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Recognising decals in Second World War camouflage German helmets.

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Abstract

This study shows the results of pulse thermography on WWII camouflage German steel helmets with the intent to visualize the decals covered by the camouflage paint and also to distinguish between the army and navy decals. Navy and army decals both had the same shield shape, with a figure inside comprising an eagle and a swastika. Most of the navy decals, however, were produced with a multilayer technique resulting in a different thickness for the eagle and the swastika inside the decal. Many decals were visible behind the paint and a multi-layered navy decal could be spotted too.

1. Introduction

The German steel helmet was introduced in the First World War, to protect the soldiers from grenade shrapnel. Between the two wars, its design was modified to avoid some problems found in the models of the First World War [1]. In 1934 insignia started to be applied to the helmets. They were water decals, different for each of the branches of service, applied in the factory or on the field by the soldiers. We can then find different decals for the army (Heer), the navy (Kriegsmarine – KM) the aviation (Luftwaffe – LW), the SS, and for other minor branches as for instance the Reich's Labor Service (Reichsarbeitsdienst - RAD) and the National Socialist Motor Corps (Nationalsozialistisches Kraftfahrkorps - NSKK). Five different manufacturers of helmets existed (ET, SE or HKP, NS, Q and EF) and they produced, in different periods, three different models, named by collectors M35, M40 and M42. The manufacturing process became ever simpler and faster from M35 to M42, to meet the needs of the war [2-5].

The German helmet, with its unique shape, became an icon of the war and, also due to the variety of models and decals, it acquired among collectors a special status. Navy (KM) helmets were produced in far fewer numbers than army and aviation helmets, and much less of them survived the war. For this reason, among collectors, they got a much higher value than other German helmets.

While LW decals had the shape of an eagle of the first or second pattern fingering a swastika in its talons (some say that the first pattern eagle resembled more a chicken than an eagle), Heer and KM decals were very similar and they had an identical shield shape with inside an eagle standing on a swastika. For the KM the decal and the swastika had gold or yellow color, while for the Heer they were silver or white (Fig. 1 and Fig. 2). Another important feature distinguishing many but not all KM decals from those of the Heer was the fact that they had a multi-layered structure, the eagle and the swastika resulting in relief and having a rim all around, as shown by the arrow in Fig. 1.

Fig. 1. *Multi-layered KM decal on a M35 ET helmet: gold color and rim.*

Fig. 2. *Heer decal on a M35 ET helmet: white color and no rim*

This particular multi-layered feature made them also more fragile and many KM decals, which survived the war, are damaged because a part of the figure has fallen off, such as the head of the eagle in Fig. 1. For this reason, an intact multi-layered KM decal on a steel helmet is even rarer today.

While multi-layered decals with a rim are definitely KM, some KM decals produced later did not have a rim and they can only be distinguished from Heer decals on the basis of their color.

Factory-applied decals had a protective transparent lacquer. In some cases, the lacquer turned yellow over the years and discussions have begun among collectors as to whether a decal is a Heer with a toned lacquer or a KM.

2. The issue of visibility

While for the parades, before the beginning or just after the beginning of the war, helmets adorned with two different decals, one on the left and one on the right were considered very appealing, with the beginning of the war it became clear that limiting their visibility was an important issue for the soldiers. The texture of the paint applied in the factory changed from M35 to M40 model, becoming rougher and less reflecting. Also the more visible national shield decal, with black, white and red stripes, was not applied anymore and, it was often removed from the already issued helmets, according to the 1940 specifications.

In many cases, soldiers applied different kinds of camouflage paints, sometimes mixed with sawdust, woodchip or sand to make them rougher and less reflective. In some cases, the decals were masked off or painted around, so that they remained visible, in some others they were completely covered.

Just the position and the shape of a decal can give precious information to the collectors. The eagle shape of an LW decal is well distinguishable from the shield shape of a Heer, a KM or a SS decal. A helmet with only one shield-shaped decal on the right belongs very probably to the SS, since for SS helmets the more visible party decal on the left was often removed. On the other hand, a helmet with only one shield-shaped decal on the left is very probably a Heer or a KM, since in this case the more visible national tricolor decal on the right was often removed.

