RESEARCH ON THE TECHNIQUE OF FILLING QUARTZ SAND IN FUSE

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ABSTRACTS

The performance of fuse can be improved by filling in the cartridge of fuse compactly with quartz sand. The higher filling compactness can be gained, when the fuse link is fixed on the plane of a vibration stand with an inclination of 10 degrees and submitted an impacting vibration in horizontal direction, the vibration frequency should be changed adequately in the course of vibration.

1. INTRODUCTION

Filling in the cartridge of fuse with appropriate quartz sand may provide two effects, first, the quartz sand can be served as an arcing-quenching medium, which would raise the breaking capacity of fuse; second, it is also a heat dissipation medium for lowering the temperature of fuse; The chemical composition, shape and size etc of quartz sand can all effect the performance of fuse. Then the filling compactness of quartz sand can also effect it directly. Generally speaking, the more compactive the quartz sand is filled, then the higher the breaking capacity of fuse will be and the lower the temperature will be.For the same property and breaking capacity of fuse, the more compactive the quartz sand is filled, the more well-knit the volume and structure of fuse can be made and the more the cost can be reduced. So it becomes one of the important techniques of fuse whether the quartz sand is filled compactly or not. What is the best way to fill quartz sand? You can get the answer in this paper.

2. The method of filling quartz sand and its evaluation criterion

The method to fill quartz sand in fuse is to put the fuse link on the vibration stand, and makes it vibrate with the vibration stand continuously, then the quartz sand in the quartz box are poured into the cartridge through the tube and hole until it is full. Obviously, the filling compactness depends on the vibration mode of vibration stand and the mounting mode of fuse link.

2.1 The following four vibration modes are adopted

A. Vibration in horizontal direction
The fuse link vibrates right and left with the vibration stand in the horizontal direction. The amplitude and vibration frequency of vibration stand can be adjusted.

B. Impacting vibration in the horizontal direction
The fuse link vibrates with the stand in horizontal direction, at the same time an impacting force is applied on the fuse link (about 5 kgf) in the horizontal direction.

C. Vibration in vertical direction
The fuse link vibrates up and down with the stand. The amplitude and frequency of the vibration of the stand can be adjusted.

D. Impacting vibration in vertical direction
The fuse link vibrates up and down with the vibration stand, at the same time an impacting force is applied on the stand with a specific frequency.

2.2 The following two mounting modes of fuse link on the vibration stand are adopted

A. Fuse link is fixed vertically on the vibration stand

B. Fuse link is fixed on the plane of the vibration stand at different inclination

Various mothods of filling with quartz sand are established by using the above-mentioned different modes of vibration and mounting,the tests of the compactness of filling with quartz sand in the fuse link have been made one by one and the best method of filling has been found. The vibration amplitude on the vibration stand of the fuse link may be 0.4, 0.3, 0.25, 0.2, 0.15 mm, the frequency may be 55, 52, 50, 48, 45, 40, 30, 20 Hz, the vibration time may be 2.5 min, the filling hole of fuse link are all covered with quartz sand during the filling. In order to establish a criterion for evaluation of different methods, we adopt a conception of compactness ΔQ:

$$\Delta Q = \frac{Q - Qo}{Qo} \times 100\%$$

where: Qo the weight of filled quartz sand before vibration,
Q the weight of filled quartz sand after vibration.
For defining the weight of quartz sand of every fuse link, the measurement is carried out three times and an average value is adopted. Quartz sand filled by little and little through the filling hole from the tube near the cover. The quartz sand is weighed with the balance of 0.01 g precision. The granule diameter and chemical composition of quartz sand used in the test are indicated in Table 1.

Table 1

Granule Diameter	Chemical Composition and Content %					
mm	SiO_2	Al_2O_3	CaO	MgO	Fe_2O_3	Loss due to burnout
0.2-0.5	99.79	0.08	0.004	0.004	0.01	0.112

3. Results of tests

3.1 Fuse link is fixed vertically on the vibration stand and vibrated in horizontal direction
A. As amplitude A=0.2 mm, duration of vibration t=2.5 min, the relations between the compactness of filled quartz sand ΔQ and vibration frequency f are shown in Table 2 and Figure 1.

Table 2

f Hz	45	48	50	52	55
ΔQ %	10.16	16.60	14.12	13.44	12.45

Table 2 and figure 1 show that there is an optimum vibration frequency when fuse link is fixed vertically and vibrated in horizontal direction. When frequency is below or over this optimum frequency, the compactness of filling with quartz sand will reduce obviously. It is better to take 48 Hz here.
B. The relations between the compactness of filled quartz sand ΔQ and the vibration amplitude A under the vibration frequency f=48 Hz and duration of vibration t=2.5 min are shown in Table 3 and Figure 2.

Table 3

A mm	0.10	0.20	0.25	0.30	0.40
ΔQ %	5.58	16.60	16.50	15.46	14.88

It is not appropriate to use an amplitude larger or smaller than (0.2-0.25)mm.

