Application Note:

Demagnetization of tungsten carbides

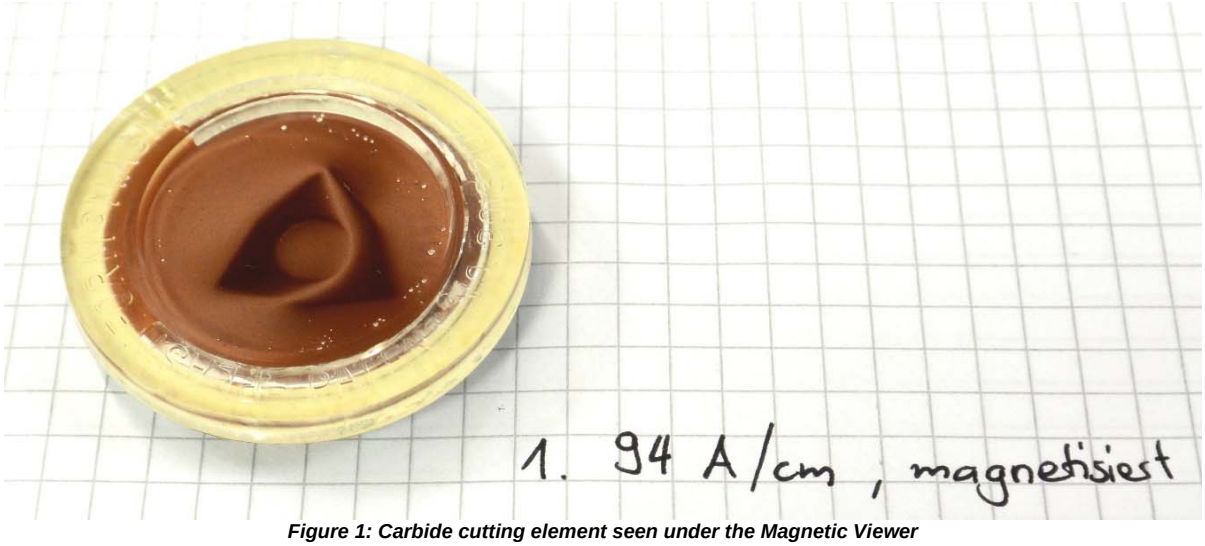


Figure 1: Carbide cutting element seen under the Magnetic Viewer

This application note discusses the demagnetization of tungsten carbides and similar materials including stellite. Tungsten carbides commonly include cobalt as a binder.

Carbide parts can become magnetized during production and in use, it is not always possible to identify a single source of the residual magnetism. A common cause is magnetic clamping during grinding, which results in strong magnetization.

Magnetism leads to problems with the following processes:

- Adhesion of shavings and particles during machining processes
- Adhesion of components and particles during forming processes
- Adhesion of particles during cleaning, non-compliance with particle limit values
- Quality problems during coating processes (PVD)

1 Magnetic properties of carbides

The ferromagnetic properties of a material are characterized by a hysteresis curve, which describes the relationship between an externally applied magnetic field (magnetic field strength, H-field) and the magnetic field induced in the material (magnetic flux density, B-field).

