SOME PRACTICAL DETAILS OF THE ELECTROLYTIC PRECIPITATION METHOD OF FLOW VISUALIZATION

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https://doi.org/10.5109/6776458

出版情報：Reports of Research Institute for Applied Mechanics. 28 (89), pp.83-89, 1980-12. 九州大学応用力学研究所
バージョン：

Reports of Research Institute for Applied Mechanics
Vol. XXVIII, No. 89, 1980

NOTE

SOME PRACTICAL DETAILS OF THE ELECTROLYTIC PRECIPITATION METHOD OF FLOW VISUALIZATION

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Technical procedures for using the electrolytic precipitation method of flow visualization are described.

Key words: Flow visualization, Electrolytic precipitation method, Technical procedures

1. Introduction

The electrolytic precipitation method has been used extensively for visualizing slow water flows[1-9]. This method of flow visualization consists in producing electrochemically white smoke of an insoluble metallic compound from the surface of a metal as an anode, and this smoke is used as a tracer of water motion. The fluid-mechanical significance of what is visualized by this method has also been discussed in preceding papers[10-13], and the concept of 'integrated streaksheets' has been proposed in connection with flow patterns of the smoke[11]. The method has been found highly effective in the study of steady and unsteady separated flows. However, no general discussions of these will be repeated here, and this note is concerned only with particular techniques for the use of the method. The properties of the smoke are described in a preceding paper[14].

2. Water tanks.

Many glass-sided water tanks ranging from about 2 to 5 m in length have been used in a dark room for applying the electrolytic precipitation method to visualize slow flows of water. Most of these are still-water tanks equipped with a motor-driven carriage of test bodies and cameras for

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photographing flow patterns. The frames of the tanks are made of iron, but their material and the presence of any other metals in the tanks do not seem to matter to an effective visualization by the use of the method. More important is that the inside and bottom surface of tanks should be painted in mat-black except transparent glass walls. This is because a sheet of the educed white smoke must be viewed against a sufficiently dark background.

3. Working fluid

In most cases common tap water may be used without any additives. Distilled water is not suitable since the electric conductivity of the water itself is very low, and even though some additives are used to enhance the conductivity the maintenance of their uniform concentration seems difficult. Repeated experimental runs degrade a working water because of the suspension of non-conducting insoluble smoke. So the degraded water must be changed with fresh water in the course of experiments.

4. Additives.

When the conductivity of water is insufficient and smoke generation is not very active, some additives may be added to enhance the conductivity. Common salt (sodium chloride) has been found most effective and convenient for this purpose. It should be noted, however, that in most cases tap water can be used as a working fluid without any additives, and even when salt is needed its quantity is not so much critical.

5. Anode

Smoke is generated most effectively when an anode is made of tin, but solder can be used more conveniently instead of tin. Depending on the shapes of test bodies, solder is processed in a variety of ways. For example, a circular solder wire may be used as it is as an anode, or a brass cylinder may be coated with solder and used as an anode. Smooth coating of solder can be made easily if the brass cylinder is heated with a gas burner previously and during the process of coating. When the surface area of the anode amounts to be large, this method does not work very well. Therefore, unnecessary parts of the anodes should be coated with a kind of spray for insulation. When a flow past a cylindrical body is two-dimensional, only a small portion around the middle of the body may be exposed to water as shown in Fig. 1. When the flow is three-dimensional this does not apply.

The anode degrades in the course of its use, and so it should be cleaned with a fine sand paper or rough cloth at times. When a cylindrical test

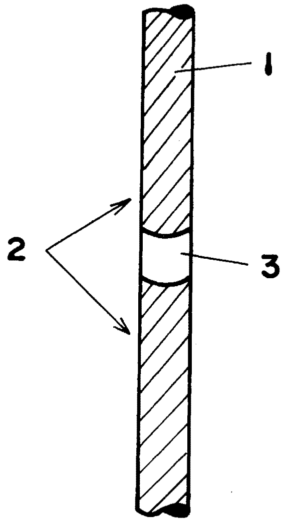

Fig. 1 Cylindrical anode. 1. Solder wire or metal cylinder, 2. spray coating for electric insulation, 3. cylinder portion coated with solder and exposed to water.

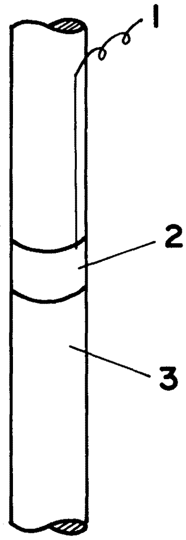

Fig. 2 Non-conducting test cylinder.
1. Cable for (+) terminal, 2. thin solder strip,
3. test cylinder.

body is made of non-conducting materials such as wood and resin, the test body cannot be used as an anode directly. In such a case a thin strip of solder may be made to round about the cylinder with adhesives as shown in Fig. 2. A thin strip of solder can be made by pressing a solder wire by using a roller machine.

6. Cathode and bubbles

A cathode is usually made of brass, but its material does not matter appreciably. The distance between the anode and the cathode should not be taken too long; in most cases it is within 1 m or so. When using a towing tank, the cathode may be moved with a carriage of test bodies (anodes), so that the distance between them remains always constant.