3.2 Fuse link is fixed on the vibration stand with a specific inclination angle and vibrated in horizontal direction.
A. Under amplitude A=2.5 mm, frequency f=48 Hz, duration t=2.5 min, the fuse link is fixed on the vibration stand with an inclination of 10^0 and vibrated in horizontal direction, the compactness ΔQ will be higher than that without inclination. The test results are shown in

Table 4.

Table 4

inclination	0^0	10^0
△ Q %	16.60	17.11

B. Under the same condition as 3.2.A, the compactness △Q will be raised, when 5 kgf impacting force is applied on the fuse link. The test results are shown in Table 5.

Table 5

inclination	0^0	10^0	10^0
condition of impact	without impact force	without impact force	with impact force
△ Q %	16.60	17.11	17.60

C. Under the same condition as in 3.2.B, if the vibration frequency is reduced adequately at two-thirds of the specified vibration duration, then △Q will be brought to an optimum value. The results of the tests are shown in Table 6.

Table 6

inclination	0^0	10^0	10^0	10^0
impact force	without impact force	without impact force	with impact force	with impact force
changing vibration frequency	without	without	without	reduce adequately the frequency at two-thirds of the specified duration of vibration
△Q %	16.60	17.11	17.60	19.17

D. Prolonging the duration of vibration in horizontal direction as A=0.2 mm, f=48 Hz, will not obviously raise the △Q. The results of the tests are shown in Table 7.

Table 7

t min	2.5	3.5
△Q %	16.60	16.70

3.3 Fuse link is fixed on the vibration stand in vertical direction and vibrated in vertical direction.

A. Under amplitude A=0.2 mm, duration of vibration t=2.5 min, the relations between the compactness △Q and vibration frequency f are shown in Table 8 and Figure 3.

Table 8

f Hz	20	30	40	50
△Q %	6.38	15.05	13.30	10.60

Table 8 and Figure 3 show that fuse link has also an optimum vibration frequency when it is fixed in vertical direction and vibrated in vertical direction. It is better to adopt 30 Hz here. It is lower than the optimum frequency vibrated in horizontal direction.
B. Under vibration frequency f=30 Hz, duration of vibration t=2.5 min, the relations between the compactness △Q and vibration amplitude A are shown in the Table 9 and Figure 4.

Table 9

A mm	0.15	0.20	0.30	0.40
△Q %	7.31	15.05	14.12	12.50

Table 9 and Figire 4 show that it is better to adopt the amplitude of vibration stand A=0.2 mm here, when fuse link is fixed on the vibration stand and vibrated in vertical direction.
C. Under amplitude A=o.2 mm, vibration frequency f=30 Hz, adequately prolonging the duration of vibration will obviously raise the △Q. It is shown in Table 10.

Table 10

t min	2.5	5
△Q %	15.05	17.47

D. under amplitude A=0.2 mm, vibration frequency f=30 Hz, duration of vibration t=2.5 min. The compactness of filling quartz sand △Q can be raised by continuously impacting the fuse link, but it is not more obvious than that vibrated in horizontal direction. The results of the test are shown in Table 11.

Table 11

Condition of impact	without impact	with impact (300 time/min)	with impact (160 time/min)
△Q %	15.05	15.78	16.28

E. Under the same condition as 3.3.D, the compactness of filling quartz sand △Q can be raised, when the vibration stand is vibrated to a certain time, the vibration frequency is reduced adequately. The results are shown in Table 12.

Table 12

Condi tion of frequency (f)	Constant (f)	Reduced (f)
△Q %	15.05	16.27

3.4 Fuse link is fixed on the vibration stand at different angles and vibrated in vertical direction.
Under amplitude A=0.2 mm, vibration frequency f=30 Hz, duration of vibration t=2.5 min the relation between the compactness of filled quartz sand ΔQ and the inclination angle α can be abtained by altering the angle between the plane of stand and fuse link,as shown in Table 13.

Table 13

	0^0	5^0	10^0	15^0
ΔQ %	15.05	15.05	14.96	14.94

Table 13 shows that if it filled sand under vertical vibration, the fuse link can be mounted without inclination.

4. The influence of the compactness of filled quartz sand ΔQ upon the breaking capacity of fuse.
After a fuse link of rated voltage 415 V ac and rated current 100 A is filled with quartz sand in different ways, the test at the maximum joule integral (I^2t) is performed under the test voltage 460 V ac, current 6.3 kA and $\cos\varphi$=0.29. Results of tests are shown in Table 14.

