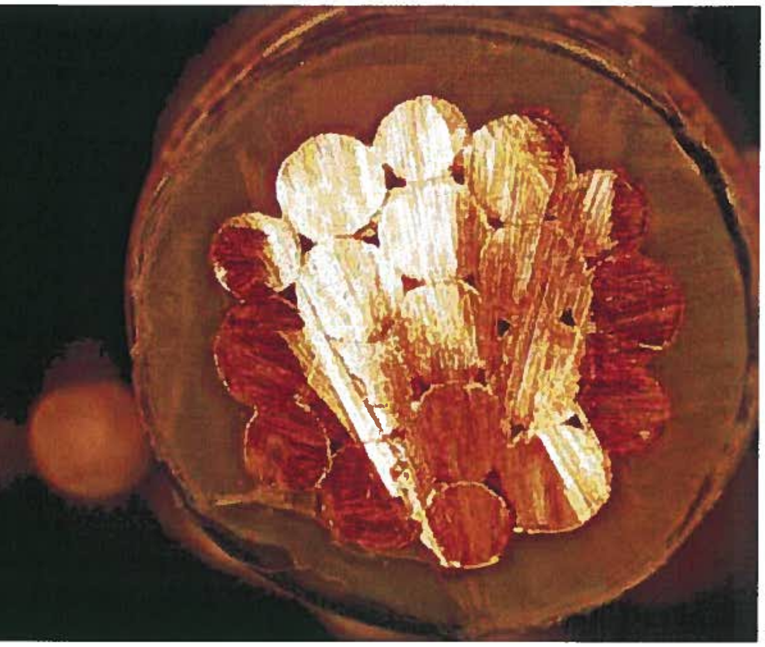
Transformer and Cable Sectioning



Mark Goodson, PE
Michael Shuttlesworth, EIT
Goodson Engineering
Denton, Texas

The proliferation of 'wall warts' and similar stepdown transformers or chargers in residences and businesses continues. Previous work done shows the difficulty in causing ignition by means of many of these devices.[1] Nevertheless, there are times when the remains of transformers are recovered after a fire, and their role in causing a fire, if any, is questioned.

The authors have been involved in many investigations where the identities or functions (i.e., telephone, saw, drill, game, alarm system) of a recovered transformer were in question. Outlined here are the steps that can be taken in helping to identify transformer remains. Note that this technique will allow a transformer to be categorized by output voltage, as well as the number of input and output turns.

By way of background, the authors describe several fire scenarios where transformer questions arose, as follows:

1. Several O&C investigators placed a fire's area of origin at the location where a transformer would be plugged n for a lawn sprinkler system. The transformer was found on the floor, in the garage. The maker of the sprinkler system claimed it was not a transformer they had supplied, based on dimensions, alone. The installer of the sprinkler system said that what was recovered was a transformer for a drill or power saw charger.

2. A fire was believed to have been started by an inline stepdown transformer for a paper shredder. The manufacturer of the shredder claimed that the transformer they used was of a different design and voltage than the one recovered.

3. A transformer was found plugged into the wall and was powered during the fire. There were nearby three low voltage appliances that could have used power from the transformer, these being a sub woofer, a set of amplified computer speakers, and a small TV. In that only one transformer was present, key to the investigation was the question of what appliance it fed.

After a fire, the remains of a transformer that is suspected to have caused the fire will naturally be heavily damaged. The windings may be distorted, the insulation pyrolyzed, and the leads disconnected or gone. The damage to the varnish (insulation) is such that resistance measurements are of little or no meaning.

The authors use a metallurgical potting technique as a way of obtaining turns ratio for such a transformer. Outlined here are both verbal narratives and pictures as to how such a transformer can be analyzed so as to determine its voltage rating. Once the voltage is known, its possible or probable function can be determined, and / or the number of primary and secondary turns can be matched with a known exemplar.

It is emphasized that this analysis is destructive, in the sense that some substantive information may be lost when these steps are carried out. Once the transformer is potted, one cannot go back and unwind the transformer, if such an analysis is desired.

1. The transformer should be placed in a small vacuum type jar, and be sitting atop small standoffs.

2. The vacuum jar is filled with a two part epoxy mounting system, such as Buehler Epoxicure.

3. A vacuum is placed on the jar, so as to help remove air pockets and insure penetration of the resin and hardener mixture into voids.

4. The epoxy is allowed to cure, per the manufacturer's instructions

5. The potted transformer is then sectioned, using a saw such as a Buehler Isomet or Struers Accutom. Kerf widths on the blades are about .6mm.

