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# Design and Manufacture of Intelligent Filter Processing System of Modular Cutting Fluid

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## Abstract

**For the needs of ecological protection and high-quality development in the Yellow River Basin, the project plans to design and produce the intelligent filtration treatment system of modular cutting fluid, which is caused by the massive application of cutting wastewater and the improper treatment will cause serious damage to the environment. Through the study of the action mechanism of semiconductor inorganic film on cutting liquid, the development and application verification of cutting liquid filtration system and the development of cutting liquid online monitoring system, a complete set of semiconductor inorganic film high strength toughness steel cutting liquid filtration technology and equipment is formed, providing technical support for green, high efficiency, energy saving and environmental protection cutting fluid treatment. To solve the problem of improper treatment of cutting waste liquid after the processing process of deep hole parts of high strength and toughness steel. Keywords: modularization, online detection, semiconductor inorganic film.**

## Keywords

**Modularization, Online detection, Intelligent filtering.**

## 1. Introduction

With the rapid development of high-end heavy equipment, the technology of deep hole machining is more and more widely used in machining. Cutting fluid has the functions of cooling, cleaning, rust prevention and lubrication in deep hole processing. Whether deep hole processing can run well largely depends on the state of cutting fluid, and a large amount of cutting fluid needs to be consumed in the processing process. Because the cutting liquid wastewater contains a large number of emulsified oil, additives (surfactants, corrosion inhibitors, defoaming agents), as well as waste oil, dust and metal debris and other impurities, and the cutting liquid composition is complex, some of the additives are toxic, carcinogenic and biological toxicity. Therefore, cutting fluid is a source of pollution from the perspective of environmental protection and human health. If it is directly discharged without recycling, cutting fluid containing a large number of harmful substances difficult to degradation will pollute the environment through water circulation, causing irreversible damage to the environment.

In addition, the recovery and utilization of cutting fluid is also an important measure to treat both the symptoms and root causes. On the one hand, the recycling of cutting fluid can not only avoid the regulatory pressure of the relevant legal system, but also has more environmental advantages, but also more in line with the new development concept. On the other hand, the recovery and utilization of cutting fluid has more economic benefits, which is mainly reflected in the following two aspects.1. Recycling and utilizing cutting fluid can reduce the cost of newly purchased cutting fluid and improve the economic benefits.2. Recycling and utilization of

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cutting fluid can realize the recycling and efficient use, reduce the production cycle time, and improve the production efficiency. To sum up, it is important and necessary to recycle cutting fluid from the perspective of environmental protection, legal theory and economic benefits.

## 2. Research Content

For the overall technical route of high strength and toughness cutting liquid intelligent filtration system based on semiconductor inorganic film. Suitable materials can improve the filtration efficiency and service life. Some common filtering materials include polyester fiber, polypropylene, glass fiber, etc. For the control equipment, the precision and reliability are the factors that must be considered. In addition, the intelligent degree of the equipment is also a negligible aspect in the design of filtering equipment.

In addition, the feasibility and effectiveness of the design should be verified experimentally. To verify the feasibility and effectiveness of the design, an experimental platform is needed. The experimental platform needs to be able to reproduce the actual working environment and operating conditions. Also, it needs to consider how to collect and analyze the experimental data. The experimental data can be used to verify the filtering effect and the accuracy of the theoretical model, while also reverse optimizing the experimental platform. The alignment of the experimental data can be divided into two ways. On the one hand, comparing the differences between experimental data and design data are needed to assess the accuracy and effect of the design. On the other hand, the differences between the experimental data and the theoretical models need to be compared to assess the accuracy and applicability of the theoretical model.

Finally, the recovery effect needs to be verified and the device performance evaluated. In this process, factors such as filtration efficiency, energy consumption, operation stability and so on of the device need to be considered, and compared and evaluated with the existing devices. Through these works, it can be determined whether the device can meet the design requirements, and make the corresponding adjustment and optimization. Finally, the desired experimental results were obtained, and the experiments were summarized.

