A NEW REPLACEABLE FUSE-ELEMENT WITH CURRENT LIMITING CHARACTERISTICS USED ON DROP-OUT FUSE

Kong Fanhong Wang Jimei Ma Zhicheng
Xi'an Jiaotong University Xi'an Fusegear Factory
Xi'an, The People's Republic of China

Abstract. The structure of new replaceable fuse-element which is made of pure copper surrounded by stone sand with current limiting characteristics was studied and the manufacture process of this element was described briefly also. The fuse-element of this type is applied to out-door drop-out fuse of 7.2-12kV. According to IEC282 this out-door drop-out fuse tested on 12kV under a short-circuit breaking capacity of 31.5kA. The results of which were analyzed in the paper.

I. INTRODUCTION

High-voltage current limiting fuse is an old-fashioned apparatus for electrical protection. However, it is still widely applied in power systems for the features of quick-acting, high breaking capacity, remarkable characteristics in current limiting, compactness in structure and so on.

At present, there are two types of high-voltage fuse under mass production and broad application in China, i.e. expulsion type and current limiting type. The drop-out fuse for out door purpose is categorized in the expulsion type of non-current limiting. The principle of arc extinguishing in drop-out fuse is dependent on that once the fuse element is self-melted, it will produce an electric arc of very high temperature to vaporize the filled material in extinguishing arc tube, thus generate abundant gases with high pressure which expels off arc itself. If the current reaches zero, the arc will be extinguished. After the arc extinguished, the fuse body will be automatically unlocked and rotationally falls down in drop-out position, forming a visible breaking space. The fuse of this type is quite simple in structure, convenient in operation, lower in production costs, visible breaking space formed after acting, etc. Therefore, it is broadly used in 10-63 kV power systems and power transformers as for over-load and short circuit protection.

The main problems of this kind of fuse are: (a) Low performance in arc extinguishing, (b) Less stability in time-current characteristics, (c) Low breaking capacity.

Based on the rapid development of power industry in China, it is estimated that the annual increament in power system capacity will be about 10 million kW. That means to say with the growing of power system capacity, the breaking capacity of expulsion type drop-out fuse will no longer meet the requirements of power system developed. The results have shown that the high-voltage fuse of current limiting type in power distribution transformers for protection exhibits its superior performance to any of the kind, e.g. remarkable current limiting to reduce greatly the requirements of thermal stability and dynamic stability of protected apparatus, thus showing the distinct increase in economical value. In order to keep pace with the development of present market situation, a drop-out high-voltage fuse of current limiting type was jointly designed and developed by Xi'an Jiaotong University and Xi'an Fusegear Factory with rated voltage 12 kV, rated current 100A and breaking capacity 31.5 kA, in which solidified silica-sand and pure copper are used as fuse element instead of the expulsion type drop-out non-current limiting fuse. Moreover, the newly designed drop-out fuse during interrupting is soundless, no light flash, safe and reliable. It has much higher breaking capacity than that of the expulsion type. Hence it opens up a new way for the development of drop-out type fuse.

II. STRUCTURE OF NEWLY DESIGNED DROP-OUT FUSE

Fig.1 shows the principal structure of the newly designed current limiting drop-out fuse where two Insulators 7 are vertically fixed on Base 8 respectively, Upper and Lower Bracket 4 and 5 are installed on each insulator, the hook of lower bracket catches the bolt positioned near the lower end of Fuse-Body 1, the upper end of Fuse-Body 1 tightly secured on Spring Plate 3 and hooked by Release-Lock Rod 2. Electric current flows in at Terminal 6 on the insulator and out at Terminal 9 through metallic Upper Bracket 4 and Fuse-Body 1, then Lower Bracket 5.

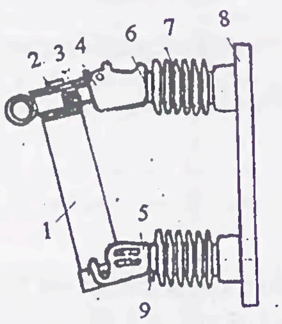

Figure 1. Principal structure of the newly designed current limiting drop-out fuse

If over-load current or short circuit current runs through the fuse, the striker will act while the fuse element is melted to push the firing pin opening Ralease-Lock Rod 2. Fuse-body 1 is released and drops down automatically along the bolt on the lower end of Fuse-body 1. Eventually, the fuse is freely hung down on Lower Bracket 5 in drop-out position.

