Overview of Oil-water Separation Equipment Technology of Refined Oil

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Abstract: With the continuous development of social industry and economy, environmental problems are increasingly prominent. The disposal of oily wastewater needs to be addressed. As a physical separation method, gravity separation of oil and water has the advantages of low price, economic benefit, convenient maintenance and recyclable oil. This paper introduces the principle of gravity oil and water separation technology, expounds the research progress of gravity oil and water separation technology and equipment, and finally, puts forward the problems existing in the future development and puts forward some suggestions.

1. Introduction
Environmental problem is one of the most concerned problems in today's society. Oil is one of the important industrial raw materials and household articles. With the continuous progress of China's industrial development, oil exploitation and maritime transportation are also expanding day by day. Oil, lubricating oil, emulsified oil, edible oil and other kinds of oil are discharged into water without treatment, causing environmental pollution and waste of resources. This oily water is called oily wastewater[1]. There are many methods to treat oily wastewater, such as ultrafiltration, biological, flocculation and so on. Gravity separation method can effectively remove floating oil and dispersed oil from oily wastewater and achieve preliminary oil removal. It has been widely used both at home and abroad. After combining with the traditional gravity separation technology, the coalescence technology improves the oil removal efficiency and becomes the research focus.

2. Oil-water separation equipment technology of refined oil

2.1. Sources and hazards of oil-containing wastewater
Oil-containing wastewater comes from a wide range of sources. For example, oil industry[2] produces oil-containing wastewater in the process of oil exploitation, refining and transportation. The locomotive waste water produced in the transportation industry and the oil washing tank in the railway locomotive depot will also produce oily waste water. Food processing industry, textile industry, paper industry, leather industry and other production processes will also produce oily wastewater; Even people can produce oily wastewater in their daily life[3, 4].
Oily waste water will cause harm to the surrounding environment, which is mainly manifested in:

1. The discharged oily waste water contains a large number of hydrocarbon carcinogens that will be transmitted to human through animals and plants, causing harm to human health.
2. Floating on the surface of the water body forms a thin oil film, which prevents oxygen from the air from entering the water body and reduces the oxygen content in the water body, resulting in the death of organisms in the water. The dead and decaying of aquatic organisms will further reduce the self-purification function of the water body and cause the water body to produce peculiar smell, which will eventually degrade the quality of the water and make it lose its use value.
3. The remaining sludge containing waste water is discharged into the water body, and bacteria decompose it to produce a large amount of toxic and harmful hydrogen sulfide gas, which is harmful to human health [5,6].

2.2. Technology for separation of oily wastewater from refined oil products

Because of the variety of pollutants in the oily wastewater of finished oil depot, different treatment processes should be adopted according to different types of pollutants to separate the pollutants from water. In general, there are physical, chemical, physicochemical and biochemical processing processes [5].

Under normal circumstances, the processing process of oil-containing sewage in finished oil depot is as follows: firstly, oil-containing sewage enters the regulating grease trap, and after it is fully settled and precipitated, the surface oil slick is skimmed off to reduce the oil content so as to reduce the emulsification degree of oil-containing sewage; The sewage passing through the grease trap is then pumped through the lift pump into the dissolved air flotation device, and the dosing is carried out in the process. After mixing the sewage through the stirring system, the turbulent flow of water can make the oil droplets and suspended particles grow up quickly, so as to realize the light phase floating up, heavy phase sinking oil, water, solid three phase full separation, further remove the dirty oil; Then the effluent enters into the biochemical treatment system, transforming the refractory substances into substances that are easy to be biochemical treated and reducing the subsequent treatment load of the structures. Then it enters the two-stage contact oxidation tank, and adopts blast aeration to degrade most of the pollutants into harmless substances such as CO2 and H2O. Finally, the water is discharged after further removal of suspended matter, chroma and odor by biological carbon filter tank. Only the first stage of separation is described here.

2.2.1. Fundamental theory of separation. Gravity separation is a traditional physical method to separate oil from water. It is the use of oil and water miscibility and the existence of density differences. The separation of water and oil can occur in the stationary or flowing state. When two-phase liquid enters the separator, gravity difference is generated due to different density, and then the dense liquid phase will settle under the action of gravity, thus realizing two-phase separation. The working principle of gravity separation method is based on "shallow pool theory" and "Stokes law"[6].

