

DESCRIPTION

SLURRY MANAGEMENT DEVICE FOR WIRE SAW

Technical Field

[0001]

The present invention relates to a slurry management device for a wire saw which is easy in regulation of slurry to be supplied to the fixed-abrasive wire saw and ensures stable cutting.

Background Art

[0002]

Wire saws, which have been used for cutting a target workpiece such as a silicon ingot into wafers, include a loose-abrasive wire saw using a row of thin tensioned running wires. With slurry being sprayed which comprises coolant for removing cutting heat and abrasive grains for cutting, the workpiece is pressed against the wire row and concurrently cut into wafers (see, for example, Patent Literature 1).

[0003]

Recently appears a fixed-abrasive wire saw using a row of thin fixed-abrasive wires with diamond or other abrasive-grains preliminarily fixed on surfaces of the

wires. With slurry consisting of coolant being sprayed, the workpiece is pressed against the wire row and concurrently cut into wafers (see, for example, Patent Literature 2).

[0004]

In the loose- and fixed-abrasive wire saws, a cutting operation from its beginning to its end is generally conducted in a single batch process for cutting a silicon ingot into a number of wafers. For slurry waste from such wire saws, slurry management has been studied to fractionally recover and reuse the slurry waste for effective utilization of resources and reduction in volume of waste.

[0005]

In the loose-abrasive wire saw, the slurry comprising the coolant and the abrasive grains mixed therewith is supplied to the wires to cut the silicon ingot, so that the slurry waste from the loose-abrasive wire saw is a mixture of the coolant with the abrasive grains (SiC) and cut chips (Si). Thus, fractional recovery of such slurry waste includes two steps of separation; the slurry waste is separated into the coolant and a solid content, and the latter is separated into the abrasive grains to be recovered and the cut chips to be scrapped. Here, in order to conduct continuous separation, the slurry waste

is continuously extracted. Then, while an extracted slurry amount and respective recovered amounts are monitored, a complex operation must be conducted which includes, for example, recovering the abrasive grains, scrapping the chips, blending a new coolant with new abrasive grains and returning the regenerated slurry, leading to difficulty in management. Thus, for slurry management of the slurry waste from the loose-abrasive wire saw, a batch process is generally prevailing.

[0006]

Meanwhile, in the fixed-abrasive wire saw, slurry consisting of coolant is supplied to fixed-abrasive wires for cutting of a silicon ingot, so that slurry waste from the fixed-abrasive wire saw is a mixture of the coolant with cut silicon particles and the like.

Citation List

Patent Literature

[0007]

[Patent Literature 1] JP 11-309674A

[Patent Literature 2] JP 2010-29998A

Summary of Invention

Technical Problems

[0008]

The fixed-abrasive wire saw, which is known to have a cutting speed substantially higher than that of the loose-abrasive wire saw, has a problem that the high cutting speed causes a cutting quality to be unstable unless slurry quality (that is, slurry concentration indicative of cuttability in consideration of particle diameters of the solid content in the slurry derived from a viscosity of the solid content concerning a concentration of the solid content in the slurry derived from a specific gravity of the solid content) is controlled with high accuracy. Specifically, even if the concentration of the solid content in the slurry is high, the cuttability may be lowered when the solid content has smaller particle diameters and higher viscosity. A batch-type slurry management, which has greatly different slurry concentrations and thus different cutting qualities at beginning and end of a cutting operation, has hardness in its application to management of slurry waste from a fixed-abrasive wire saw. Moreover, supply of the slurry stabilized in quality through batch process to the fixed-abrasive wire saw will require plenty of slurry stored, resulting in a problem of installation and cost increased.

[0009]

Thus, desirable for slurry waste in the fixed-abrasive wire saw is slurry management where slurry waste

from a cutting operation with a small amount of slurry is continuously separated for reuse. However, there is no conventional disclosure on slurry management by which solid particles can be separated easily and stably from slurry waste and slurry adjusted to a slurry concentration suitable for cutting can be stably supplied to a fixed-abrasive wire saw.

[0010]

The invention was made in view of the above and has its object to provide a slurry management device for a wire saw which is easy in regulation of slurry to be supplied to the fixed-abrasive wire saw and ensures stable cutting.

