Study on the preparation high performance microfiber glass blanket with high water resistance for buildings

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Abstract: The high performance microfiber glass blanket with high water resistance is mostly used as insulation and sound absorption materials in the construction field, such as roof insulation materials, wall insulation materials. The high performance microfiber glass blanket was prepared by centrifugal method with spraying binder. The influence of fiber diameter and aging time on the water resistance, strength, filtration efficiency and resistance was investigated. The results show that the optimum kiln pressure is 24±2Pa, kiln temperature is 490±5℃ and leakage current is 787±5mA; the optimum dosage of phenolic resin compound and water-resistant agent is 7% and 0.4% respectively; the fracture strength of the prepared samples in the direction of length and width is better than that of the same products abroad by using the above optimum preparation conditions. The microfiber glass mat was prepared by the flame method with spraying binder at the same time. The preparation condition of microfiber glass mat was mainly investigated and optimized. Shing currency was 787±5mA. The optimal added content of phenolic resin adhesive and water resistant agent was 7% and 0.4%, respectively. Through utilizing the optimal conditions, the prepared microfiber glass mat obtained more excellent mechanical properties than the overseas products.

1. Introduction

Microfiber glass blanket with high water resistance is mostly used as insulation and sound absorption materials in the construction field, such as roof insulation materials, wall insulation materials, auditorium and other building materials. Oversea 85% of microfiber glass blanket is used for insulation and sound absorption in building materials. Microfiber glass has the characteristics of fine diameter (<4μm), high porosity, small bulk density and non-flamability so that microfiber glass blanket has excellent sound insulation and thermal insulation properties. Microfiber glass blanket is a loose and porous mat material which is made of fiberglass cotton by bonding the fibers together and then cured by heating. It has excellent insulation, heat preservation and sound absorption performance, and is the basic raw material for sound insulation in aviation, high-speed rail and vacuum insulation panel (VIP) and other fields [1-3].

At present, the filtration microfiber glass blanket is mainly prepared by centrifugal sizing method and the diameter of the fiber is distributed in the range of 0.5 to 4μm. Compared with the ultra-fine fiberglass cotton fabricated by flame method, the diameter of fiberglass cotton fabricated by centrifugal method is thicker, which results in the poor sound insulation performance of the prepared felt. At the same time, because the glass fiber cotton prepared by centrifugal method is longer and the
sizing is not uniform, the glass fiber cotton felt produced has high hardness, high bulk density and poor comprehensive mechanical properties. Therefore, the manufacture of ultra-fine glass fiber cotton felt with finer fiber diameter and uniform sizing has become a research hotspot in the field of thermal insulation [4-6].

In this paper, the high performance microfiber glass blanket was prepared by centrifugal method with spraying binder. The influence of fiber diameter and aging time on the water resistance, strength, filtration efficiency and resistance was investigated.

2. Experimental method

2.1 Sample preparation

23.5 quartz sand, 11 soda, 4.5 potassium feldspar, 5.5 albite, 2.5 calcite, 8.5 borax, 6 dolomite, 1.5 barium carbonate and 1 zinc oxide were selected according to the weight ratio and mixed evenly in the kiln to melt the glass liquid with uniform composition and transparent impurities. Then the glass liquid was thrown out by high-speed rotating centrifugal disc. Ultrafine glass fibers, 95% of the diameter of the prepared Ultrafine glass fibers are normally distributed at 2.5-3μm, and 90% of the length of the fibers are normally distributed at 20-30mm. Acrylic acid mixed with 1% KH560 silane coupling agent is sprayed on the surface of Ultrafine glass fibers evenly, in which the injection pressure is controlled at 0.4Mpa and the injection pressure is controlled at 0.4Mpa. The flow rate is controlled at 200Kg/h, and then sucked into the cotton collector by negative pressure air induction to form dry composite ultra-fine glass fiber cotton. Finally, the dry composite microfiber glass blanket is cured at 600℃ for 8mins.