Of course, for a collector, even partial removal of the camo paint to show a completely hidden decal would be unacceptable and a non-destructive technique capable of showing the presence of a decal behind the paint surface would be of great interest.

3. Thermal non-destructive testing using IR thermography

Infra-Red (IR) pulsed thermography was introduced in 1986 by W. N. Reynolds [6]. In IR pulsed thermography a heat pulse is generated by a flash lamp to warm up the component to be inspected. The heat propagation inside the component is modified by the presence of a defect under the surface. A fast IR camera recording images of the temperature of the component surface can visualize the defect as a surface temperature inhomogeneity. IR images show the shape of the defect and can quantify its depth with some post-processing.

In 1992 G. Busse, D. Wu and W. Karpen used a modulated heat source to perform lock-in thermography [7], generating an amplitude and a phase image. The phase image of the modulated surface temperature has the advantage of being independent of the surface emissivity and of the non-uniform illumination of the sample.

Pulsed Phase Thermography, introduced by X. Maldague and S. Marinetti in 1996 [8] uses a flash lamp as a heating source. An elaboration of the IR images after the pulse allows obtaining phase and amplitude images at different frequencies.

This study applies IR pulsed thermography to camo German steel helmets to see the decals behind the paint. The thermal behavior of a decal interposed between the metallic surface of the helmet and the camouflage paint was unknown before performing the experiments.

4. Thermographic inspection

An IR pulsed thermography investigation on more than thirty German helmets with different camouflages was conducted using a FLIR Titanium IR camera having a 320 x 256 InSb Focal Plane Array sensor and working in the *3–5 μm* waveband (Fig. 3).

Fig. 3. *One of the authors exhausted from hours of hard work on the J.M. Meland's extensive collection*

The flash lamp used as heating source was an Elinchrom Style RX 1200. In order to eliminate the IR radiation from the lamp, which could produce reflections disturbing the IR image quality, a glass with an IR reflective coating was placed in front of the flash lamp.

The thermal transient in which decals were visible was fast, typically lasting 0.2 – 0.3 seconds, depending on the thickness and on the kind of paint covering the decal. Fig. 4a and Fig. 4b are the visible and IR image of an M40 helmet. In the IR image the shape of a second pattern LW eagle is clearly visible. However, in some cases, the sawdust or the sand added to the paint hindered or completely prevented from seeing the decals. Some examples are given in Fig. 5, in which the decal is nevertheless visible through the paint mixed with woodchip, and in Fig. 6, in which the presence of a decal is very doubtful.

Fig. 4a. *M40 helmet with a camouflage adapted to the Italian front (courtesy Marco Pisani)*

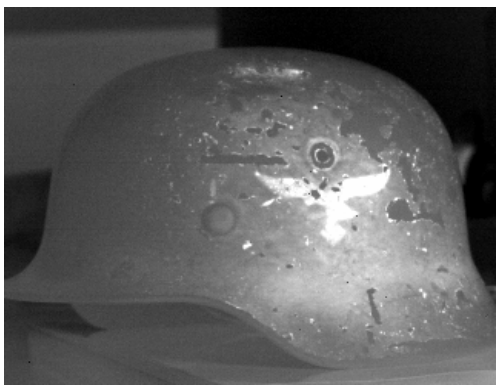


Fig. 4b. *Pulsed thermography of the same helmet showing a second pattern Luftwaffe eagle.*

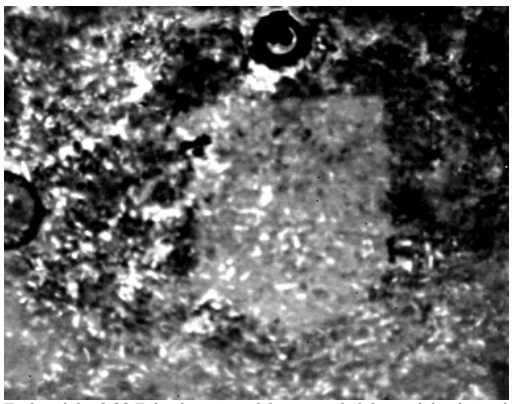


Fig. 5. *In this M35 helmet, with woodchip added to the camo paint, the decal is still visible*