Ⅲ. SOLIDIFYING PROCESS OF FUSE ELEMENT

Place a mixture of solidification agent and silica sand in proper proportion into a mixer, mix up them evenly for 15-20 min., then pour out the mixture into an assembled fuse body. To impact silica sand in the fuse body tightly, it is placed on a vibrator for mechanical vibration. Keep the impacted fuse body in an oven for 2 hrs at 120℃, then remove it out to cool down at room temperature. Seal the fuse body before assembling.

Ⅳ. TESTING RESULTS AND DISCUSSION

Main parameters of the sample is rated voltage 12 kV, rated current 100A and breaking capacity 31.5 kA. The dimension of the fuse-element is shown in Fig. 2. The element material used is of pure copper (electrical grade) with δ=0.13mm in thickness and resistance per meter 68 milli-ohm. The fuse body is made of glass fibre in 4mm thickness which is sustained to high temperature, moisture-proof, fire-proof, high strength, and prevention from ageing of ultraviolet rays.

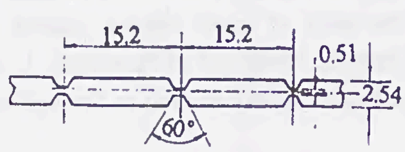

Figure2. The dimension of the Fuse-element

Ⅳ.1 Testing Results

Breaking capacity test of Test duty 1 and Test duty2, temperature-rise test and time-current characteristics test were completed on the sample fuse.

1. Breaking capacity test of Test duty 1

Fig.3 shows the prospective current oscillograph under metal short circuit for breaking capacity of Test duty 1, where U, the voltage of power source and I_k, the prospective short circuit current.

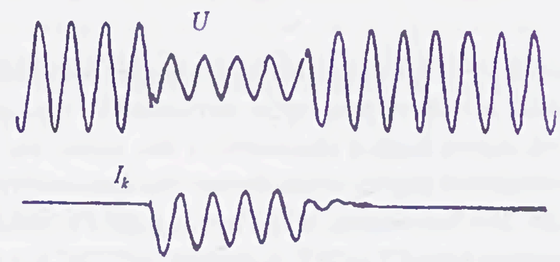

Fig.3 The prospective short circuit current

Fig.4 shows the typical oscillograph of breaking capacity of Test duty 1 for solidified fuse element. The striker acted normally after the fuse melted, then dropped out to normal position.

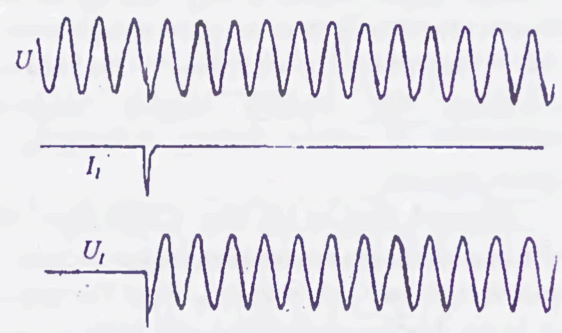

Fig.4 Typical oscillagram of Test-duty 1

2. Breaking capacity test of Test duty 2

The prospective current oscillograph under metal short circuit for Test duty 2 is shown in Fig.5, in which U, the voltage of power source and I_K, the prospective short circuit current .

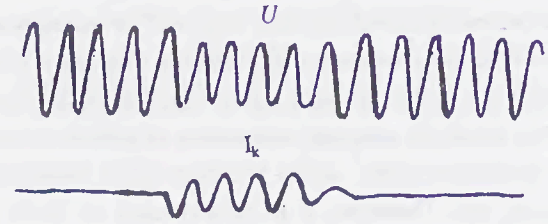

Fig.5 Prospective short circuit current

Fig.6 shows the typical oscillogram of Test duty 2 for solidified fuse element. After the fuse melted, the striker acted normally and the fuse dropped out to normal position.

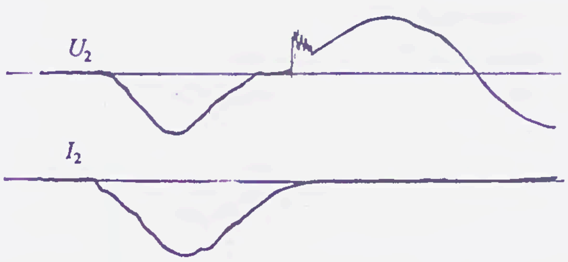

Fig.6 The typical oscillogram of Test duty 2

3. Temperature rise test

The points of temperature measurement for temperature rise test is shown in Fig.7. The temperatures measured are listed in Table 1.

