PTFE Application in Oilfield Development

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Abstract. This paper expounds the PTFE high molecular compound excellent physical properties and chemical properties, and resulting excellent chemical stability, corrosion resistance, weather resistance, electrical insulation, low friction and not sticky, etc. This paper introduces it has been widely used in various industrial areas, it emphatically analyzes the application and developing prospect of stable corrosion resistance in the oilfield development after coating processing of downhole drilling string.

Introduction

PTFE is abbreviation for polytetrafluoro ethylene, it is called fluorine nylon for short in our country, also called fluoride fiber, trade name in the United States and Japan is Teflon. In 1938, The Dr. R.S.Plunkett from Dupont research laboratory in New Jersey United States first invented the teflon[1], it was commercially available in 1946, and put into industrial production since 1954. PTFE is high crystallization of polymer of TFE monomer, a kind of synthetic polymer material hydrogen atoms are replaced by fluorine atoms , white, non-toxic, odourless. It's polymer molecules have been made up of $\left( \begin{array}{c} \text{CF2} \\ \text{CF2} \\ \text{CF2} \end{array} \right)$ structural units which are connected repeatedly, it is the latest engineering plastic which is used in various industries. Because of the excellent physical and chemical properties, corrosion resistance, weather resistance, electrical insulation, high lubrication, low frictional and non-viscosity, etc, is praised as "plastics king", "coating of never contamination", And obtain continuous development.

At present, PTFR has been widely used in national defence, aerospace, navigation, chemical, machinery, petroleum, textile, food, medical, electronics, environmental protection and other fields, application in oilfield development is increasingly extensive, and has great prospect.

Physical and Chemical Properties of PTFE

PTFE is a highly symmetrical linear polymers compounds and not with the polarity or contain any branched chain, thus excellent physical and chemical properties are formed.

Physical Properties

PTFE is high crystallization of polymer of TFE monomer, a kind of synthetic polymer material hydrogen atoms are replaced by fluorine atoms. Due to its special molecular structure, excellent physical and chemical properties are formed. General crystallinity of PTFE is 90 ~ 95%, the melting temperature is 327 ~ 342 °C. CF2 units in PTFE molecular range in saw tooth shape, due to the radius of fluorine atom is a little larger than hydrogen atom, so the adjacent CF2 units can't completely cross tropism, and they form a spiral twisted chains, fluorine atoms almost cover the entire surface of the polymer chain, so PTFE has excellent mechanical properties: because of low friction factor of PTFE, is the lowest of the existing synthetic materials, but also it remains the same between a wide range of temperature and load; surface tension of PTFE is minimal , it can avoid being wetted by liquid surface tension above 0.02 N/m, so it gets property of not adhere to any material . PTFE is the most difficult combustion of organic matter, it doesn't burn in the air, the
limit oxygen index up to 95%, it has excellent electric properties, is the ideal C grade insulating materials.

**Chemical Properties**

PTFE has chemical corrosion resistance, weather resistance. Except for molten alkali metals, PTFE can resist almost any chemical corrosion. Through experiments in concentrated sulfuric acid, nitric acid, hydrochloric acid and aqua regia, weight and properties of PTFE both are no change, and it is almost insoluble in all solvents, only slightly soluble in fully alkane at above 300 °C. PTFE don't absorption of moisture, it is non-combustible, and extremely stable to oxygen and ultraviolet radiation, so it has excellent weatherability[21].

**Application of PTFE in the Production Engineering**

As the oilfield has entered high water cut period, production engineering technology gradually enter the tertiary recovery phase, with application of high adhesion, strong corrosive solution such as polymer, ternary solution, the demands of downhole tools have improved further. Modified PTFE has good chemical stability to acid and alkali corrosive medium, it can be used in anti-corrosion engineering instead of metal, ceramics, particularly suitable for high temperature, strong corrosion occasion, and plays a vital role in the key corrosion parts of the downhole tool. In addition, PTFE is a kind of solid material with the minimum surface energy, Surface tension is only 0.019 N/m, almost all solid materials can't stick on the surface, Only below 0.02 N/m surface tension liquid can infiltrate the surface completely. It can effectively relieve the problem of tool wall scaling and easy blockage, when the high adhesion liquid such as polymer, the ternary solutions is injected into the downhole tools.

