

Application of Trace Property in Fire Cause Identification

Liantie Wang and Qingshan Meng

Shenyang Fire Research Institute, 110034, Huanggu District, Wenda road 218-20 first, Shenyang, China

Email: wangliantie@syfri.cn

Abstract. In the investigation of fire causes, there are many kinds of weld marks extracted from the fire site, such as the first and second short circuit weld marks. The relationship between the melting property and the cause of fire can be identified according to the different microstructure characteristics of the weld marks formed on the copper and aluminium wires. Therefore, in the determination of the cause of fire, the nature of the weld mark will directly affect the result of the determination, and sometimes a completely different conclusion will be drawn. However, sometimes in the same fire scene can be extracted from more than one weld mark, and the nature of the weld mark is not the same, which will bring certain difficulties to the fire cause identification work, so the organic combination of all kinds of weld mark, reasonable use, in order to better complete the fire scene cause identification work.

1. Introduction

Society is progressing and science and technology are developing. With the continuous expansion of electrical applications, electrical fires have an increasing impact on people. The number of electrical fires has been ranked first among all kinds of fires in China. According to the fire department of the ministry of public security "China fire statistics yearbook" data show [1]: in 2008, a total of 13.30,000 fires (refer to statistics month, excluding forest, grassland, army and underground part of mine, the same below), and 40,000 electrical fires, accounting for 30 percent of the total number of fires.1%.In the 15 years from 1993 to 2007, 152 fires broke out across the country.760,000, including 37 electrical fires.370,000 fires, or 24 percent of the total.5%, which has caused huge loss of life and immeasurable loss of property to the society. Fire scene, however, differ in thousands ways, could even say that no two the same fire scene, this gives the fire cause investigation work bring greater difficulties, which gather relevant evidence, the scene of the fire and scientific analysis, using these material evidence, to provide fire cause investigation is the most direct evidence that is particularly important.

According to the fire rescue bureau of the emergency management department [2], in 2018, a total of 237,000 fires were reported nationwide, resulting in 1,407 deaths and 798 injuries. Direct property losses of 3.675 billion yuan have been counted. Among them, there was one particularly serious fire, one more than the previous year; there were four major fires, one less than the previous year; 67 major fires occurred, two more than the previous year. The fire situation is still not optimistic. Among all the fires, electrical fires still account for a large proportion and the total number of fires caused by the violation of the regulations on electrical installation and use accounts for 34.6%.Major fires have a greater impact, and the number of major fires increased year on year.

2. Extraction of Physical Evidence

Fire cause investigation is a multidisciplinary comprehensive technology. Physical evidence to be extracted on site can be divided into physical evidence, chemical evidence and electronic evidence, etc. Only by mastering multidisciplinary knowledge can the most valuable fire material evidence be



extracted to provide strong evidence for the investigation of fire cause. The identification of fire material evidence plays a very important role in fire investigation. The accuracy of material evidence extraction can ensure the accuracy of cause investigation and greatly improve the efficiency of fire investigation.

Copper, aluminum conductor short-circuit arc formation of weld mark are sometimes caused by high temperature melting, sometimes is formed by the fire, but no matter how, the nature of weld mark are can represent the characteristics of the atmosphere at that time, due to the different environment atmosphere in the whole process of the welding scar formation and microstructure of the present also has the characteristics of each are not identical, so keep the weld mark formed their respective characteristics. Therefore, from the extraction of physical evidence at the scene of fire, to the analysis of the property of the material evidence, and then to the application of the property of the weld mark, each step has an internal relationship.

3. Trace Metallographic Analysis

In 2016, when a fire broke out in a comprehensive shopping mall, fire investigators examined the site and extracted the remnants of the fire site, including several molten beads, cable tray and residual wires. Professional and technical personnel carried out technical appraisal on the samples submitted for inspection. The equipment used includes digital camera, grinding machine, metallographic microscope, etc.

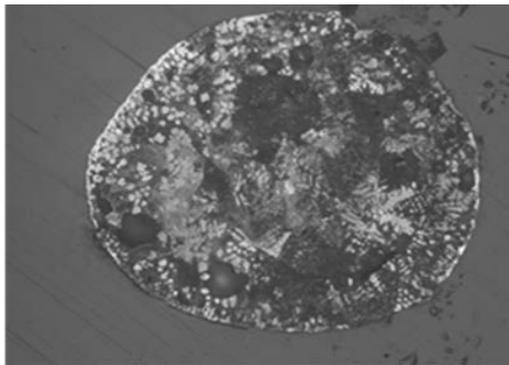


Figure 1. Metallurgic structure of short circuit splashbead

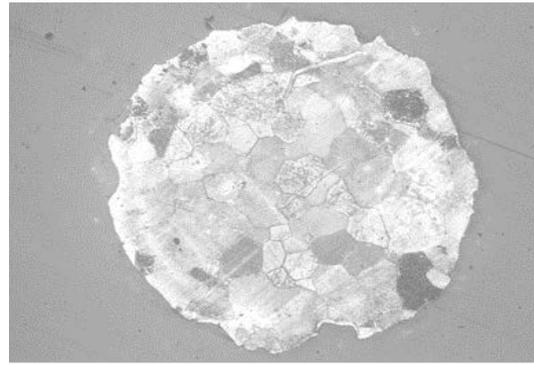


Figure 2. Metallurgic structure of fire bead

3.1. Sample Metallographic Analysis

After metallographic analysis, the sample of # 1 molten bead sent for inspection contains short-circuit splashing molten bead and fire bead (the metallographic photos of one of them are attached respectively, see Fig.1 and 2; 2# molten beads are all fire beads, see Fig.1; 3# melted mark is secondary short circuit melted mark, see Fig. 4.

