

WATER-BASED COOLANT PURIFICATION AND RECYCLING DEVICE AND METHOD FOR CNC WIRE EDM MACHINES

Cross-Reference To Related Applications

5 The present application claims a filing date of an earlier Chinese Utility Model application number 202520322001.1 and invention patent application number 202510221174.9 as its priority dates, which were both submitted to China National Intellectual Property Administration (CNIPA) on the same day of 27 February 2025. All contents or relevant subject matters of the priority applications are hereby
10 incorporated entirely and/or wherever appropriate by reference.

Technical Field

 This application relates to the field of coolant purification technology, in particular to a water-based coolant purification and recycling device and method for
15 CNC Wire EDM machines.

Background Technology

 During the machining process of CNC (i.e., Computer Numerical Control) Wire EDM (i.e., Electrical Discharge Machining) machines, water-based coolant serves as
20 a cooling and lubrication medium, playing a crucial role in ensuring machining quality and prolonging the lifespan of the wire cutting machine. As the wire cutting machine operates (for approximately 200 hours), a large amount of impurities (including metal shavings, cutting powders, and others, mostly black in color) gradually accumulates in the coolant, resulting in coolant deterioration which subsequently affects the
25 coolant performance.

Under certain electrical and chemical conditions during the machining process, these impurities can agglomerate into larger particles and settle in the coolant. The resulting issues comprise:

- 1) The impurities cannot be filtered using paper filters, necessitating the replacement of the water-based coolant. However, water-based coolant is expensive, significantly increasing production costs;
- 2) If the deteriorated coolant is not replaced and machining continues, the surface smoothness and the precision of the workpiece will deteriorate; and
- 3) The impurities can also contaminate the wire cutting machine environment, increasing the environmental burden and maintenance costs.

As a limitation of existing technology, microfiltration filters are ineffective in filtering the impurities, whereas nanofiltration membranes can effectively filter the impurities but will simultaneously remove essential components from the coolant, resulting in coolant loss. In the field of water-based coolant purification technology for CNC Wire EDM machines, the existing technology lacks a purification and recycling device that can effectively remove impurities while retaining the coolant.

Summary of the Application

This application aims to resolve the limitations of the existing technology, by which microfiltration filters cannot effectively filter impurities and nanofiltration membranes can efficiently filter impurities but will simultaneously remove effective components in the coolant, resulting in coolant loss.

This application provides the technical solutions as follows:

A water-based coolant purification and recycling device for CNC Wire EDM machines, comprising:

at least one storage assembly, the storage assembly comprising at least one primary water tank, the primary water tank comprising at least one machining fluid collection tank, at least one coolant tank, and at least one impurity storage tank, the primary water tank is connected to at least one machine tool water tank by a pipeline, the machine tool water tank comprising at least one machine tool machining fluid collection tank and at least one machine tool coolant tank, the machine tool machining fluid collection tank is connected to the machining fluid collection tank by the pipeline, and the machine tool coolant tank is connected to the coolant tank by the pipeline;

at least one diversion filtration assembly, comprising at least one inlet end and at least one outlet end, an inlet end 1 is connected to the machining fluid collection tank by the pipeline, and an outlet end 1 is connected to the coolant tank by the pipeline, an outlet end 3 is connected to the impurity storage tank by the pipeline; and

at least one ion removal assembly, comprising at least one output terminal and at least one outlet terminal, the output terminal is connected to an inlet end 2 and an outlet end 2 by the pipeline, while the outlet terminal is connected to the coolant tank by the pipeline;

characterized in that the ion removal assembly comprises at least one secondary water tank and at least one external tap water source, the secondary water tank is connected to the external tap water source by the pipeline for replenishing tap water, the ion removal assembly comprising at least one ion remover, the ion remover connected to at least one immersion pump by the pipeline, deionized water can be sent through the secondary water tank and the pipeline to the diversion filtration assembly, the diversion filtration assembly comprising at least

one membrane filter and at least one water pump, the machining fluid can be transferred from the machine tool machining fluid collection tank and the machining fluid collection tank to the inlet end 1 and the inlet end 2 by the pipeline, coolant can be transferred from the outlet end 1 by the pipeline to the coolant tank and the machine tool coolant tank, impurities can be transferred from the outlet end 2 to the outlet end 3 and the impurity storage tank by the pipeline.