Table 14

modes of filling quartz sand / results of tests	general	according to the mode of 3.2.C
Pre-arcing $I^2t.10^3$ A^2s	45.3	32
Operating $I^2t.10^3$ A^2s	85.7	64
Peak value of cut-off current kA	6.63	5.92

Table 14 shows that in a certain range, to increase the compactness of filling quartz sand ΔQ may raise the breaking capacity of fuse. The reason for this is that to raise the compactness of filled quartz sand can increase the thermal capacity of sand in unit volume of cartridge and the capacity sucking up arc energy (2.1 kw.s per gram of quartz sand). At the same time it may limit the expansion of arc diameter and the increase of pressure in arc area, so as to strengthen de-ion of arc area, thus making the arc-quenching easier.

5. Results

5.1 No matter how vibration is performed in horizontal direction or in vertical direction, when the quartz sand is filled, the best vibration amplitude A and frequency f are existed in all cases. So we can gain higher compactness ΔQ under these circumstances.

5.2 When the quartz sand is filled, no matter how vibration is performed in horizontal direction or in vertical direction, ΔQ will be raised by reducing the frequency adequately after two-thirds of the specified duration of vibration.

5.3 When the fuse link is fixed on the plane of the vibration stand with a certain inclination, vibration in horizontal direction can raise the compactness of filled quartz sand. But vibration in vertical direction can't obviously increase it.

5.4 Under the same compactness ΔQ and optimum condition, the duration of vibration in horizontal direction will be one half of that in vertical direction.

5.5 The fuse link is fixed on the plane of the vibration stand with an inclination about 10^0

and vibrated in horizontal direction with impact, the vibration frequency is reduced after a certain appropriately time of vibration the methods can bring the compactness ΔQ to maximum. Besides, the duration of the vibration may be shortened. This method is suitable for using in the factory production.

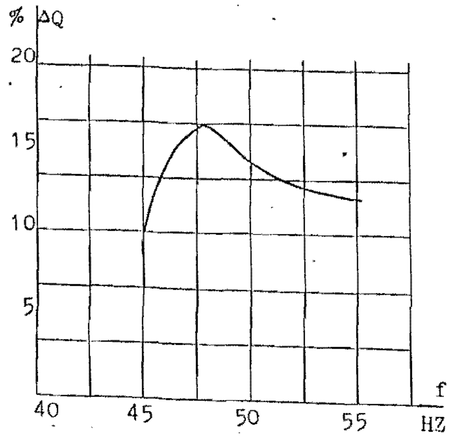

Fig.1 Relation between the compactness ΔQ and frequency f, at amplitude A=0.2 mm duration of vibration t=2.5 min. (in horizontal vibration)

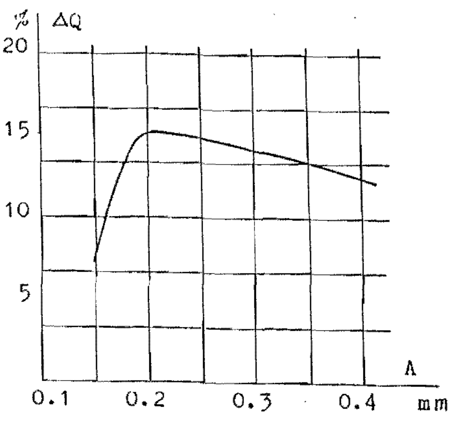

Fig.2 Relation between the compactness ΔQ and amplitude A, at vibration frequency f=48 Hz, duration of vibration t=2.5 min (in horizontal vibration)

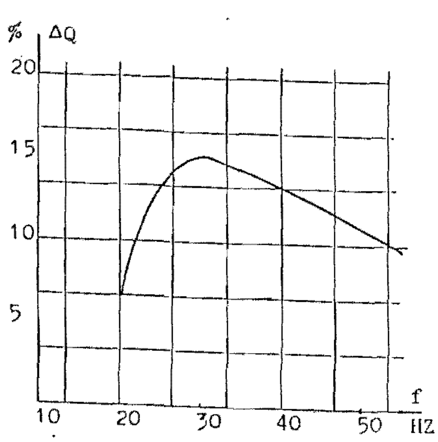

Fig.3 Relation between the compactness ΔQ and frequency f at amplitude A=0.2 mm duration of vibration t=2.5 min (in vertical vibration)

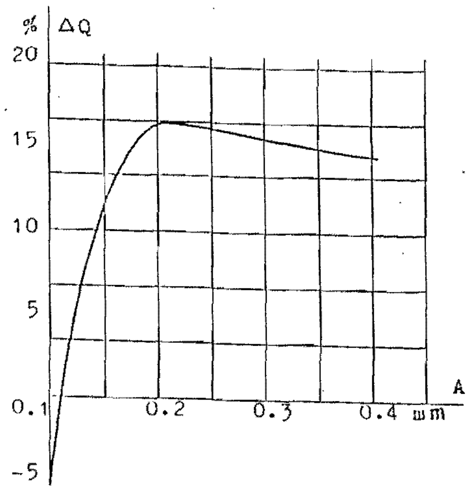

Fig.4 Relation between the compactness ΔQ and amplitude A at vibration frequency f=30 Hz, duration of vibration t=2.5 min (in vertical vibration)

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Session VI

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