The surface and cross-section microstructure of the prepared microfiber glass sample was observed and characterized by KYKY 2800B scanning electron microscope (SEM). Since the glass sample is not electrically conductive, it is necessary to process the gold spray treatment before the observation.

For characterization of filtration performance of the prepared microfiber glass blanket, according to Washburn's formula, the through hole is regarded as a capillary with different apertures and lengths. Due to the effect of surface tension, if a completely wetted liquid is used, it will naturally fill the pore. At this time, another medium is used to overcome the surface tension by increasing pressure. To replace the liquid, when the pressure rises to enough to remove the infiltrating liquid with the largest pore diameter, that is to say, the bubble point pressure is reached and the corresponding pore diameter is the largest pore diameter. If the pressure continues to increase, there will be smaller pores gradually opened. Through the monitoring of the flow variation of the two curves of thousand sample and wet sample, the pore diameter fraction can be calculated. Gas permeability can also be calculated by dry curve with cloth, minimum aperture and average flow aperture.

3. Experiment and discussion

![Fig. (1) Microfiber glass blanket processing (a) with and (b) without binder](image-url)
The microstructures of the samples were observed by SEM. The measurement was carried out by cutting three samples with nominal size of 200*70mm from the prepared microfiber glass blanket. Make sure there is no caking, folding, folding or other protrusion on the surface of the material. When sampling, it makes sure to take one edge from the middle of the prepared blanket and the third one from the center. The length direction of 200mm is parallel to the length direction of the glass fiber coil. The other two pieces are taken from positions equal in width to both sides. Place the sample flat, flat but not tight. The average diameter of each specimen was recorded to 0.01mm. The arithmetic mean values of all five specimens were recorded as the diameter of the material. By comparing the with Fig. (1a) and without Fig. (1b) of the fiberglass precursor in the ultra-fine microfiber glass blanket, it can be observed that the glue has been uniformly sprayed on the surface of the fiberglass, and the sticky nodules are formed at the nodes of the fiberglass network structure, which makes the prepared microfiber glass blanket have better mechanical properties. As shown in Fig. (2), the normal distribution of average fiber diameter of prepared microfiber glass blanket were sampled and analyzed by SEM. The average value of the prepared samples was 1.98μm, the standard deviation was 0.24, and the range of values was 1.83-2.45μm.

The effect of microfiber diameter on the water resistance, strength, resistance and filtration efficiency properties of prepared microfiber glass blanket is shown as Fig. (3), as can be seen, the filtration efficiency of prepared microfiber glass blanket increases firstly with increasing the diameter of microfiber glass. Firstly, from the aspect of fiber fineness, the single fibers of the filter mat are arranged irregularly, and the smaller the linear density of the fibers is, the smaller the pore formed by them interlacing in disorder. At this time, the easier it is to intercept the dust passing through, the greater the filtration efficiency. So when the mixing ratio is small, the ultra-fine microfiber glass plays a leading role. The filtering efficiency of prepared microfiber glass blanket decreases slightly as the diameter microfiber glass gradually increasing; Secondly, from the aspect of cross-section of fibers, the specific surface area of fibers with special cross-section is larger, so the probability of collision between fibers and particles is larger, and the particles are easier to be trapped; when the filtering conditions are the same, the collision opportunity between fibers and dust particles is proportional to that of fibers. The cross-section effect makes the filtering efficiency of prepared microfiber glass blanket gradually improve.