Further, the water-based coolant purification and recycling device for CNC Wire EDM machines is connected to a control system, the control system comprising at least one control valve, at least one solenoid valve, at least one temperature sensor, at least one pressure sensor, at least one cooling fan, at least one flow sensor, at least one liquid level sensor, and at least one conductivity sensor.

Further, the control valve comprises a control valve 1 and a control valve 2, the control valve 1 connects the outlet end 2 to the water pump and the outlet end 3, the control valve 2 connects the water pump to the inlet end 1 and the output terminal.

Further, the solenoid valve comprises a solenoid valve 1 and a solenoid valve 2, the pipeline connecting the outlet terminal to the coolant tank is equipped with the solenoid valve 1, the pipeline connecting the secondary water tank to the external tap water source is equipped with the solenoid valve 2.

Further, the pipeline connecting the inlet end 2 to the water pump is equipped with the pressure sensor, the temperature sensor, and the cooling fan.

Further, the pipeline connecting the outlet end 1 to the coolant tank is equipped with the flow sensor.

Further, the coolant tank is equipped with a liquid level sensor 1, while the secondary water tank is equipped with a liquid level sensor 2 and the conductivity sensor.

Further, the impurity storage tank is equipped with at least one impurity discharge valve.

Further, the pipeline connecting the inlet end 1 to the machining fluid collection tank is equipped with at least one check valve.

5 This application provides a method for purifying and recycling water-based coolant for CNC Wire EDM machines, utilizing the water-based coolant purification and recycling device to achieve coolant recycling, including the following steps:

The machining fluid in the machining fluid collection tank is sent from the inlet end 1 through the control valve 2 and the pressure of the water pump to the inlet end
10 2. The machining fluid flows into the membrane filter for filtration, exits from the outlet end 2, and undergoes a purification filtration cycle under the pressure of the water pump and the control valve 1. The purified coolant is sent from the outlet end 1 to the coolant tank.

When the flow sensor detects that the current flow rate is less than half of the
15 initial flow rate, the control valve 2 opens. The deionized water from the secondary water tank and the output terminal is sent through the control valve 2 and the pressure of the water pump to the inlet end 2. The deionized water flows into the membrane filter for cleaning and coolant recycling, exits from the outlet end 2, and undergoes a cleaning recycling filtration cycle under the pressure of the water pump
20 and the control valve 1.

After the cleaning recycling filtration cycle has been performed for a period of time, the control valve 1 opens, and the impurities are sent to the impurity storage tank. The impurity discharge valve can be opened to discharge the impurities.

After impurities have been discharged for a period of time, the control valve 1 and
25 the control valve 2 close, returning to the purification filtration cycle.

Furthermore, the pressure of the water pump is 0.2-0.6 bar. When the current flow rate is less than or equal to 50% of the initial flow rate, the control valve 2 opens to perform the cleaning recycling filtration cycle.

5 Additionally, the membrane filter is made of polymer material, and an ultrafiltration membrane is placed inside the membrane filter. The pore diameter of ultrafiltration membrane fibers of the ultrafiltration membrane is 40-100 nm.

Furthermore, when the liquid level sensor 2 in the secondary water tank detects a low liquid level, the solenoid valve 2 opens to replenish tap water from the external tap water source. When the conductivity sensor in the secondary water tank
10 detects a high conductivity, the tap water flows into the ion remover by the immersion pump, where the ions in the tap water are removed before being sent to the secondary water tank.

When the liquid level sensor in the coolant tank detects a low liquid level, the solenoid valve 1 opens, and the deionized water from the secondary water tank is
15 sent to the coolant tank.

