

EFFECTIVE CLEANING OF WINDOWS IN FIELD TURBIDIMETERS

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Abstract: The main problem in operation of industrial turbidimeters is a buildup of parasitic deposits on transparent windows of light sources and photodetectors. The analysis of possible designs of sensors-cleaning devices for field turbidimeters is developed. The classification and several versions of practical constructions are offered.

Keywords: turbidimeter, cleaning system, optical sensors.

1. INTRODUCTION

The main problem limiting efficiency of field optical devices, such as turbidimeters, is parasitical deposits on sensors. The character of these deposits can be different: gas bubbles, salt growth, sticky dispersed phase pickup etc. Therefore, the special actions for deposits influence neutralization must be used.

The most typical solutions are concerned with direct influencing factor eliminating. There are two ways: *periodical cleaning of windows* and *contactless structure of devices*.

If contactless structure is not possible, different methods of cleaning are applied: hydraulic, chemical, thermal, ultrasonic and mechanical. A lot of optical nephelometers structures with mechanical wipers which clean the optical transducers' glasses [1, 2] are known. This method is usually applied for reducing hard deposits of insoluble salt. However, due to the frequent using, the resources of brushes, packing glands and other rubbing parts decrease.

This problem can be solved with a help of ultrasound. Ultrasonic vibrations of windows and neighboring parts of case are able to reduce formation and growth of hard deposits significantly [3].

Described means of cleaning are ineffective if there is a sticky dispersed phase in liquid. As sticky parts of organic compounds have a good adhesion with glass it is difficult to eliminate them just with mechanical methods.

The most universal and effective ways of cleaning windows of photometric devices from deposits are chemical methods with application of various reagents: acidiferous solutions, surface-active substances, organic solvents. The purpose of influence by a reagent on deposits is modification of their chemical composition or structure.

The modification may consist of one of the following:

- complete deposit dissolution;
- fission of complex organic compounds into simple easy-flowing substances;
- influence on the deposit structure for reducing its

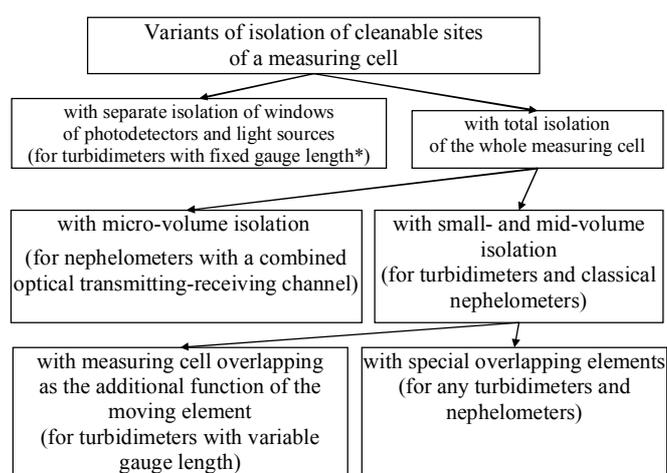
adhesive properties;

- transformation of soft and sticky particles into hard phase which may be removed after mechanical action.

In known field photometric devices in which the chemical method of windows cleaning is used, the process of cleaning, as a rule, is reduced to a simple continuous circulation of a liquid reagent through the measuring cell. This procedure is carried out manually during routine maintenance. Such a way of consumption of a reagent is very expensive. Therefore it is very useful for the period of routine maintenance to create the closed loop with the compressor, the photometer device and the device of reagent feeding. In this case the reagent consumption sharply decreases, but time, labour, power and material costs of such a way of cleaning remain still high.

The obvious effective solution is isolation of the measuring cell for the period of cleaning procedure and the dosed injection of a reagent into this temporarily isolated compartment with small volume. Moreover, for intensification of process of chemical cleaning, mechanical influence on deposits is also required. However, nowadays there are no serial field photometric devices with such a system of automatic cleaning.

After the analysis of possible variants of isolation of cleared sites inside the measuring cells of turbidimeters the following classification was proposed (Fig. 1).



* - gauge length – distance between windows of light source and photodetector in turbidimeters [4]

Fig. 1. Classification of possible variants of isolation of cleanable sites of a measuring cell

2. PROPOSED VARIANTS OF DESIGN

2.1. Separate isolation of photodetector and light source windows

The example of separate isolation of photodetector and light source windows is shown in Fig.2. This method of isolation is more applicable for turbidimeters with fixed gauge length, i.e. for such a case when light source and photodetector are quite far from each other. In that case, the isolation of the whole measuring cell would lead to significant expenses of a reagent and long cycle of cleaning.