6. The 'face(s)' of the sectioned transformer are polished at a metallurgical polishing station until the smearing caused by the blade is eliminated.

7. The polished faces, showing the cross sections of the primary and secondary, are examined microscopically, with photos being taken.

8. The photos can be printed, and a wire count for both primary and secondary determined from the photos.

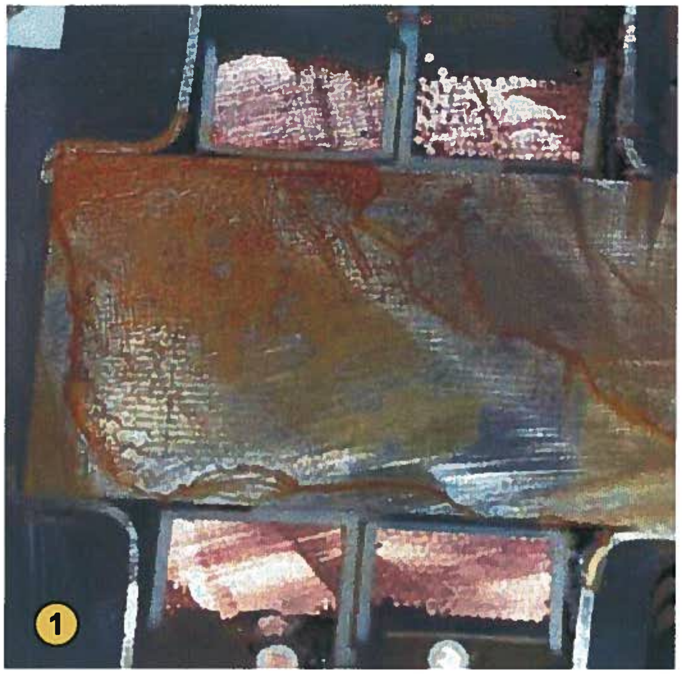


Photo 1 shows a cross section of a transformer after it has been potted and sectioned in half. The primary windings are on the left and the secondary are on the right.

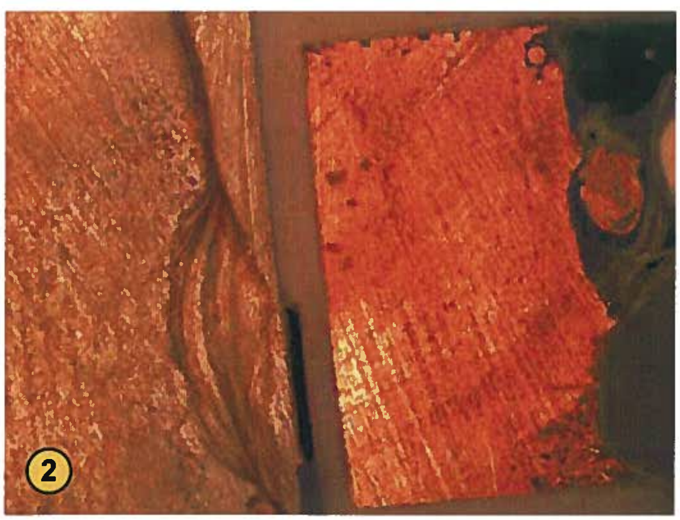


Photo 2 is a microscopic view of the primary windings (the right side of the picture) after sectioning (sawing) but prior to polishing. Notice how the fine conductors are somewhat smeared together by the action of the cutting wheel. The material to the left of the picture is a part of the iron core / laminate stack.

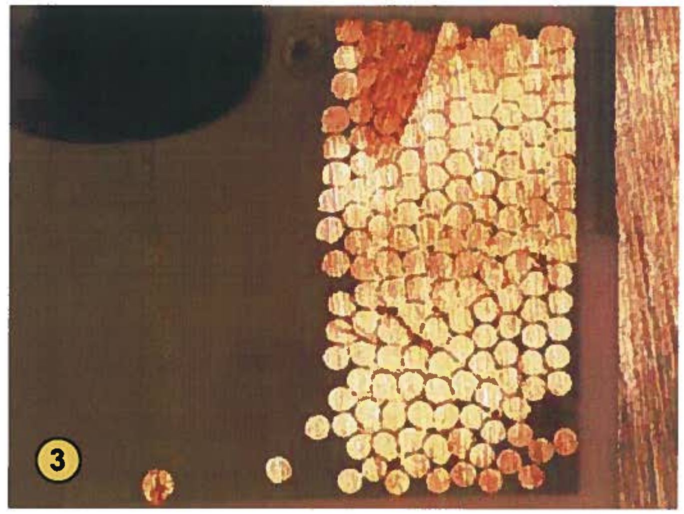


Photo 3 depicts the secondary windings after polishing with 180 size grit. The majority of the conductors are easily counted on the secondary at this point.

