Low-level demagnetization as preparation process for shaping of metal powder parts

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Maurer Magnetic AG, your specialist for:

- Industrial demagnetizing machines
- Instruments for measuring magnetic fields
- Degaussing services
- Troubleshooting in the field of magnetism
- Permanent magnets and magnetic systems

Abstract

Metal powder pressed parts are mainly used in mass production for the automotive industry. Short production times, precisely controlled material properties, and minimum rework of the parts make this process particularly interesting.

An important production cost factor are the punches and dies, which are usually made of sintered tungsten carbides and often provided with wear resistant coatings. These tools are subject to strong mechanical wear, and hence have a limited life.

Ferromagnetic sintered tungsten carbides (STC) show, in conjunction with the outstanding hardness and wear endurance, hard magnetic properties (high magnetic coercivity). After exposure to external magnetic fields, STC retain residual magnetism values of up to 100A/cm (~ 125 Gauss). As an example, for steel parts of the automotive industry, the limit is set at 4A/cm or lower.

Continuous developments in the field of powder metallurgy allow the production of parts with increasingly narrower dimensions and weight, at an ever increasing rate of production. Complex parts with thin walls can be manufactured today by use of multi-stage press adapters and tools. The residual magnetic fields amplified in small air gaps, will thus impact progressively the compacting process of ferromagnetic powders.

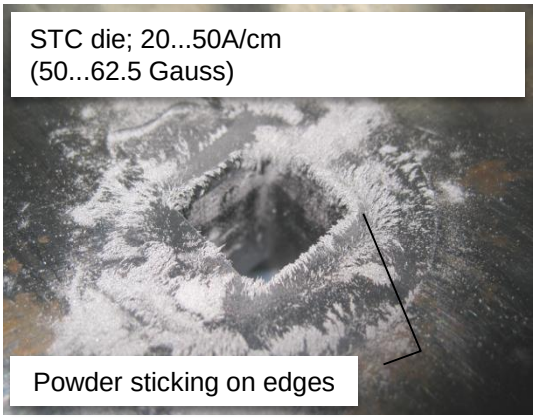
Magnetic clamping and lifting systems offer great advantages in the time required for setup and handling of ferromagnetic workpieces. The usual demagnetizing functions on those systems are able to reduce previously impressed magnetization close to the initial values. However, such systems meet their performance limits when the technical requirements for low residual magnetism become lower, as in the case of the powder metallurgy.

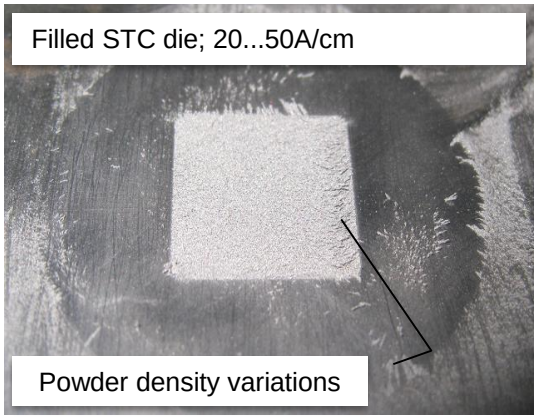
Problems due to residual magnetism of powder presses are observed in many production facilities during degaussing services. Suitable demagnetizing and measurement instruments are often missing in the concerning companies or do not meet state of the art requirements.

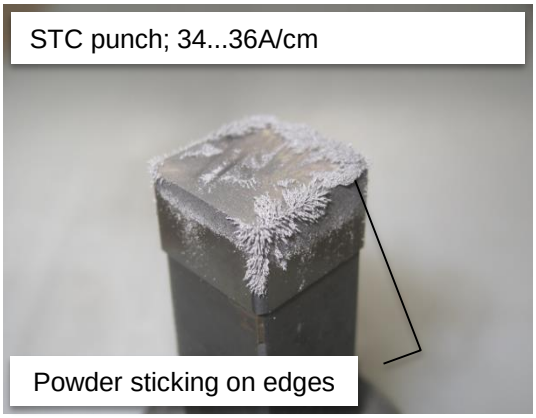
The ferromagnetic powder compacting process performed with completely demagnetized tools and press structures offers the following advantages:

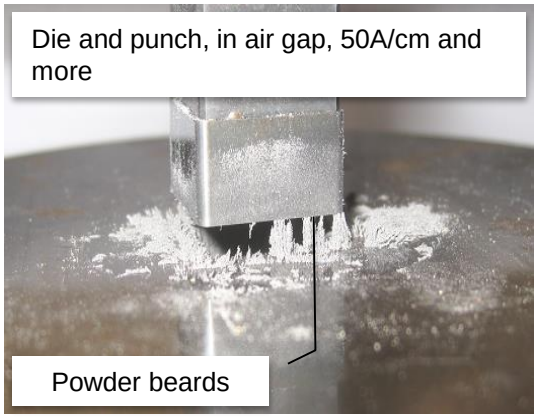
- Improved flow of the metal powder
- Shorter cycle times in powder compacting
- Extended lifetime of the punches and dies
- Reduced density variations of the green compact
- Less waste of powder

With modern demagnetizing machines, a safe and total degaussing of hard metal tools, adapters and press frames is achieved. In addition to this, the demagnetization of fully assembled presses with mounted adapters is possible.









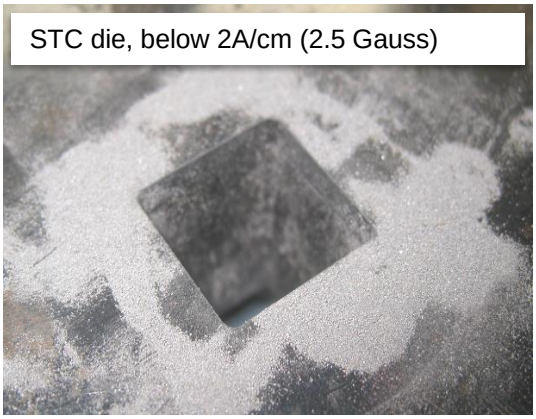
Behavior of the ferromagnetic powder on magnetic dies and punches

Magnetic field lines take the path of minimum resistance. With a relative magnetic permeability of μ_r~1, air represents for magnetic field lines a high resistance. Ferromagnetic steel conducts magnetic fields much better, due to values of μ_r=200…1000. Magnetic field lines have always a closed path. They run as far as possible in the steel, due to the low magnetic resistance, and return at the end, typically on the edge or corner of the part, back through the air. This leads to concentrated field lines at corners, edges, and in air gaps.

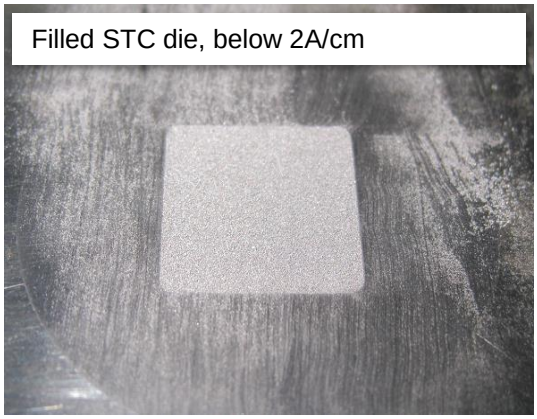
Dies and punches with increased residual magnetism impart the magnetism on the magnetically conductive, ferromagnetic metal powder. The metal powder aligns itself to the corresponding magnetic field lines, and this leads to the typical accumulation at edges and corners. The observed high residual magnetism for STC of up to 50A/cm leads to effects as shown on the pictures above. The flow behavior of the metal powder is significantly affected by the magnetic fields. The magnetic sticking of the metal powder is increased at the spots with the high field densities. After some time, signs of use and increased wear occurs, such as wear marks at the tool flanks. Highly abrasive metal powders, such as diamond containing powders, lead to a particularly pronounced wear of the tooling. More disturbing effects occur on the filling of metal powder into dies with high residual magnetism. Variations in density, irregular surface of the filling powder, and increased powder losses affect the compacting process. Lowering the punch on the filled die results in narrowing the air gap. The increased field density induces the unwanted powder beards, and consequently leads to variations in density of the green compact, and increased wear of the tool on edges.

For the tests shown, die and punch were set up outside the press adapter.