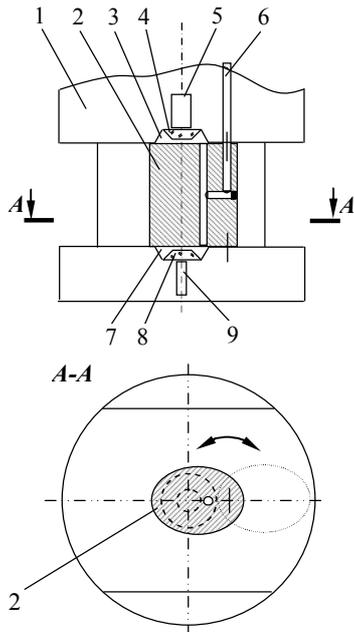


Fig.2. The design of turbidimeter with separate isolation of photodetector and light source windows

The design, schematically shown in Fig.2, includes cylindrical case 1, in which a through rectangular window with the moving overlapping element 2 are located. This element is able to make the limited rotary movements around its vertical rotation axis. At the necessary moment it performs its motion and occupies one of two possible positions.

The butt surfaces of element 2 isolate micro-volumes 3 and 7 near transparent windows 4 and 8 of detector 5 and light source 9 respectively. The feeding of reagent to micro-volumes 3 and 7 is provided through channel 6. The clearance between windows 4, 8 and respective butt surfaces of element 2 must be small – about 0,5..1 mm. It is important, that the overlap of chambers 3 and 7 must be not completely hermetic, else feeding of liquid reagent through channel 6 under pressure would be impossible.

The advantage of this solution is effectiveness of windows cleaning because of minimum volume of isolated chambers. The disadvantage is a relatively sophisticated design.

2.2. Total isolation of the measuring cell

Total isolation of the whole measuring cell may be realized in different ways in accordance with functions and design parameters of the turbidimeter.

2.2.1. Micro-volume isolation

The easiest case (in point of isolated volume minimization) is that when the photodetector and the light source have the common optical channel and only one small common window is in contact with liquid medium. Such a design may be realized in so-called back scattering nephelometers which have fiber optic dual branch light guides for arrangement of separated light signal transmission and receiving through the common window (Fig.3).

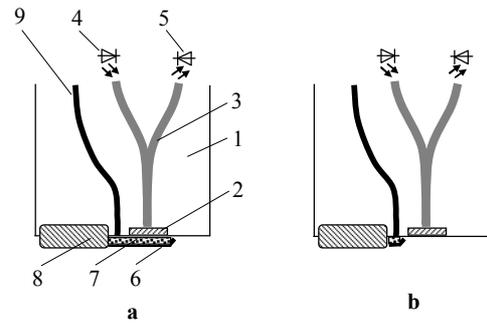


Fig. 3. Cleaning device for the turbidimeter with the common window for transmitting and receiving:
a – cleaning element is in extended position;
b - cleaning element is retracted

In this example the enumerated positions mean the following: 1 – turbidimeter case; 2 – transparent window; 3 – fiber optic dual branch light guide; 4 – light source; 5 – photodetector; 6 – overlapping element hard cover; 7 – overlapping element cleaning sponge; 8 – controllable drive of the overlapping element; 9 - chemical reagent feeding channel.

At a certain time, when it is necessary to clean window 2, the overlapping element cover 6 with sponge 7 moves forward and isolates window 2 from the liquid medium. Then a small quantity of a liquid reagent comes under pressure through channel 9 into sponge 7 and drenches it. This reagent covers the window surface. After a short delay overlapping element cover 6 moves back by means of drive 8. Sponge 7 operates as a cleaning brush. A few such reciprocating motions must be done.

In such a construction very small volume near the window surface is isolated during the cleaning process. Due to the micro-volume isolation it is possible to use expensive and effective reagents. Another advantage is relatively short duration of cleaning. The obvious shortcoming of this design is the limited resource of sponge 7.

2.2.2. Measuring cell overlapping as the additional function of the moving element

For devices, in which a detector and a light source are significantly far from each other and separate isolation is not possible, it is reasonable to apply other solutions.