Fig. (3) shows that the thicker the fiber, the easier the fiber structure unfolds, resulting in more effective fiber space structure. Therefore, with the decrease of the content of superfine fibers and the incorporation of microfiber glass with higher linear density, the surface of prepared microfiber glass blanket is smoother, and the resistance of strength decreases.
The effect of aging time on the strength, resistance and filtration efficiency properties of prepared microfiber glass blanket is shown in Fig. (4), as can be seen, for the adhesive prepared microfiber glass blanket, the aging time increases greatly after the temperature rises to 75°C followed by the particle size of 0.17μm, the filtration efficiency of prepared microfiber glass blanket was almost stable. But the efficiency decreases greatly, followed by the particle size of 0.39μm and the particle size of 1.22μm cannot see the change of m because the efficiency is close to 100%. For non-adhesive prepared microfiber glass blanket, after the temperature rises to 75°C, it still follows the previous trend of change and there is no sudden change. The MPPS point of the efficiency curve moves right to about 0.17μm. The MPPS point moves to the right and the efficiency curve of the rubber filter paper changes abruptly, the strength and resistance value increase with the aging time rising. Therefore, when the test is carried out according to the standard conditions, the efficiency value obtained by MPPS method is on the safe side. The primary glass filament strand is formed by glass liquid passing through the leaky plate. The primary glass filament strand is melted and pulled into ultra-fine glass fibers under the action of high temperature and high speed flame airflow. The solution containing adhesives and processing aids was evenly sprayed on the surface of superfine glass fibers and evenly dispersed on the forming net.
Fig. (4) The effect of aging time on the strength, resistance and filtration efficiency properties of prepared microfiber glass blanket

4. Conclusion
The glue has been uniformly sprayed on the surface of the fiberglass, and the sticky nodules are formed at the nodes of the fiberglass network structure, which makes the prepared microfiber glass blanket have better mechanical properties. The average value of the prepared samples was 1.98μm, the standard deviation was 0.24, and the range of values was 1.83-2.45μm. The thicker the fiber, the easier the fiber structure unfolds, resulting in more effective fiber space structure. With decreasing of the content of superfine fibers and the incorporation of microfiber glass with higher linear density, the surface of prepared microfiber glass blanket is smoother, and the resistance of strength decreases. The solution containing adhesives and processing aids was evenly sprayed on the surface of superfine glass fibers and evenly dispersed on the forming net.

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Reference
[1] Les S. Chapter 3-Hydraulic unit equipment features. Hydraulic Rig Technology and Operations, 2019, 59-187.
[2] Xu B B, Chen D Y, Li H H, Zhuang K Y, Hu X, Li J W, Hans I, Kong J H, Edoardo P. Priority
analysis for risk factors of equipment in a hydraulic turbine generator unit. Journal of Loss Prevention in the Process Industries, 58 (2019) 1-7.

[3] Babak K, Gholamreza J, Kamran S, Mohammadreza N. Scaling and thermal-hydraulic design of a test loop for the VVER-1000 reactor. Progress in Nuclear Energy, 113 (2019) 18-27.

[4] Ghiban B, Safta C A, Ion M, Crina E C, Grecu M C. Structural aspects of silt erosion resistant materials used in hydraulic machines manufacturing. Energy Procedia, 112 (2017) 75-82.

[5] Yu, H, Sneha S. Fibrillated fibers for liquid filtration media. US Patent 9511330. Dec. 19, 2013.

[6] Cambo W H, Huang M T. Pleatable composite filter media. US Patent 8545607. Oct. 1, 2013.

[7] Dorner C, RÜhe J. Wetting of silicon nanograss: From superhydrophilic to superhydrophobic surfaces. Advanced Materials, 20 (2008) 159-163.

[8] Si Y, Guo Z. Superwetting materials of oil–water emulsion separation. Chemistry Letters, 44 (2015) 874-883.

[9] Zhu Y Z, Wang D, Jiang L, Jin J. Recent progress in developing advanced membranes for emulsified oil/water separation. NPG Asia Materials, 6 (2014) 101-111.

[10] Huang M, Si Y, Tang X, Zhu Z, Ding B, Liu L, Zheng G, Luo W, Yu J. Gravity driven separation of emulsified oil-water mixtures utilizing in situ polymerized superhydrophobic and superoleophilic nanofibrous membranes. Journal of Materials Chemistry A, 45 (2013) 14071-14074.

[11] Lin X D, Heo J W, Jeong H J, Choi M Y, Chang M W, Hong J K. Robust superhydrophobic carbon nanofiber network inlay-gated mesh for water-in-oil emulsion separation with high flux. Journal of Materials Chemistry A, 4 (2016) 17970-17980.