Furthermore, the low liquid level is less than or equal to 50%, the high conductivity is greater than 60 $\mu\text{S}/\text{cm}$, and the conductivity of the deionized water is 0-50 $\mu\text{S}/\text{cm}$.

20 Beneficial Effects of the Application:

1) After continuous processing (approximately 80 hours) by a wire cutting machine, the water-based coolant purification and recycling device and method can effectively remove impurities after operating for approximately 20 hours;

2) After filtration, the coolant is purified while retaining its effective
25 components, ensuring optimal performance and processing quality;

3) This application resolves the technical limitations of the prior art, enabling removal of impurities and retaining the effective components of the coolant simultaneously;

4) The integrated design employs deionized water to improve membrane
5 filtration efficiency and operational stability, as well as to clean and recover the effective components of the coolant, significantly improving the recycling rate of the coolant; and

5) The overall system is simple and efficient, with a low operating pressure in the internal circulation filtration system (0.2-0.6 bar), low energy consumption
10 (approximately 0.37 kW), optimizing both environmental protection and economic performance.

Description of the Drawings:

FIG. 1: Schematic diagram of the overall system of the present application
15 (view 1).

FIG. 2: Schematic diagram of the overall system of the present application (view 2).

FIG. 3: Schematic diagram of the diversion filtration assembly of the present application.

20 FIG. 4: Schematic diagram of the internal structure of the membrane filter of the present application.

FIG. 5: Flowchart of the method of the present application.

Detailed Description of the Application

The present application will be further explained in detail with reference to the accompanying drawings and preferred embodiments.

In the description of the present application, it should be understood that the terms "left," "right," "upper," "lower," etc., refer to the orientation or positional relationship based on the orientation or positional relationship shown in the drawings. These terms are used solely for the convenience of describing the present application and simplifying the description. They do not indicate or imply that the devices or components must have a specific orientation or operate in a specific direction. The terms "first," "second," etc., do not indicate the importance of the components and should not be understood as limitations on the application. The specific dimensions used in this embodiment are merely for example purposes to illustrate the technical solution and do not limit the scope of protection of the present application.

This embodiment provides a water-based coolant purification and recycling device and method for CNC Wire EDM machines, which can effectively remove impurities, retain the effective components of the coolant, and achieve efficient coolant recycling.

Referring to FIG. 1, a water-based coolant purification and recycling device and method for CNC Wire EDM machines comprises: a storage assembly 1, a diversion filtration assembly 3, and an ion removal assembly 2. The storage assembly 1 stores machining fluid, purified coolant, and impurities. The diversion filtration assembly 3 performs filtration, circulating purification, and cleaning recycling of the coolant to separate the machining fluid into purified coolant and impurities. The ion removal assembly 2 removes ions from the tap water, provides deionized

water to the purified coolant in the storage assembly 1, and provides deionized water to the diversion filtration assembly 3 for cleaning and recovering the coolant.

Referring to FIG. 2, the storage assembly 1 comprises a primary water tank (111), the primary water tank comprising the machining fluid collection tank 16, the coolant tank 15, and the impurity storage tank 13. The primary water tank (111) is connected to the machine tool water tank 12 through a pipeline 4. The machine tool water tank 12 comprises the machine tool machining fluid collection tank 18 and the machine tool coolant tank 17. The machine tool machining fluid collection tank 18 transports the machining fluid that needs purification to the machining fluid collection tank 16 through the pipeline 4, and the coolant tank 15 transports the purified coolant to the machine tool coolant tank 17 through the pipeline 4.

Referring to FIG. 2 and FIG. 3, the diversion filtration assembly 3 comprises: a membrane filter 31 and a water pump 32. Under the pressure of 0.2-0.6 bar from the water pump 32, the machining fluid from the machining fluid collection tank 16 is sent through the check valve 7 and the inlet end 1 341 to the inlet end 2 342 by the control valve 2 332. The machining fluid flows into the membrane filter 31 for a purification filtration cycle. It then flows out from the outlet end 2 352, and through the control valve 1 331, the water pump 32 circulates it back to the inlet end 2 342 for the purification filtration cycle. The purified coolant is sent from the outlet end 1 351 to the coolant tank 15 for storage.

