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The Development of Electric Arc Fault Simulation Test Device

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Abstract

Any arc fault is a dangerous and multiple electrical faults that is one of the main reasons to cause civil building electrical fire in our country. Describe briefly the current situation of researches for prevention of electric arc faults at home and abroad. Develop according to the arc fault features a simulation test device which can produce real electric circuit fault arcs and present the principle of operation, the mechanical principle block diagram and the validation test results. This equipment can produce real electrical faulting arc and it not only can be used for the basic theory research of electric arc faults, but also can be used in the testing of electric arc fault protection products.

Keywords: electric arc fault; simulation test device; develop

1. Introduction

Any arc fault is a dangerous and multiple electrical fault that is one of the main reason to cause civil building electrical fire in our country. According to statistics from the relevant departments, there were 193,700 electrical fires from 2000 ~ 2007 inclusive in the country, accounting for 28.23% of fires investigated of the same period. In our country, the fires which caused by any arc fault due to any short circuit, undesirable contact, current leakage or the like account for 61.3%[1] of the total number and therefore constitute the main reasons for the electrical fires. Researches show that, only 2 A ~ 10 A arc current can produce a local high temperature up to 2000 ℃ ~ 4000 ℃ and any 0.5 A arc current is enough to cause fire[2]. At the same time, an arc fault can occur anywhere within a residential or business electrical system, so a fire is likely to be incurred once there is any inflammable substance nearby and such a fire would cause heavy property loss and even casualties.

In foreign countries there exist an earlier awareness of the damage about arcing faults and some literature concerned have recorded a deepened study of arcing fault features and related mathematical models. For many years, the development and application of technologies for arc fault-caused fires always take much attention from the field of fire control and low-voltage apparatus all over the world. There were a lot of discourse especially introduce the Arc-Fault Circuit Interrupter (AFCI)[4-6] on the 21st International Academic Conference on Electricity held in Swiss in the year 2002. At present, many nations have initiated establishment of corresponding standards and are actively developing new types of protective products, which is regarded as one of the important direction in the current low-voltage apparatus field. The hazards of fire caused by arc faults are also serious in our country, which enables the skills for arc fire prevention and control have acquired due attention. With people's further understanding of arc fault fires and with a variety of new protective products

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come into being in foreign countries, some Chinese research institutes and enterprises have carried out researches on both basic theory and application technology as concerned.

Currently, in its 2011-2015 plan for fire science and technology development, the Ministry of Public Security definitely takes electrical fire prevention & control technology as one of the key breakthrough technologies and directs its aim to the development of both fire-resulting electrical failure detection and corresponding early warning technologies, in order to achieve an early control of electrical failures, if any. Thereby, China is bound to promulgate some criteria and mandatory stipulations upon installation of arc protecting equipment, so it is necessary to develop test equipment for scientific simulation of electrical arc faults, so as to lay a good foundation for arc fault preventing technology development.

2. The design of the electric arc fault test device

The main causes of the fault electric arc can be divided into: any aging or damage in a wire or cable; any bad connection of wire or electric equipment or there-between; grounding short circuit and so on. The related factors of any arc fault harm degree are: the power voltage rating, power supply frequency, load power, load type, environmental factor etc. At the present stage, the main method for electric fault identification is to collect such data as the voltage, current, frequency and phase of the protected circuit and equipment and thereupon to make analysis thereof within the time domain or frequency domain. However, in the course of such research, owing to uncertainty and randomness etc. in faulting arc generation, it is rather difficult to give the definite electrical feature of any faulting electric arc as generated under various conditions. This paper starts from the possible electric arc inducing conditions and factors on low voltage distribution systems and various kinds of electric apparatuses in our daily lives, and references the U.S. UL1699 standards related to laboratory equipment, to develop a laboratory-use simulation device that can generate real electrical circuit arc fault, and can also be used for performance testing of relevant arc fault detection products.

