STUDY ON FLUID-SAND (STONE-SAND) METHOD FOR HIGH-VOLTAGE FUSE

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Abstract. In this paper a new fluid-sand (stone-sand) method used in high-voltage current limiting fuse was studied. It may simplify the solidification process of silica sand, reduce the production period and cost raising the efficiency of production. Consequently it deserves to be extended in production. The new process involves three steps. Firstly, mix silica sand with sodium silicate solution of modulus 1 to make sodium silicate crystals filmed on the whole surface of silica sand, and then a certain amount of pure alcohol is added to dehydrate the mixture which will become fluid similar to dry sand. Finally, dry the mixture in an oven at constant temperature till to get enough strength. Moreover, the mechanism of adhesion in the mixture was studied and the breaking capacity of fuse with solidified silica sand was tested showing much better performance than that of ordinary silica sand.

INTRODUCTION

So far, silica sand is quite widely used as arc extinction medium in electric fuse. Furthermore, the breaking capacity of fuse can be much improved by using the technology of stone-sand. That is why so many manufacturers in the world produce their fuses with stone-sand as arc extinction medium to meet their consumers' requirement. Consequently, the stone-sand method is in need of further study.

Generally, the stone-sand method can be briefly described as follows:

Blending Stone-Sand Method

Mix sodium silicate solution of certain modulus with silica sand, stir the mixture well to clayish state, then fill it into a fuse cartridge compactly and tightly. Finally, keep the fuse with the mixture in an oven at constant temperature till dry, then cool down. The shortcomings of this process involve: to fill the mixture in a fuse cartridge needs great effort; the compactness of silica sand can not be what is expected; and to make the mixture dry enough requires much electrical energy consumed, thus lengthen the production period.

Stone-sand Vacuum Method

Fill silica sand in a cartridge of fuse, then place the assembled fuse in a vacuum-tight vessel. Vaccumize the vessel to a certain degree of vacuum, then inject sodium silicate solution. Finally, dry silica sand infiltrated with sodium silicate in an oven at constant temperature. The method is characterized by high efficiency, but too much electrical energy is needed due to the lengthy time of drying.

Stone-sand Sodden Method

Place the assembled fuse with silica sand in a proportionally prepared sodium silicate solution which will infiltrate into silica sand through the hole where silica sand was poured , till silica sand is wholly sodden. It will take a long time to make silica sand sodden with sodium silicate solution and dry the infiltrated sand. The method has similar shortcomings as mentioned above.

Fluid-Sand (Stone-sand) Method

Make sodium silicate crystallize on the surface of silica sand to form a film which will have the quality of flowing as easily as dry silica sand with no film. When the filmed sand is filled in a fuse cartridge to enough compactness, only vibrating operation of fuse cartridge is required with no tamping necessary. It takes less time for drying sand, so high in efficiency. This is supposed to be an advanced than stone-sand method.

ADHESION MECHANISM OF FLUID-SAND METHOD AND MIXING TECHNOLOGY

Adhesion Mechanism.

The modulus of sodium silicate solution commonly used in the foundry ranges from 2.0~3.3 with specific gravity between 1.3 and 1.5 approximately. Fig. 1 shows the trielemental phase diagram of Na_2o-Sio_2-H_2o (Isothermal section), where the material in the region 1 enclosed by the dashed lines (Shadow Portion) is of a table colloidal solution, but the material in the region is under unstable state where sodium silicate crystallizes out and the saturated solution of sodium silicate is formed. In region 3, there are sodium silicate crystals set out from the solution.

When some amount of sodium hydroxide is added to adjust the modulus of sodium silicate to 0.7~1.2 and make the solids($Si0_2$+Na_20) content to 40~50% by weight, mix this solution of low modulus

with silica sand. At this time there will be sodium silicate depositing on silica sand and forming a thin film on the surface during mixing. Naturally, the sand filmed like this will have the similar quality of flowing like that unfilmed. So it is called "fluid sand".

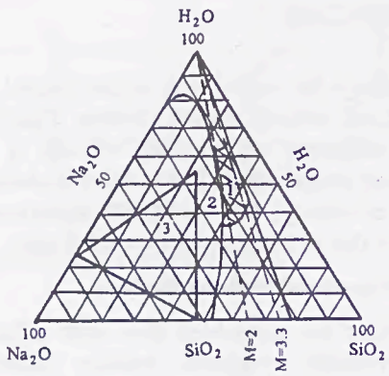

Fig. 1 Trielemental phase diagram of Na_2o-Sio_2-H_2o

In order to speed up the deposition of sodium silicate solution with low modulus, some hydration agents like alcohol are often applied to improve the quality of flowing of sodium silicate. Meanwhile, the evaporation of alcohol will take some heat away by which the undesired drying effect of wet sand is avoided and that will be convenient for the subsequent technical process.

Mixing Technology

Silica sand is mixed with the proportionally prepared sodium silicate solution by a specialized mixer of 500 mm in diameter at 36 rpm for this purpose. Meantime pure alcohol is properly poured in the mixer. Let the mixture be agitated for about 10 minutes.

