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AN ELECTROLYTIC DETECTION METHOD FOR COLLISION OF A PARTICLE WITH WALL

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Introduction

A novel method for detecting collision between a particle suspended in a liquid and a solid surface is proposed. The contact of the tracer particle with the solid surface is detected electrochemically, and the method will be referred to as the electrolytic particle tracer method (EPTM). By this method the collision between a particle and a solid surface can be detected accurately as an electric signal. This paper describes the principle and constitution of EPTM, and shows an example of application to a fluidized-bed electrode.

1. Basic Principle

The principle behind the method is similar to that of controlled-potential electrolysis, in which a solute reactant is oxidized or reduced on a working electrode, its potential being held constant. In EPTM the solute reactant is replaced by a tracer particle of a base metal. The tracer particle and the detector electrode of the present method correspond to the reactant and the working electrode of controlled-potential electrolysis, respectively.

First, an anodic EPTM is described. Selecting materials of the tracer particle and the detector electrode is the key to the method. **Figure 1** shows two potential-current curves of metals I and II which are used as a tracer electrode and a detector electrode, respectively. When an anodic potential A is applied, metal I will be oxidized into an ionic form according to Eq. (1):

$$M \longrightarrow M^{+} + e \tag{1}$$

which provides an anodic current. On the other hand, metal II at the potential A will hardly be oxidized and little current will be produced. A detector electrode of metal II at the potential A and a freely moving tracer particle of metal I in an electrolyte solution is the basic constitution of the method. When the tracer particle is out of contact with the detector electrode, it has a rest potential C much less than B, which is the onset potential of anodic current of metal I against the surrounding electrolyte solution, and therefore little anodic current flows. However, when the tracer particle comes in contact with the detector electrode as shown in **Fig. 2**, the potential of the tracer particle of metal I will be A. Therefore, at the contact, the metal of tracer particle will be oxidized, providing a large anodic current.

The anodic current observed at the contact is either pulse-like or continuous depending on whether there is a momentary collision or elapsed contact. For a successful application of EPTM the following should be kept in mind:

(1) Generally speaking, copper, silver, gold and

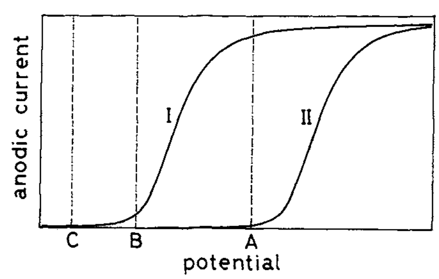

Fig. 1. Potential-current curves of metals.

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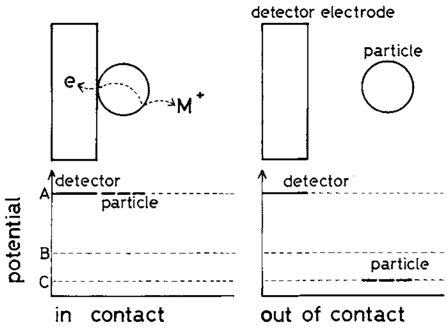

Fig. 2. Principle of particle contact detection.

platinum can be used for metal II, and aluminum and zinc for metal I, but the selection of their combination depends on the system to be tested. Sufficiently large difference in onset potential is necessary between the metals of the tracer particle and the detector electrode.

(2) For obtaining as large a current as possible the potential of the detector electrode should be controlled as highly positive as possible, e.g. potential A in Fig. 1, but it should be lower than the potential of self-oxidation.

(3) To decrease the electric resistance of the measurement system the electrolyte concentration should be higher so long as the effect of density and viscosity of the electrolyte solution on the measurement is negligibly small.

A cathodic EPTM is also available in a similar way by using a reducible material such as lead dioxide as a tracer particle.

2. Constitution of EPTM

The constitution of EPTM is shown in **Fig. 3**. A detector electrode is set at the place where the particle contact is examined. A tracer particle of base metal is put into an electrolyte solution. The density and size of the particle can be easily controlled by chemical and/or electrochemical plating of a suitable inert particle. **Figure 4** shows a typical configuration of such a tracer particle. A counter electrode, a reference electrode and a salt bridge are installed carefully so as not to disturb the flow field. The surface area of the counter electrode is much larger than that of the tracer particle. The salt bridge connected with the reference electrode is placed as near the detector electrode as possible to control the potential accurately. An electrolyte solution contains only supporting electrolyte which does not dissolve the metals of the tracer particle or the detector electrode.

3. An Application Example

EPTM is successfully applied to detecting the collision between a particle in a fluidized bed electrode and a feeder electrode. Some measurements of potential difference between fluidized particles and a feeder electrode have been reported by using a small electrode probe.[1] But the methods reported so far provide no precise information about the contact between the fluidized particles and the feeder electrode.

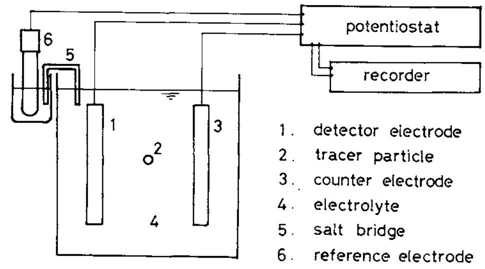

Fig. 3. Constitution of EPFM.

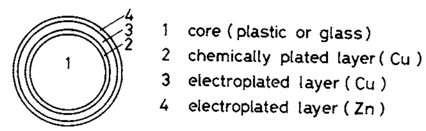

Fig. 4. Example of tracer particle configuration.

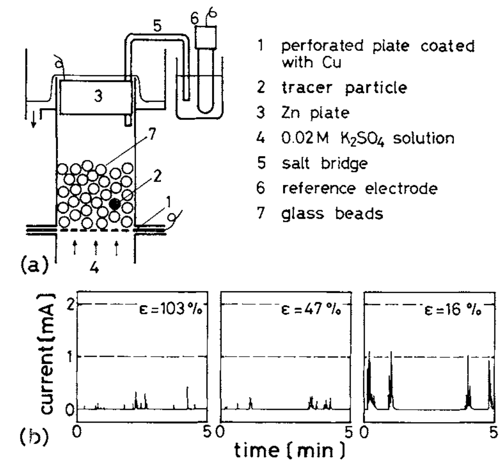

Fig. 5. Application of EPTM to fluidized-bed electrode (a) experimental setup (b) example of recorded current (ε: bed expansion).

Figure 5(a) shows a schematic diagram of the measurement system. The fluidized-bed electrode consists of an acrylic column of 5.15 cm in diameter, a perforated-plate distributor plated with copper, glass beads and a tracer particle. The tracer particle is glass bead electroplated with zinc after being plated chemically with copper. The copper-coated perforated plate serves as a detector electrode. The detector electrode potential is set at zero voltage against a silver-sliver chloride electrode. A counter electrode and a salt bridge are placed at the top of the column as shown in Fig. 5(a). Figure 5(b) shows some examples of the recorded signal of particle contact with the perforated plate. The contact is clearly detected and the signal change with liquid flow rate is discerned distinctly. The recorded information can be analyzed quantitatively. The results of precise analysis will be reported elsewhere.

EPTM can be applied to an analysis of the collision frequency of fluid element with a solid surface of equipment if the properties of the tracer particle are properly controlled. This method was used to obtain the collision frequency of a fluid element with the bottom of a mixing vessel.[2)]

EPTM is applicable to many studies related to the collision or contact of solid particles, drops or bubbles in a liquid with a solid surface of equipment.

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