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Metallurgical Investigation into an Automotive Fire

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Failure analysis requires many forms of investigations; some are straightforward and others are conducted to eliminate alternate possibilities. This failure investigation occurred during a litigation assignment several years ago and concerned a recreational vehicle (RV) that caught on fire, killing one of the owners. It was important to identify the origin of the fire, and this paper describes how metallurgical analysis helped in determining that origin.

Keywords: aluminum, copper, corrosion, iron, melting temperature, recrystallization temperature

Background

A fire occurred in a recreational vehicle (RV) and resulted in one death and one severe injury. A liquid propane (LP) leak was suspected as the fuel source for the fire. However, this RV was also equipped with a dual fuel supply, and the same LP tank supplied fuel to the engine as well as the appliances.

The leak in the LP lines could have come from numerous locations throughout the RV, because the gas lines feed the engine, stove, refrigerator, hot water heater, and so forth. Additionally, there is always the question of whether a valve was open or closed, and an open valve could have been the fuel source. The insurance technical investigator pointed out that usually the fire is hottest at its fuel source. Therefore, a survey of metallic components from the wreckage was conducted in an attempt to establish the temperatures to which the components were exposed.

Examination

An exemplar RV was located and examined as a point of reference (Fig. 1 and 2). The LP tank area, appliances, and accessible LP piping were reviewed. With this background information the burnt RV was examined visually, and Fig. 3 to 5 show some of the details of that examination. The insurance technical investigator noted that the debris generally fell down, remained in place, or was located close to its original position. Therefore, any debris located on the unit or underneath was assumed to come from that location or from a location directly above the debris pile.

Metal samples were removed from a variety of locations including the engine compartment, LP

Fig. 1 Exemplar recreational vehicle

Fig. 2 Engine compartment of exemplar recreational vehicle

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tank area, and living quarters, including the appliances. These samples were examined in the laboratory by optical macroscopy, scanning electron microscopy (SEM), and energy-dispersive spectroscopy (EDS). Oxidation, melting, and pitting were some of the features expected.

Discussion of Results

None of the samples taken from the LP tank area and the living quarters revealed any melting, even of the aluminum. However, the samples from the engine compartment showed a large range of temperature indications as determined by comparison with the melting and recrystallization temperatures[1,2] for the metals and alloys examined.

The melting and nominal recrystallization temperatures for aluminum are 660 and 100 °C (1220 and 212 °F), respectively. The temperature of the aluminum siding near the passenger's seat was approximately 648 °C (1200 °F). The temperature of the aluminum siding near the driver's seat was approximately 93 °C (200 °F) but did not approach the passenger side temperatures. This was established by noting excessive oxidation of the aluminum. Indications of high temperature (as determined via SEM, Fig. 6, and EDS) included the presence of porosity (Fig. 7) and incipient melting (Fig. 8) on the passenger-side aluminum sample. These indications were not found on the driver-side aluminum sample (Fig. 9).

The melting and nominal recrystallization temperatures for copper are 1450 and 415 °C (2640 and 780 °F), respectively. The temperature of the copper electrical wiring near the passenger-side engine valve cover was 415 to 1370 °C (780-2500 °F), while the temperature of the copper electrical wiring near the driver-side engine valve cover was less than 415 °C (780 °F). This was established by noting grain growth (Fig. 10) and grain-boundary degradation (Fig. 11) on the passenger-side copper sample. These indications

Fig. 3 Burnt recreational vehicle

Fig. 4 Engine compartment

Fig. 5 Liquid propane tank and control valves

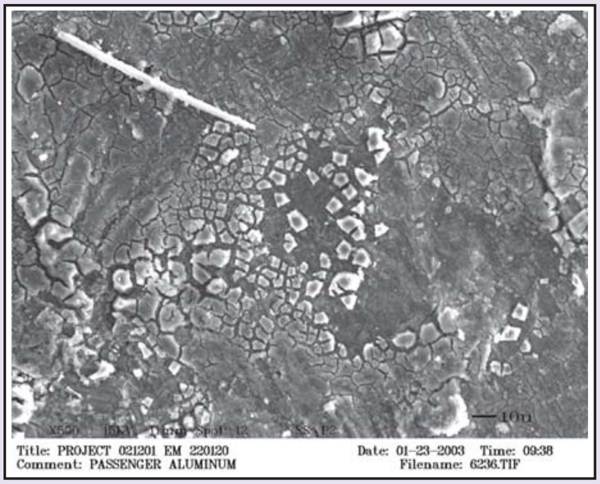

Fig. 6 *Micrograph of passenger-side aluminum sample showing excessive oxidation. 500×*