## 3. Study on the Action Mechanism of Semiconductor Inorganic Film on Cutting Fluid

At present, the membrane separation method involves the separation membrane mainly includes organic film, composite film and inorganic film, the project for the different membrane material influence on filter performance do a lot of research and experiments, involves the materials including the PVDF polyvinylidene fluoride organic microporous film represented by the organic filter film, titanium metal film, alumina ceramic film, silicon carbide ceramics, etc. After experimental data and a large number of data, the filtration characteristics of such filter films are summarized.

According to the summarized experimental data and relevant data, the polymer organic membrane control means of membrane pollution and membrane cleaning methods are limited, mainly manifested as low flux, high operating pressure and the oil content of water is difficult to be stable. And the membrane is easy to deform, resulting in the change of the membrane aperture, and eventually lead to the unstable water quality of the effluent liquid. The imported organic membrane equipment has a large one-time investment, the membrane tube is easy to age, about 2 to 3 years, the operation energy consumption is large, the normal operation and maintenance cost is high, the treatment effect and membrane flux are unstable due to the concentration of cutting fluid wastewater, prone to the fast flux decline and low retention rate. Alumina ceramic film itself is britunchy, easy to collapse, and the alkali corrosion resistance is poor, the daily maintenance cost is high. Although the titanium metal film has high mechanical

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strength, good membrane flux and weldability, the metal film is greatly affected by the liquid environment, which is easy to decrease due to membrane pollution, acid and alkali corrosion and other factors.

Compared with the above filter film material, the semiconductor inorganic film is suitable for more than 90% oil and water mixture applications at the present stage. Specifically, compared with the polymer organic membrane, the semiconductor inorganic membrane material cost is lower, the pure water flux per square meter of membrane area reaches 3500L / hour, and the water is stable, its isoelectric point is near pH3, the membrane surface can maintain negative charge in a wide PH range, further ensure the pollution resistance of the membrane surface. Compared with alumina film and titanium metal film, semiconductor inorganic film is good hydrophilic, high porosity, large flux, small footprint, stronger corrosion resistance, long life, which greatly reduces the material cost and labor cost brought by film change.

The silicon carbide (SiC) ceramic film used in the project has the advantages of high strength, high hardness, acid and alkali corrosion resistance due to the covalent bond between non-metallic elements. Silicon carbide ceramic membrane can be divided into symmetric membrane and asymmetric membrane, symmetrical membrane structure single actual use effect is poor, so it is not considered. And the asymmetric membrane generally contains the support body, the transition layer, and the separation layer. The support body is generally made of raw materials with large particle size. The pores formed between particles has large pore size and high porosity, which has the advantage of high strength. The transition layer is 35 μ m-45 μ m thick, which covers the support body. The particles accumulate between the particles or enter the membrane hole of the support body, which can effectively reduce the pore size and improve the filtration efficiency. The separation layer plays a major role in the filtration process. The thickness of the layer is generally about 15 μ m, and the thinner the separation layer, the higher the filtration efficiency, and the smaller the energy consumption required in practical application. Figure 1 shows the SEM diagram of the asymmetric silicon carbide ceramic membrane. Due to the excellent filtration capacity brought by the structure of ceramic film, combined with material performance, liquid environment impact, cost and other factors, this project locks the filter material as the semiconductor inorganic film led by silicon carbide ceramic film as the main material of cutting liquid filtration experiment.