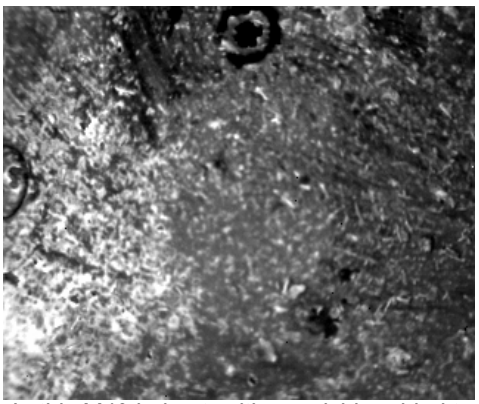


Fig. 6. *In this M40 helmet, with woodchip added to the camo paint, the presence of a decal is very doubtful*

***Fig. 7**. M35 helmet with a very rough and lumpy sand paint. Inside, near the rear edge, the inscription "Hpt W. Hlare" is visible (courtesy J. Meland).*

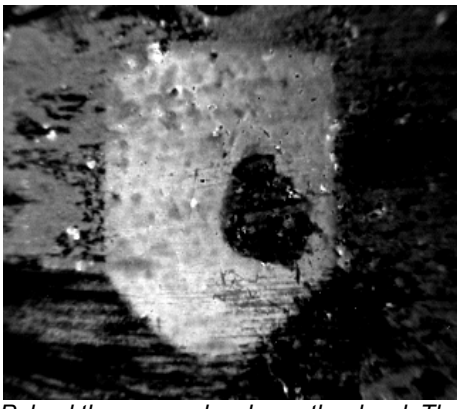


***Fig. 8.** Pulsed thermography shows the decal. The paint is not transparent in the IR and nothing is visible except the shape of the decal.*

Normally, the paint on the decal allows detecting just the shape of the decal and nothing inside it. Fig. 7 shows, for instance, an M35 helmet with a very rough and lumpy sand paint. This helmet has the inscription "Hpt W. Hlare" on the inside, near the rear edge. "Hpt" is an abbreviation for *Hauptman*, a grade attached to the artillery. The helmet was therefore supposed to be a Heer. Fig. 8 shows the pulsed thermography result, revealing a decal on the left side with a big damage similar to a hole, which was produced before the camo paint was applied. The eagle and the swastika within the decal are of course not visible.

The IR inspection of a large number of helmets showed however that in almost 30% of the cases the paint used for the camouflage was semi-transparent to the IR radiation in the waveband 3-5 μm [9].

Fig. 9a and 9b show an M35 found in Norway and completely covered by a shipboard grey paint. This helmet is supposed to be a KM, for the camo color, also used on ships. The outlines of the decals are visible on both sides.

***Fig. 9a.** M35 shipboard grey ET62 found in Norway*

***Fig. 9b.** Particular of the left side*

Fig. 10a shows the decal under the paint on the left side, visible to the IR camera before the flash. Fig.10b shows the same decal after the flash. Here, the edges of the decal and the figure inside appear clearly. In this case, for instance, the dimple in the far-right eagle talon (red arrow in Fig. 10a) allows the decal to be identified as an ET, thus matching with the producer of the helmet. This is an important point in favor of the originality of the helmet. Due to the not perfectly homogeneous paint thickness, the brush marks are visible on and outside the decal and they disturb at some points the quality of the image. From Fig. 10b, however, it is not possible to see the rim around the eagle and the swastika, and for sure also the gold color of a KM decal is not visible either. From this inspection, the definitive proof that the helmet is really a KM is missing.