2.1. Carbonized route electric arc test equipment

This equipment mainly simulates the electrical features of any arc induced from a current passing through a carbonized route that is formed by such isolating materials around any damaged wire as arising from any indirect arc due to failures like electric leakage or electric arc grounding-resulted short circuit. Carbonization path parallel and series arcing can be produced through this equipment. The operational principle is, firstly to impose a high voltage on a lead under test to result in an insulation breakage and then to make the insulation breakage form a carbonization path and to give access to the test loads at last. Here impose the rating working power supply (AC220V/50HZ) and record the voltage and current waveforms when any faulting arc comes into being. The main function is to collect data relating to electrical features during generation of any of such faulting arcs, so as to provide a basis for inspection and judgment of such faulting arcs. In addition, the test device also functions in performance testing of arc fault-protecting products.

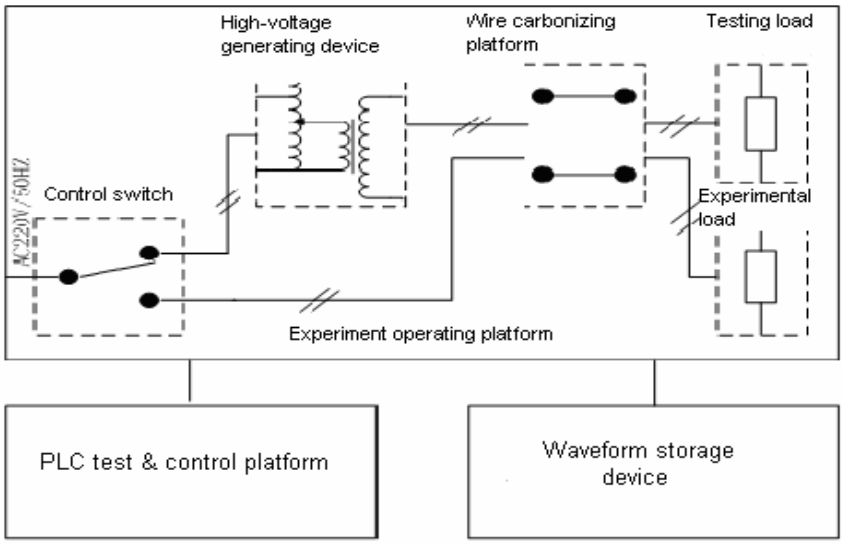

Fig. 1 Block diagram of carbonizing path arc test equipment

As shown in Figure 1, carbonizing path arc test equipment mainly consists of experiment operating platform, PLC test and control platform and waveform storage device. Experiment operating platform mainly consists of control switch, high-voltage generating device, wire carbonizing platform and loads, completing carbonizing path formation and arc-generating test under a given load, under the control of PLC test and control platform. Waveform storage device is used for recording real-time data in test circuit such as voltage and current.

2.2. Guillotine-type point-contact parallel arc test equipment

This equipment mostly simulates the electric features of any electric circuit that encounters a metal grounding short-circuit and therefore generates parallel arcs but the faulting arc current thus resulted cannot reach the actuation value of the air circuit breaker. The operating principal is: to connect both test load and test power with two parallel test leads; cut the test leads with a steel cutter; make an actual contact to Lead A and make a point contact to Lead B by adjusting both cutting angle and cutting speed; and collect the arc current and voltage waveform data with the aid of a recorder. Functions: collect electrical features upon the faulting arc occurrence in order to provide a basis for the inspection and judgment of such faulting arcs. In addition, the test device also functions in performance testing of arc fault-protecting products.

The point-contact parallel arc test equipment referred in Fig 2 consists of a stepper motor, a stepper motor drive, a LM intelligent combination unit of rolling guides, a waveform recorder, a software platform, a power inverter and other components. The operating principal is as follows:

This equipment introduces a step motor with a step angle of 1.8 ° and a static torque of 23kg.cm as its main driving power. The step motor is connected to a LM intelligent combination unit of rolling guides that would change the step motor rotation from angular displacement into linear displacement. A guillotine is installed in the slider of the LM intelligent combination unit of rolling guides via a connection assembly. A control of the guillotine's cutting test leads can be achieved by controlling the stepper motor's step angle. And the electrical features upon parallel arc occurrence can be recorded by a high speed camera and a waveform recorder.