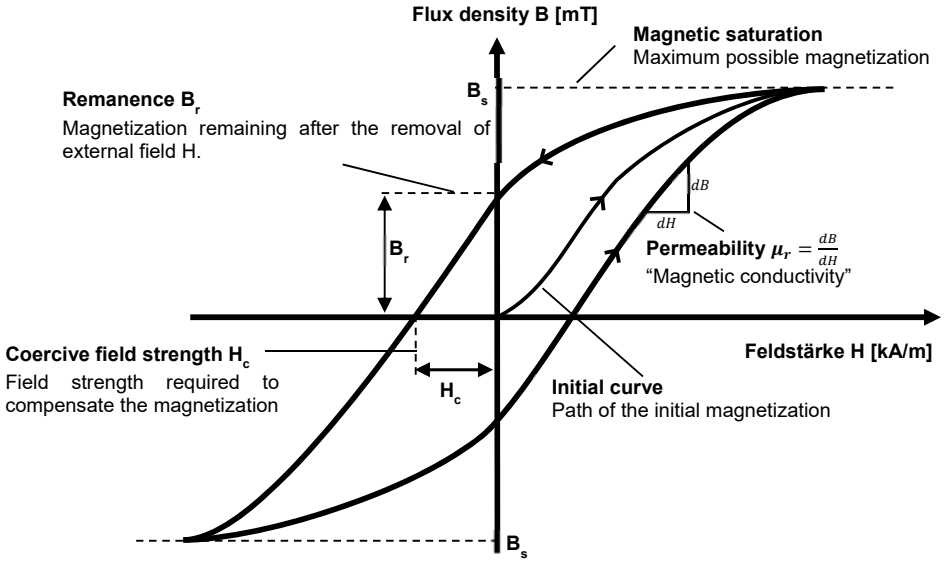


Figure 2: Magnetic hysteresis

The most important parameters are:

- The *permeability* ($\mu = \frac{\mathrm{dB}}{\mathrm{dH}}$) amplifies the magnetic field in the material and describes the relationship between the B field and the H field.
- The *magnetic saturation* describes the maximum flux density in the material.
- The *remanence* describes the residual magnetism remaining in the material after removal of the H field. *Remanence* and *coercive field strength* withstand the change of the magnetic state.

Ferromagnetic materials can be classified as either magnetically hard or magnetically soft. Magnetically soft materials (such as cast iron and low allow/annealed carbon steel) can be strongly magnetized under the influence of a a strong external magnetic field but exhibit little residual magnetism once the field is removed. Magnetically hard materials (extreme case: permanent magnet) are characterized by high remanence and retain a great deal of residual magnetism. Hard magnetic materials require very high magnetic field strengths to change their magnetic state.

Carbides are typical magnetically hard materials:

- Carbides are magnetizable, due to the ferromagnetic properties of cobalt.
- Because of the high remanence, a high field strength is required for demagnetization.
- A high permeability amplifies the magnetic field in a material and therefore helps demagnetization. As carbides exhibit a low permeability, a high field strength is required to reach magnetic saturation and thus for demagnetization.
- Magnetizability can be reduced by using nickel as a binder.[1]

[1] HARTMETALL ESTECH AG "Hartmetall–Sorten und ihre Eigenschaften" 04.2014:
http://www.hartmetall-estech.ch/files/2014/05/verkaufsbrosch%C3%BCre_hartmetall_sortenliste_deutsch_oSM-low1.pdf

2 Demagnetization of carbides

The demagnetization of small production quantities works relatively well when using a coil with a high permeable core (yoke, plate, choke demagnetizer). The induction leads to very high flux densities in the core, which emerge as high field strengths at the open ends of the core.

A procedure of this kind is often not possible or inefficient when applied to larger quantities of parts, part in racks, or large components. Conventional air-core coils without cooling systems reach field strengths of up to ~30 kA/m (377 Gauss). This does reduce the residual magnetism; but does not achieve complete demagnetization or compliance with limits.

The Maurer-Degaussing® pulse demagnetization with Field Multiplicator Technology (FMT®), feeds a controlled current trough the coil. The use of a short/pulsed electric current substantially reduces heating, thus making very high magnetic field strengths possible.

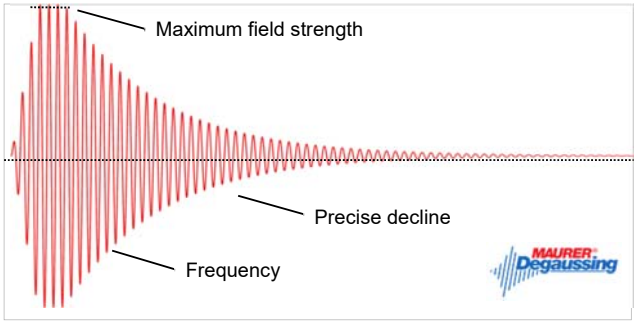


Figure 3: Maurer-Degaussing® demagnetization pulse

With air-cooled type VE coil very strong magnetic field strengths of up to 400 kA/m (5,024 Gauss) can be reached.

3 Test procedure

- A carbide insert is strongly magnetized using a standard neodymium magnet. This produces a magnetization similar to magnetic clamping.
- The carbide tool element is demagnetized at various field strengths. Before each demagnetization, the part is freshly magnetized.
- The residual magnetism in the part is measured both in the initial state and after demagnetization and visualized with a Magnetic Viewer[2] .
- Measurement of the residual magnetism is performed using a Maurer Magnetic M-Test LL measuring device. Residual magnetism in carbide is commonly fine-poled magnetism which is only detectable when measurements are made very close the surface. The M-Test LL's measuring element is only 0.5 mm (0.020" from the probe/material interface. measurement distance. The M-Test LL probe is scanned over the entire surface of the insert and the highest value noted.