Referring to FIG. 4, as a preferred embodiment of this application, the membrane filter 31 is made of polymer materials such as PAN, PS, PSF, PES, PVDF, PVC, PP, or PTFE. The membrane filter 31 contains an ultrafiltration membrane 311, with a pore diameter of the ultrafiltration membrane 311 fibers ranging from 40-100 nm.

Referring to FIG. 2, FIG. 3, and FIG. 5, the ion removal assembly 2 is connected to the secondary water tank (112). When the flow sensor 46 at the outlet end 1 351 detects that the current flow of the purified coolant is less than or equal to 50% of the initial flow, the control valve 2 332 opens. Under the pressure of 0.2-0.6 bar from the water pump 32, the secondary water tank (112) provides the deionized water, which is sent to the inlet end 2 342 from the output terminal 24 through the control valve 2 332. The deionized water flows into the membrane filter 31 to clean and recover the coolant, flowing out from the outlet end 2 352, and, through the control valve 1 331, the water pump 32 circulates it back to the inlet end 2 342 for cleaning recycling filtration cycle. After a certain period of cleaning recycling filtration cycle, the control valve 1 331 opens, and the impurities are sent from the outlet end 2 352 through the pipeline 4 to the outlet end 3 353 and stored in the impurity storage tank 13. The impurity discharge valve 19 can be opened to discharge the impurities. After discharging impurities for a period, the control valve 1 331 and the control valve 2 332 are closed, restoring the purification filtration cycle.

Referring to FIG. 2, FIG. 3, and FIG. 5, the liquid level sensor 2 52 in the secondary water tank (112) detects when the liquid level is less than or equal to 50%. In this case, the solenoid valve 2 412 opens, and the external tap water source 23 replenishes the tap water. The conductivity sensor 6 in the secondary water tank (112) detects when the conductivity is greater than 60 $\mu\text{S}/\text{cm}$, causing the tap water to flow into the ion remover 22 through immersion pump 21. The ion remover 22 removes the ions from the tap water, and the deionized water is then returned to the secondary water tank (112). As a preferred embodiment, the ion remover 22 removes the ions from the tap water, and the conductivity of the deionized water is between 0-50 $\mu\text{S}/\text{cm}$. The liquid level sensor 51 in the coolant tank 15 detects when

the liquid level is less than or equal to 50%, in which the solenoid valve 1 411 opens, and the deionized water from the secondary water tank (112) is sent to the coolant tank 15.

Operation Principle: The machining fluid flows from the machine tool
5 machining fluid collection tank 18 to the machining fluid collection tank 16, while the coolant flows from the coolant tank 15 to the machine tool coolant tank 17. The diversion filtration assembly 3 separates the machining fluid, coolant, and impurities through the membrane filter. The machining fluid enters the inlet end 1 341, the coolant enters the coolant tank 15, and the impurities enter the impurity storage tank
10 13. The ion removal assembly 2 prepares the deionized water through the ion remover 22 and delivers it to the diversion filtration assembly 3. After mixing with the machining fluid, the deionized water enters inlet end 2 342 and is returned to the coolant tank 15. The system is automatically controlled by the control valve 33, the solenoid valve 41, and various sensors to ensure stable operation. The impurity
15 storage tank 13 is equipped with a impurity discharge valve 19 for periodic discharge of the impurities. A check valve 7 is installed in the pipeline 4 connecting inlet end 1 341 with the machining fluid collection tank 16 to prevent backflow.

The preferred embodiment has been described in detail above, but the application is not limited to the specific details of the above embodiments. Various
20 equivalent modifications can be made within the technical scope of the application, and these equivalents fall within the protection scope of the application.

