Research on the Effect of Vulcanizing Agent and Vulcanizing Process on the Properties of Sealing Gasket

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Abstract. Rubber plays the role of elastic adhesive in the preparation of compressed rubber sheet gasket reinforced by non-asbestos fibre, and it has an effect on the comprehensive performance of gasket. The performance of rubber is influenced by the choice of vulcanizing agent and vulcanizing process parameters. Therefore, the tensile strength, compression-resilience, creep relaxation and leak rate of the non-asbestos gaskets are affected. By adjusting the ratio of vulcanizing agent and vulcanizing process, the properties of the gaskets were compared. The results show that the gasket developed by using the experimental results has excellent performance.

1. Introduction
The sealing material made of asbestos as reinforced fiber has been widely used in many industries for a long time due to its good sealing performance. Because asbestos is found to be a great harm to human health and can lead to lung cancer, asbestosis and other diseases, it is gradually banned by countries around the world. In recent years, it has become an urgent task to develop an excellent non-asbestos sealing gasket with non-asbestos fiber as reinforcing fiber. However, non-asbestos fibers are obviously different from asbestos fibers, especially non-asbestos fibers, which are usually negatively charged and difficult to bond with rubber. When non-asbestos fiber is used as reinforced fiber of sealing gasket, the preparation process becomes more difficult, especially the adjustment of curing agent and curing process.

In order to obtain the non-asbestos sealing material with excellent performance, the author compared the properties prepared by different curing agent systems and curing process parameters, and optimized them.

2. Experimental materials and methods
Vulcanization is a complex chemical and physical process. Under the action of pressure temperature and time, vulcanization crosslinking reaction takes place. With the help of vulcanizing agent, the rubber
molecular chain is transformed from linear to three-dimensional space network structure, which improves the elasticity and strength of the material.

### 2.1. Vulcanizing agent

Although vulcanizing agent is only a small part of the raw material, it plays an important role in the properties of gaskets. Vulcanizing agent, vulcanizing accelerator, vulcanizing active agent and anti-aging agent are often used in the preparation of sealing gaskets. This topic selects S, TMTD, MBT and ZnO. Five crosslinked density vulcanization systems have been developed to study the influence of different curing agent content on the properties of sealing materials.

| Scheme | S  | TMTD | MBT  | ZnO |
|--------|----|------|------|-----|
| 1      | 1.5| 1.5  | 1.0  | 5.0 |
| 2      | 2.5| 2.5  | 1.5  | 5.0 |
| 3      | 5.0| 2.5  | 1.5  | 5.0 |
| 4      | 2.5| 1.5  | 1.0  | 5.0 |
| 5      | 2.5| 3.0  | 2.0  | 5.0 |

### 2.2. Vulcanization technology

The influence of vulcanizing time, vulcanizing temperature and vulcanizing pressure on sealing gasket cannot be ignored. Vulcanization is easy to lead to solvent too fast volatile, which will cause the surface of the plate blister or even rupture. Pre-vulcanization is essential because it will allow the solvent to evaporate slowly.

The sealing gaskets were prepared by different vulcanization processes, and the vulcanization process was optimized by comparing their sealing properties.

Two vulcanization schemes are selected in this paper:

| Scheme | Pre-vulcanization | Vulcanization |
|--------|-------------------|--------------|
| Time (Min) | Temperature (℃) | Pressure (MPa) | Time (Min) | Temperature (℃) | Pressure (MPa) |
| 1      | 5   | 150  | 0    | 10  | 150  | 3     |
| 2      | 5   | 150  | 0    | 20  | 150  | 8     |
| 3      | 10  | 150  | 0    | 10  | 150  | 3     |
| 4      | 10  | 150  | 0    | 20  | 150  | 8     |

### 2.3. Methods for measuring performance

At present, the sealing performance test is generally carried out at room temperature. ASTM F37 provides methods for gasket sealing performance against gas and liquid media at room temperature, in which method A is only used for testing liquid and method B is applicable to both liquid and gas. This standard can be used to test the leakage rate of gaskets under different loads. Nitrogen is usually chosen as the test sealing medium. This standard is suitable for the evaluation of material stability, comparison between gasket materials and acceptance test due to certain limitations, as the specified specific pressure of gasket and internal pressure of medium are small, which are 20.7mpa and 0.2mpa respectively.