[2] A Magnetic Viewer contains magnetic particles that orient themselves according to the field lines, thus making the emerging field lines visible.

4 Results

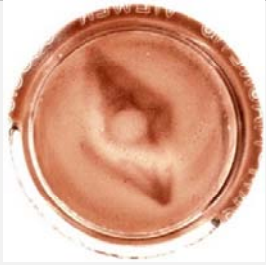
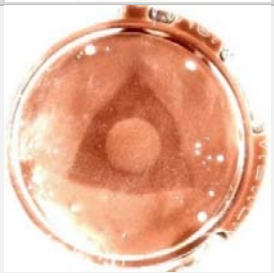
State	Workpiece 1		Workpiece 2	
Magnetized		88 A/cm		94 A/cm
Demagnetized 56kA/m (71mT) [3]		11 A/cm		35 A/cm
Demagnetized 107kA/m (135mT) [3]		2.7 A/cm		7.3 A/cm
Demagnetized 223kA/m (280mT) [3]		0.6 A/cm		2.5 A/cm
Demagnetized 277kA/m (349mT) [3]		0.5 A/cm		0.9 A/cm
Demagnetized 400kA/m (500mT) [3]		0.4 A/cm		0.4 A/cm

Table 1: Results of demagnetization

[3] Peak values, measured over the whole surface

5 Conclusions

- The field strength required for demagnetization is component-specific and should be determined in a preliminary test.
- For complete demagnetization of carbides, very high field strengths are required, which sometimes exceed 200 kA/m (251 mT / 2,512 Gauss).
- A reduction of residual magnetism can be achieved at lower field strengths.

6 Solutions by Maurer Magnetic

With customer-specifically, air-cooled VE coils, individual components or racks with large numbers of hard metal tools can be demagnetized before cleaning or coating. Large-sized carbide components and tools with carbide inserts can also be demagnetized.

The field strength required for a specific case is determined in a non-binding preliminary test and a suitable VE/HLE coil is designed according on the requirements (field strength, area of active opening and cycle time).

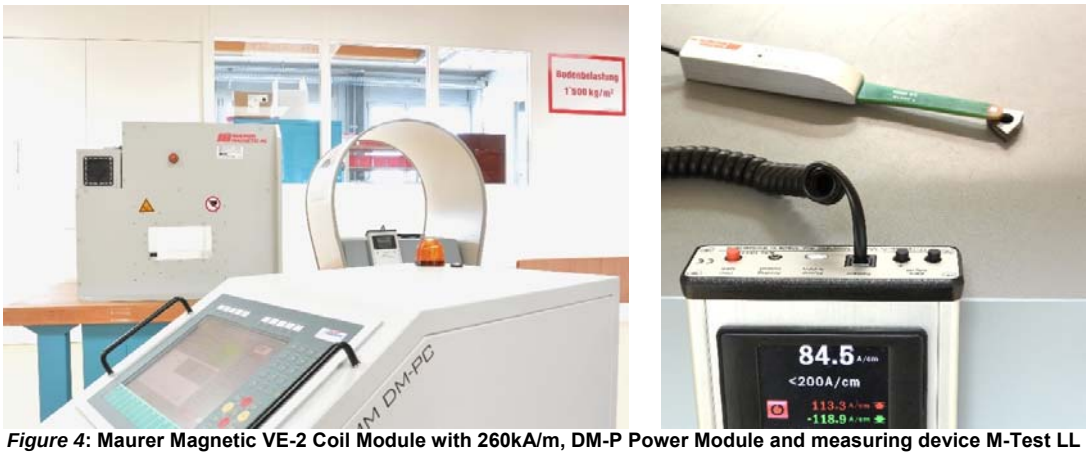


***Figure 4*: Maurer Magnetic VE-2 Coil Module with 260kA/m, DM-P Power Module and measuring device M-Test LL**

Systems used:

- Demagnetization system MM VE coil and DN power module
- Measuring device M-Test LL
- Magnetic Viewer for magnetic field visualization

Publication: April 2017, Remo Ughini, M.Sc. ETH Masch.-Ing.