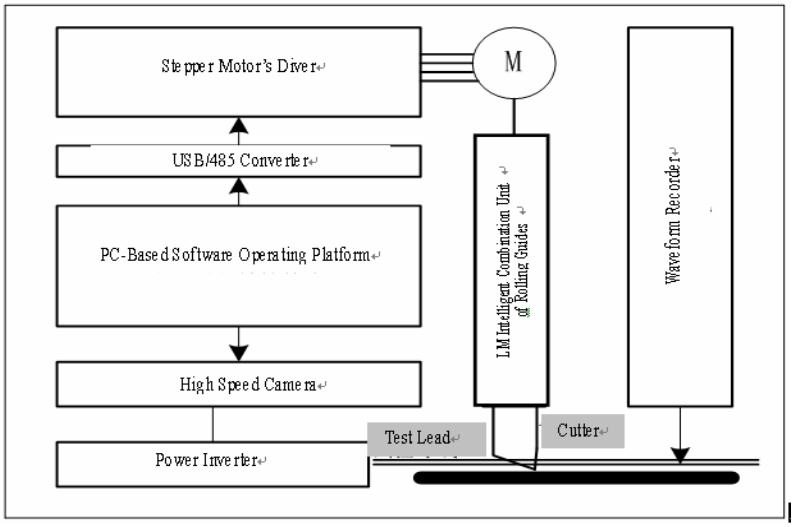

Fig. 2. Block diagram of guillotine-type point-contact parallel arc test equipment

2.3. Serial arc test equipment

This equipment mostly simulates the electric features of any electric circuit that encounters a bad contact. The operating principal is: to realize stimulation of serial arcs resulted from a bad contact by controlling two electrodes' slow contact. The control process is: to control two electrodes' slow contact or slow separation or frequent rapid contact or separation there-between to bring the test loop to generate faulting arcs. It mainly functions in generating the serial faulting arcs. In addition, the test device also functions in recording electrical features upon occurrence of such serial faulting arcs.

The electrical arc test equipment consists of a static electrode that is composed of an 8mm-diametered changeable graphite rod and an active electrode that is composed of a copper rod, and both of them are fixed via an insulating holder in a slider of an LM intelligent combination unit of rolling guides. The combination unit is driven by a 2-phase stepper motor and faulting arcs may be generated by controlling the stepper motor's step angle. The principle scheme for this test device is indicated in Fig. 3.

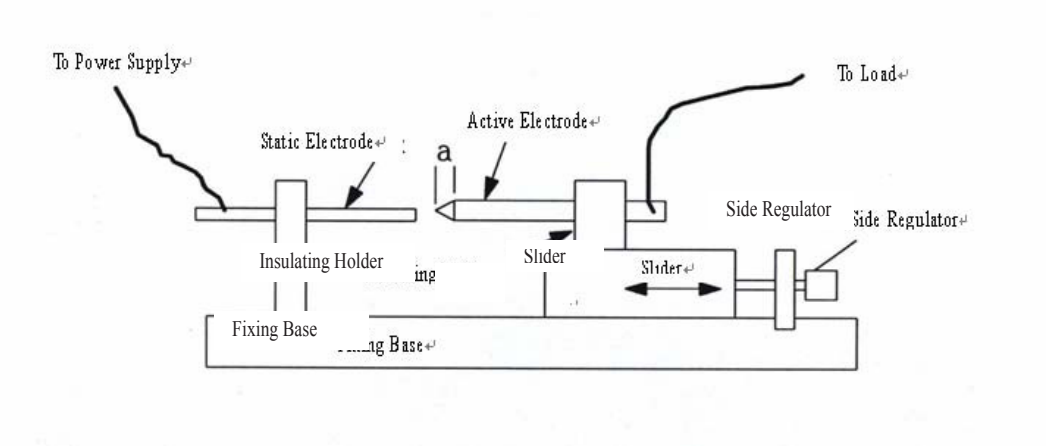

Fig. 3 Block diagram of serial Arc Fault Test Equipment

3. Arc fault simulation test

For verifying whether the test device can comply with the design requirements, we have made the verification test and the test results are shown in Fig. 4-9 below.