EFFECT OF SODIUM SILICATE ON FLUID SAND

Modulus of Sodium Silicate Solution

In the preparation of fluid sand , the proper modulus of sodium silicate solution is the key technique for the sand solidification. Effect of the modulus on the fluidity and strength of fluid sand is shown in Fig.2. It can be seen that the modulus too high or too low will significantly affect the fluidity and strength of silica sand as shown in Fig.2. The optimal modulus prepared is between 0.9 and 1.0, in which the collapsing diameter is 360 mm, the compactness greater than 1.22g/cm^3 and the dry shearing bigger than 10.5kg/cm^2.

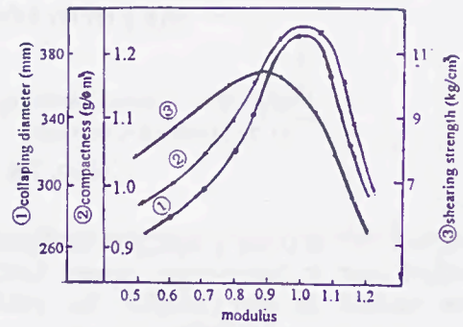

Fig.2 Effect of the modulus on the fluidity and strength of fluid sand

Influence of Weight Percentage of Solids in Sodium Silicate Solution

Fig.3 shows the effect of solids content in sodium silicate on the fluidity and strength of fluid sand. In general, the best choice for the solids content in sodium silicate is 40~50% by weight. If it is lower than 40% by weight, the indexes of collapsing diameter, compactness and dry shearing strength will be depreciated.

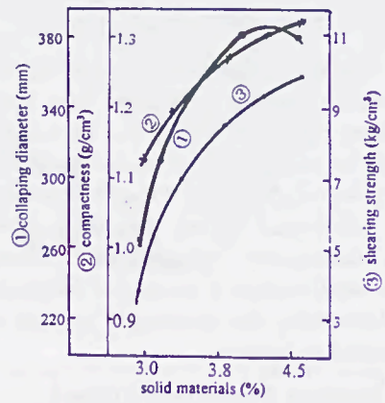

Fig.3 The effect of solids content in sodium silicate on the fluidity and strength of fluid sand

Ratio of Sodium Silicate Solution to Silica Sand

Fig.4 shows the effect of ratio of sodium silicate solution to silica sand on the fluidity and strength of fluid sand. The ratio nearly makes no influence on the fluidity of fluid sand , but exhibits an obvious and great effect on the strength of fluid sand. The more sodium silicate solution is mixed, the higher the strength of fluid sand will be. The ratio of 1.5% is the optimal percentage to be chosen in consideration of the dielectric strength of silica sand.

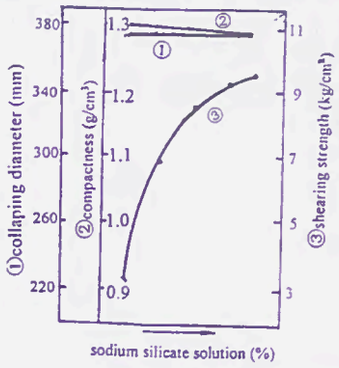

Fig.4 The effect of ratio of sodium silicate solution to silica sand on the fluidity and strength of fluid sand

Effect of Standing Time of Fluid Sand in Fluidity

As soon as the fluid sand is prepared, it should be used up for filling the fuse cartridge within 1hr. Otherwise, the fluidity of it will be lessened. It becomes solidified and adhered together, forming small solid blocks and can no longer be used.

Effect of Various Solidification Methods on Fluidity

Base on the adhesion mechanism of fluid sand, sodium silicate crystals will be dehydrated when exposed in air and become effloresced and solidified finally. The sample fuse was experience by heating in an oven in addition to natural drying for solidification. The experimental results show that when the fluid sand mixture is prepared and immediately kept in an oven at 100℃for 20~30 minutes, the dry shearing strength is read higher than 10kg/cm^2.

Effect of Sand Mixing Process

The mixing process for fluid sand should strictly follow that the surface of sand must be evenly covered by sodium silicate solution, the crystals of which will be deposited on to ensure the good fluidity of sand. The time is critically important in this process. In the very beginning of the mixing process, fluid sand is viscous. With the time elapsed the sand becomes fluid. When small amount of alcohol is added, the sand viscosity becomes obviously less. Therefore, the time of sand mixing should be well controlled. Otherwise, the fluidity of sand will increase while the strength of it will decrease. Normally, the time of sand mixing needs 3~5 minutes, then small alcohol is poured in. Stirred for 2~3 minutes, the mixture can be filled into the fuse cartridge.

EXPERIMETAL RESULTS

The electric fuse with silica sand prepared following the above process was conducted for the short-circuit current breaking capacity and antioxidant ability tests

Short-circuit Current Breaking Capacity Test

Three fuse samples with fluid sand solidification were tested to interrupt the short-circuit current as high as 35.2 kA. The experimental results show that the samples fuses exhibited good current limiting characteristics. The peak value of current is 5.2 kA.. The fuse elements was deserved uniform burst when the samples detached apart.

Antioxidant Ability Test

The copper fuse element was assembled with solidified sand by fluid-sand method. The fuse was continuously tested with a rated current of 50A for one year, and then the resistance of fuse-element was measured. The experimental result showed that there was little change in resistance and no obvious oxidation was observed on the surface of copper element.

CONCLUSION

The fuse with copper fuse element and silica sand prepared by the fluid sand method shows the breaking capacity as same as ordinary current limiting high voltage fuse. with silver

No obvious oxidization on the surface of copper element. The new stone-sand method deserves to be widely extended in the field of high-voltage fuse.

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