Solution to Problems

[0011]

In order to attain the above object, a slurry management device for a wire saw according to the invention is characterized in that it comprises a first tank for receiving and storing slurry waste from the fixed-abrasive wire saw, a centrifugal separator for receiving the slurry waste from said first tank to separate solid particles therefrom, a second tank for receiving and storing the solid-content-containing slurry having been separated from the solid particles in said

centrifugal separator, a slurry supply passage for supplying the slurry from said second tank to said fixed-abrasive wire saw, a specific gravimeter and a viscometer provided for a circulation passage for extraction of the slurry from said second tank for circulation, a controller for receiving detected specific gravity and viscosity from said specific gravimeter and said viscometer, respectively, to determine a slurry concentration in consideration of particle diameters of a solid content in the slurry derived from a viscosity of the solid content concerning a concentration of the solid content in the slurry derived from a specific gravity of the solid content, a slurry discharge passage for discharging part of the slurry in the second tank as waste slurry and a new slurry supply passage for supplying new slurry to said second tank, said controller conducting the discharge of the waste slurry through said slurry discharge passage and the supply of the new slurry through said new slurry supply passage so as to maintain said determined slurry concentration at a stipulation concentration.

[0012]

It is preferable in the above-mentioned slurry management device for the wire saw that said first tank is provided with a cyclone separator to which the slurry waste from said fixed-abrasive wire saw is guided for

supply of the slurry waste with increased concentration of solid particles to said centrifugal separator.

[0013]

It is preferable in the above-mentioned slurry management device for the wire saw that said stipulation concentration is a maximum concentration within which stable cutting by the fixed-abrasive wire saw is possible.

[0014]

It is preferable in the above-mentioned slurry management device for the wire saw that said first and second tanks are integrally formed, the slurry waste in the first tank being allowed to flow over an overflow wall into the second tank.

Advantageous Effects of Invention

[0015]

According to the slurry management device for a wire saw of the invention, the slurry waste received by the first tank is guided to the centrifugal separator for separation of the solid particles therefrom. Thus obtained solid-content-containing slurry is supplied to the second tank and the slurry in the second tank is supplied to the fixed-abrasive wire saw. In order that the slurry concentration in consideration of the viscosity indicative of the particle diameters of the solid content

concerning the specific gravity indicative of the concentration of the solid content in the slurry in the second tank may be the stipulation concentration, part of the slurry in the second tank is discharged as waste slurry while new slurry is supplied to said second tank. Thus, obtainable are excellent effects that the first and second tanks with relatively small volumes and the centrifugal separator can stably produce the slurry with the stipulation concentration from the slurry waste and that the supply of the slurry with the stipulation concentration to the fixed-abrasive wire saw can always ensure stable cutting.

Brief Description of Drawings

[0016]

Fig. 1 is a block diagram showing an embodiment of a slurry management device for a wire saw according to the invention; and

Fig. 2 is a diagram showing, in comparison, slurry management according to the invention and conventional management in batch treatment of slurry waste.

Reference Signs List

[0017]

1 fixed-abrasive wire saw

2 slurry
2a new slurry
3 slurry waste
3a slurry waste
3b slurry waste
5A first tank
5B second tank
6 overflow wall
7 cyclone separator
14 centrifugal separator
15 solid particle
23, 24 specific gravimeter
26 slurry supply passage
28 circulation passage
29 specific gravimeter
30 viscometer
31 waste slurry
33 slurry discharge passage
38 new slurry supply passage
41 controller
S stipulation concentration

Description of Embodiment

[0018]

An embodiment of the invention will be described as

illustrated example.

[0019]

Fig. 1 is a block diagram showing the embodiment of a slurry management device for a wire saw according to the invention in which reference numeral 1 denotes a fixed-abrasive wire saw. Supplied to the fixed-abrasive wire saw 1 is slurry 2 consisting of a coolant so as to cut an ingot by fixed-abrasive wires (not shown). Slurry waste 3 from the fixed-abrasive wire saw 1 is received by a liquid-receiving vessel 4.

[0020]

In the figure, reference numeral 5 designates a storage tank partitioned by an overflow wall 6 therein into first and second tanks 5A and 5B. Disposed in the first tank 5A is a downwardly tapered cyclone separator 7.