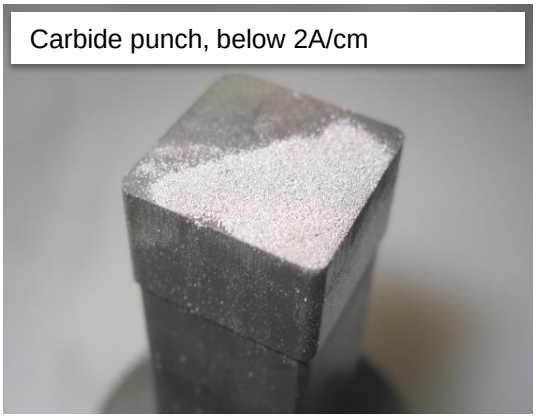
STC die, below 2A/cm (2.5 Gauss)



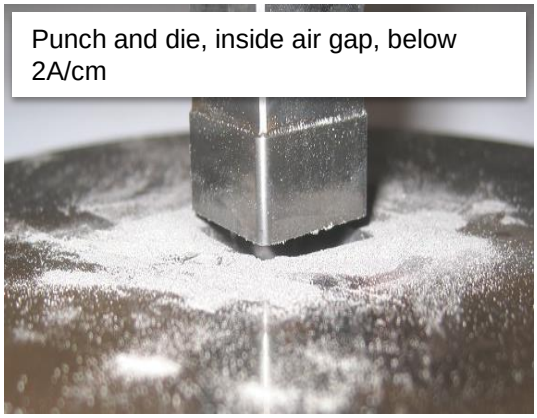
Filled STC die, below 2A/cm



Carbide punch, below 2A/cm



Punch and die, inside air gap, below 2A/cm



Behavior of the metal powder in perfectly demagnetized dies and punches

The demagnetization of the carbide metal dies and punches shown here was performed using a degaussing pulse sequence of high power density, characterized by very high field strengths, and a field completely enveloping the part. The high field strength ensures that all magnetic moments of the hard metal are reversed, and the enveloping field volume guarantees a uniform flux over the entire piece. With this method, on all points of the dies and punches, residual magnetism values significantly lower than 2A/cm were achieved.

The flow behavior of the iron powder is not influenced any longer by such demagnetized tools. The powder is distributed evenly on the surfaces without adhering to edges. On edges and corners, powder accumulations are not visible anymore. Powder beards aren't recognizable, even in the small air gap between punch and die. The previous density variations in the magnetized die have been overcome.

Experiences of customers show the following benefits when compacting metal powder with demagnetized tools:

- Extended lifetime of the dies and punches of up to 20% (diamond metal powder)
- Reduced weight variations and lower porosity of the green compact
- Reduced metal powder losses due to optimum filling behavior
- Faster production rate due to shorter filling time of the dies with metal powder
- Less production waste through improved process conditions
- No residual magnetism of the produced green compacts

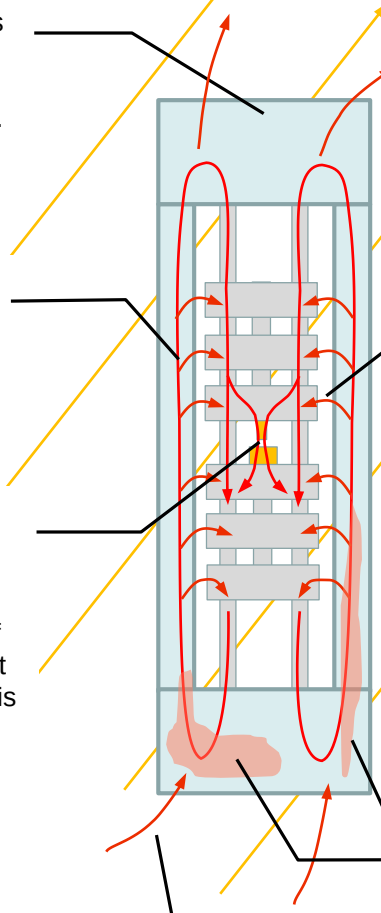
Field lines in a powder compacting press with high residual magnetism

The directions and the flux densities of the field lines in the press depend on the magnetization of the ferromagnetic structures and the direction and strength of the geomagnetic field at the site.

External static magnetic fields, such as for example the magnetic field of earth, induce magnetic fluxes in the press.

Upper and lower cross bars close the magnetic circuits between the outer press frame and the inner guides.

Typically the magnetic field of earth is in a ~ 45° angle to the horizontal.



The magnetic flux is reinforced in the long ferromagnetic press columns.

Between the adapter plates and the press frame higher residual field strengths appear due to the small air gap.