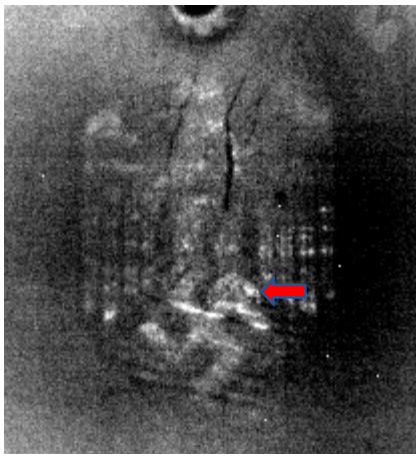


Fig.10a. *IR image of the decal on the supposed KM helmet of Fig. 9 showing the transparency of the grey paint in the 3-5 μm waveband.*

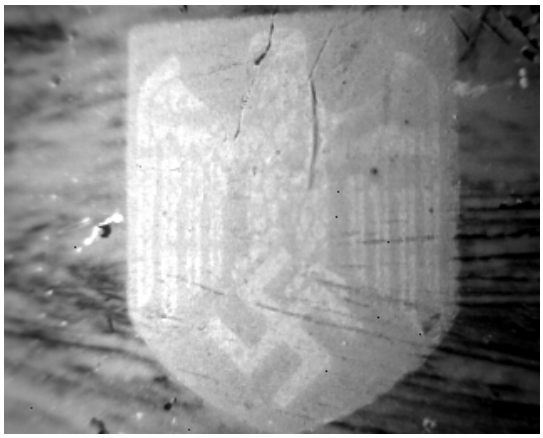


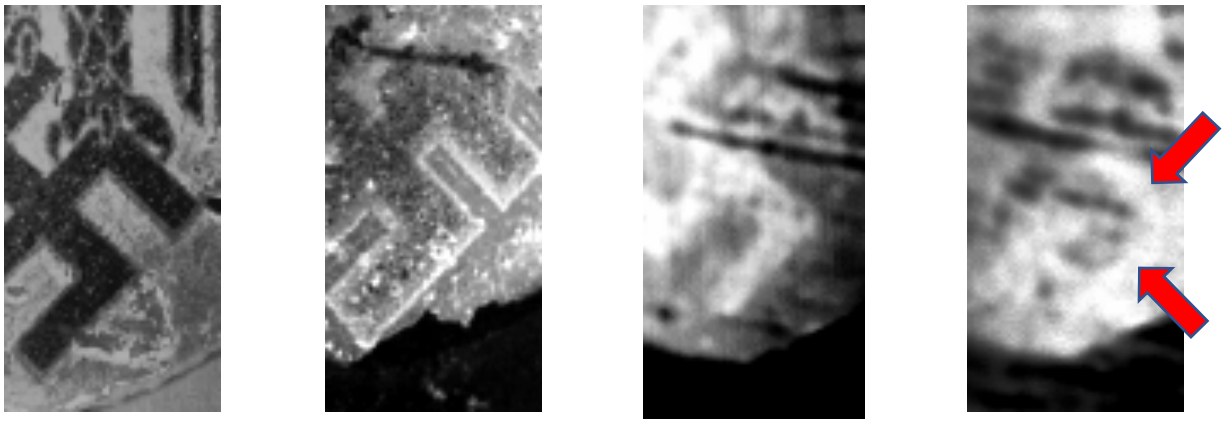
Fig. 10b. *IR Pulse Thermography image taken after the flash, on the helmet of Fig. 9. Due to the transparency of the paint all details are visible inside the decal*

IR images acquired on this helmet were processed in different ways, trying to evidence the step around the swastika and the eagle. Windowing up to 787 Hz was used in order to collect more images of the thermal transient and improve the elaboration.

Fig. 11a and 11b show the pulse thermography IR images taken directly on a Heer and on a KM decal without any paint. The edge of the KM decal appears definitely sharper. Fig. 11c shows an image taken on the shipboard grey helmet of Fig. 9 using windowing and an acquisition frequency of 787 Hz. Fig. 11d is the result after an elaboration using the following algorithm:

$$R = \frac{A_n - A_0}{A_1 - A_0} \qquad (1)$$

where R is the resulting image, A_n is the general image in the acquired sequence, A_0 is the image acquired before the flash and A_1 is the first image acquired after the flash. The resulting image R is similar to the phase image obtained in pulsed phase thermography. The result obtained after the elaboration showed a thicker edge of one arm of the swastika (see the red arrows). This result was however too unclear to be considered a proof of a KM decal.



