Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 135 (2016) 482 – 485

Procedia Engineering

www.elsevier.com/locate/procedia

# Study on metallographic structure of melted breakpoint mark for copper wire current overloading

Yang Li[a,*] , Xing-hua Liu[b]

[a]Chinese People's Armed Police Force Academy, Langfang 065000, China
[b]Qinhuangdao Municipal Fire Brigade, Qinhuangdao 066000, China

**Abstract**

As a common electrical fault causing fire, current overload results in some trace evidences on the wire. However, most of relative evidences, such as insulating layer, metal core, are likely to be destroyed or disturbed by fire. The majority of wire evidences from fire are asked to test melted breakpoints marks of the wire. Thus, it is significant to clearly reveal the metallographic features of melted breakpoint mark for wire overloading for fire investigators. This paper selected two kinds, single-core and multi-cores, 1.5mm$^2$ copper wires to make melted breakpoints with 100A current overload. Then, this paper did some research on the fire heat influence on the microstructure of melted breakpoints. Experimental results indicated that the metallographic structure of the melted breakpoint mark caused by current overload was significantly different from that of melted mark caused by fire and short circuited melted mark. As for melted breakpoint marks of copper wire overloading, the most distinctive feature of the metallographic structure was dendritic segregations existing.


Peer-review under responsibility of the organizing committee of ICPFFPE 2015

Keywords: fire investigation, current overload, melted breakpoint mark, metallographic structur

## 1. Introduction

Electrical fire is the most common one in all fire. In general, four types of electrical faults, such as short circuit, current overload, current leakage, poor contact, cause fire. After short circuit, current overload is the secondary common reason for electrical fire. Therefore, it is important for fire investigation to find and identify wire trace evidence to testify current overload happening before fire. To my knowledge, domestic researches about overload wire trace in fire scene focus on states of insulating layer unaffected by fire. Furthermore, there are some related studies on how wire core metallographic structure change due to overload current value. However, fire evidence identification work mainly pays attention to various states of melted breakpoint marks on wire in fire. Little information has been done on melt breakpoint on current overload wire. The purpose of this paper is to discuss on metallographic structure of copper wire melted breakpoint marks due to 10 times rated current overload. In addition, we will also discuss how the melted breakpoint mark exposed to fire will change. Our discussion aims to help fire investigators discriminate between melted breakpoint mark caused by overload, melted mark caused by fire and short circuited melted mark in fire scene. Further studies on other current overload, other material and other fire scenarios will be summarized in our next study.

* Corresponding author. Tel.: +86-15831609698
*E-mail address:* 406541533@qq.com


Peer-review under responsibility of the organizing committee of ICPFFPE 2015
doi:10.1016/j.proeng.2016.01.159

## 2. Experimental

### *2.1. Experiment equipment*

This experiment was conducted in a self-made instrument, which can change the current size between two ends of a wire. The range of current is 20A to 340A. The metallographic change was observed with a 4XCZ microscope. The dimension of the heating furnace is 0.4×0.2×0.3 (length×width×height) to heat melted breakpoint marks.

### *2.2. Experiment materials*

Two kinds of 1.5mm2 PVC copper wires, single-core and multi-cores, were used to be overloaded with 10 times rated current. 0.2g/ml FeCl3 is selected to be metallographic etchant.

### *2.3. Experiment methods*

(1) Melted breakpoint marks preparation methods

A 0.5 meters long copper wire was installed in both ends of 220V voltage, 100A current for some time. 0.2 meters thick sawdust was close to below copper wire ignited. The preparation lasted until about 5min after the time of the wire automatic turning off.

(2) Heating experiment methods

After the heating furnace temperature elevating to 800℃or 1000℃ respectively, single-core wire melted breakpoint marks, prepared using the above methods, were put into this furnace. After 1 hour, turn off the furnace and open the door. When the furnace cooled to room temperature, took out the samples.

## 3. Results

### *3.1. observation of single copper wire melted breakpoints*

The metallographic structure of single-core wire melted breakpoint marks was shown in Fig.1. It was found that the breakpoint mark microstructure was different from the body's microstructure, with distinct borders. None of pores was found in the structure. The grain boundaries were shown clearly and thick. The microstructure of breakpoint was unidirectionally arranged dendrite, indicated by red arrows. There was obviously dendritic segregation in microstructure. The microstructure of the body was annealing twin.

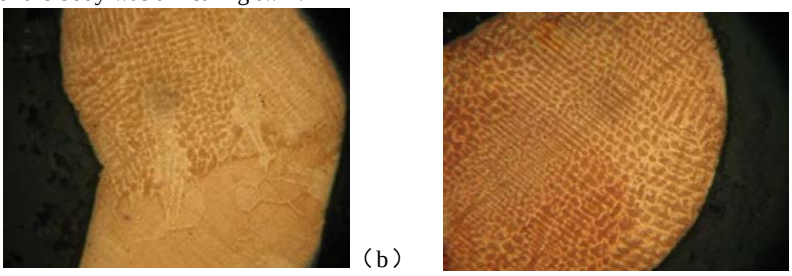


Fig.1.The microstructure of (a) 1 single-core wire breakpoint marks sample (50×) and (b) 2 single-core wire breakpoint marks sample (50×)

### *3.2. Observation of multi-cores copper wire melted breakpoint*

In Fig.2, the optical micrographs of multi-cores wire breakpoint marks were obviously different from that of single-core wire breakpoint marks. Some large inclusions or pores could be found in the microstructure. Most of the microstructure consisted of( α +$Cu_2O$ )hypereutectic. Copper primary α -phase appeared obovate grains and dendrites. Dead color zone was $Cu_2O$ hypereutectic, as the basic body. Compared with the dendrites of single wire breakpoint, grains grew less directionally.