Critical spot:
Field concentration in the small air gap between die and punch. The polarity of the magnetic field does not matter, only the total value is crucial for the application.

Press parts with magnetized zones enhance the magnetic fluxes inside the powder press, depending on their polarity. Together with the magnetic field of earth, very high values might occur (> 100A/cm) in the region of the dies and punches.

Schematic representation of magnetic field lines.

Field lines in a demagnetized powder compacting press

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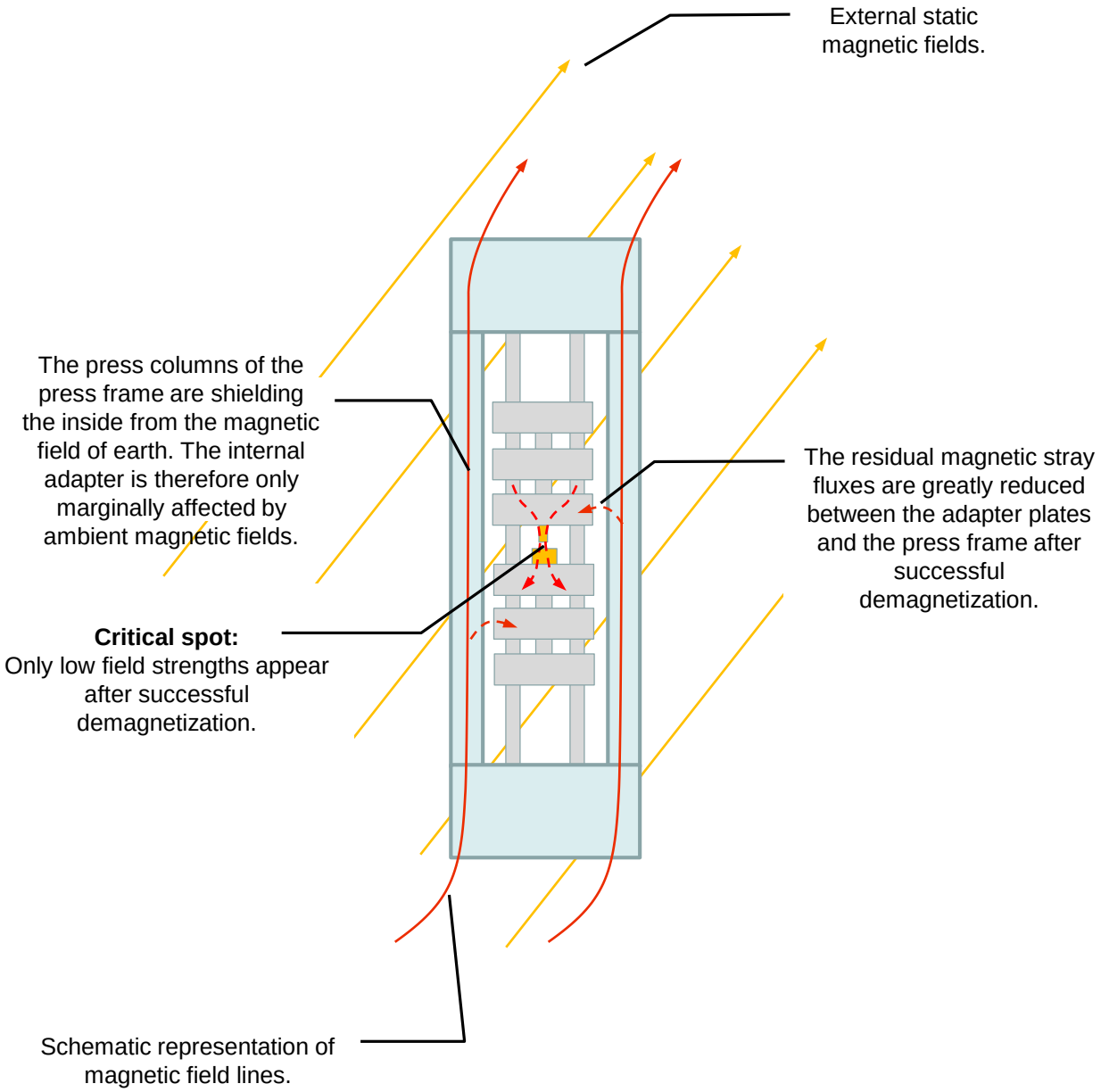