Claims

1. A water-based coolant purification and recycling device for CNC Wire EDM machines, comprising:

- 5 at least one storage assembly (1), wherein the storage assembly (1) comprises at least one primary water tank (111), the primary water tank (111) comprising at least one machining fluid collection tank (16), at least one coolant tank (15), and at least one impurity storage tank (13). The primary water tank (111) is connected to at least one machine tool water tank (12)
- 10 through a pipeline (4), wherein the machine tool water tank (12) comprises at least one machine tool machining fluid collection tank (18) and at least one machine tool coolant tank (17). The machine tool machining fluid collection tank (18) is connected to the machining fluid collection tank (16) by the pipeline (4), and the machine tool coolant tank (17) is connected to the coolant
- 15 tank (15) by the pipeline (4);
- at least one diversion filtration assembly (3), wherein the diversion filtration assembly (3) comprises at least one inlet end (34) and at least one outlet end (35), wherein an inlet end 1 (341) is connected to the machining fluid collection tank (16) and an inlet end 2 (342) through the pipeline (4), an outlet end 1
- 20 (351) is connected to the coolant tank (15) through the pipeline (4), and an outlet end 3 (353) is connected to the impurity storage tank (13) by the pipeline (4); and
- at least one ion removal assembly (2), wherein the ion removal assembly (2) comprises at least one output terminal (24) and at least one outlet terminal
- 25 (25), the output terminal (24) is connected to the inlet end 2 (342) and an

outlet end 2 (352) by the pipeline (4), and the outlet terminal (25) is connected to the coolant tank (15) through the pipeline (4),

characterized in that the ion removal assembly (2) comprises at least one secondary water tank (112) and at least one external tap water source (23).

5 The secondary water tank (112) is connected to the external tap water source (23) through the pipeline (4) for replenishing tap water from the external tap water source (23). The ion removal assembly (2) comprises at least one ion remover (22), which is connected to at least one immersion pump (21) through the pipeline (4), the ion remover (22) sending deionized water through the
10 secondary water tank (112) and the pipeline (4) to the diversion filtration assembly (3), the diversion filtration assembly (3) comprises at least one membrane filter (31) and at least one water pump (32) for sending a machining fluid from the machine tool machining fluid collection tank (18) and the machining fluid collection tank (16) through the pipeline (4) to the inlet end
15 1 (341) and the inlet end 2 (342), for sending a coolant from the outlet end 1 (351) through the pipeline (4) to the coolant tank (15) and the machine tool coolant tank (17), and for sending impurities from the outlet end 2 (352) through the pipeline (4) to the outlet end 3 (353) and the impurity storage tank (13).

2. The water-based coolant purification and recycling device for CNC Wire EDM machines according to claim 1, wherein the water-based coolant purification and recycling device for CNC Wire EDM machines is connected to a control system, wherein the control system comprises at least one control valve (33), at least one solenoid valve (41), at least one temperature sensor (43), at least one pressure sensor (44), at least one cooling fan (45), at least one flow sensor (46), at least one liquid level sensor (5), and at least one conductivity sensor (6).

3. The water-based coolant purification and recycling device for CNC Wire EDM machines according to claim 2, wherein the control valve (33) comprises a control valve 1 (331) and a control valve 2 (332), the control valve 1 (331) connects the outlet end 2 (352) with the water pump (32) and the outlet end 3 (353), and the control valve 2 (332) connects the water pump (32) with the inlet end 1 (341) and the output terminal (24).

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4. The water-based coolant purification and recycling device for CNC Wire EDM machines according to claim 2, wherein the solenoid valve (41) comprises a solenoid valve 1 (411) and a solenoid valve 2 (412). The pipeline (4) connecting the outlet terminal (25) and the coolant tank (15) is equipped with the solenoid valve 1 (411), and the pipeline (4) connecting the secondary water tank (112) and the external tap water source (23) is equipped with the solenoid valve 2 (412).

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5. The water-based coolant purification and recycling device for CNC Wire EDM machines according to claim 2, wherein the pipeline (4) connecting the inlet end 2 (342) and the water pump (32) is equipped with the pressure sensor (44), the temperature sensor (43), and the cooling fan (45).

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6. The water-based coolant purification and recycling device for CNC Wire EDM machines according to claim 2, wherein the pipeline (4) connecting the outlet end 1 (351) and the coolant tank (15) is equipped with the flow sensor (46).