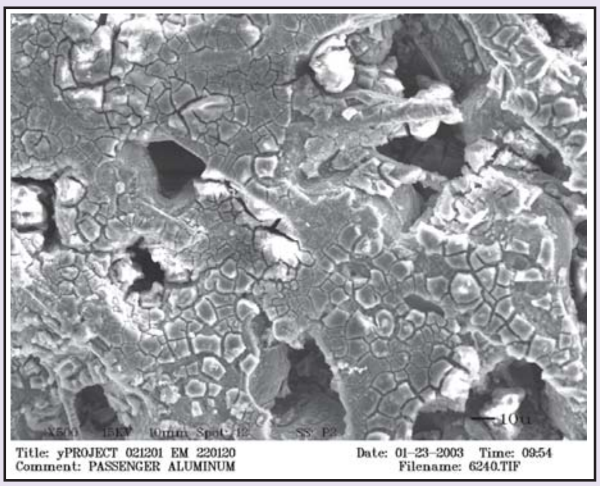

Fig. 7 *Micrograph of passenger-side aluminum sample showing porosity. 500×*

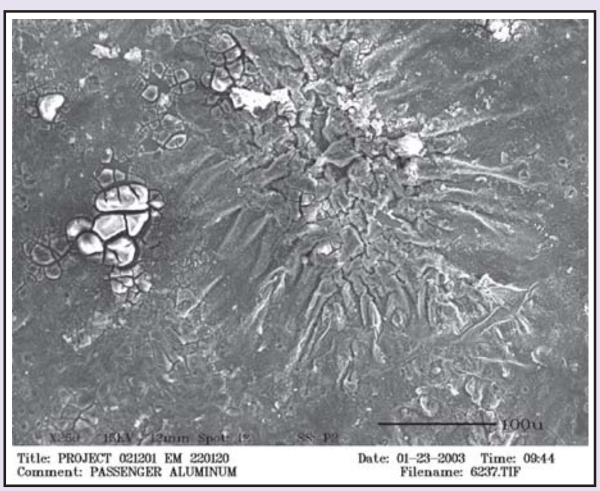

Fig. 8 *Micrograph of passenger-side aluminum sample showing incipient melting. 250×*

