1776 – 2026

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Patent

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1776-2026

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If this application was filed prior to June 8, 1995, the term of this patent begins on the date on which this patent issues and ends on the later of seventeen years from the date of the grant of this patent or the twenty-year term set forth above for patents resulting from applications filed on or after June 8, 1995, subject to the payment of maintenance fees as provided by 35 U.S.C. 41(b) and any extension as provided by 35 U.S.C. 156 or any disclaimer under 35 U.S.C. 253.

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Fan et al.

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(45) **Date of Patent: Jul. 14, 2026**

(54) **METHOD OF UTILIZING OPTICAL PATH DIFFERENCE IN TWO-PHASE FLOW FOR ANALYTICAL CALCULATION OF PARTICLE SIZE GRADATION AND SOLID CONTENT**

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CPC . ***G01N 15/0211*** (2013.01); *G01N 2015/0053* (2013.01)

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CPC G01N 15/0211; G01N 2015/0053; G01N 15/0205; G01N 15/06; G01N 21/49; G01N 15/075; Y02A 90/10
See application file for complete search history.

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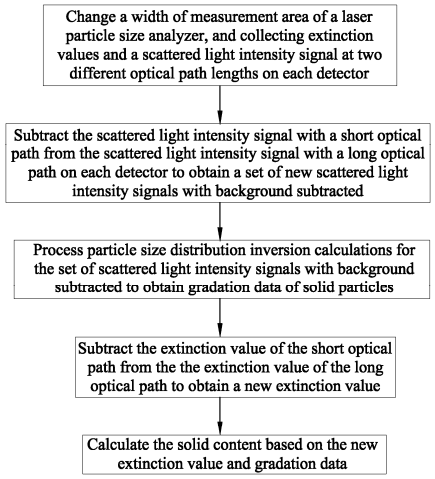
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(57) **ABSTRACT**

A method utilizing optical path difference in two-phase flow for analytical calculation of particle size gradation and solid content comprises: changing a width of measurement area of a laser particle size analyzer, and collecting extinction values at two different optical path lengths and a scattered light intensity signal on each detector during monitoring; utilizing the scattered light intensity signal with a long optical path to subtract the scattered light intensity signal with a short optical path on each detector to obtain a set of new scattered light intensity signals with background subtracted; processing particle size distribution inversion calculations for the set of scattered light intensity signals with background subtracted to obtain gradation data of solid particles; processing subtraction of the logarithm of the extinction value of the short optical path from the logarithm of the extinction value of the long optical path to obtain new extinction value; calculating the solid content based on the new extinction value related data and the gradation data obtained. Neither the measured scattered light intensity signal of particle gradation nor the extinction value signal of measured solid content is affected by window lens contamination. A pure scattered light intensity signal can be obtained without measuring the background signal in the pure medium state. The long-term real-time underwater or atmospheric monitoring is realized.