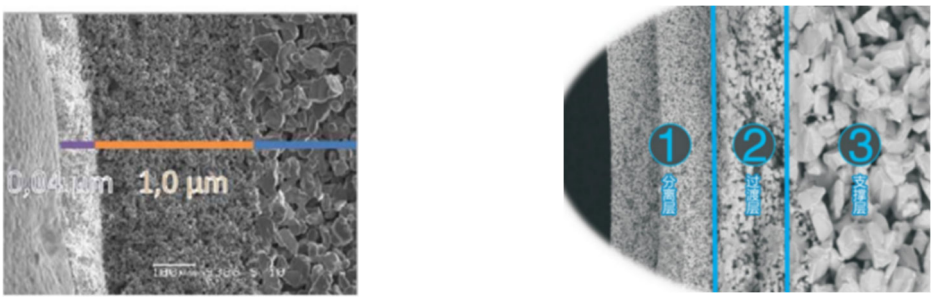


**Figure 1.** The SEM diagram and structure diagram of the asymmetric silicon carbide ceramic membrane

Therefore, in the early stage of the study, the hydrodynamic simulation of the internal flow field of the ceramic membrane element filter was mainly completed through CFD numerical simulation to analyze the filtration principle of the membrane element filter, as shown in Figure 2. For different inlet pressure and membrane aperture conditions, analyze the influence of inlet pressure and membrane aperture on the filter internal flow field and flow velocity, pressure and flux distribution.

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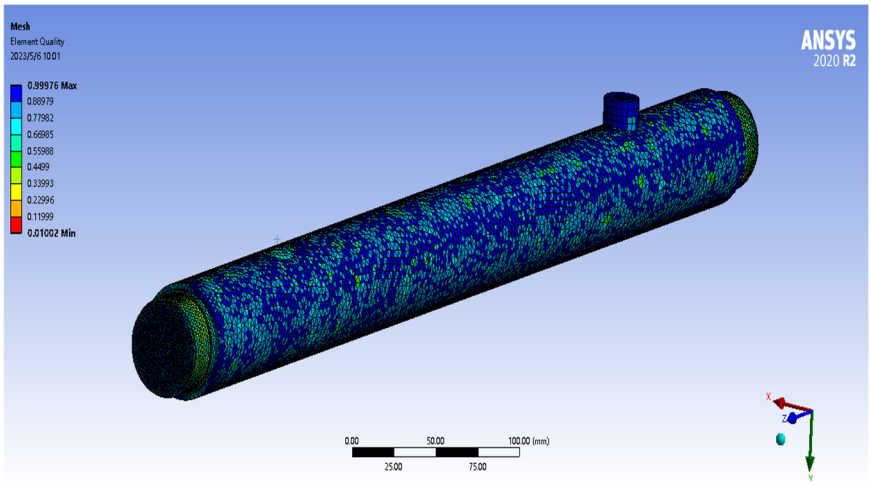


**Figure 2.** Ceramic film modeling and grid division

Then, through long-term corrosion test under extreme conditions, multiple groups of Ph filtration environmental flux experiments and multi-type processing liquid flux experiments, the filtration characteristics of three kinds of ceramic inorganic films represented by silicon carbide, aluminum oxide and titanium alloy on water-based cutting liquid and oil-based cutting liquid were revealed. Complete three kinds of ceramic inorganic membrane filter sample classification of physical and chemical properties detection, combined with the test results, to explore the ceramic inorganic membrane of cutting fluid conditions, summarizes the ceramic inorganic membrane filtration process flux stability change rule and discusses the results of cutting fluid filtration reuse value, get the most meet the actual conditions of cutting fluid filtration medium.

Inorganic membrane filter corrosion loss rule and contrast different material inorganic film filter experiment, for the membrane flux, cutting fluid COD content, solid mass, suspended matter content factors are analyzed, evaluate the performance of semiconductor inorganic film, using genetic algorithm analysis to optimize the change of different control factors under the membrane parameters, as shown in figure 3.

