HIGH VOLTAGE VACUUM TYPE FULL-RANGE CURRENT LIMITING FUSE

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Abstract: Actually it is a high voltage vacuum fuse coupled with a full range current limiting fuse in tandem used to protect electric power system. The fuse configuration, basic principle, speedy expansion of electric power capacity in China it is in urgent need to develop a fuse of this kind.

Keywords:

1 Introduction

Presently, no high voltage vacuum type full range current limiting fuse is available in our domestic market for protection of electric power system in case of short circuit and over-load current. However, the full range current limiting fuse plays a functional role in close coordination with the intelligent power system currently.

The application of full range current limiting fuse for electric power system protection has been popularized in the world. It is obvious that the back-up fuses arc still being used in China. It will become obsolete and then gradually eliminated.

2 Configuration and basic principle of high voltage vacuum type full-range current limiting fuse

Figure 1 shows the cross-sectional profile of the fuse which is composed of a vacuum fuse element I fully immersed in epoxy resin and a current limiting fuse 2 wholly embedded in silica sand medium within an insulated envelop, both of them are coupled in tandem.

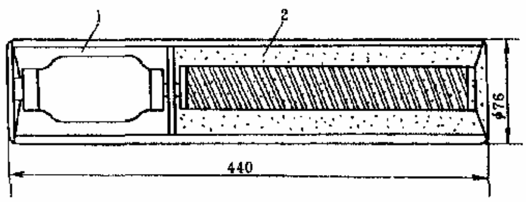

Fig. 1. Configuration of high voltage vacuum type full range current limiting fuse

2.1 Vacuum fuse part

The main construction of vacuum fuse part is as a vacuum interrupter shown in Fig.2. the vacuum Fuse consists of glass envelope l, glass shielding 2, conducting rods 3 and 5, input terminal 4, output terminal 6 and fuse element 7. The envelope should be vacuumized to 10^{-3}Pa. The shielding is made of glass to prevent from metallic vapour spraying lo the glass envelope during the course of current breaking as vaporized metallic particles condensed on the internal surface of the envelope readily form a conductor between the input and output terminals.

The conducting rods and input/output terminals are made of OHNC copper material. The material of fuse clement may be selected to satisfy design requirements, as shown in Table 1.

Table 1 Physical characteristics of fuse materials used in vacuum fuse

Material	Symbol	Density	Melting point °C	Heat conductivity W/m°K	Resistivity $10^{-8}\Omega m$
Cadmium	Cd	8.65	321	92	7.4
Copper	Cu	8.96	1084	398	1.69
Iron	Fe	7.86	1536	80	9.71
Gold	Au	19.32	1063	315	2.4

A fuse element is commonly used with a current density ranged from 100 to 160 A/mm^2. In our designed fuse, for instance, a copper strap of 4 x 0 1 mm^2 in cross-area is selected for rated current 63A fuse, the current density of which will be approximately 63/4x0.l = 160A/mm^2. Both length and area of the fuse element are used to define the rated current and the ampere-second characteristics as in our designed where the rated voltage and current are 12kV and 63A respectively. The geometrical dimensions of the fuse element arc show n in Fig.3