Demagnetization of press components and fully assembled powder presses

The main structures of powder presses are made of ferromagnetic steel. Powder compacting presses over 250 tons of pressure force require heavy steel parts with massive cross sections to handle the forces. The successful demagnetization of such parts can be achieved only with high performance degaussing devices. The press components are generally produced by several sub-processes, done by sub contractors, and the parts are also transported several times. It is hard to exclude that such parts are magnetically clamped or lifted during manufacturing. Often the raw steel material from the steel manufacturer is already showing high residual magnetism. To avoid increased residual magnetism values at the critical pressing tool, a process capable of demagnetizing the press components with sufficient depth prior to assembly of the press is necessary.

The demagnetization of a complete powder press is always more complex than a demagnetization of the single parts prior to assembly. The overall increased steel mass of the press and the limited accessibility to the components complicate the demagnetization. Because of the size of an assembled press, a completely enveloping degaussing field would require an unreasonable amount of electrical power. But only this enveloping field would prevent the sometimes occurring displacement of the residual magnetism within the entire press.

A much simpler situation is achieved when the press adapter is removed from the press. The outer frame and the press adapter can then be demagnetized separately. With a powerful pulse degaussing process and a flexible cable coil, good results are achieved. The target value of residual magnetism is about 2...8A/cm, taking in account the large masses of steel and the field inductions caused by the geomagnetic field.

Dies and punches made of highly alloyed tool steels and hard metals must always be demagnetized separately due to the required high field strength. For such parts, values below 2A/cm after degaussing are generally targeted. To ensure a sufficient measuring resolution, the residual magnetism has to be measured with a Hall sensor applied close to the critical spots on the measurement surface.

After demagnetization of the critical structures of the press, the residual magnetism of ferromagnetic materials is removed, and the remaining values are only caused by external magnetic fields, such as the magnetic field of earth. After installation of the compacting press, disturbing residual magnetism at the press tool is excluded. The precondition is, that no further magnetic tools, like for example electromagnetic chucks, have been used for the assembly of the press.

The described procedure prevents the occurrence of critical magnetic fields within the punch and die. However, a re-magnetization of the ferromagnetic structures of the press after a certain time can not be excluded.

Demagnetization of a press adapter with flexible demagnetizing cable coils and pulse degaussing method.

Gain competitive advantage through your own know-how

Process security in the mass production of ferromagnetic sintered parts has made a big step ahead through perfectly demagnetized powder presses and tools. Companies that are active in powder metallurgy must any time be able to perform required in-house demagnetizations on short notice. Only by this, a consistent high production and quality level without prolonged interruption and without dependence on external service providers is maintained. The investment cost of the demagnetizing systems is paid back after a short time by the increased tooling life and reduced amount of production rejects.

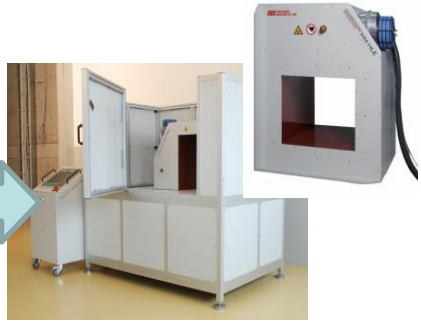
Modular degaussing machines for comprehensive coverage of the task

The demagnetization of different part sizes and hard magnetic materials, the mastery of process safety, and safe and simple operation constitute a demanding requirement profile for the degaussing process.

With a modular system consisting of flexible cable coils, high performance coils with optional protective housings, and mobile power modules, conditions are fulfilled for the successful on-site demagnetization of the powder press units.

The automatic degaussing process provided by the MaurerDegaussing systems yields reproducible results. The release of the degaussing pulse, triggered by pressing a button, ensures simple and reliable operation without complicated adjustments.

Mobile power module + flexible cable coils
For the demagnetization of:
•Press adapters
•Press frame
•Steel parts of any kind



Mobile power module + high performance coil with protective housing for demagnetization of:
•STC dies
•STC punches
•Other hardmagnetic parts

The mobile power module MM DM produces the degaussing pulses in the different coils

Deployment of the demagnetizing method within the manufacturing process flow

The three magnetically critical components of a powder press, tooling, adapter, and press frame, are demagnetized according to the scheme presented below.

The following priorities have to be taken into account:

1. Tooling
2. Adapter
3. Press frame