9 Claims, 2 Drawing Sheets



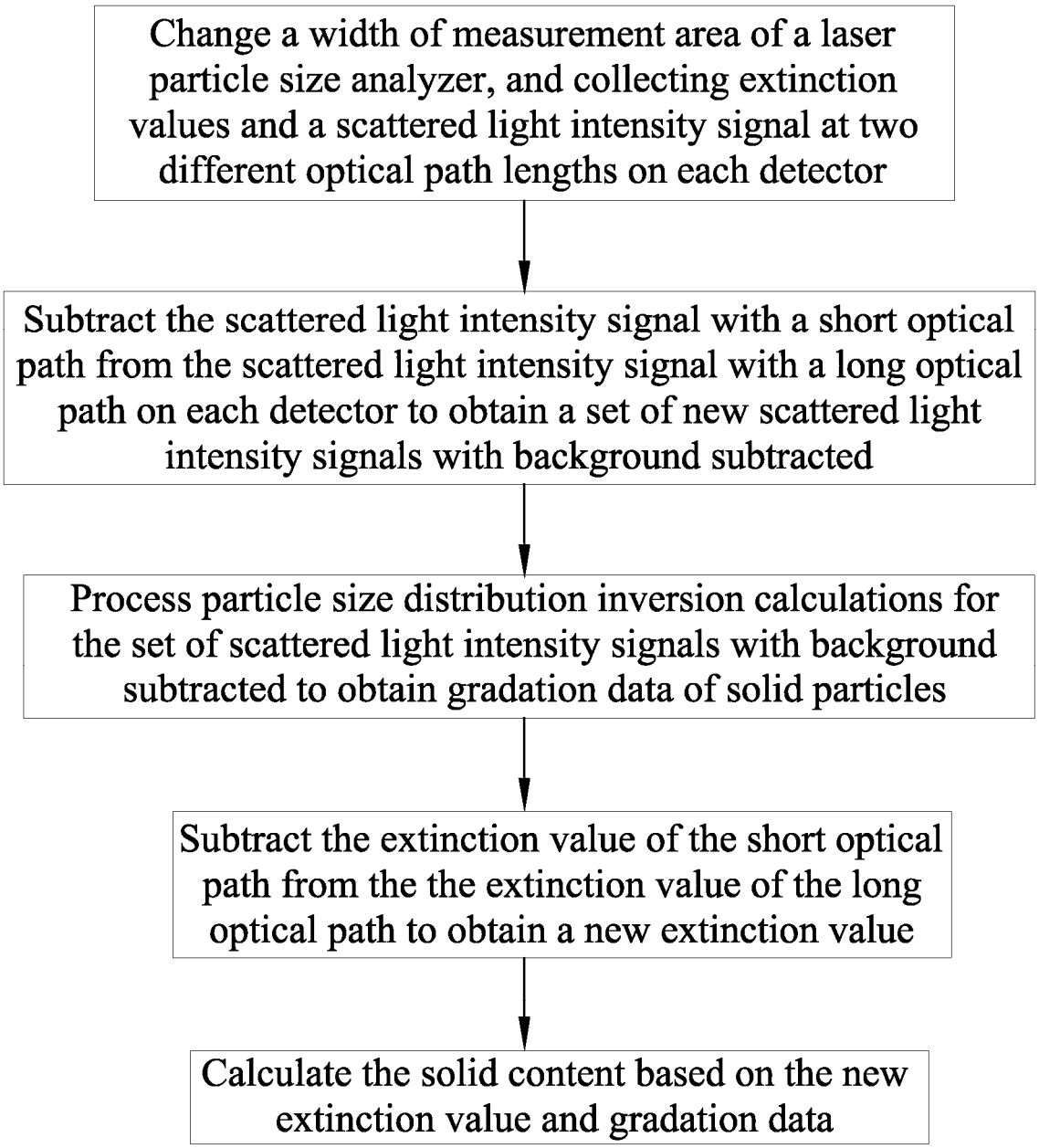

Change a width of measurement area of a laser particle size analyzer, and collecting extinction values and a scattered light intensity signal at two different optical path lengths on each detector
Subtract the scattered light intensity signal with a short optical path from the scattered light intensity signal with a long optical path on each detector to obtain a set of new scattered light intensity signals with background subtracted
Process particle size distribution inversion calculations for the set of scattered light intensity signals with background subtracted to obtain gradation data of solid particles
Subtract the extinction value of the short optical path from the the extinction value of the long optical path to obtain a new extinction value
Calculate the solid content based on the new extinction value and gradation data