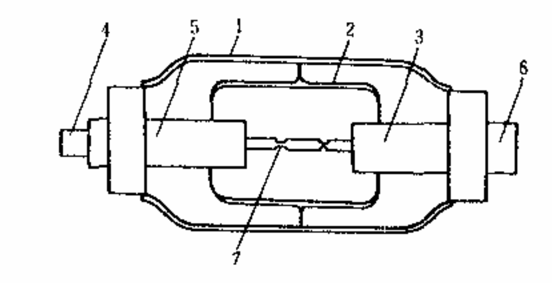

Fig.2. Schematic diagram of vacuum fuse

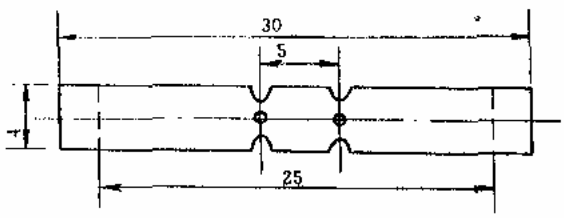

Fig.3. Geometrical dimensions of fuse element

2.2 Current limiting fuse part

As show n in Fig.4, Insulating envelope made of high strength glass fibre with resin polymerized, quartz sand 2 of 98% in purity, terminal cup 3 made of silver plated copper, fuse element 4 of 99.99% silver with cross-area 2.54x0.145 mm^2 and length 640mm wound on an asterisk ceramic supporter. The profile of fuse element is shown in Fig.5. At the end of terminal cup, an acting indicator or a striking pin to show whether the fuse has been operated or its switchgear mechanism has been acted.

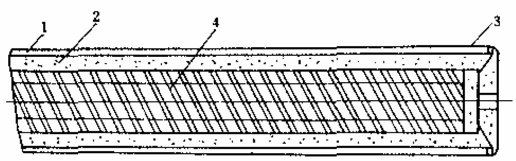

Fig.4. Configuration of current limiting fuse

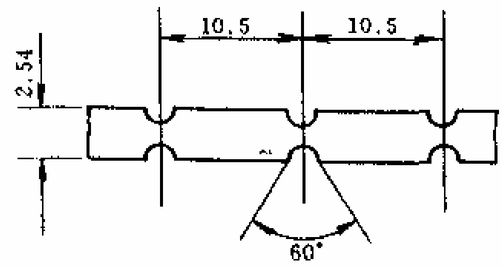

Fig.5. Profile of full range current limiting fuse element

3 Characteristic tests and measured results

The following characteristic tests and analyses were conducted on our designed sample of high voltage vacuum fuse coupled with current limiting fuse in tandem.

3.1 Test and result analysis conducted on vacuum fuse

In Fig.6 it shows the circuit diagram for pre-arc time vs prospective current curve test (i.e. ampere-second characteristics test) of the vacuum fuse, in which source supply switch Km, voltage regulator T of large capacity, stabilizing resistor R, short circuit switch Ks, ammeter A or oscillograph to be instead, in case the test current being two times greater than rated current of vacuum fuse sample to be tested
The measured results of pre-arc time vs prospective current of the tested vacuum fuse arc shown in Fig 7. It can be seen that the curve at small over-current varied quite steeply, that means to say the fuse has high sensitivity and reliability for protective function.

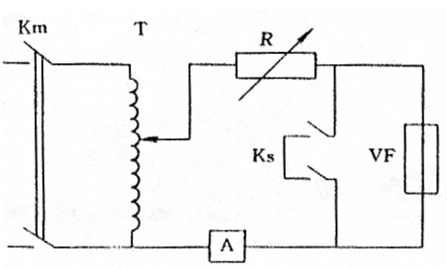

Fig.6. Circuit diagram for vacuum fuse pre-arc time vs prospective current curve test

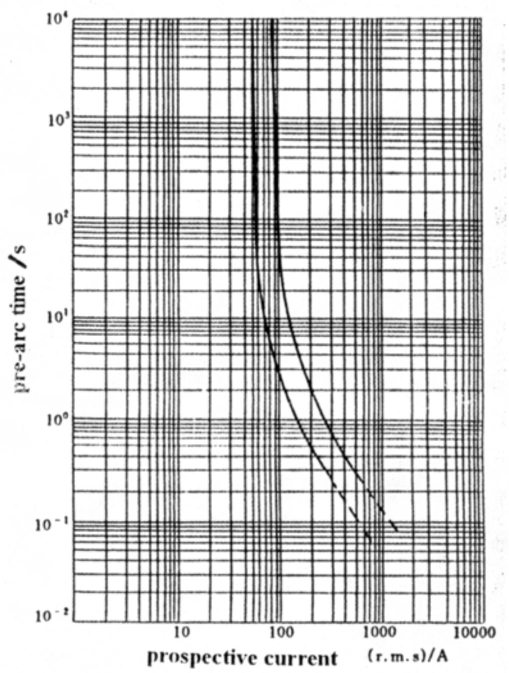

Fig.7. Characteristic curve of pre-arc time vs prospective current curve of vacuum fuse

3.2 Test and result analysis conducted on current limiting fuse

The circuit diagram of pre-arc time vs prospective current curve (i.e. ampere-second characteristics test) for the current limiting fuse is exactly same as that shown in Fig.6. The measured results are shown in Fig.8, from which it is observed that when over current in the current limiting fuse was as about 4 times less as the rated value (the dotted line Fig.8), the fuse has no capability to interrupt the short circuit current.