DIN3535 provides a test method for the permeability of gasket at room temperature, the specific pressure of gasket is 32MPa, and the internal pressure of medium is 4MPa. There are many options for
testing gasket dimensions, and the test can be carried out at high temperatures. The test condition is more close to the actual working condition, and the result can evaluate the sealing performance of the test gasket more accurately.

Other key performance, such as creep relaxation, tensile strength, compression-resilience, which are tested using asbestos gasket standard. They are ASTM F38, ASTM F152 and ASTM F36 respectively.

3. Results and Discussion
In order to analyse the influence of different material content on the comprehensive performance of gaskets, this paper conducted tests from four aspects: tensile strength, compression rebound, creep relaxation and tightness.

3.1. Effect of crosslinking system on performance
The properties of sealing gaskets prepared by different vulcanization schemes are shown in the table 3. The results show that the comprehensive performance of sealing gasket can be improved significantly with the increase of crosslinking density. The high crosslinking density accelerates the vulcanization rate of rubber, which makes the rubber and the reinforcing fiber fuse more fully. High crosslinking density will not further improve the performance of gaskets, on the contrary, it will make the material hard and brittle which are adverse to the sealing ability. The sealing gasket prepared by scheme 2 has the best comprehensive performance.

| scheme | tensile strength (MPa) | compression (%) | resilience (%) | leak rate (ml/min) | creep relaxation (%) |
|--------|------------------------|-----------------|----------------|-------------------|---------------------|
| 1      | 11.52                  | 18.03           | 34.98          | 1.28              | 35.28               |
| 2      | 13.86                  | 13.38           | 49.78          | 0.18              | 22.07               |
| 3      | 13.22                  | 10.88           | 43.65          | 0.58              | 25.33               |
| 4      | 12.44                  | 17.25           | 45.55          | 0.92              | 30.77               |
| 5      | 13.52                  | 12.37           | 46.93          | 0.74              | 28.67               |

3.2. Effect of vulcanization process on properties
When the vulcanizing time is 10 minutes, the vulcanizing temperature is 150°C, the vulcanizing pressure is 3MPa, the pre-vulcanizing time from 5 minutes to 10 minutes has little impact on the performance of the sealing gasket. The resilience and leak rate become worse with increasing precuring time.

When the vulcanizing time is 20 minutes, the vulcanizing temperature is 150°C, the vulcanizing pressure is 8MPa, the pre-vulcanizing time from 5 minutes to 10 minutes has an effect on the compression-resilience and sealing performance and no significant effect on other. It is obvious that increasing the pre-vulcanizing time from 5 minutes to 10 minutes cannot improve the sealing effect of gasket. The influence of vulcanizing time and pressure on the properties of gasket is further analysed. The purpose of vulcanization pressure in the vulcanization process is to eliminate bubbles, improve the density of gasket and strengthen the adhesion between fiber and binder, so as to improve the sealing and mechanical properties.
The test results showed that and the curing pressure increased from 3MPa to 8MPa, the properties of gaskets decreased when the curing time increased from 10 minutes to 20 minutes. Leakage rate increased to 0.48 ml/min. Improper vulcanization time and pressure lead to over curing. The gasket prepared by scheme 1 has the best performance.

4. Conclusions
The effect of vulcanizing agent and vulcanizing process on the properties of compressed rubber sheet gasket reinforced by non-asbestos fiber was studied and optimized:

1) Crosslinking densities has obvious effect on the properties of gaskets. Sulphur is selected as the vulcanizing agent, and its content is 2.5%; vulcanizing accelerator M and TMTD are 2.5% and 1.5% respectively; vulcanizing activator selectes ZnO and its content is 5%.

2) Too long pre-vulcanizing time will not improve the performance of gasket. Vulcanizing time, temperature and pressure have great influence on the properties of gasket. Gaskets have the best performance when pre-vulcanizing time, vulcanizing time, temperature and pressure are 5min,10min, 150°Cand 3MPa respectively.

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