FIG.1

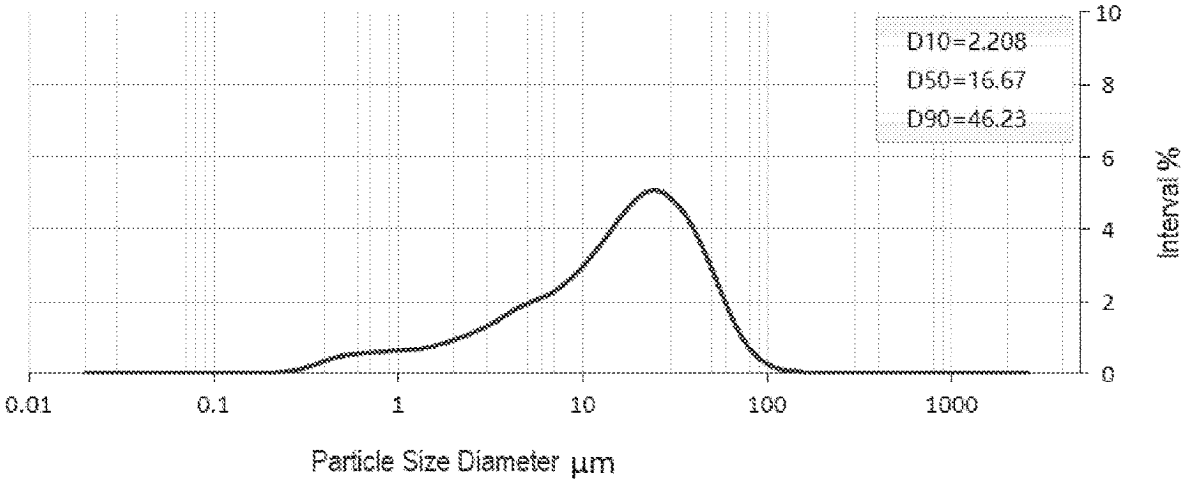

D10=2.208
D50=16.67
D90=46.23
10
8
6
4
2
0
Interval %
0.01
0.1
1
10
100
1000
Particle Size Diameter µm

FIG. 2

METHOD OF UTILIZING OPTICAL PATH DIFFERENCE IN TWO-PHASE FLOW FOR ANALYTICAL CALCULATION OF PARTICLE SIZE GRADATION AND SOLID CONTENT

FIELD OF INVENTION

The present invention relates to the field of underwater sand content and particle size grading monitoring, and is related to a method of utilizing optical path difference in two-phase flow for analytical calculation of particle size gradation and solid content.

DESCRIPTION OF RELATED ARTS

In hydrological monitoring work, the particle gradation and sand content analysis of sediment in rivers, oceans, and ports is an important task, which is of great significance for preventing soil erosion, sand discharge and siltation prevention in dam maintenance, and river and waterway regulation and dredging.

Sediment in rivers belongs to two-phase flow of liquid-solid. From the measurement process and application, there are two aspects in the current underwater online laser particle size analyzer, the sand content and particle size gradation monitoring instrument where there are drawbacks that affect the actual application effect. First, because river water is not a pure medium environment, the background signal of the instrument cannot be measured in real time but a fixed background signal is used as a penalty, which will have a certain impact on collecting the actual scattering signal of sediment. Second, contamination will occur if the test window lens is immersed in water for a long time, and there will be certain errors in the measured extinction value and scattering signal, which will affect the accuracy of the calculation results of particle size gradation and solid content.

Particulate matter in the air also belongs to two-phase flow of gas-solid, and its quality monitoring also has the same drawbacks as two-phase flow of liquid-solid monitoring. Therefore, there is an urgent need for a method with higher accuracy and more convenient to use to improve the monitoring accuracy of particle size gradation and solid content in two-phase flow.

SUMMARY OF THE PRESENT INVENTION

An object of the present invention is to provide a method utilizing optical path difference in two-phase flow for analytical calculation of particle size gradation and solid content to solve the problem of errors in the calculation of particle size gradation and solid content caused by the use of fixed background signals and contamination of the test window lens (of the laser particle size analyzer).

According to the present invention, a method utilizing optical path difference in two-phase flow for analytical calculation of particle size gradation and solid content comprises the following steps:

Step 1: Changing a width of measurement area of a laser particle size analyzer, and collecting extinction values at two different optical path lengths and a scattered light intensity signal on each detector during monitoring;

Step 2: the scattered light intensity signal with a short optical path is subtracted from the scattered light intensity signal with a long optical path on each detector to obtain a set of new scattered light intensity signals with background subtracted;

Step 3: processing particle size distribution inversion calculations for the set of scattered light intensity signals with background subtracted to obtain gradation data of solid particles;

Step 4: Processing subtraction of the logarithm of the extinction value of the short optical path from the logarithm of the extinction value of the long optical path to obtain new extinction value related data;

Step 5: Processing calculation of the solid content based on the new extinction value related data and the gradation data obtained from the above steps.

