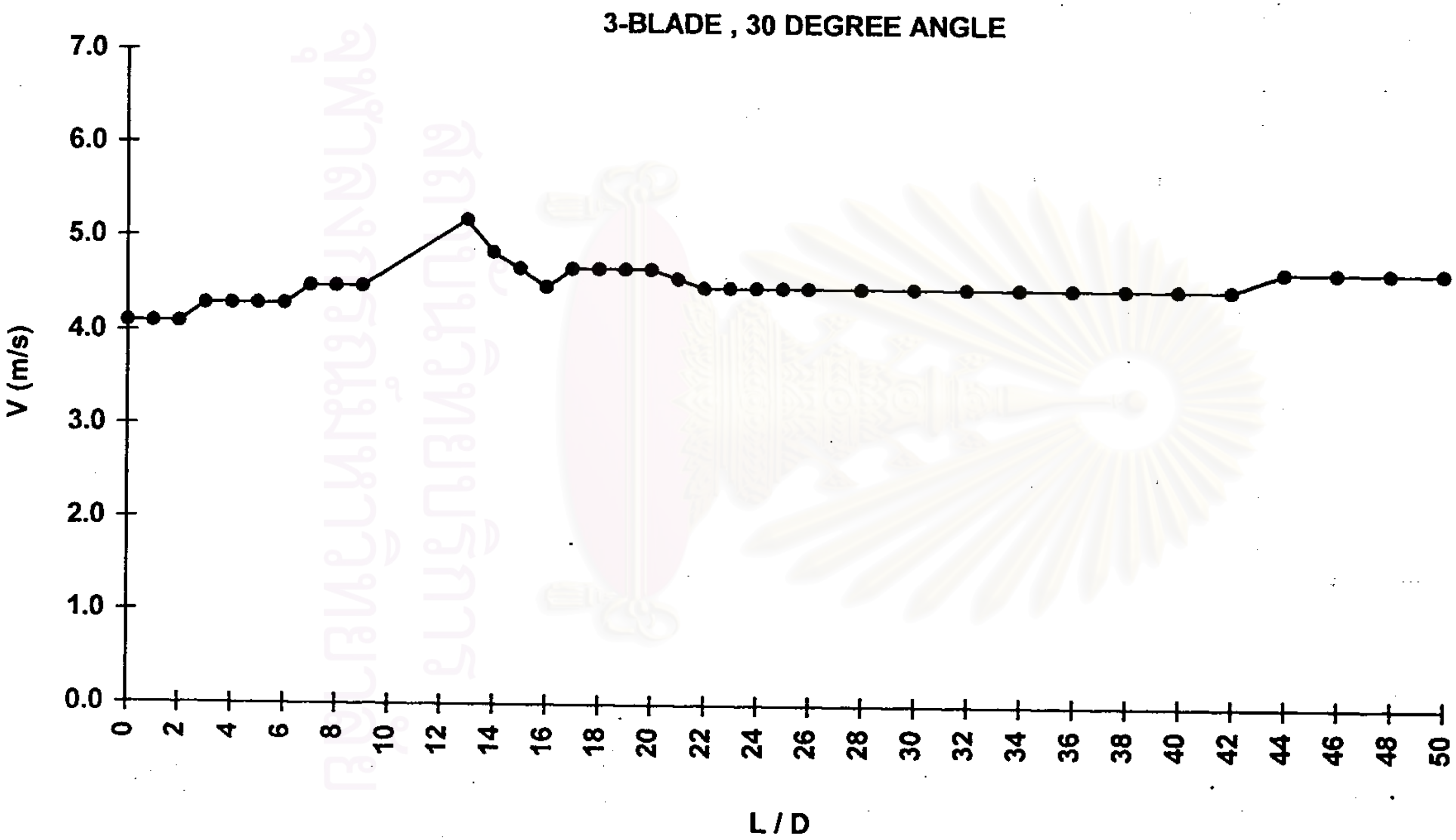

Figure 6.6 Centerline mean-longitudinal-velocity distribution of 3-blade damper with 30 degree angle.