For turbidimeters with variable gauge length it is possible to apply the effective solution, minimizing isolated volume, based on using movements of basic turbidimeter elements. This solution is schematically shown in Fig.4.

The turbidimeter includes stationary part 1 and moving

part 2 (cylindrical form both). Due to the forward-rearward movements of part 2 the measuring base changes. Photodetector 3 is inside the stationary part, and light source 4 is inside the moving part. They are protected by the corresponding windows 5 and 6.

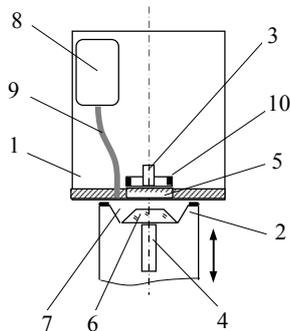


Fig.4. Minimization of isolated volume in the turbidimeter with variable gauge length

In case of a need for cleaning moving part 2 closely approaches stationary part 1, forming the narrow isolated clearance 7 between windows. It is possible because of window 6 is slightly sunk (0.5..1 mm) relative to end surface of moving part 2. After clearance 7 becomes isolated, reagent portion from special reservoir 8 is injected through channel 9 under pressure. After that, ultrasonic vibrator 10, realized in the form of piezoelectric ring which embraces photodetector 3 and hard connected with window 5, comes into action for a certain period of time. Combined action of chemical reagent and ultrasonic sound destroys the deposits on windows, whereupon moving part 2 moves aside, and residuum of the reaction is washed away by stream.

The advantage of this solution is small isolated volume and, reagent saving.

2.2.3. Isolation with special overlapping elements

For cases when minimization of gauge length is impossible and it is difficult to minimize the volume of the measuring cell, the special design was proposed (Fig.5).

The measuring cell in such a construction is formed by the through rectangular aperture in the cylindrical case. Inside this aperture the photodetector and the light source are located oppositely on the axis of the case. When the aperture is open the liquid can flow through it.

Overlapping of the flow-type measuring cell is realized by means of the rotatable double gate which closes the measuring cell on either side at a certain time, when implementation of cleaning process goes on. The double gate unit is forced on the driving shaft located on the bottom of the turbidimeter case. Rotation of the shaft may be executed by a drive of electrical, pneumatic or hydraulic type. Placement of other parts (ultrasonic vibrator, reagent feeding channel, reagent-supply reservoir) is the same one that shown in Fig.4.

The volume of the measuring chamber formed in such a way is fixed and may have typical values 30..100 ml. It requires the corresponding volume of the reagent-supply reservoir.

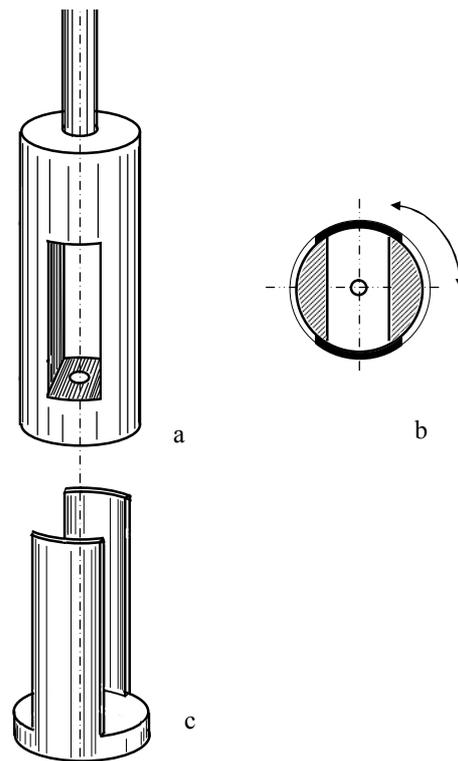


Fig. 5. Overlapping of the flow-type measuring cell by means of the rotatable double gate:
a – turbidimeter case; b – rotatable double gate (shown separately);
c – turbidimeter case cross-section

3. CONCLUSIONS

1. The possible options for design of automatic machines for cleaning windows of field turbidimeters have been analyzed.

2. The classification of automatic window-cleaning devices is proposed, based on temporarily isolation of measuring cell from liquid.

3. Several versions of automatic window-cleaning systems are proposed.

4. For reducing time, labor expenditures and material costs it is reasonable to isolate measuring cell during the cleaning procedure.

4. REFERENCES

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