According to the method utilizing optical path difference in two-phase flow for analytical calculation of particle size gradation and solid content of the present invention, in step 2, the new scattered light intensity signals on the detector is calculated by the followings:

$$S = A_1 - A_2 = (S_1 + B) - (S_2 + B) = S_1 - S_2$$

wherein A_1 refers to a scattered light intensity signal with long optical path and background on the detector, A_2 refers to a scattered light intensity signal with short optical path and background on the detector, B refers to the background signal, S_1 refers to a scattered light intensity signal with long optical path after the background is subtracted, S_2 refers to a scattered light intensity signal with short optical path after the background is subtracted, S refers to a scattered light intensity signal difference for scattered light intensity signal with different optical paths, that is, the new scattered light intensity signal; the new scattered light intensity signal on each detector constitutes a new set of scattered light intensity signals.

According to the method utilizing optical path difference in two-phase flow for analytical calculation of particle size gradation and solid content of the present invention, in step 4, the specific calculation of the new extinction value is:

$$\ln\left(\frac{I_1}{I_0}\right) = -\frac{3C_v L_1 K_{ext}}{2D}$$

$$\ln\left(\frac{I_2}{I_0}\right) = -\frac{3C_v L_2 K_{ext}}{2D}$$

$$\ln\left(\frac{I_1}{I_0}\right) - \ln\left(\frac{I_2}{I_0}\right) = -\frac{3C_v L_1 K_{ext}}{2D} + \frac{3C_v L_2 K_{ext}}{2D} = -\frac{3C_v K_{ext}}{2D}(L_1 - L_2)$$

Wherein I_1 refers to transmitted signal for long optical path, I_2 refers to transmitted signal for short optical path, I_0 refers to the initial light intensity signal, D refers to the surface area mean diameter of the solid particles calculated by the scattered light intensity inversion in step 3, and Kext refers to the extinction coefficient, L_1 refers to a length of the long optical path, L_2 refers to a length of the short optical path, Cv refers to a volume concentration of solid particles.

According to the method utilizing optical path difference in two-phase flow for analytical calculation of particle size gradation and solid content of the present invention, in step 5, the solid content H is calculated according to the following formula:

$$H = C_v \times \rho = -\frac{\left[\ln\left(\frac{I_1}{I_0}\right) - \ln\left(\frac{I_2}{I_0}\right)\right]2D}{3K_{ext}(L_1 - L_2)} \times \rho$$

Wherein ρ refers to a density of solid particle.

The method utilizing optical path difference in two-phase flow for analytical calculation of particle size gradation and solid content at least has the following advantageous effect:

The scattered signals with long optical path and short optical path are both scattered signals with background. When they are compared, it is equivalent to subtracting the background from the two scattered signals with background. The remaining signal is the difference in intensity of the scattered signal, which is also the scattered signal of the group of particles in the two-phase flow system and completely contains the particle size distribution information. If the window lens (of the laser particle size analyzer) is contaminated, then the scattered signal generated by the contaminant is in the background and can be completely subtracted. The resulting scattered signal is the true scattered signal of the sediment in the two-phase flow. The extinction value is also measured by subtracting the extinction value under the short optical path from the extinction value under the long optical path. In this way, due to the contamination of the window lens (of the laser particle size analyzer), the part of the extinction value that is not caused by sediment particles will be subtracted, and the extinction value will not be affected by the contamination of window lenses.

The present invention is not affected by window lens contamination (of the laser particle size analyzer), whether it is the measured the scattered light intensity signal of particle gradation or the extinction value signal of measured solid content, and can obtain simple and pure scattered light intensity signal without the step of measuring the background signal in pure medium, thereby realizing a long-term operation of underwater or atmospheric online monitoring (through the laser particle size analyzer).

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a flowchart of method utilizing optical path difference in two-phase flow for analytical calculation of particle size gradation and solid content according to the present invention.