[0021]

Slurry waste 3 in the liquid-receiving vessel 4 is supplied through a waste intake passage 9 with a pump 8 to the cyclone separator 7 in the first tank 5A. Specifically, the waste intake passage 9 is connected to a tangential supply port 10 on a large diameter portion of the tapered cyclone separator 7 for introduction of the slurry waste 3, so that slurry waste 3b with enhanced slurry concentration is extracted through a small diameter end 11 of the cyclone separator 7 while slurry waste 3a

with lowered slurry concentration is discharged through a large-diameter-side central port 12 into the first tank 5A.

[0022]

The small diameter end 11 of the cyclone separator 7 is connected through a takeoff passage 13 to a centrifugal separator 14. The slurry waste 3b with the enhanced slurry concentration from the small diameter end 11 is separated by the centrifugal separator 14 into solid particles 15 with larger diameters and the solid-content-containing slurry 2 with reduced solid particles, the solid particles 15 and the slurry 2 being recovered to a recovery vessel 16 and a slurry tank 17, respectively.

[0023]

The slurry 2 in the slurry tank 17 is supplied through a supply pipe 19 with a pump 18 to the second tank 5B. The takeoff passage 13 and the supply pipe 19 have specific gravimeters 23 and 24, respectively. A removal rate of the solid particles in the centrifugal separator 14 is determined by measurement of the specific gravities by the specific gravimeters 23 and 24.

[0024]

The slurry 2 in the second tank 5B is supplied through a slurry supply passage 26 with a pump 25 to the fixed-abrasive wire saw 1. A circulation passage 28 is provided to extract and return the slurry 2 in the second

tank 5B by a pump 27 to the second tank 5B. The circulation passage 28 is provided with a specific gravimeter 29 and a viscometer 30 with a thermometer 30a.

[0025]

The circulation passage 28 is provided with a slurry discharge passage 33 for discharge of the circulating slurry 2 as waste slurry 31 to a waste slurry tank 32. The passages 28 and 33 have changeover valves 34 and 35, respectively, for discharge of the slurry 2 to the waste slurry tank 32. In the above, illustration is made on a case where the slurry discharge passage 33 is connected to the circulation passage 28; alternatively, the slurry discharge passage 33 may be arranged independently to discharge the slurry 2 in the second tank 5B directly to the waste slurry tank 32.

[0026]

A new slurry supply passage 38 is connected to the second tank 5B for supply of new slurry 2a stored in a new slurry tank 36 through a pump 37. In Fig. 1, reference numeral 39 designates an agitator arranged in the second tank 5B; and 40, a guide wall which guides and directs the slurry waste 3a downward into agitation by the agitator 39 when the slurry waste 3a in the first tank 5A flows beyond the overflow wall 6 into the second tank 5B.

[0027]

In Fig. 1, reference numeral 41 denotes a controller. The controller 41 having a detected specific gravity value and a detected viscosity-temperature value inputted by the specific gravimeter 29 and the viscometer 30 with the thermometer 30a, respectively, determines a slurry concentration (a value pertinent to cutting performance in the fixed-abrasive wire saw 1) in consideration of particle diameters of the solid content in the slurry 2. When the slurry concentration determined by the controller 41 reaches a stipulation concentration, the controller 41 operates the valves 34 and 35 to discharge a predetermined amount of slurry 2 in the second tank 5B as waste slurry 31 to the waste slurry tank 32 and, at the same time, drive the pump 37 to supply the new slurry 2a stored in the new slurry tank 36 to the second tank 5B in an amount equal to that of the discharged waste slurry 31. Thus, the slurry concentration of the slurry 2 in the second tank 5B is brought back below the stipulation concentration.

[0028]

Next, a mode of operation of the above embodiment will be described.

[0029]

The slurry waste 3 discharged to the liquid-receiving vessel 4 from the fixed-abrasive wire saw 1 is supplied by

the operation of the pump 8 through the waste intake passage 9 to the cyclone separator 7 in the first tank 5A. Then, the slurry waste 3b with the enhanced slurry concentration is taken off through the small diameter end 11 of the cyclone separator 7 while the slurry waste 3a with the reduced slurry concentration is discharged through the large-diameter-side central port 12 to the first tank 5A.