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7. The water-based coolant purification and recycling device for CNC Wire EDM machines according to claim 2, wherein the coolant tank (15) is equipped with a liquid level sensor 1 (51), the secondary water tank (112) is equipped with a liquid level sensor 2 (52) and the conductivity sensor (6).

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8. The water-based coolant purification and recycling device for CNC Wire EDM machines according to claim 1, wherein the impurity storage tank (13) is equipped with at least one impurity discharge valve (19).

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9. The water-based coolant purification and recycling device for CNC Wire EDM machines according to claim 1, wherein the pipeline (4) connecting the inlet end 1 (341) and the machining fluid collection tank (16) is equipped with at least one check valve (7).

10. A water-based coolant purification and recycling method for CNC Wire EDM machines, characterized in that it utilizes the water-based coolant purification and recycling device for CNC Wire EDM machines according to claims 1-9 to purify and recycle coolant, comprising:

- 5 the machining fluid in the machining fluid collection tank (16) is sent from the inlet end 1 (341) to the inlet end 2 (342) under the pressure of the water pump (32) and the control valve 2 (332). The machining fluid flows into the membrane filter (31) for filtration. It then flows out from the outlet end 2 (352), and undergoes a purification filtration cycle under the pressure of the water
- 10 pump (32) and the control valve 1 (331). A purified coolant is then sent from outlet end 1 (351) to the coolant tank (15);
- the flow sensor (46) detects when a current flow is less than half of an initial flow, at which the control valve 2 (332) opens. The deionized water from secondary water tank (112) and the output terminal (24) is sent to the inlet
- 15 end 2 (342) under the pressure of the water pump (32) and the control valve 2 (332). The deionized water flows into the membrane filter (31) for cleaning and recovering coolant. It then flows out from the outlet end 2 (352) and undergoes a cleaning recycling filtration cycle under the pressure of the water pump (32) and the control valve 1 (331); and
- 20 after a certain period of the cleaning recycling filtration cycle, the control valve 1 (331) opens, and the impurities are sent to the impurity storage tank (13), where the impurity discharge valve (19) can be opened to discharge the impurities.
- After discharging the impurities for a period, the control valve 1 (331) and the
- 25 control valve 2 (332) close, and the system returns to the purification filtration

cycle.

11. The water-based coolant purification and recycling method for CNC Wire EDM machines according to claim 10, characterized in that the pressure of the water pump (32) is 0.2-0.6 bar. When the current flow is less than or equal to 50% of the initial
5 flow, control valve 2 (332) opens to initiate the cleaning recycling filtration cycle.

12. The water-based coolant purification and recycling method for CNC Wire EDM machines according to claim 10, characterized in that the membrane filter (31) is made of polymer material with an ultrafiltration membrane (311) placed in the
10 membrane filter (31), comprising ultrafiltration membrane fibers in the ultrafiltration membrane (311) with a pore diameter of 40-100 nm.

13. The water-based coolant purification and recycling method for CNC Wire EDM machines according to claim 10, characterized in that:

15 the liquid level sensor 2 (52) of the secondary water tank (112) detects a low liquid level, at which solenoid valve 2 (412) opens to replenish tap water from the external tap water source (23);

the conductivity sensor (6) of the secondary water tank (112) detects a high conductivity, at which the tap water flows into the ion remover (22) by the
20 immersion pump (21) to remove the ions from the tap water and then is returned to secondary water tank (112); and

the liquid level sensor (51) of the coolant tank (15) detects a low liquid level, at which the solenoid valve 1 (411) opens to deliver the deionized water from the secondary water tank (112) to the coolant tank (15).

14. The water-based coolant purification and recycling method for CNC Wire EDM machines according to claim 13, characterized in that the low liquid level is less than or equal to 50%, the high conductivity is greater than 60 $\mu\text{S}/\text{cm}$, and the conductivity of the deionized water is 0-50 $\mu\text{S}/\text{cm}$.