The technology of coalescence separation [8,9] originated from the collision of raindrop and water drop, and later developed into a common separation technology in the industrial field[7,8,9]. The basic principle of this method can be divided into two types according to the different modes of dispersed aggregation: collision coalescence and wetting coalescence. The colliding coalescence mainly depends on the external force collision between droplets to realize coalescence. The key of coalescence lies in controlling the state of droplets after colliding. Wetting coalescing is to wetting and adsorbing the dispersed phase through a certain coalescing medium, so that the dispersed phase is gradually separated from the continuous phase and oil and water are separated. In practical industrial applications, collision coalescence and wetting coalescence are not independent of each other, but exist together.

2.2.2. Oil-water separation technology and equipment. At present, according to the separation principle, it is divided into parallel plate oil-water separator and coalesce-type oil-water separator. Parallel plate type oil and water separator is a number of parallel to each other, the spacing of the same
plate placed in the ordinary gravity oil and water separator. Coalescer can be divided into three types[7]: plate coalescer, packing coalescer and filter element coalescer. The plate coalescer uses the coalescer installed in the shell to separate oil from liquid. The two-phase plate coalescer is divided into inclined plate coalescer and corrugated plate coalescer. Corrugated plate coalescer has the advantages of simple structure, low energy consumption and high separation efficiency. The packing coalescing separator is a kind of separating device which can make the oil droplet bigger by coalescing bed. The filter core coalescer is used in the fine field of oil and water separation.

2.3. Development status of gravity oil-water separation equipment technology
At present, the combination of traditional gravity separation technology and coalescence separation technology has become the research focus. Now the close combination of the two will greatly improve the oil removal efficiency. The separation effect of the oil-water separator is affected by many factors. In order to improve the separation efficiency, several factors need to be analyzed one by one, such as the shape of the steady flow component, the material and shape of the coalescence plate, the placement of the internal components, etc. [10,11]. Then the optimization design is carried out.

In the study of oil-water separation inlet components, Ma Yangyang et al. [12] obtained through model simulation that spiral inlet components can further separate oil drops with small particle size. In addition, there are many scholars [13-17] through the method of numerical simulation to study this. Zhang Haitao of Tianjin University [18] used CFD software to simulate the inlet components (baffle type, orifice box type and centrifugal type) to effectively improve the internal flow field distribution, effectively buffer the impact of the inlet fluid on the initial flow field, which is conducive to the separation of oil and water. Chen Zhijun of China University of Petroleum [19] found through experiments that choosing appropriate inlet components can effectively improve the flow pattern and separation efficiency. At the same time, the structural parameters of inclined plate and corrugated plate are optimized.

In the study of flow stabilizing components, Shu Fangqi et al.[20] used CFD software to conduct numerical simulation, and found that "tian" shaped rectifier components installed at 0.5d after the inlet components can achieve a better rectification effect. Li Dongfang et al. [21] of China University of Petroleum can realize k-ε model and multiphase flow mixing model through FLUENT software, carry out numerical simulation on the three-dimensional flow field inside the gravity oil-water separator, and carry out quantitative research on the size of the backmixing area of the gravity oil-water separator. The results show that the Tian Zi plate rectifying component has better rectifying effect and the improved Tian Zi plate component (without holes above) can eliminate the reflux. The separation space flow characteristics and separation characteristics are better than the modified Tian Zi plate component Structure before entering. It provides a reference for the selection and design optimization of flow stabilizing components of gravity oil-water separator. Wang Xiaojing et al.[22] used Fluent numerical simulation software to conduct three-dimensional numerical simulation and analysis of the flow field characteristics in the oil-water separator, and the results showed that the internal and external sparse grid steady flow components had good oil-water separation characteristics.