Fig. 4 Serial Arc Test Picture, Resistive Load, Carbonized Route

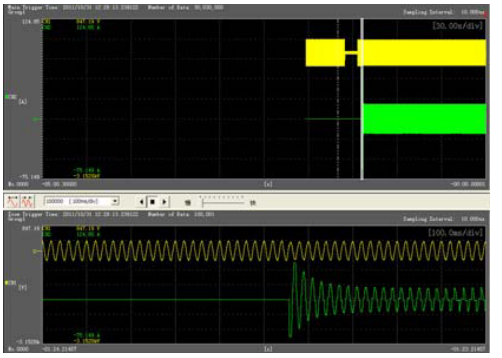

Fig. 5 Waveforms from Serial Arc Test, Resistive Load, Carbonized Route

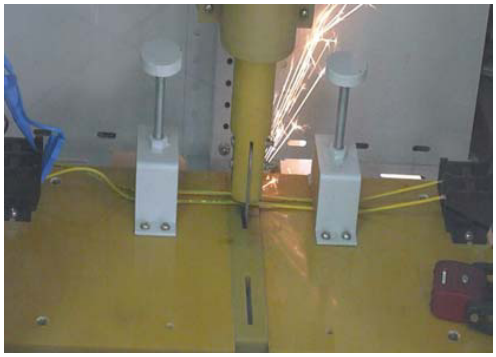

Fig. 6 Point Contact Test Picture, Resistive Load

Fig. 7 Waveforms from Point Contact Test, Resistive Load

Fig. 8 Serial Metal Point Contact Test Picture,, Resistive Load

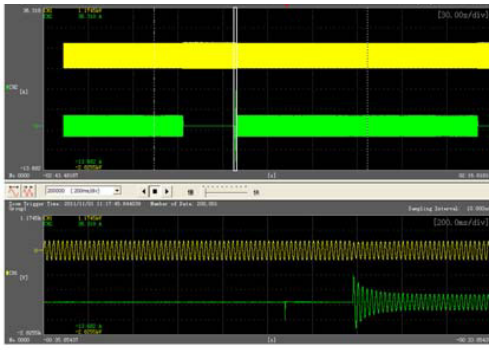

Fig. 9 Waveforms from Serial Metal Point Contact Test, Resistive Load

4. Conclusions

This paper has discussed electrical arc fault simulation test equipment that is developed according to the arc fault features. This equipment can produce real electrical faulting arc and it not only can be used for the basic theory research of electric arc faults, but also can be used in the testing of electric arc fault protection products.

Acknowledgements

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References

[1]Di-Man, Zhang-Ming, Qi Xibo. 2003-2007 Domestic Electrical Fire Statistics & Analysis [C]. Zhongqing city: Paper Collection from 11st Annual Symposium of China Association of Science and Technology, 2009.
[2] Marty Ahrens. The U.S. fire problem overview report: leading causes and other patterns and trends [J]. National Fire Protection Association, 2001.
[3] Nian Peixin, Luo Shili, Dong Baosheng et al. Faulting Arc Prevention in Low Voltage Distribution [J], Low Voltage Electrical Appliance, January, 2000.
[4] BRANSTON D W. Innovation in Low Voltage Switching Technology [c]//21st International Conference on E1ectrical Contacts. Switzerland, 2002: 283-289.
[5] MECHLER P. Simulation of AC Arc Faults in Aircraft Electrical Networks[C] //21st International Conference on E1ectrical Contacts. Switzerland, 2002: 290-295.
[6]HETYMANNSEDER E, ZUERCHER, HASTINGS J K. Method for Realistic Evaluation of Arc Faults Detection Performance [C]//21st International Conference on E1ectrical Contacts. Switzerland, 2002: 296-302.