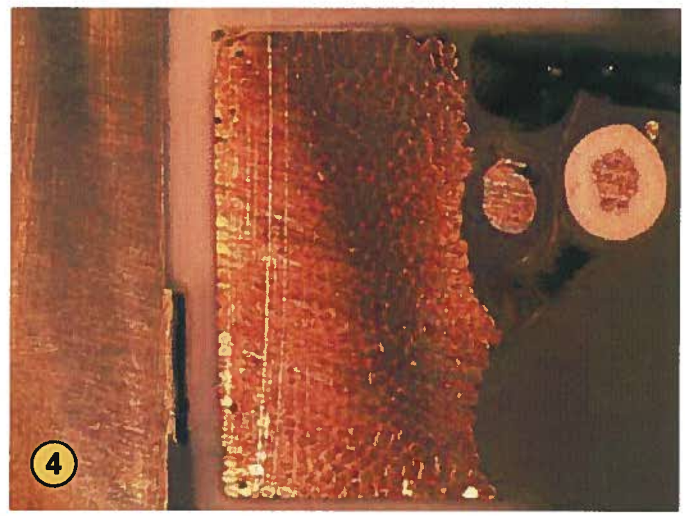


Photo 4 depicts the primary windings after polishing with 320 size grit.

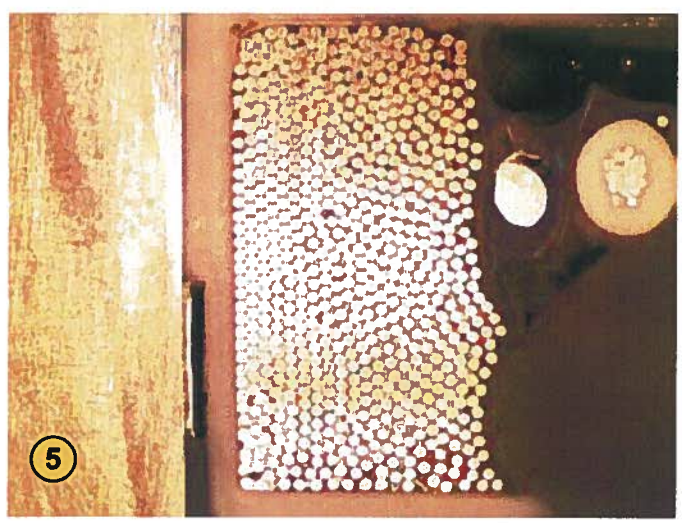


Photo 5 depicts the primary windings after polishing with 600 size grit.

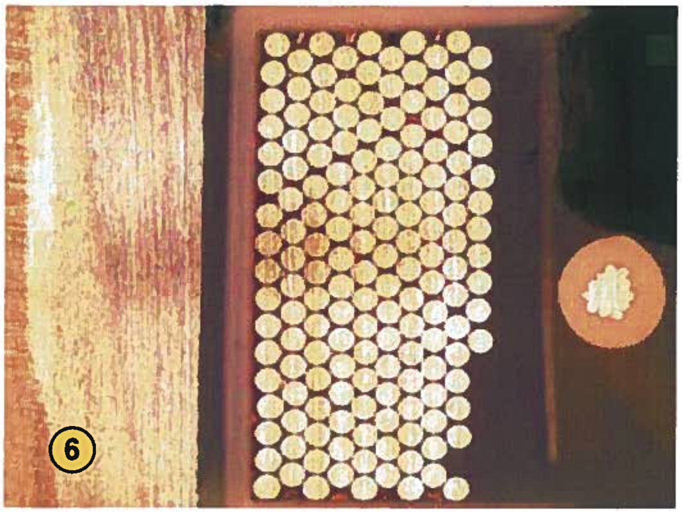


Photo 6 depicts polishing of the secondary with 600 size grit. *(Note: this is a different side of the secondary than is shown in Photo 3).*