Table 1 Results of temperature rise test

Measured points	Temperature rise ℃
ΔT_1	23
ΔT_2	38
ΔT_3	80

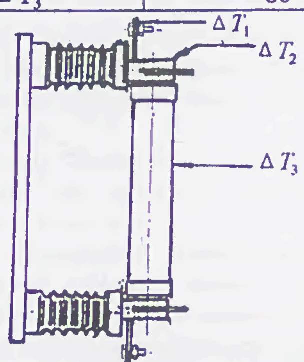

Fig.7 Measured points for temperature rise test

4. Time-current Characteristics test

When the rated currents of fuse were set at 6.3 to 100 A, the time-current characteristic tests on the fuses under low voltages are shown in Fig.8.

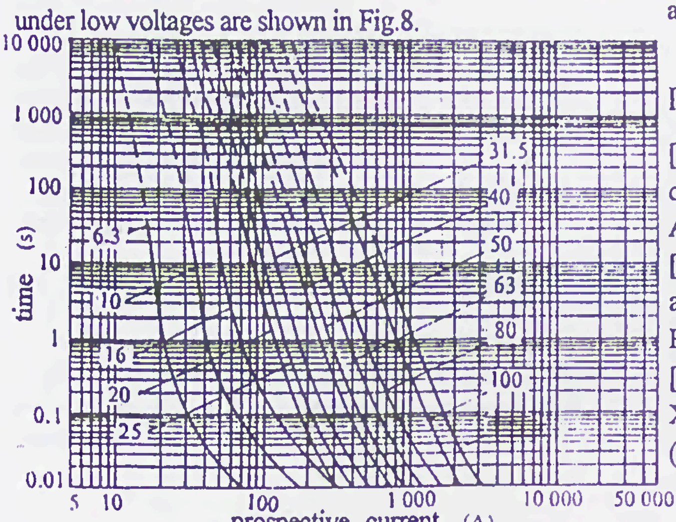

Fig.8 Time-current characteristic curves

IV.2 Discussion (Analysis of results)

A number of fuse samples were used to complete Test duty 1 and Test duty 2, some of them were dissected for observation. As shown in Fig.9, it can be seen that the element was melted much evenly just as prospected in our design requirements.

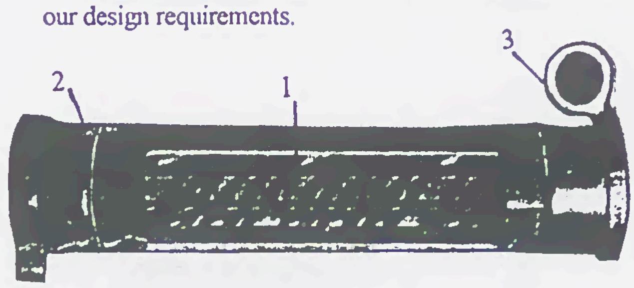

Fig.9 Photo of interrupted fuse element

1-interrupted fuse element; 2-lower terminal;

3-upper terminal

The data of temperature rise as listed in Table 1 are below the specified standard temperature. Moreover, little variation in resistance was measured pure copper element after solidification for one year's. No trace of metallic oxides on the surface of fuse element was detected. Also, the time-current characteristic curve of fuse element showed less difference in comparison with that made of pure silver.

V. CONCLUSION

The current limiting drop-out fuse made of pure copper element as fuse element is possible to be used in power systems range from 7.2 to 12 kV for over-load current and short circuit current protections. The breaking capacity of which is much higher than that of the expulsion type one. The element shows no obvious metallic oxides on the surface and ageing phenomenon after action.

REFERENCES

[1] Jiao Qiuzhong, "Summarize in out door high-voltage drop-out fuse", China High-voltage Switch-gear Industry Association, 1995, No.2. (Chinese)

[2] Wang Pu, "Brief introduction of high-voltage fuse. application and development in domestic and abroad." High-voltage Apparatus, 1994, No.6, P46 (Chinese)

[3] Wang Jimei, "High-voltage current limiting fuse". Xi'an Jiaotong University Publishing House, 1994 (Chinese)