a b c d

Fig. 11*. a) IR Pulse Thermography image on a Heer decal; b) IR image on a KM decal c) IR Pulse Thermography image obtained at 787 Hz; d) Elaboration of the previous image using algorithm (1)*

The last attempt was done using a FLIR Jade II IR camera with a HgCdTe sensor working in the 8-12 μm IR waveband, chosen because in such a waveband the camouflage paint was not transparent. The aim was to obtain an image showing the shape of the inner figure only, eagle and swastika, produced by its different thickness. Fig. 12 shows the result obtained. Inside the shield-shaped decal, it appears the clear shape of the eagle and the swastika. No other detail is visible. This was considered to be the visualization of the multi-layered structure of the decal, definitely a KM. Since the figure is colder than the surrounding part of the decal, it means that the thicker figure inside the decal is made of

a thermally conductive material, probably a metal alloy. It is therefore believed that the decal was produced with a very thin sheet of metal, having the shape of an eagle and a swastika together, interposed between another two non-metallic layers.

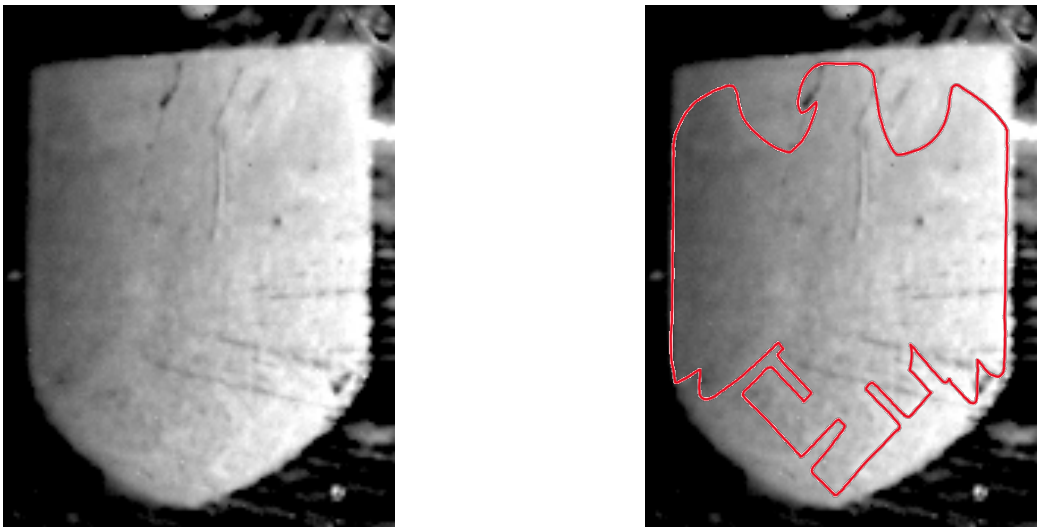


Fig.12. *Pulse Thermography image obtained on the helmet of Fig. 9 using an IR camera working in the 8-12 μm waveband, in which the paint is not transparent: the darker shape of the eagle and the swastika is visible within the shield of the decal, with no other detail inside. Since the shadow of the eagle and the swastika is very faint, a red line going around it has been superimposed in the figure on the right.*

5. Conclusions

Pulse thermography was applied to WWII camouflage German steel helmets, in order to visualize service decals hidden behind the camo paint. In most cases, decals could be easily seen. In some cases, sand, sawdust or woodchip added to the paint to make it more rough hindered or totally prevented to see the decals. In approximately 30% of the cases, the paint resulted transparent in the 3-5 μm waveband used by the IR camera and pictorial details could be seen within the decal, thus allowing, for instance, to determine its producer. Transparency of the paint was however an obstacle in singling out multi-layered KM decals from single-layer Heer decals. Decisive was the use of an IR camera working in the 8-12 μm waveband, in which the paint was not transparent, which allowed detecting the thickness difference and the rim all around the figure inside a KM decal comprising the eagle and the swastika. The lower temperature of the figure inside the decal after the flash shows that the intermediate layer in KM decals is probably made of a thin sheet of metal.

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