[0030]

The slurry waste 3b with increased slurry concentration from the small diameter end 11 of the cyclone separator 7 is supplied through the takeoff passage 13 to the centrifugal separator 14 where the slurry waste is separated into the solid particles 15 and the solid-content-containing slurry 2 with a reduced content of solid particles; the solid particles 15 and the slurry 2 are recovered by the recovery vessel 16 and the slurry tank 17, respectively. In this case, the higher the concentration of the slurry supplied is, the higher separation performance the centrifugal separator 14 exhibits. As a result, the slurry waste 3b with the slurry concentration increased by the cyclone separator 7 as mentioned in the above is supplied to the centrifugal separator 14, so that the centrifugal separator 14 conducts effective separation of the solid particles 15.

[0031]

The slurry 2 recovered by the centrifugal separator 14 to the slurry tank 17 is supplied by activation of the pump 18 through the supply pipe 19 to the second tank 5B. The slurry 2 in the second tank 5B is fed by the operation of the pump 25 via the slurry supply passage 26 to the fixed-abrasive wire saw 1 for circulated use thereof.

[0032]

The detected specific gravity and viscosity-temperature values respectively from the specific gravimeter 29 and from the viscometer 30 with the thermometer 30a on the circulation passage 28 provided for the second tank 5B are inputted to the controller 41 where the slurry concentration is determined in consideration of particle diameters of the solid contents in the slurry 2.

[0033]

Fig. 2 shows, in comparison, the slurry management according to the invention and the conventional management in batch process of slurry waste; abscissa and ordinate denote time and specific gravity, respectively. Here, in the management according to the invention, the specific gravity is detected together with the viscosity to determine the slurry concentration which affects the cutting performance by the fixed-abrasive wire saw 1. Specifically, the centrifugal separator 14 has a

separation feature that the solid particles (solid content) with smaller particle diameters may accumulate. As a result, even if the concentration of the solid content in the slurry is maintained in a level, increase of fine particles in the solid content may cause enhanced viscosity, resulting in lowered cutting performance of the fixed-abrasive wire saw 1. In order to overcome this problem, the control is made by determining the slurry concentration in consideration of particle sizes of the solid content in the slurry 2.

[0034]

When the slurry concentration is lower than the stipulation concentration S shown in Fig. 2, supply of the slurry 2 in the second tank 5B as it is to the fixed-abrasive wire saw 1 is continued. In this case, X in Fig. 2 shows a limit value for stable cutting by the fixed-abrasive wire saw 1, the stipulation concentration S is a maximum concentration which is near the limit value X and within which stable cutting is possible by the fixed-abrasive wire saw 1.

[0035]

When the slurry concentration determined by the controller 41 reaches the stipulation concentration S in Fig. 2, the controller 41 operates the valves 34 and 35 to discharge a predetermined amount of slurry 2 in the second

tank 5B as waste slurry 31 to the waste slurry tank 32; concurrently, it drives the pump 37 to supply the new slurry 2a in the new slurry tank 36 to the second tank 5B in an amount equal to that of the discharged waste slurry 31. Thus, the slurry 2 in the second tank 5B is diluted with the new slurry 2a to have a restored slurry concentration lower than the stipulation concentration S.

[0036]

By the above-mentioned operation, the slurry 2 in the second tank 5B is always stably kept to be lower than the stipulation concentration S in Fig. 2. By supply of the slurry 2 with the stable slurry concentration to the fixed-abrasive wire saw 1, the stable cutting is always attained in the fixed-abrasive wire saw 1.

[0037]

On the other hand, Y in Fig. 2 denotes conventional batch treatment of the slurry waste. In the batch treatment as shown by line Y, the slurry concentration gradually increases at the cutting operation continues. Thus, firstly, the slurry concentration at the end of the cutting is set to be a value which is just lower than the limit value X; and, so as to keep the set value at end of the cutting operation, the slurry concentration at the beginning of the cutting operation is calculated back for adjustment, so that conventionally the slurry

concentration at the beginning of the cutting operation must be adjusted to an extremely low value, which in turn brings about necessity of minute separation by a separator such as a membrane filter, leading to a problem of cost increase.

