Research Progress of Groundwater Pollution Prevention Technology in Petrochemical Enterprises

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Abstract. With the increasingly serious pollution of groundwater and soil, the stricter prevention indicators, seepage prevention technology as an effective way to prevent and cure the groundwater and soil pollution, its theoretical research has become a hot spot in the field of petrochemical and environmental protection. In this paper, domestic and foreign research progress on groundwater seepage prevention technology were reviewed. Then, division of seepage prevention, seepage prevention material, structure type of seepage proof layer present development were analyzed, the natural impermeable layer, flexible impermeable layer and rigid impermeable layer characteristics were mainly illustrated. Moreover, combing the research achievements of seepage prevention technology in China, some suggestions on main research direction of seepage prevention were put forward. And thus, significant demand on sustainable development of petrochemical industry can be satisfied better.

1. Introduction
In the process of storage and transportation of petrochemical products, the phenomena of "leakage, overflow and dripping" are easy to occur. When the pollutants are infiltrated from the ground into the underground water layer, it will lead to the pollution of the groundwater environment in the petrochemical field[1]. Since 2008, according to the regulations of the Ministry of environmental protection, the groundwater environmental assessment has become one of the contents of the review and approval of the petrochemical project[2], which requires a variety of prevention and treatment measures to prevent the occurrence of groundwater pollution. As the national environmental protection examination and approval index is more and more refined, the related departments pay more attention to the enterprise engineering behavior and the ground seepage prevention technology in the petrochemical industry is facing new challenges. The domestic research on seepage prevention technology starts relatively late and the treatment of groundwater environment is weak relative to the atmosphere and surface water environment. Therefore, it is imminent to strengthen the technology of anti-seepage in petrochemical industry in China. Based on this, this paper summarizes the current research status of water seepage control technology at home and abroad, and puts forward some ideas and suggestions for future research directions of seepage prevention technology.
2. Development generalizations
As early as 1960, the National Environmental Protection Administration issued the "Regulations on Prevention of Oil Pollution", which required all petrochemical projects to take measures to prevent groundwater pollution in the petrochemical area.

Due to various historical reasons, China's research on seepage prevention design started late. In the early construction of petrochemical projects, seepage prevention process are often ignored. In 2013, the China Petrochemical Corp led the preparation of the technical specification for the seepage prevention engineering of petrochemical industry (GB/T50934—2013), which became the only guiding standard for the current seepage prevention design of petrochemical enterprises in China. This specification has put forward specific measures for the zoning, design, construction, material, construction and quality inspection of pollution prevention and control requirements.[3].

3. Seepage prevention design

3.1. Area division of seepage prevention
Due to the large area of the petrochemical project, considering the economy and rationality of the project construction, it is necessary to divide the area of pollution prevention and control. According to the difference of the variety, property and concentration of the pollutants that leak to the ground in the petrochemical plant area[2], the region is divided into non pollution control area, general pollution control area and key pollution control area. Yepin He[4] analyzed the factors that should be considered in the division of the impervious area, and explained the importance of the zoning of pollution prevention and treatment combined with the examples. Xingsheng Du[5] put forward the method of typical pollution prevention and control in petrochemical plant area according to the difficulty of controlling the pollution and suggested that the seepage prevention grade of the petrochemical project should be determined according to the anti fouling performance of the natural gas zone and the groundwater environmental impact assessment conclusion. Chunbao Xiao[2] take the Anqing petrochemical project as the research object, detailing the design, construction and technical requirements of the seepage prevention project. As the first step in the prevention and control of groundwater pollution, regional seepage prevention should not blindly learn from the previous practices. According to the actual situation of various petrochemical fields, the optimization and adjustment of regional division should be carried out from two aspects of rationality and economy.

3.2. Seepage prevention material
In accordance with the principles of material availability and economic applicability[6], the seepage prevention materials selected by petrochemical enterprises mainly include natural impervious materials, synthetic organic impervious materials, cement-based osmotic crystalline impervious materials and impermeable cement with steel fiber.

3.2.1. Natural impervious materials. Natural impervious material refers to clay, bentonite, bentonite waterproof blanket (Geosynthetic Clay Liner, GCL) and the material by artificial modification to meet the requirements of seepage prevention performance[7]. The permeability coefficient of some clay can reach 10⁻⁷ cm/s can be used directly in petrochemical projects[8]. For example, the vertical permeability coefficients of compacted Prenjas clay and Wyoming clay are 7.26×10⁻⁸ cm/s and 3.1×10⁻¹⁰ cm/s respectively[9-10]. The adsorption rate of natural clay to naphthalene, phenanthrene and fluoranthene reached 39.76%, 78.09% and 97.60%[11]. It can be seen that natural clay has a strong ability to intercept pollution and can effectively block the migration and diffusion of underground pollutants in the petrochemical field. However, this kind of clay resources is very limited. For most clay that cannot meet the impervious performance, the method is to modify the modified material such as bentonite, activated carbon, zeolite and so on, so as to meet the impervious performance requirements. Many scholars have studied how to improve the performance of natural impervious materials[8].