Very often, hydrogen bubbles are generated actively around a cathode and disturb an ambient still or flowing water considerably. When the conductivity of a working fluid is large, the voltage applied between the anode and the cathode should be kept as low as possible to suppress the bubble generation. A standard is d. c. 10 V and 10 mA for common tap water without additives, but the voltage should be determined also by taking accunt of flow speeds. At relatively high speeds above several centimeters per second, the quantity of generated smoke is likely to be insufficient for effective visualization of the flow. Some rising bubbles around the cathode are thus inevitable. The bubbles, however, can be confined so as to rise

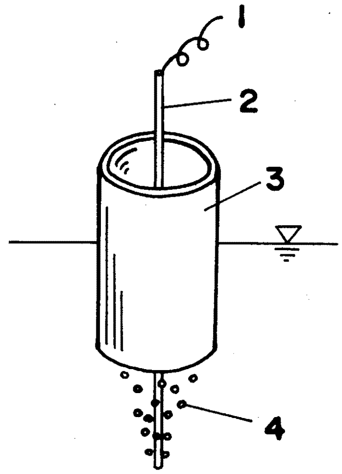

Fig. 3 Confinement of rising bubbles in a pipe.
1. Cable, 2. cathode, 3. pipe, 4. bubbles.

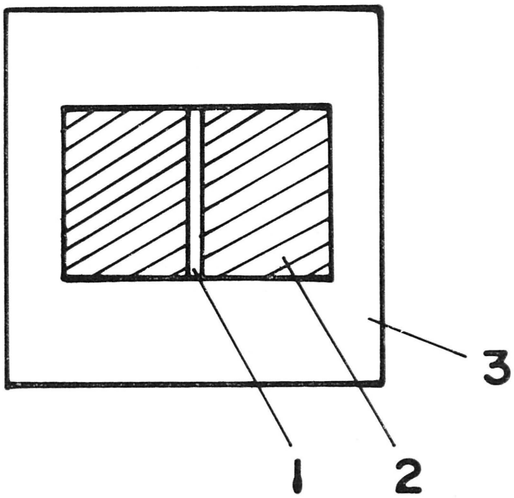

Fig. 4 Slit for illumination of a slice of water.
1. Slit (1-3 mm wide), 2. blinded plane,
3. slide mount.

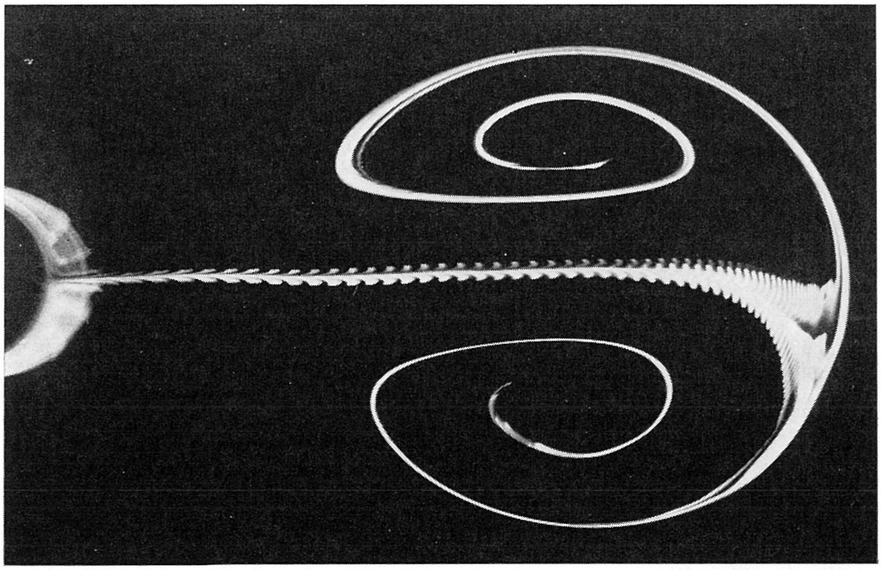

Fig. 5 Induced streaming around an oscillating cylinder. Cylinder diameter = 3.80 cm, oscillation frequency = 0.53 Hz, amplitude = 0.70 cm, time from start of cylinder oscillation = 4 min.

up through a half-submerged pipe, through which the cathode is immersed into the water from above as shown in Fig. 3. When the cathode is towed together with a test body, the wet depth of this pipe should be short enough; otherwise it may disturb the primary flow.

7. Illumination

The white smoke generated cannot be seen clearly unless proper illumination is made. As mentioned before, the smoke must be viewed against a sufficiently dark background. The easiest method of illumination is to use a slide projector of preferably 800 W or 1 kW; light is projected through a narrow slit cut in a 35 mm slide mount as shown in Fig. 4. The shape of the slit may be varied according to the types of flows to be observed. When a test body is towed by a carriage, the slide projector may also be made to move together with the body in order to illuminate it continuously during the observation.

An example of smoke pattern is presented in Fig. 5. This figure shows a two-dimensional streaming induced by a circular cylinder oscillating harmonically in the left and right direction in water at rest. A thin solder strip was fixed to the surface of this cylinder made of acrylic resin, and a horizontal slice of water was illuminated with a 1 kW slide projector.

8. Conclusion

Tap water added with a small quantity of salt if necessary and solder may be used most conveniently in employing the electrolytic precipitation method for visualizing slow water flows.

We are indebted to H. Amamoto and K. Ishi-i for their technical help. A grant from the Ministry of Education, Science and Culture is also gratefully acknowledged.

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(Received September 30, 1980)