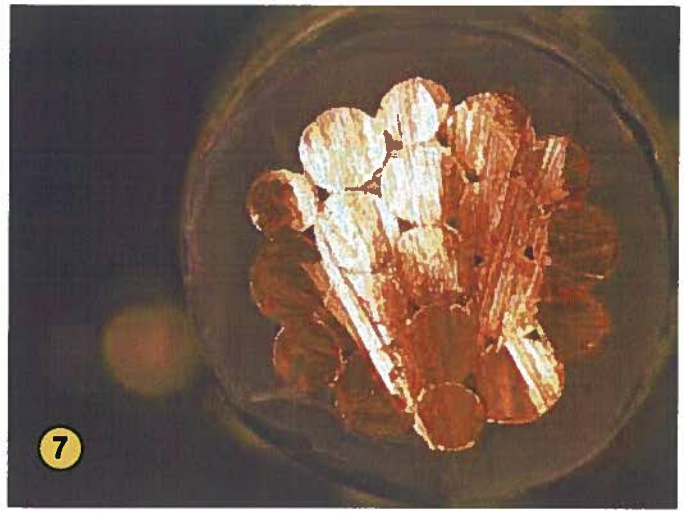


Photo 7 shows the cross section of a conductor that has been sectioned, but not polished.

In this case, counting of the wires showed a ratio of 674:160, input to output turns. Assuming a 120 volt input, the transformer's output is found by the formula:

Vout = Vin x (N secondary / N primary),
or 120 x (160 / 674) = 28.5 volts.

Cabling Analysis

While this article has initially focused on transformers, the same type of procedure can be used to accurately count strands on a line cord or electrical cable. A two inch (length) section of line cord is usually more than adequate for making the count. The section of cabling should of course be taken from an area that is either non fire damaged or a section that is not suspect; these techniques insure that no portion of evidentiary value is damaged.

In one examination the authors were involved with, a claim was made that the cabling used was undersized. The engineer making this claim had measured one of the 19 strands, determined its cross sectional area, and multiplied by 19 to obtain the effective wire gauge. A section of the cable was potted and cross sectioned, and the error of that engineer's assumptions was shown. There ARE 19 strands, but the strands are not all the same size, as shown by photos 7 and 8.

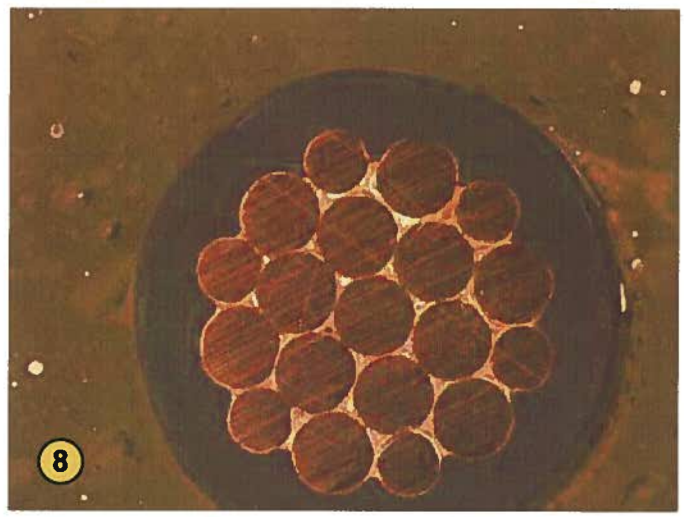


Photo 8 shows the same cable as in photo 7, but with polishing at the ~ 2000 grit level, using a polishing cloth. Note that the outer 'ring' of conductors has 6 larger conductors alternated with 6 smaller conductors.

Summation

This technique of potting, sectioning, and polishing is a time-accepted metallurgical technique. The potting holds the fine conductors in the same geometric arrangement for cutting. The cutting should be executed with a fine (~ .6 mm metallurgical saw) so as to minimize smearing. The polishing removes the effects of the smearing and allows for accurate wire counts to be made of both transformers and cables.

References

[1] Goodson, ME, et al, *AC Adapter Fire Causation*, FIRE & ARSON INVESTIGATOR, October 2006.

About the Authors

MARK GOODSON PE
Mr. Goodson is the Principal in the firm Goodson Engineering of Denton, Texas. He holds a BSEE from Texas A&M (1979) and then studied forensics at UT Southwestern Dallas. He holds two patents and has two patents pending, all related to fire protection. He is a PE in ten states, and is licensed in both electrical and mechanical engineering. Mr. Goodson has authored in excess of 25 peer reviewed papers. He was the first PE to serve on the State of Texas Electrical Board. From 1989 to 1991, he was a Court Special Master in Dallas. He is a member of the Fire and Arson Investigator Editorial Review Board. He is a consultant to many medical examiner's offices, and is a Fellow in the AAFS.

MICHAEL SHUTTLESWORTH EIT
Michael Shuttlesworth received his BSME from Oklahoma Christian University in 1997. He is a consulting engineer / EIT with Goodson Engineering, and manages the laboratory. He has been employed with Goodson Engineering for 1 year.