Yangsheng Liu[12] studied the effect of bentonite admixture on the permeability of the material. The
study showed that the permeability of the modified material was most affected by the addition of 8% bentonite in the red soil, and the permeability coefficient after modification was equivalent to the 1/30 of the original soil. Zhihui Qu[13] made a double layer of bentonite and double cation organobentonite composed of 450℃ temperature roasting bentonite and double cation organic bentonite, respectively, to make a comparison between the two combinations of anti-seepage property and the ability to intercept the pollution. The results showed that the permeability coefficients of the two combinations were all lower than 1×10^{-7} cm/s and their pollution objects were different.

3.2.2. Synthetic organic impervious materials. Synthetic organic impervious material is usually called flexible membrane, which is a geomembrane composed of plastic film and non-woven fabric[14], mainly including polyethylene film (HDPE), PVC film, polyethylene film (PE) and so on. The HDPE film is the most widely used. HDPE seepage prevention film is a high density material. The primary resin of HDPE accounts for 97% of its content. The other components are carbon black, anti aging agent, antioxidant, stabilizer and other auxiliary materials[15]. The permeability coefficient of HDPE film is below 10^{-12}cm/s[16], and it has strong seepage prevention property. The HDPE impervious film is not hygroscopic and has good waterproof steam property[17]; it has good resistance to environmental stress cracking and tearing strength, strong anticorrosion performance and high tensile strength[18-19]. HDPE impervious membrane as a general material for environmental protection is widely used in environmental protection, water conservancy and municipal engineering seepage prevention[7]. However, the HDPE film is poor in bearing capacity and resistance to piercing, and the construction process is complex and expensive, so the experience of artificial synthetic seepage prevention materials used in domestic petrochemical enterprises is not much. Deqiu Zhang[20] introduced the Anqing petrochemical refining and chemical integrated storage and transportation supporting project, and expounded the technical difficulties, construction schemes and construction methods of the application of HDPE film to the tank foundation and ground floor seepage prevention. Feng Liu[21] outlined the general situation of the oil depot in Guilin, and discussed the application method of HDPE membrane in the oil depot.

3.2.3. Cement-based osmotic crystalline impervious materials. The cement-based osmotic crystalline material is an active chemical that uses water as the carrier to permeate the concrete, and forms the crystallization of the capillary in the concrete, thus making the concrete compacted and impervious[22]. Chengwu Zhang[23] compared untreated concrete with concrete adding XYPEX "sirbus" admixture. After adding an admixture, the concrete has formed a dense, internal space, so it can bear strong water pressure and the erosion of various pollutants for a long time. Hailong Wang[24] in the 30000 m² plant used the WP-501 admixture cement-based osmosis proof material, its permeability coefficient is lower than 10^{-12} cm/s, the seepage prevention project has passed the national environmental assessment examination and the implementation effect is good.

3.2.4. Impermeable cement with steel fiber. The steel fiber reinforced concrete is a new type of composite material formed by mixing the short steel fibers distributed randomly in ordinary concrete. Randomly distributed steel fibers can effectively prevent the expansion of concrete micro cracks and the formation of macrocracks[25]. Longbang Qing[26] is used to study the enhancement effect of the anti cracking properties of the disordered and directional steel fibers. The results show that the strengthening of the anti cracking performance of the directional steel fiber is better than that of the disorderly steel fiber. Xian Wang[27] combined with some successful cases at home and abroad, mixed steel fiber into concrete, and formulated the ratio of steel fiber to impervious cement. By comparison with traditional impervious materials, steel fiber penetration resistance can save about 30% of resources and greatly reduce the cost.

4. Conclusions
With the continuous improvement of the theoretical research on the seepage prevention technology in
petrochemical industry, based on the strict requirements of the state for the quality of the groundwater environment, in view of the effectiveness of the impervious measures and a more in-depth study should be carried out from the following aspects:

1. Seepage prevention design scheme. The area of the petrochemical enterprises is large, and the area of pollution prevention and control is difficult to be divided accurately. In the selection of the seepage prevention design scheme, it should be combined with the rationality of the pollution prevention and control area and the feasibility of the impervious measures to design a type of seepage prevention structure, which meets the environmental standards and technical requirements, and has strong operability and construction.

2. The quality and acceptance requirements of impermeable materials. In view of the fact that the products of HDPE membrane manufacturers in China are not good at all, the quality varies greatly, and the price of products varies greatly\[28\]. In order to improve the effectiveness and supervision of the impervious measures, the relevant departments should introduce the unified standards for the quality inspection and acceptance of impervious materials and perfect the quality supervision and management system of the impervious material.

3. Environmental impact assessment of groundwater seepage prevention. At present, the environmental impact assessment report on the petrochemical project pays more attention to air and surface water pollution. The treatment of groundwater pollution has not been promoted to the same status as surface water pollution\[3\], which leads to the more general and less guidance on the design of seepage control in the groundwater environmental impact assessment. It is suggested that the relevant departments take the standard as the lead, formulate detailed, complete and reasonable review requirements, and guide the petrochemical enterprises to take effective and effective measures to prevent seepage according to the risk assessment conclusions.

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