



Application of Silicone Rubber in Textiles

Silicone rubber refers to the main chain of molecules to Si-O bond-based, the side groups are linear polymers of organic groups (mainly methyl groups). Its structure contains not only "organic group", also contains "inorganic structure", this special structure makes it both inorganic and organic polymer elastomer. In recent years, with the rapid development of silicone rubber industry, its temperature performance continues to accelerate, textile products have been extended to many special areas, these areas of the performance of textile products put forward high requirements. In this paper, on the basis of fully understanding the performance of silicone rubber, combined with the current development trend of organic silicone rubber, and introduced the application of silicone rubber in textiles, which described its performance and features, and the future development of the silicone rubber on textile.

1. The basic properties of the silicone rubber

1.1 Low temperature performance

Rubber has high elasticity, due to the thermal motion of rubber molecules weakened in low temperature environment, macromolecules and molecular chain segments are frozen, which will gradually lose elasticity. Two important factors affecting the low-temperature properties of the rubber are the glass transition temperature and the crystallization temperature. For all current rubber products, silicone rubber has the lowest glass transition temperature. Russian scientists made non-crystalline silicone rubber at $-60\text{ }^{\circ}\text{C}$, $-90\text{ }^{\circ}\text{C}$, $-100\text{ }^{\circ}\text{C}$ and $-120\text{ }^{\circ}\text{C}$ low temperature and rubber products can work long-term in the air, inert gas and vacuum environment. Some people improve the low-temperature performance of silicone rubber by copolymerization modification in the polydimethylsiloxane molecular chain on the introduction of other large volume groups. The principle is to destroy the regularity of molecular chains by using the large volume of structural units. This modification can make the glass transition temperature of silicone rubber increase slightly, but it can reduce the crystallization rate of silicone rubber, inhibit its crystallization, thereby improving the low temperature silicone rubber properties. With the study of silicone rubber properties, Ethyl silicone rubbers with the lowest operating temperatures of $-120\text{ }^{\circ}\text{C}$ to $-90\text{ }^{\circ}\text{C}$ were present. The minimum operating temperatures for various silicone rubbers are dimethyl silicone rubber (MQ) $-60\text{ }^{\circ}\text{C}$, methyl vinyl silicone rubber (MVQ) $-70\text{ }^{\circ}\text{C}$ to $-60\text{ }^{\circ}\text{C}$, phenyl silicone rubber $-70\text{ }^{\circ}\text{C}$, methylphenyl Vinyl silicone rubber $-100\text{ }^{\circ}\text{C}$ to $-70\text{ }^{\circ}\text{C}$, methyl ethyl silicone rubber $-100\text{ }^{\circ}\text{C}$, ethyl silicone rubber $-120\text{ }^{\circ}\text{C}$ to $-90\text{ }^{\circ}\text{C}$, fluorosilicone rubber (FMVQ) $-60\text{ }^{\circ}\text{C}$.





1.2 High temperature performance

There are two main processes for the thermal aging of silicone rubber: Firstly, the side chain of the main chain of oxidative decomposition, resulting in excessive crosslinking, the silicone rubber becomes brittle, hard. Secondly, the main chain scission, generates low molecular weight cyclic and linear polysiloxane oligomers, silicone rubber soft, sticky, which is mainly related to its main chain, side chain groups, terminal structure and the type of additives are closely related. Therefore, many scholars have made a lot of research in this field. It is proposed to improve the thermal aging resistance of silicone rubber by changing the main chain and side chain structure of polysiloxane, using new curing system, adding additives, adding silicon nitrogen compounds to improve the thermal aging properties of silicone rubber. At present, RTV silicone rubber has been able to work continuously at 150 °C for a long time, and can work continuously for 10 000 h in the environment of 200 °C, even some silicone rubber products can work at 350 °C for a short time. Although silicone rubber products are superior to other rubbers in heat resistance, they need to be able to work continuously at higher temperatures for a longer period of time, so the future development of the normal work at 300 °C silicone rubber as the focus of the study.

1.3 Weather resistance

Silicone rubber has excellent weather resistance, and it is not sensitive for ozone aging, even if a long time in the wind and rain, ultraviolet radiation and other conditions exposed to its physical properties will not be substantial damage. The silicone rubber nitrile rubber and styrene-butadiene rubber together placed in natural light, the first time to observe the rubber surface crack the time required, the results showed that nitrile rubber only six months to a year, while the styrene-butadiene rubber takes two years to two and a half of the time and the silicone rubber will take about 10 years. Another test is to expose the above three kinds of rubber under natural light to calculate the elongation to reduce the original half of the time required, the results show that nitrile rubber takes about 7 years, styrene-butadiene rubber takes about 4 years, while the silicone rubber It takes more than 10 years. These data indicate that silicone rubber has better Weather resistance than other rubbers.