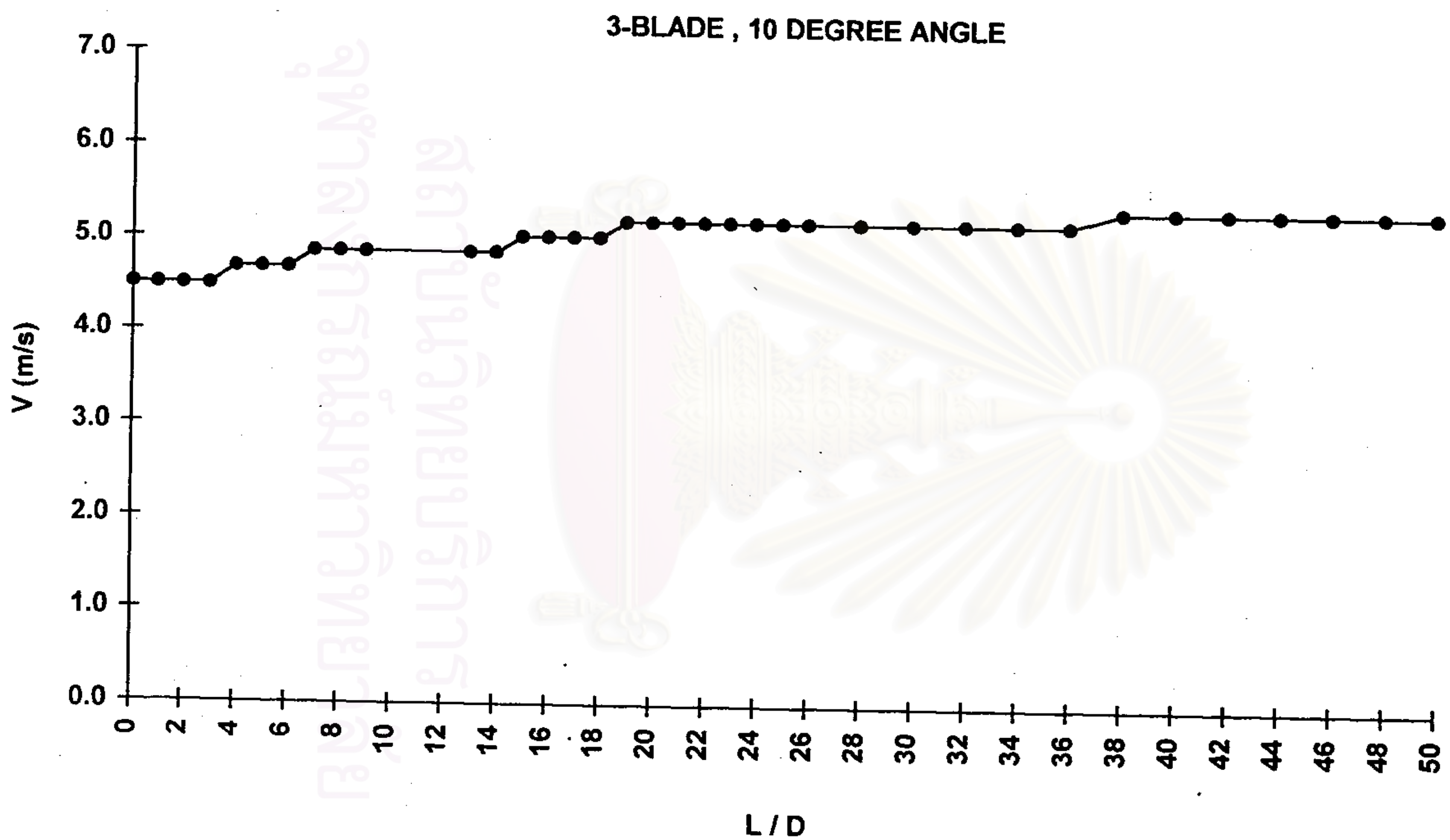

Figure 6.7 Centerline mean-longitudinal-velocity distribution of 3-blade damper with 10 degree angle.