FIG. **2** is a particle size distribution diagram obtained based on Mie scattering theory.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **1**, a method utilizing optical path difference in two-phase flow for analytical calculation of particle size gradation and solid content according to the present invention comprises the following steps:

Step 1: The width of measurement area of a laser particle size analyzer is changed. During monitoring, the extinction values at two different optical path lengths and a scattered light intensity signal on each detector are collected.

According to this embodiment, as shown in Table 1, the collected scattered light intensity distributions at two different optical path lengths are as follows

Length of Measurement Area: 2 mm Optical Path Measured Extinction Value $\ln(I_2/I0) = -0.0943$ The Scattered Light Intensity of each Detector is as follows:	Length of Measurement Area: 3 mm Optical Path Measured Extinction Value $\ln(I_1/I0) = -0.287$ The Scattered Light Intensity of each Detector is as follows:	Difference Calculation Extinction Value Difference=– Difference between the Scattered Signals of each Detector is as
5167.23	3588.963	−1578.267
3956.379	3260.721	−695.658
1534.273	1364.772	−169.501
1001.801	909.718	−92.083
548.776	513.048	−35.728
490.915	450.363	−40.552
354.166	331.968	−22.198
333.446	309.917	−23.529
280.98	266.197	−14.783
270.817	257.28	−13.537
241.91	235.644	−6.266
248.5	245.216	−3.284
237.408	240.078	2.67
260.722	268.173	7.451
259.116	274.643	15.527
272.375	295.618	23.243
292.769	325.546	32.777
328.452	373.51	45.058
383.206	443.302	60.096
427.557	505.911	78.354
523.84	628.434	104.594
601.167	730.885	129.718
689.158	848.572	159.414
802.222	999.399	197.177
944.272	1186.075	241.803
1097.906	1391.366	293.46
1296.674	1645.303	348.629
1514.234	1932.2	417.966
1762.493	2267.687	505.194
2043.676	2647.561	603.885
2359.548	3069.963	710.415
2654.656	3463.351	808.695
2941.415	3851.256	909.841
3631.194	4604.883	973.689
3483.78	4572.389	1088.609
3896.296	5083.865	1187.569
4161.654	5492.191	1330.537
4535.62	5984.344	1448.724
4965.422	6563.453	1598.031
5308.882	7008.687	1699.805
5715.995	7537.142	1821.147
6192.446	8062.983	1870.537
6415.429	8468.343	2052.914
6758.973	8871.968	2112.995
7041.008	9275.152	2234.144
7321.049	9634.642	2313.593
7599.674	10002.993	2403.319
7853.106	10327.616	2474.51
8054.424	10594.912	2540.488
8361.472	11011.056	2649.584
8699.398	11440.092	2740.694
9034.359	11891.172	2856.813
9366.257	12313.862	2947.605
9786.41	12867.667	3081.257
10131.857	13363.827	3231.97
10481.914	13843.943	3362.029
10888.937	14362.57	3473.633
11217.049	14871.9	3654.851
11489.425	15283.211	3793.786
11750.904	15701.206	3950.302
12036.368	16150.397	4114.029
12305.886	16663.214	4357.328
12468.702	16999.625	4530.923
12724.211	17504.46	4780.249
12783.646	17725.052	4941.406
12938.338	18047.344	5109.006
13229.308	18599.631	5370.323
13396.673	18970.73	5574.057
13583.191	19354.514	5771.323
13830.258	19772.346	5942.088
14019.414	20226.03	6206.616

-continued

Length of Measurement Area: 2 mm Optical Path Measured Extinction Value ln(I_2/I0) = −0.0943 The Scattered Light Intensity of each Detector is as follows:	Length of Measurement Area: 3 mm Optical Path Measured Extinction Value ln(I_1/I0) = −0.287 The Scattered Light Intensity of each Detector is as follows:	Difference Calculation Extinction Value Difference=− Difference between the Scattered Signals of each Detector is as
14237.112	20583.46	6346.348
12258.941	17791.09	5532.149
11868.634	17245.083	5376.449
11496.996	16693.347	5196.351
10812.336	15682.237	4869.901
10083.973	14549.012	4465.039
9318.834	13421.222	4102.388
8500.133	12219.003	3718.87
7884.584	11274.975	3390.391
7032.316	10043.987	3011.671
6343.078	9034.326	2691.248
5460.253	7724.258	2264.005
4737.527	6678.556	1941.029
4119.438	5824.263	1704.825
3747.709	5303.985	1556.276
2893.277	3339.839	446.562
1503.234	1983.828	480.594
1137.452	1524.015	386.563
816.863	1115.841	298.978
534.471	737.838	203.367
283.284	385.478	102.194