1.4 Water resistance

Excellent water repellent properties of silicone rubber, which was soaked in water for a long time, can only absorb about 1% moisture, and will not cause damage to its mechanical properties and electrical properties. The water vapor test of silicone rubber found that under normal pressure, the water vapor will not cause





damage to silicone rubber, but with the pressure increases, the impact of silicone rubber will become increasingly evident. The data show that: 150 °C under high pressure conditions, polysiloxane molecular chain fracture, the performance of silicone rubber decreased, this situation can be selected by adjusting the appropriate intermediate material to improve the structure of silicone rubber, there are many modified silicone rubber products can withstand high temperature steam.

1.5 Corrosion resistance

Silicone rubber has a good resistance to oil, even at high temperatures, can also be a good resistance to oil erosion. In some common organic rubber, nitrile rubber and chloroprene rubber at 100 °C below also has excellent resistance to oil, but at a higher temperature silicone rubber can show than their excellent oil resistance. In addition, silicone rubber also has excellent resistance to organic solvents and chemical reagents, it is basically free from polar organic solvents, in non-polar organic solvents, silicone rubber will be swelling phenomenon, but unlike other Organic rubber degrades, and when the silicone leaves the solvent, it returns to its original state. Silicone rubber is poor on the strong acid resistance, thus should make attention when using it .

1.6 Other properties

In addition to the above-mentioned characteristics of organic silicone rubber there are other important properties. Silicone rubber is a good insulating material, the resistivity can reach 1~100 TΩ·m, and the insulation in a large temperature range can remain stable so it is ideal for some electronic components insulating material. Silicone rubber thermal conductivity rate is about 0.2W / mΩ·K, slightly higher than other rubber, is conducive to the production of friction surface with its equipment, such as textile machinery on the rubber roller. When the silicone rubber close to the flame is not easy to ignite, but once ignited will continue to burn down. By adding fire protection ingredients can make it self-extinguishing, and some silicone rubber products have passed the United States UL94 combustion performance standards. In the use of rubber gasket, due to high temperature, gasket deformation recovery ability is particularly important, silicone rubber compression deformation recovery ability to be stable at -60 °C~250 °C. Vibration in some mechanical products, rubber vibration absorption capacity of the gasket is also very important that the actual performance of silicone rubber gasket absorption vibration is also very good. In addition, silicone rubber also has good sealing, can be applied to the air bag airbags.





2. Application of silicone rubber in textiles

2.1 Buffer air bag

The United States used the silicone rubber as a cushioning balloon coating material launch Pathfinder Mars probe in the end of 1996. On the one hand, the lowest temperature of the surface of Mars is $-83\text{ }^{\circ}\text{C}$, thus requiring balloon coating material has good low-temperature rigidity; On the other hand, when the airbag inflator discharges high-temperature gas at a high speed, the strength of the airbag material is able to withstand an instantaneous strong impact load in a high-temperature environment. Practice has proved that silicone rubber successfully resisted the harsh space environment, the detector successfully delivered to the surface of Mars. Silicone rubber has excellent weather resistance, it is also used in the car's airbag, so as to effectively prevent the aging of the balloon coating to reduce the function of the balloon, the balloon in place after a long time can still be effective work. In addition, the buffer airbag is a precision airdrop, unmanned aerial vehicles landing areas of important components, at present, many people have carried out related research on this subject, the same balloon coating materials made of its stringent requirements, compared to other rubber Or coating materials, silicone rubber is the ideal choice

2.2 Softening agent

Softening agent is a kind of textile auxiliaries that can adsorb on the fiber surface, improving the smoothness of the fiber, making the fabric have a comfortable feeling. Silicone softening agent originated in the the end of the 1950s, so far, the development has gone through four stages: (1) the United States Dow Corning emulsified polymerization directly to produce hydrocarbon-based silicone oil firstly, that marked the birth of the first generation of silicone softening agent, but because of its use of mechanical emulsification method directly to emulsify the silicone oil, silicone oil does not contain active groups, which combined with the textile is not strong, and not washable. (2) On this basis, the researchers developed the metal as a catalyst, with a hydrocarbon-based seal of the second generation of silicone softener, which is still a single function, easy "Floating oil and demulsification", in the beginning before the industrialization of the third generation silicone softener replaced, before the start of industrialization was substituted with the third generation of silicone softeners; (3) Third-generation silicone softening agent is incorporated into the silicone backbone by the presence of reactive groups, these reactive groups can improve the soft effect, increase the fabric washable ability. (4) With the improvement of clothing requirements, the researchers introduce more active groups into the silicone main chain, so that





softening agent really applied to all kinds of fabric. At present, some people have been modified silicone softening agent, and its role in the textile industry is growing.