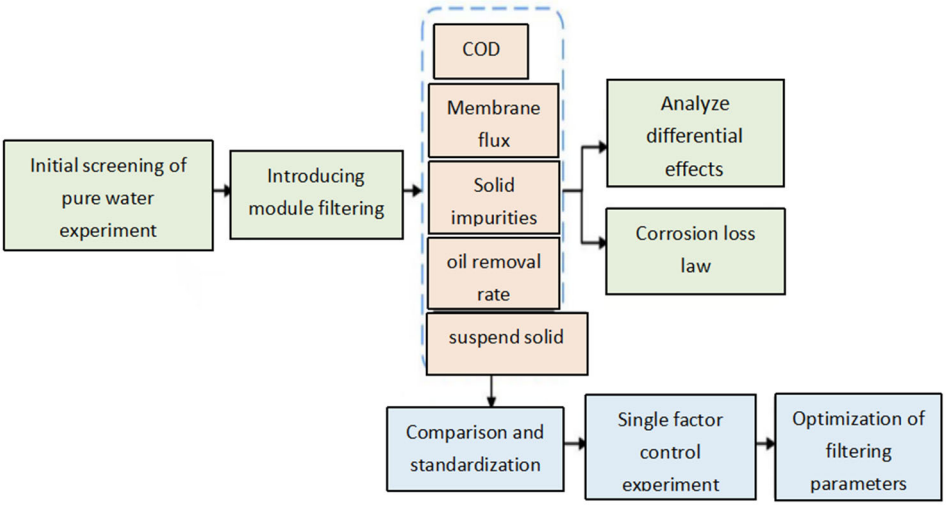


**Figure 3.** Study route of mechanism of inorganic membrane

ISSN: 2710-0588

## 4. Control and Monitoring System Design of The Cutting Liquid Filtration Device

The design and research content route of the online monitoring system are shown in Figure 4. The construction part of the online monitoring platform requires that the control part of the high strength toughness steel cutting liquid filtration system of semiconductor inorganic film should have the function of real-time adjustment parameters, and can monitor the working state of the filtration system in real time, and carry out timely overhaul and maintenance. The core of the control system adopts Xinjie XC-3 PLC as the control unit, and adopts Kunlun state touch screen to input parameters, monitor the running status of the equipment, and record the alarm data. Communicate through RS485 interface and reserve Ethernet interface. Its control hardware includes: control board, flowmeter, liquid level meter, thermometer, frequency converter, alarm and so on. The functions of the self-control system include: automatic filtration, automatic judging whether the filter element is blocked, automatic cleaning, regular operation (or stop), no liquid alarm (or stop filtration), automatic slag discharge, etc.

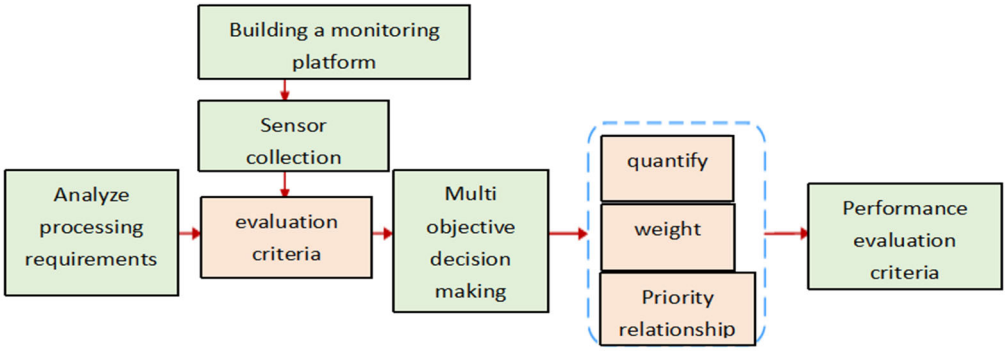


**Figure 4.** Design and research content of the online monitoring system

Main electrical components such as frequency converter, circuit breaker, AC contactor, thermal relay, intermediate relay, control button, indicator light are selected Chint; wiring terminals are domestic or joint venture products; all electrical metal components, including motors, cabinets and switches, have reliable grounding and protection measures; the system is equipped with emergency control button, which can stop system operation directly by manual operation in emergency situations.

The system operation process is the PLC to control the water pump operation. The running screen is divided into manual parts and automatic parts, and all the operation is carried out on the touch screen. The manual part is mainly used for system debugging and maintenance, and each execution unit can run independently; the automatic part is mainly used for the chain control process of system filtering and reverse cleaning. The stop time can be set on the touch screen. After the automatic operation of the system, when the pipe pressure exceeds the set value, the filter tank starts to reverse in turn and continues the filtration process; the lifting pump and supply pump will chain operation according to the liquid level of the tank. The whole operation process realizes unmanned operation, and the filtering and backwashing chain control process is stable and reliable. And through the control system to judge and achieve the automatic sewage discharge function. The concentrated liquid in the circulating liquid bucket is automatically pumped into the concentrated liquid bucket through the sewage pump. When the liquid level of the concentrated liquid bucket reaches the set liquid level, the control system will alarm.