Step 2: On each detector (of the laser particle size analyzer), subtracts the scattered light intensity signal with a short optical path from the scattered light intensity signals with a long optical path to obtain a set of new scattered light intensity signals with background being subtracted.

In specific implementation, the calculation process of the new scattered light intensity signal in step 2 is as follows:

$$S = A_1 - A_2 = (S_1 + B) - (S_2 + B) = S_1 - S_2$$

wherein A_1 refers to a scattered light intensity signal with long optical path and background, A_2 refers to a scattered light intensity signal with short optical path and background, B refers to the background signal, S_1 refers to a scattered light intensity signal with long optical path after the background is subtracted, S_2 refers to a scattered light intensity signal with short optical path after the background is subtracted, S refers to a scattered light intensity signal difference for scattered light intensity signals with different optical paths, that is, the new scattered light intensity signal.

Step 3: For the new set of scattered light intensity signals, process particle size distribution inversion calculation to obtain gradation data of solid particles.

In specific implementation, through the new set of scattered light intensity signals, the particle size distribution is obtained according to Mie scattering theory, which is shown in FIG. **2** of the drawings. The typical characteristic values are calculated, which includes grading data such as volume mean diameter, surface area mean diameter, length mean diameter, number mean diameter, peak particle size diameter, specific surface area, span, and etc. The details are shown in Table 2 as follows:

-continued

D00	0.205 μm	volume mean diameter D[4,3]	21.15 μm
D10	2.208 μm	surface area mean diameter D[3,2]	5.013 μm
D16	3.817 μm	length mean diameter D[2,1]	0.936 μm
D25	6.599 μm	number mean diameter D[1,0]	0.500 μm
D50	16.67 μm	peak particle size diameter	24.39 μm
D75	30.37 μm	specific surface area	443.2 m^2/kg
D84	38.37 μm	Span	2.640
D90	46.23 μm		
D100	151.1 μm		

Step 4: Process subtraction of the logarithm of the extinction value of the short optical path from the logarithm of the extinction value of the long optical path to obtain new extinction value. In particular, the calculation of the new extinction value is as follows:

$$\ln\left(\frac{I_1}{I_0}\right) = -\frac{3C_v L_1 K_{ext}}{2D}$$

$$\ln\left(\frac{I_2}{I_0}\right) = -\frac{3C_v L_2 K_{ext}}{2D}$$

$$\ln\left(\frac{I_1}{I_0}\right) - \ln\left(\frac{I_2}{I_0}\right) = -\frac{3C_v L_1 K_{ext}}{2D} + \frac{3C_v L_2 K_{ext}}{2D} = -\frac{3C_v K_{ext}}{2D}(L_1 - L_2)$$

Wherein I_1 refers to transmitted signal for long optical path, I_2 refers to transmitted signal for short optical path, I_0 refers to the initial light intensity signal, D refers to the surface area mean diameter of the solid particles calculated by the scattered light intensity inversion in step 3, and Kext refers to the extinction coefficient, L_1 refers to a length of the long optical path, L_2 refers to a length of the short optical path, Cv refers to a volume concentration of solid particles.

Step 5: Process calculation of the solid content based on the new extinction value and the gradation data obtained from the above steps.

In specific implementation, the solid content H is calculated according to the following formula:

$$H = C_v \times \rho = -\frac{\left[\ln\left(\frac{I_1}{I_0}\right) - \ln\left(\frac{I_2}{I_0}\right)\right]2D}{3K_{ext}(L_1 - L_2)} \times \rho$$

Wherein ρ refers to the density of solid particles.