First of all, let me show you the fire scars. As the name implies, it is the mark formed by melting after receiving the high temperature of the flame, which is one of the consequences of the fire rather than the cause of the fire. 2# weld mark, 3# melted mark and 4# melted mark do not support that the cause of fire is related to electricity.

3.2. The Relationship between Microstructure Characteristics of Fusion Marks

Secondary short circuit melted mark with a short circuit melted mark belongs to the instantaneous electric arc of high temperature melting, cooling speed, the characteristics of the melting range is small, but they have differences, secondary short circuit melted mark [3], secondary short circuited melted mark refers to the copper and aluminum wire charged, under the effect of external fire or high temperature, the insulation failure leads to short circuit after traces of residue. Secondary short circuit occurred in the fireworks and the temperature of the atmosphere [4-5], and is often a good fire hot

melting trace, their time, temperature and different from a short circuit, it has long time temperature, large range of fire, melting temperature is lower than the short-circuit arc temperature, so the organization grain is relatively bulky, according to this characteristic, which can determine the secondary short circuit mark of molten is formed after the fire. And a short circuit occurs in the normal atmosphere, is the short circuit before the fire, but in this case there is no short circuit weld mark, so do not make too much explanation. The short circuit splashes and thermal-electric crevices have similar properties, both of which may be formed before and after fire. The fusion mark formed by electrothermal action is the melting mark formed under the action of electric current or arc, including: leakage fusion mark, local overheat fusion mark formed by electric action, short-circuit fusion mark between charged body and other metal with different potential, etc. Short circuit splash bead is a kind of bead melting trace which is adhered to other carriers when copper and aluminum wires have short circuit fault. In this case, the short circuit scattering bead is separated from the body of the generated bead and exists independently. The short circuit fusion mark formed by the contact between the electrically charged body and other metal cable tray with different potential produces arc.

Therefore, the short circuit splash bead in sample 1# and the secondary short circuit fusion mark in sample 6# can indicate that the trace is formed under the charged condition, but it cannot directly prove that the cause of fire is related to the electrical.

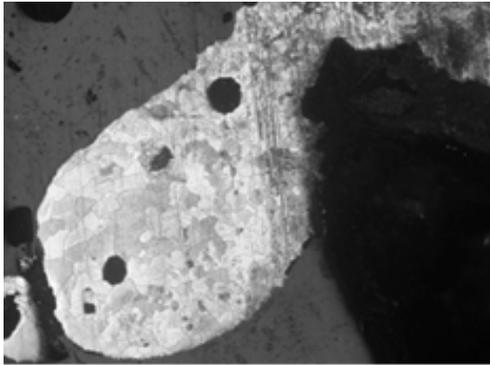


Figure 3. Metallurgic structure of fire melted mark

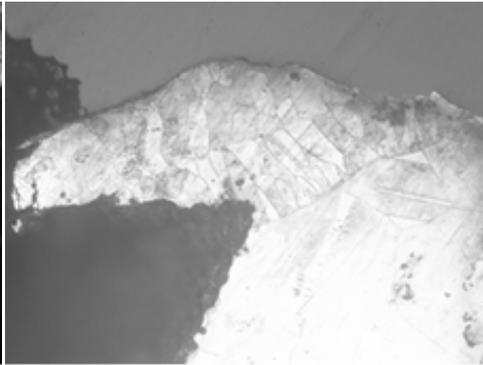


Figure 4. Metallurgic structure of secondary short circuited melted mark

4. Analysis of Causes

Based on the above analysis, none of the weld marks obtained in this case can directly prove that the fire was electrical related. However, if field inspection can prove that the material evidence is within the range of the fire site, and can exclude the cause of fire other than electrical, then the above mentioned short circuit splashes and electric hot melt are the most direct and powerful evidence, which can prove that the fire is caused by electrical fault.

5. Conclusion

The fire scene is complex and changeable, and the application of physical evidence should also be combined with the actual situation, which can be demonstrated from both positive and negative aspects rather than simple comparison. Only in this way can we ensure that everything is foolproof.

6. Reference

- [1] Fire department of the ministry of public security. China fire statistics yearbook [M]. Beijing: China personnel publishing house, 2016
- [2] <https://www.jianshu.com/>.
- [3] Wang xiqing, Han baoyu, Di man, etc. National standards for the People's Republic of China. GB 16840.4 1997
- [4] Information on <http://www.esafety.com.cn/case/21580.html> (In Chinese)
- [5] Fire Science and Technology, Vol. 24 (2005) No.4, p.495 (In Chinese)