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After the completion of the overall system, the application verification test of the strong steel cutting fluid filtration system of semiconductor inorganic film is carried out. The filtration test of the strong steel cutting fluid, the filtration efficiency, pH and other parameters of the cutting fluid are tested, and the recycled cutting fluid is used to verify the recovery and filtration effect of the cutting fluid.

The core PLC controller of the monitoring part selects the credit XC3 series programmable controller, which can expand 7 different types of modules and one BO board. In the process of XC3 analog acquisition, because there is an analog temperature mixing module XC-E2AD2PT2DA in the extended analog module of the PLC system, the module has 2 channels PT 100 as the temperature input, so the PT 100 sensor can directly access the analog input module for subsequent data acquisition and control process, the remaining sensors can be connected to other analog input and output modules, XC-E 6 TCA-P, XC-E2AD2PT2DA modules, each way can be separate PID control, can be self-fixed, Exchange exchange with the ontology through FROM and TO instructions.

## 5. Hardware System Design of The Cutting Fluid Filtration Device

The construction of the hardware system is promoted according to the following ideas: start the pumping pump, and the waste water reaches the filtration tank through the pipeline under the driving force of the pumping pump. After the coarse filter bucket and nano oil trap pretreatment, it is sent to the tubular filtration film group by the circulating pump for circulation filtration. In the process of filtration, the filter solution containing impurities can be discharged from the filter tank along the membrane surface or returned to the sewage liquid tank for filtration. The system uses compressed air, and the normal filtration function of the filter membrane can be restored after the impurities and the tank are hydraulic out of the filter tank. The collected dirty liquid can be precipitated, the upper cutting liquid can be returned to the dirty liquid pool to continue to participate in filtration, the lower precipitation can be cleaned to the slag collection box in the later stage of centralized treatment, and the cleaning bucket is conducive to the cleaning and maintenance of the device in the later stage.

According to the design requirements, the membrane element with the diameter of φ25.4mm, the number of channels and the diameter of φ 3.3mm, and the length of the membrane tube is 1230mm. The maximum processing capacity of membrane device: 0.5$m^3$ / hour; according to the reference test results, the single membrane flux is 100-200 L/h (adjusted as the situation), and 4 branches of membrane are required. During the internal pressure operation of the membrane element, the tangential fault flow speed of the surface of the membrane surface is 4-6 m/s, and the value is 6 m/s, then the circulation amount required by the device is 20$m^3$ / h, power 5.5kW, and head 45m. The circulating pump adopts centrifugal pump (frequency conversion control), and the pump body and pump cover both adopt metal matrix, which has the characteristics of wide range of corrosion resistance, high strength and durability. The circulation pump is connected with the circulation bucket and the cleaning bucket through the three-way valve, and the circulation pump switches the circulation bucket or the cleaning bucket through the three-way valve.

support blue support filter bag filter, produce the ideal solid-liquid separation to achieve the effect of liquid medium is filtered. Use stainless steel filter core, filter accuracy: 0.5um, used to intercept solid impurities and protect the pump and pipeline. The nano oil tank is hydrophilic and hydrophobic, the membrane material water passage speed, high oil separation purity, high separation efficiency, separation device, low separation cost, the other end of the oil nano oil tank is connected with the circulation bucket and the other end of the oil nano oil tank is connected with the circulation.

ISSN: 2710-0588

## 6. Conclusion

This project focuses on the demand of deep hole processing for the circulation filtration of cutting fluid and cutting liquid wastewater discharge in the actual production process, and studies the cutting liquid filtration material and its action mechanism, the online monitoring of various indicators during the service and the overall filtration system. The system can meet all the requirements of automation and stabilization of cutting fluid treatment system, and has good reliability and real-time.

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