3.3 Determination of intersecting point

Based on the results measured above, it can be observed that the rated current of 50A or 60A current limiting fuse is not competent lo interrupt the circuit current less than 200A or 500A respectively. When a high voltage vacuum fuse is coupled with a current limiting fuse in tandem (i.e. the curves in Fig 7 and Fig.8 overlapped one another), two intersecting points are found at 280A and 420A respectively as shown in Fig.9, thus forming two continuous characteristic curves through these two points. Obviously, the vacuum fuse displays its capability to interrupt minimum over-current lo maximum short-circuit current, thus forming a full range fuse.

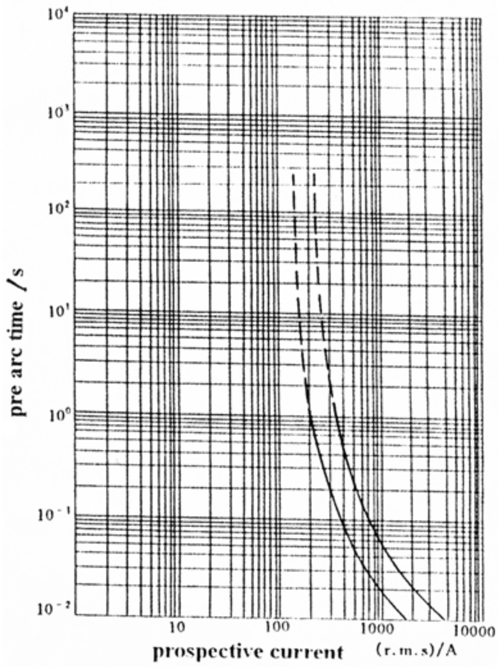

Fig.8. Characteristic curve of pre-arc time vs prospective current of current limiting fuse

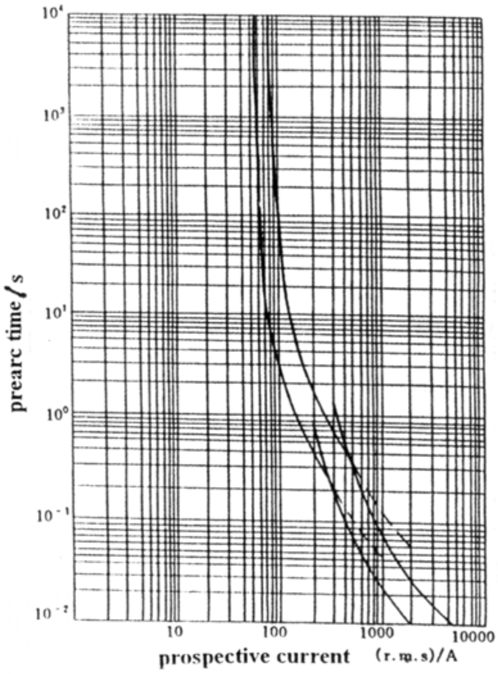

Fig.9. Characteristic curve of full range performance fuse

4 Conclusion

Despite of the fact that Gdansk Technical University of Poland and Xi'an Jiaotung University of China have conducted on research and development of a fuse of this kind in 1998, no high voltage vacuum type full range current limiting fuse is available at home and abroad currently. It is quite necessary to develop this kind of fuse in order to meet speedy expansion of electric power system capacity. Fortunately Hangzhou Baoda Electric Co,Lid of Zhejiaug province, P.R.. China has developed the fuse and undertaken the business in the production of it for power system protection.

References

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