The image below is dissection of downhole tools (with downhole working of 8 months), there is no corrosion and scaling phenomenon on the coating surface.

![Figure 1. Inside surface of downhole tools.](image)

Technology of "Integration of the whole process of polymer flooding injection" meets the request of the polymers and the ternary solution in long-term work, spraying PTFE anti-corrosion coating on the key easily scaling parts of downhole tools, it can prolong the service life of tools more than 3 times, the problem of the downhole tools have to back operations due to the serious corrosion is solved. It makes the downhole tools long-term work in polymers, ternary solution possible, thus promoting the large-scale popularization of the technology of tertiary oil recovery.

Along with the progress of science and technology, the anti-corrosion equipments made of traditional anticorrosion nonmetallic materials is more perfectly developed, new corrosion resisting nonmetallic material products continuously turn up. Ptef anti-corrosion products outshine others in the tide of the rapid development of adopting new technologies, new materials in developing anti-corrosion new products. PTFE has high chemical stability, almost can tolerate all of the commonly used strong corrosion, strong oxidizing chemicals, it also has the characteristic of high temperature resistant, so it is a kind of ideal anticorrosion material, through the research of processing and molding process, application of PTFE products in the production engineering is much more widely [3].
Application of PTFE in Other Aspects of the Production Engineering

The Seals

Because of good heat resistance and chemical resistance of PTFE, it can be used as excellent sealing material. But considering disadvantages on the seal by the cold flow property of PTFE, in order to improve the ability to withstand pressure only can be made up by the design of the seal structure.

PTFE teflon tape has the characteristics of high strength, long fiber, and because of its large plasticity, good drawability, it is much more effective on the surface of uneven or precision structure through the test, it only needs very little pressure force applied can make parts completely sealed, it has very good sealing performance and corrosion resistance can be improved. Sliding parts using PTFE packing for sealing, has certain resilience compressibility, sliding resistance is small, and it can obtain good corrosion resistance stability. PTFE packing sealing materials can be used in wide temperature range, it is the main substitute of traditional asbestos gasket material currently, and it combines capabilities such as high modulus, high strength, creep resistant, fatigue resistance, and high thermal conductivity, thermal expansion coefficient and small friction coefficient, the application range can be expanded more by mixing different packing materials.

Friction Parts

PTFE friction parts are commonly used in mechanical engineering, including the piston ring, bearing (including porous copper impregnated plastic metal bearing) and gear, etc. In the case of piston ring, it is an important parts in power machinery, and related to the dynamic mechanical performance, the work environment is very harsh. Thus, it usually made of PTFE packing, not only no need of lubricating oil, but also has strong sealing function. Meanwhile, PTFE can be used by the motion transmission and power transmission components gears and bearings which working in the very harsh environment such as the printing, dyeing, paper making, textile and food industries. Because of its a number of advantages of corrosion resistance, little vibration, low noise, no pollution, light quality and good self-lubrication etc., Thus it has been widely applied[4].

Conclusion

Abroad research on the application of PTFE in recent years, has made it a very mature material. Although in our country it has certain development already, but there is a larger gap in its processing, molding process and modification research opposite with overseas. PTFE has excellent performance in many ways, and other materials are incomparable, its application field is very broad.

With the continuous development of PTFE application technology, its performance has been increased to a new level, and make many idea used unable to realize in the production engineering field into possible. After PTFE packing and modified, it not only can maintain its original features, but also can reduce the cold flow property and linear expansion coefficient, improve dimensional stability, abrasion resistance and thermal conductivity, and comprehensive mechanics performance is improved, thus it can be widely used in every area of production engineering, and used for the production of the seals, friction parts, corrosion parts and electrical insulating parts, etc. PTFE has a broad application prospect.
Reference