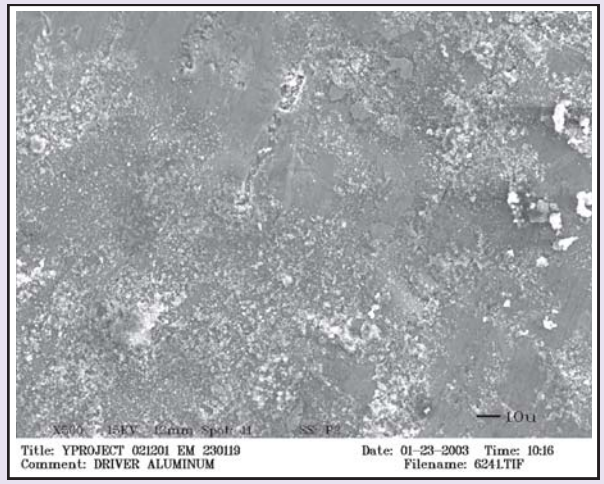

Fig. 9 *Micrograph of driver-side aluminum sample. 500×*

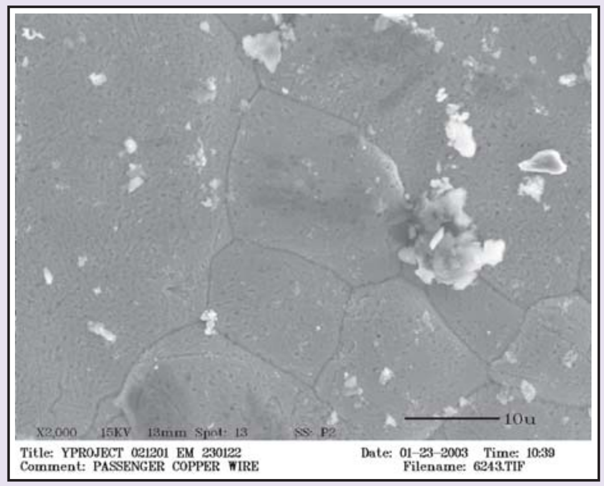

Fig. 10 *Micrograph of passenger-side copper sample showing grain growth. 2000×*

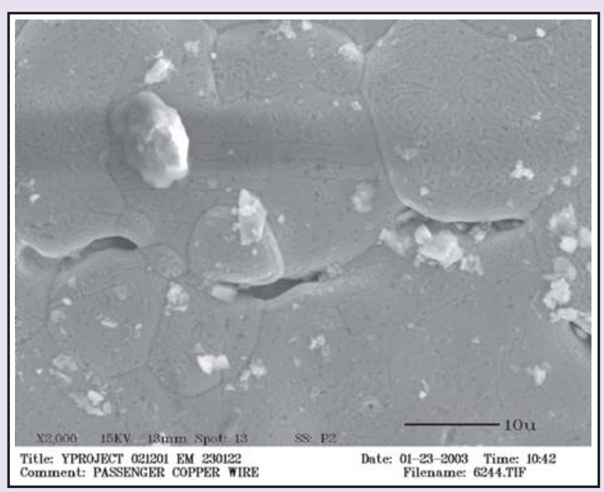

Fig. 11 *Micrograph of passenger-side copper sample showing grain-boundary degradation. 2000×*

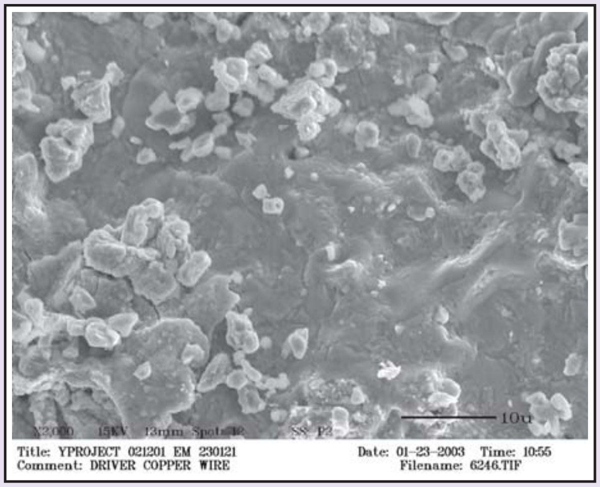

Fig. 12 Micrograph of driver-side copper sample. 2000×

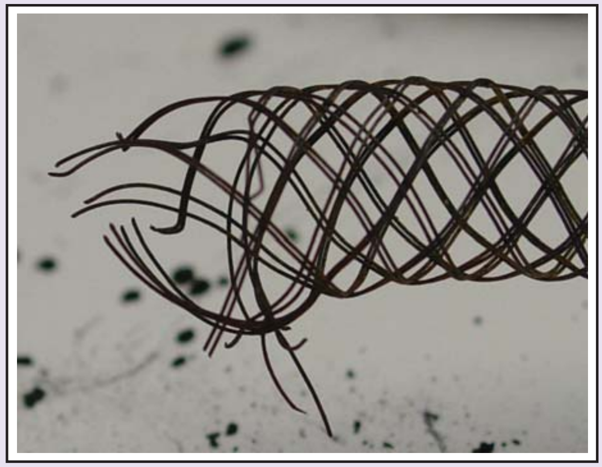

Fig. 13 Melted end of liquid propane feed line to mixer in engine compartment

Fig. 14 Overall view of recreational vehicle with approximate maximum fire temperatures noted

were not found on the driver-side copper sample (Fig. 12).

The melting temperature of iron is approximately 1535 °C (2800 °F). The steel braided tubing for transporting liquid propane to the mixer in the engine compartment disappeared due to volatilization of the rubber coating and melting of the end of the reinforcing steel braid (Fig. 13). This was the only area to attain this high of temperature, which indicated that a steady supply of fuel must have been available.

The LP fuel line ran through the front passenger wheel well and it was opined that abrasion by road debris created a hole in the line.

Conclusions

These results are summarized in Fig. 14, which depicts the temperatures experienced by the various components and their locations. This analysis shows that the maximum temperatures during the fire were experienced by materials on the passenger side near the engine, suggesting that the fire fuel source was near the engine compartment, and is consistent with the origination site being in the passenger-side front wheel well due to abrasion of the LP fuel line behind the front wheel.

References

1. *Metallography, Structures and Phase Diagrams,* vol. 8, *Metals Handbook*, 8th ed., American Society for Metals, Metals Park, OH, 1973.
2. D.R. Askeland and P.P. Phule: *The Science and Engineering of Materials,* 4th ed., Thomson-Brooks/Cole, Pacific Grove, CA, 2003.