METHOD AND DEVICE FOR TESTING SEPARATORS BY MEASURING LOCAL TRANSVERSE ELECTRICAL RESISTANCE

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Introduction

The usual procedure for characterizing battery separators is to cut several test samples from the finished material. As a result, only a small portion of the separator is actually examined. Thus, the determined separator characteristics (such as separate resistance in a pre-selected electrolyte) are, in effect, integrated values because the area of sample evaluated is typically only about 10 - 15 cm^2.

The principle of the separator evaluation technique proposed here is as follows. The separation material is passed through an electrolyte bath between electrical resistance measuring transducers. Each transducer continuously measures the transverse electrical resistance of the separator only within a small area accessible to the transducer (about 20 mm^2). The resistance is determined by the current passing through the separator within this area.

The set of transducers installed in the bath transverse to the moving sheet of separator material examines the whole surface of the material. If the production process ensures good uniformity in the physicochemical properties of the separator material over the whole surface, the transducer outputs will clearly be close to one another. A non-uniform separator will cause significant deviations from the average value at various sections of the material. In this case, the sections having lower or higher resistance compared with the average value should be regarded as flawed. The low-resistance sections usually display either inferior mechanical properties or excessively large pores. Sections with local high resistance are usually caused by increased compaction or inferior wettability of the separator material. Thus, in effect, the device monitors the quality of the material production process itself because significant fluctuations in electrical resistance of various sections of the material are due to processing faults.

The siting of faulty sections presents no difficulties because the device registers which transducer has detected a significant deviation from a preselected level. If necessary, the device can transmit the signal that identifies the faulty section to the appropriate system.

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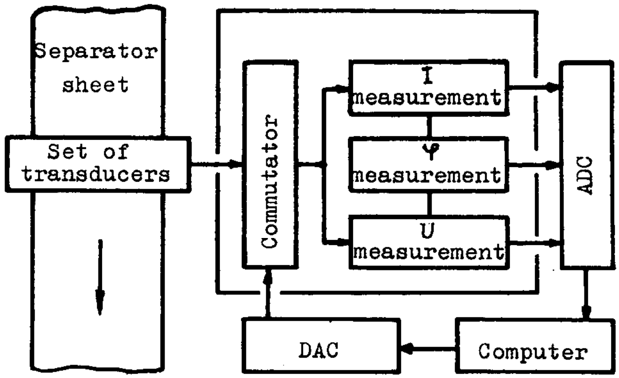

Fig. 1. Schematic of a device for measuring separator resistance.

The proposed device (Fig. 1) includes the following components.

(i) A set of transducers is located in the electrolyte bath. The assembly consists of a group of electrode cells through which the separator sheet passes. Each cell is an electrode system engaged in continuous measurement of transverse electrical resistance of a small section of the separator. The size of the section is dependent on the design parameters of the cell and is determined from the required differentiation degree of the separator. For practical purposes, the required size of the section is 10 - 50 mm^2. The material is passed through the set of transducers and the electrode cells scan the entire surface of the separator.

(ii) A measuring unit (local transverse electrical resistance conversion unit) is responsible for the consecutive connection of the electrode cells, through a commutator, to the measuring system. The unit determines the voltage of the cell (in the voltage measurement channel) and the current passing through the cell (in the current measurement channel). Since each cell is supplied with alternating current and the resistance of the cell is of a pronounced capacitance nature, the measuring unit has a channel for the determination of the phase shift between the current and the voltage.

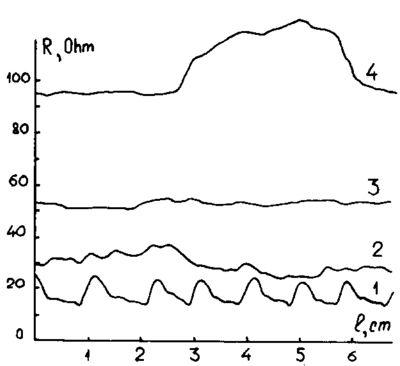

Fig. 2. Plots of resistance data.

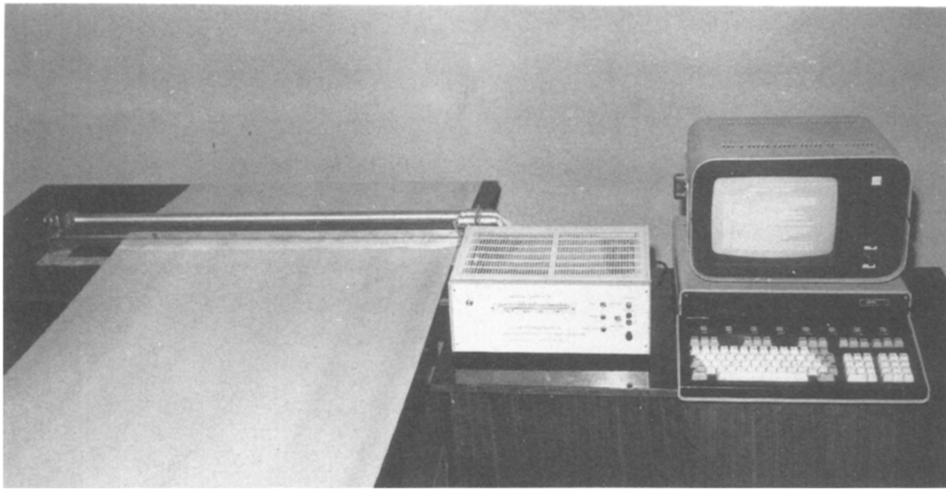

Fig. 3. Device for measuring separator resistance.

(iii) An analog–digital converter converts the output signals of the measuring unit into digital code for computer loading.

(iv) A computer controls the operation of a commutator via the digital–analog converter. In addition, the computer handles the signals coming from the measuring unit and transfers the output of the received information to some peripherals in a form requested by the operator. If the electrical resistance of the separator goes beyond the pre-selected range, the computer generates control signals for appropriate devices.

The operation of the unit is illustrated in Fig. 2. The plots reflect fluctuations in the electrical resistance of the separator in a 1% NaCl solution. Each curve has been obtained during continuous operation of only one transducer; this is achieved by blocking the commutator. Curves 2 - 4 refer to separator movement along the separator stiffening ribs and curve 1 to the movement transverse to the ribs. The data show a clear difference in the electrical resistance of separators. Curve 4 features a flaw manifested by increased electrical resistance of the separator. The size of the flaw is about 1 cm^2. Visual examination of the section failed to distinguish it from nearby sections.

A general view of the system (without the electrolyte bath for immersion of the set of transducers) is shown in Fig. 3.

The specifications of the system are as follows:

(i) accuracy of electrical resistance measurement: 5%;

(ii) range of absolute values of resistance measurements: 10 - 10 000 Ω;

(iii) area of local section being monitored: 25 mm^2; the area is dependent on the design dimensions of the transducer and can be changed;

(iv) rate of transducer interrogation: 10 - 100 Hz; the rate is determined by technical requirements and the speed of separation-material movement relative to the set of transducers.