On the research of polymer structure parts, Sun Zhiqian et al.[23] found on the basis of theoretical analysis and combined with experimental research that the reticulated corrugated plate structure has a good coalescence effect on small droplets, which can significantly improve the oil-water separation effect and shorten the residence time. Perforated corrugated board is next, and the wrong corrugated board is the worst. At the same time, three conditions for polymer structure with good performance were found, which provided a basis for further development of efficient and compact separation equipment. Liang Long et al.[24] work on the basis of theoretical analysis, use the RNG k-ε epsilon turbulence model and discrete phase model of two kinds of gravity oil-water separator fault by corrugated plate, no hole corrugated plate (SY3 type) and open hole corrugated plate (SY5 type) for experiments and simulation studies, get inside the corrugated plate holes droplets lifter can shorten the time and improve the separation efficiency. It provides the design and reference for the structure design of the oil-water separator and the type selection of the corrugated plate coalesce. Zhang liming
et al.[25] of China university of petroleum explored the connection between separation effect and internal component design. The order of the separation effect of different forms of coalescing plates and the phenomenon that the separator is most suitable for working conditions are verified. This study has guiding significance for recovery and economic benefit.

Li Penghao et al. [26] of China university of petroleum conducted numerical analysis on the flow field distribution and oil phase concentration inside the separator through Fluent simulation software, analyzed and compared the influence of different structural parameters on its separation effect, and completed the optimization of inclined plate packing. This research makes the structure of the gravity type oil-water separator more compact, which is beneficial to reduce its volume and footprint. Zhou Jian[27] based on the study of the structural parameters of the plate, obtained the best values such as the three-dimensional structure of the clustering second shift and the plate spacing of the coalescent plate. In addition, the influence of different inclination angles on the separation efficiency is studied[28].

In addition, the study of coalescing materials and coatings. Gao Zhifang etc.[29] based on coalescence of oil and water separation principle, specific analysis of the current used in the jet fuel filter separator coalescing filter element of the structure and material composition, and the coalescing filter composition of each layer of material in the fibre, fibre diameter, layer thickness and had been used to characterize the surface contact Angle and measurement, for coalescence filter design and research of the system provides a train of thought. In addition, many scholars and experts[30,31] have carried out researches in this field.

3. Research focus and development trend

The traditional methods of dewatering and separating diesel oil include gravity sedimentation, parallel plate coalescence, hydrocyclone and so on. But these methods can not remove moisture well, it is difficult to meet the demand for high-quality diesel. At present, the filter element coalescing separator is often used in the process of hydrocarbon separation in petrochemical industry. The coalescer is equipped with two filter elements, coalescing filter and separating filter, which are specially designed for dehydration of hydrocarbon media. Diesel oil passing through the inner part of the coalescer needs to go through four processes: filtration, coalescing, settling and separation, thus removing water in the medium. At the same time, we can learn from the filter on the internal combustion engine. It is a multi-stage filtration system, the whole system can be divided into three filtration: the first stage is the pre-filtration system, the second stage is the coalescing system, the third stage is the separation system, the filtration process can be simplified as: first remove the particle impurities, then coalescing from the diesel and separation of water.In other words, we can use the method of multi-stage separation and filtration to separate different substances in different stages to improve the separation efficiency of oil-water separation equipment.

In the future design, we should consider the mechanical properties, structural properties and thermodynamic properties of the components of the oil-water separator as much as possible, and conduct further research and exploration. Combined with mechanical design and computer simulation, the separation efficiency of the separator is improved, and the separator is developed in the direction of low pollution, low price and easy maintenance. From the perspective of overall design, the separator design is more reasonable and standardized, forming an effective and unified international design standard, and getting rid of the constraints of design relying on experience. For the internal components such as separator inlet members, rectifier members and polymer structure members, new materials, new structures and new technologies are studied to improve the performance of related components, and reduce the size of components as far as possible to achieve lightweight and economic. The theoretical analysis system of coalescence mechanism in gravitational field is more perfect, and the new coalescence structures generated by relevant theories can shorten the separation time, improve the separation efficiency, and reduce the cost of manpower and material resources. In addition to the gravity field, the coalescence separation in centrifugal field and electric field is vigorously developed, and the combination of gravity, centrifugation, electrodeionization, chemical methods, biological
separation, air flotation and adsorption are studied in the new oil-water separator to improve the separation efficiency by integrating various technologies.

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