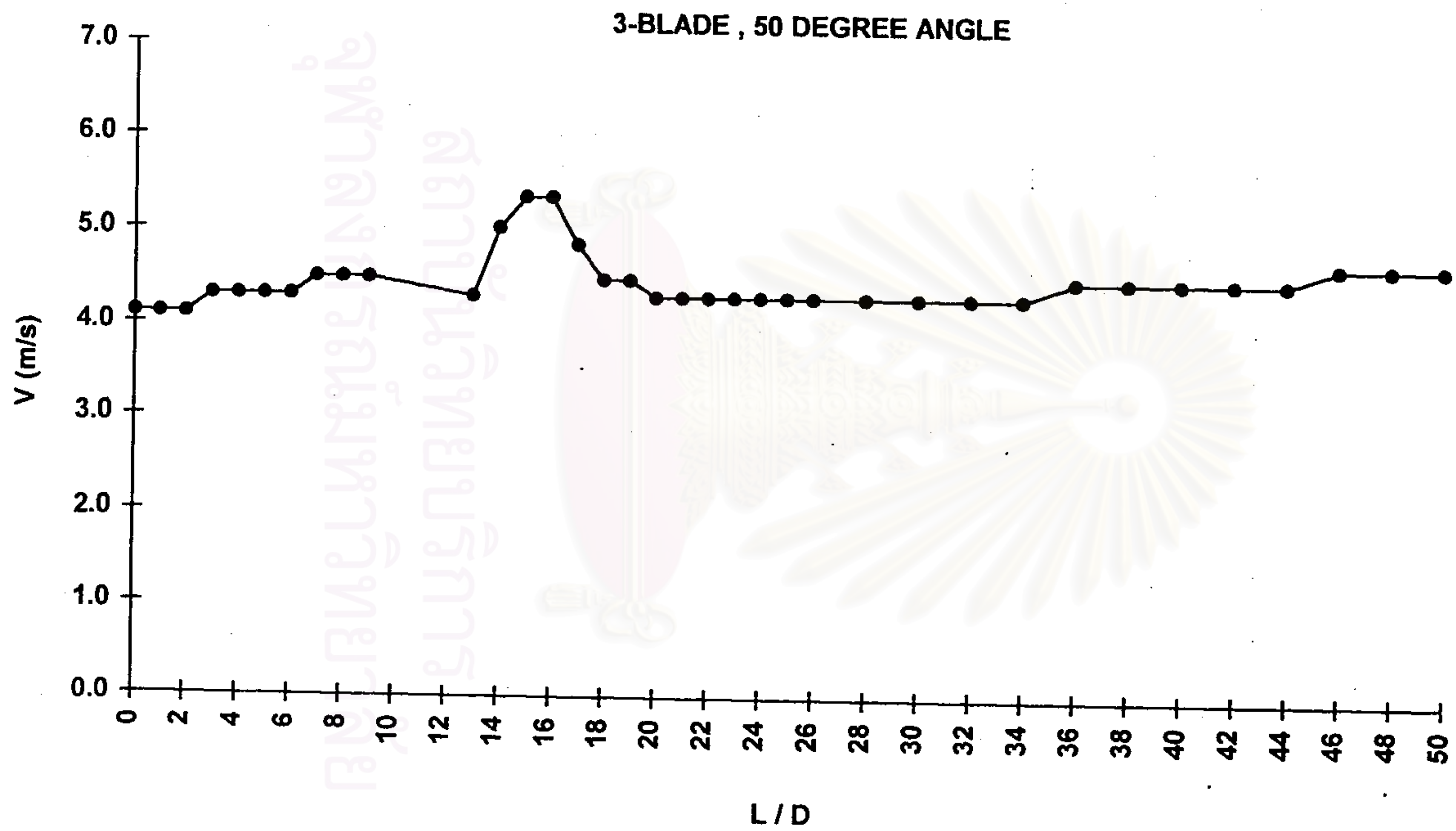

Figure 6.8 Centerline mean-longitudinal-velocity distribution of 3-blade damper with 50 degree angle.