In the formula, the value of D is D[3,2] in the typical value of particle size distribution data, which is 5.013 μm. K_{ext} is an extinction coefficient corresponding to D[3,2] 5.013 μm, based on Mie scattering calculation, it is 2.0015 . . . L_1=3 mm, L_2=2 mm,

$$\frac{I_1}{I_0} = 0.75, \ \frac{I_2}{I_0} = 0.91.$$

The parameters are brought into the formula to calculate the Cv value, which is 0.000322. According to this embodiment, the test sample is sediment, and the density is taken as a constant of 2.4. When put into the formula, the solid content is 0.000775, usually the unit of solid content is g/L, and the solid content of this test is 0.775 g/L after unit conversion.

The present invention is a method for analyzing and calculating particle size gradation and solid content using optical path difference method in two-phase flow, which belongs to the field of underwater sand content measurement and particle size gradation.

This sand content and particle size gradation monitoring method with optical path difference collects the extinction values at two optical path lengths and the scattered light intensity signal on the detector, and subtracts the short optical path signal from the long optical path signal to obtain a new set of scattered light intensity signals and extinction values. The scattered light intensity signal is the scattering signal of the particle group in the two-phase flow system, including particle size distribution information. The sediment content can be calculated based on the scattered light intensity signal and extinction value. Whether it is the measured scattered light intensity signal of particle gradation or the extinction value signal of measured solid content, they are not affected by window lens contamination, and can realize long-term operation of underwater or atmospheric online monitoring. There is no need to measure the background signal in the pure medium state, and a pure scattered light intensity signal can be obtained.

The above description includes the preferred embodiments of the present invention only and is not intended to be limiting the concept of the present invention. Within the spirit and principle of the present invention, any modifications, equivalent substitutions, improvements, etc., shall be included in the protection scope of the present invention.

What is claimed is:

1. A method of solid content measurement utilizing optical path difference in two-phase flow, characterized in that, said method, carried out through a laser particle size analyzer comprises the following steps:

step 1: providing the laser particle size analyzer with a plurality of detectors, changing a width of measurement area of the laser particle size analyzer, and monitoring and collecting extinction values from direct source at two different optical path lengths and a scattered light intensity signal on each detector at two different optical path lengths, wherein the two different optical path lengths are defined as a long optical path length and a short optical path length, and the long optical path length is greater than the short optical path length;

step 2: utilizing the scattered light intensity signal at the long optical path length to subtract the scattered light intensity signal at the short optical path length on each detector to obtain a set of new scattered light intensity signals with background subtracted;

step 3: processing particle size distribution inversion calculations for the set of scattered light intensity signals with background subtracted to obtain gradation data of solid particles;

step 4: processing subtraction of the logarithm of the extinction value of the short optical path from the logarithm of the extinction value of the long optical path to obtain new extinction value related data;

step 5: processing calculation of the solid content based on the new extinction value related data and the gradation data obtained.

2. The method of solid content measurement utilizing optical path difference in two-phase flow according to claim **1**, characterized in that: in step 2, the new scattered light intensity signals on each detector is calculated by the followings:

$$S = A_1 - A_2 = (S_1 + B) - (S_2 + B) = S_1 - S_2$$

wherein A_1 refers to a scattered light intensity signal with long optical path and background on the detector, A_2 refers to a scattered light intensity signal with short optical path and background on the detector, B refers to the background signal, S_1 refers to a scattered light intensity signal with long optical path after the background is subtracted, S_2 refers to a scattered light intensity signal with short optical path after the background is subtracted, S refers to a scattered light intensity signal difference for different optical paths, that is, the new scattered light intensity signal; the new scattered light intensity signal on each detector constitutes a new set of scattered light intensity signals.