[0038]

By contrast, according to the invention, as shown in Fig. 2, the slurry concentration of the slurry 2 is adjusted to the stipulation concentration S close to the limit value X , so that it is easy to use the centrifugal separator 14 to maintain slurry concentration to the stipulation concentration S approximate to the limit value X . Specifically, the centrifugal separator 14 has a performance that a recovery amount increases as the concentration of the solid particles increases, so that the supply of the slurry waste 3b condensed by the cyclone separator 7 to the centrifugal separator 14 enables sufficient separation of the solid particles 15; thus, the slurry concentration can be easily maintained to be lower than the stipulation concentration S . In a case where the slurry concentration becomes larger than the stipulation concentration S even by the separation by the centrifugal separator 14, part of the slurry 2 in the second tank 5B is disposed and new slurry 2a is supplied for recovery to the stipulation concentration S , with an advantageous

results that management of the slurry 2 can be conducted easily and at a lower cost and the slurry 2 can be always stably supplied to the fixed-abrasive wire saw 1.

Preferably, for the waste slurry 31 to be discharged outside due to the slurry concentration greater than the stipulation concentration S, a membrane filter such as a swing separator may be attached for enhancement of recovery rate of the coolant. In this case, the membrane filter can be dramatically of small size in comparison with conventional batch-type separators.

[0039]

Introduction of the slurry waste 3 from a plurality of fixed-abrasive wire saws 1 into the first tank 5A can be dealt with by allowing the slurry waste 3a in the first tank 5A to flow over the overflow wall 6 into the second tank 5B. Since the slurry waste 3a in the first tank 5A has been separated from the slurry waste 3b with higher slurry concentration by the cyclone separator 7, such slurry waste 3a with the lower slurry concentration may be supplied to the second tank 5B with no trouble. Thus, the storage tank 5 with the first and second tanks 5A and 5B integrally formed and partitioned by the overflow wall 6 can simplify deliver and receive the liquid and can be satisfactorily applied to treatment of plenty of slurry waste 3.

[0040]

The waste slurry 31 discharged to the waste slurry tank 32 may be guided to a filter or the like for solid-liquid separation, filtrate being recoverable as slurry for efficient use.

[0041]

It is to be understood that a slurry management device for wire saw according to the invention is not limited to the above embodiment and that various changes and modifications may be made without departing from the scope of the invention. For example, the first and second tanks 5A and 5B may not be integrally formed but may be arranged separately.

Industrial Applicability

[0042]

A slurry management device for a wire saw according to the invention is applicable to stable and efficient cutting of a workpiece by a fixed-abrasive wire saw through adjustment of slurry concentration suitable for cutting.

CLAIMS

1. A slurry management device for a wire saw, characterized in that it comprises a first tank for receiving and storing slurry waste from the fixed-abrasive wire saw, a centrifugal separator for receiving the slurry waste from said first tank to separate solid particles therefrom, a second tank for receiving and storing the solid-content-containing slurry having been separated from the solid particles in said centrifugal separator, a slurry supply passage for supplying the slurry from said second tank to said fixed-abrasive wire saw, a specific gravimeter and a viscometer provided for a circulation passage for extraction of the slurry from said second tank for circulation, a controller for receiving detected specific gravity and viscosity from said specific gravimeter and said viscometer, respectively, to determine a slurry concentration in consideration of particle diameters of a solid content in the slurry derived from a viscosity of the solid content concerning a concentration of the solid content in the slurry derived from a specific gravity of the solid content, a slurry discharge passage for discharging part of the slurry in the second tank as waste slurry and a new slurry supply passage for supplying new slurry to

said second tank, said controller conducting the discharge of the waste slurry through said slurry discharge passage and the supply of the new slurry through said new slurry supply passage so as to maintain said determined slurry concentration at a stipulation concentration.

2. The slurry management device for wire saw as claimed in claim 1, characterized in that said first tank is provided with a cyclone separator to which the slurry waste from said fixed-abrasive wire saw is guided for supply of the slurry waste with increased concentration of solid particles to said centrifugal separator.

3. The slurry management device for wire saw as claimed in claim 1 or 2, characterized in that said stipulation concentration is a maximum concentration within which stable cutting by the fixed-abrasive wire saw is possible.

4. The slurry management device for wire saw as claimed in claim 1 or 2, characterized in that said first and second tanks are integrally formed, the slurry waste in the first tank being allowed to flow over an overflow wall into the second tank.

5. The slurry management device for wire saw as claimed in claim 3, characterized in that said first and second tanks are integrally formed, the slurry waste in the first tank being allowed to flow over an overflow wall into the second tank.