2.3 Fire - resistant insulation materials

The principle of thermal insulation cloth in textile products is different, but there are two kinds of: One is the use of functional particles plus resin for processing; the other is the use of coating materials coated on the fabric surface. Silicone rubber as a high temperature resistance material, is an important insulation coating material. Some people had researched silicone rubber aluminum insulation cloth in the early 1980s in China, fiberglass as base fabric, coated with silicone rubber in the surface, and then through the vacuum spray technology to foil an aluminum layer. This insulation cloth can be in $-60\text{ }^{\circ}\text{C} \sim 250\text{ }^{\circ}\text{C}$ long-term working, generally used in aircraft cockpit, umbrella cabin and booster cabin and other parts need to be insulated. Silicone coated glass fiber fabrics can be used as high-temperature anti-corrosion conveyor belt, some high-temperature protective gloves, asbestos insulation blanket, insulation blanket, high temperature service fabrics, glass fiber fire cloth and other products.

2.4 Insulation Materials

Silicone rubber coated fabric has a high electrical insulation level, which can withstand high voltage load, so as to be made of insulating cloth, sleeving and other products. In the electrical industry, insulating tape is a commonly used material, a lot of insulating tape is produced by rubber coated fabric, but there are many kinds of ordinary rubber can not meet the stringent requirements of the electrical industry, such as resistance to high voltage performance, adhesive properties, adhesion of hot air aging and anti-corrosion properties of metal, but the silicone rubber has advantages in these areas .

2.5 Screen printing Silicone

Silicone printing for textiles is a new hot spot in the textile industry in recent years, through the screen printing, silicone can be firmly attached to the fabric surface. Screen printing Silicone is widely used, its design has a strong three-dimensional, soft, printed pattern has a high peel strength, abrasion resistance, brightness, also has a waterproof, anti-skid and high temperature resistance. As the silicone rubber are easy to color, bright color, solid, its clothing, clothing accessories, shoes and hats, luggage and other handbags and other textile products are widely used.





2.6 Lace / ribbon dripping

For some clothing, especially women's underwear, stockings, etc., need to do some anti-skid treatment, to prevent clothing slippage. Lace has become an important decorative women dress, high-grade women's underwear, stockings roots will be modified with lace, but this part often occurs slippage, the use of silicone rubber dispensing process came into being. Silicone rubber treatment can achieve rounded, right-angle effect, three-dimensional sense of strong, excellent tear resistance, and contact with the human body comfort, both to ensure the beauty of clothing, but also to ensure its functional role.

2.7 Silicone cloth

Silicone cloth is a kind of high-performance and multi-purpose textile composite material, which is made of high-temperature resistant and high-strength glass fiber fabric and compounded by special technology. It is widely used in aerospace, chemical, petroleum, Equipment, machinery, metallurgy, electrical insulation, construction and other fields. Silicone cloth can also be used as the aforementioned fire-resistant insulation materials and insulation materials used, in addition to high temperature insulation, its main performance characteristics has high strength, soft and toughness, tailorability, chemical corrosion resistance, oil and water resistance. Some people had researched the performance of silicone cloth as a thermal gasket, and found that silicone cloth can not only ensure the insulation, but also can improve the thermal conductivity of insulation gasket, coupled with the strength of silicone rubber itself, making it a good performance in all aspects. Silicone glass fiber cloth coated with nickel chromium can be made into the aviation equipment, instrumentation often used in heating elements, in some of the more large products called electric blanket, its role is to rely on energy heat, by temperature control system to control the operating temperature of the instrument.

2.8 other aspects

The silicone rubber surface has a high friction, it can be coated on the surface of some anti-skid pad, anti-skid effect is better, such as the bath mat, car mats, etc. In addition, in some special clothing, the body needs to focus on the protection of parts coated with a certain thickness, a certain shape of silicone rubber can improve people's wear safety, such as racing suits knee, elbow, shoulder and other parts.

3 Conclusion

(1) In addition to silicone rubber has excellent temperature resistance, weather resistance, good water repellent properties and corrosion resistance, but also has





a very good electrical insulation, compression elasticity and vibration absorption capacity, these excellent properties of silicone rubber In many areas are widely used. In the textile field, silicone rubber can be applied in three categories of textile products, silicone rubber has become an important raw materials in textile industry.

(2) Silicone rubber is nontoxic, it does not cause pollution, and also suitable to replace the additives(will cause pollution) of the finishing process, while improving product quality, so silicone rubber will be widely used in textile finishing processes.

(3) The current technology can dye the color for silicone rubber, and it can change the color of silicone coated fabric to change the clothing color. Silicone surface is not easy to contaminate, it' s suitable for winter garments fabric. It' s believed that through the development of scientific research, this technology can be applied in textile products.