3. The method of solid content measurement utilizing optical path difference in two-phase flow according to claim **1**, characterized in that: in step 4,

the new extinction value is:

$$-\frac{3C_vK_{ext}}{2D}(L_1 - L_2)$$

and a specific calculation of the new extinction value is:

$$\ln\left(\frac{I_1}{I_0}\right) = -\frac{3C_vL_1K_{ext}}{2D}$$

$$\ln\left(\frac{I_2}{I_0}\right) = -\frac{3C_vL_2K_{ext}}{2D}$$

$$\ln\left(\frac{I_1}{I_0}\right) - \ln\left(\frac{I_2}{I_0}\right) = -\frac{3C_vL_1K_{ext}}{2D} + \frac{3C_vL_2K_{ext}}{2D} = -\frac{3C_vK_{ext}}{2D}(L_1 - L_2)$$

wherein I_1 refers to transmitted signal for long optical path, I_2 refers to transmitted signal for short optical path, I_0 refers to the initial light intensity signal, D refers to the surface area mean diameter of the solid particles calculated by the scattered light intensity inversion in step 3, and Kext refers to the extinction coefficient, L_1 refers to a length of the long optical path, L_2 refers to a length of the short optical path, Cv refers to a volume concentration of solid particles.

4. The method of solid content measurement utilizing optical path difference in two-phase flow according to claim **3**, characterized in that: in step 5, the solid content H is calculated according to the following formula:

$$H = C_v \times \rho = -\frac{\left[\ln\left(\frac{I_1}{I_0}\right) - \ln\left(\frac{I_2}{I_0}\right)\right]2D}{3K_{ext}(L_1 - L_2)} \times \rho$$

wherein ρ refers to a density of solid particle.

5. The method of solid content measurement utilizing optical path difference in two-phase flow according to claim **2**, characterized in that: in step 4,

the new extinction value is:

$$-\frac{3C_vK_{ext}}{2D}(L_1-L_2)$$

and a specific calculation of the new extinction value is:

$$\ln\left(\frac{I_1}{I_0}\right)=-\frac{3C_vL_1K_{ext}}{2D}$$

$$\ln\left(\frac{I_2}{I_0}\right)=-\frac{3C_vL_2K_{ext}}{2D}$$

$$\ln\left(\frac{I_1}{I_0}\right)-\ln\left(\frac{I_2}{I_0}\right)=-\frac{3C_vL_1K_{ext}}{2D}+\frac{3C_vL_2K_{ext}}{2D}=-\frac{3C_vK_{ext}}{2D}(L_1-L_2)$$

wherein I_1 refers to transmitted signal for long optical path, I_2 refers to transmitted signal for short optical path, I_0 refers to the initial light intensity signal, D refers to the surface area mean diameter of the solid particles calculated by the scattered light intensity inversion in step 3, and Kext refers to the extinction coefficient, L_1 refers to a length of the long optical path, L_2 refers to a length of the short optical path, Cv refers to a volume concentration of solid particles.

6. The method of solid content measurement utilizing optical path difference in two-phase flow according to claim **5**, characterized in that: in step 5, the solid content H is calculated according to the following formula:

$$H=C_v\times\rho=-\frac{\left[\ln\left(\frac{I_1}{I_0}\right)-\ln\left(\frac{I_2}{I_0}\right)\right]2D}{3K_{ext}(L_1-L_2)}\times\rho$$

wherein ρ refers to a density of solid particle.

7. The method of solid content measurement utilizing optical path difference in two-phase flow according to claim **1**, wherein the processing particle size distribution inversion calculations is based on Mie scattering theory, which comprises the steps of:

calculating characteristic values comprising volume mean diameter, surface area mean diameter, length mean diameter, number mean diameter, peak particle size diameter, specific surface area, and span.

8. The method of solid content measurement utilizing optical path difference in two-phase flow according to claim **2**, wherein the processing particle size distribution inversion calculations is based on Mie scattering theory, which comprises the steps of:

calculating characteristic values comprising volume mean diameter, surface area mean diameter, length mean diameter, number mean diameter, peak particle size diameter, specific surface area, and span.

9. The method of solid content measurement utilizing optical path difference in two-phase flow according to claim **6**, wherein the processing particle size distribution inversion calculations is based on Mie scattering theory, which comprises the steps of:

calculating characteristic values comprising volume mean diameter, surface area mean diameter, length mean diameter, number mean diameter, peak particle size diameter, specific surface area, and span.

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