

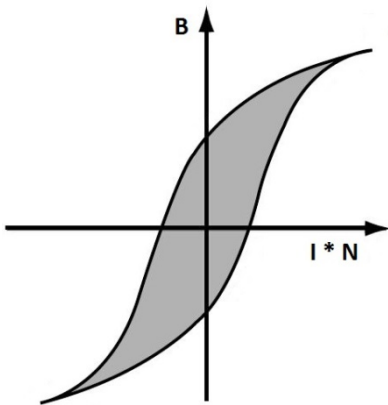
# Degaussing of ferromagnetic materials

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When arc welding ferromagnetic materials, magnetism is not desired because it causes the process to become very unstable and leads to insufficient welding results. Magnetism may even make arc welding impossible. This short paper deals in detail with the mechanism of magnetism in connection with welding processes and solutions for degaussing workpieces are examined to enable high-quality, reproducible and economic results.

## 1 Magnetic fields

Magnetism and magnetic phenomena have been known for a long time. While in ancient times magnetism was observable only in magnetic iron ore, we see it in many natural phenomena and technical applications today. For example, when looking at the earth's magnetic field and its effects on a compass [1] [2]. In terms of physics, the strength of a magnetic field can be defined by the magnetic field intensity  $H$  [A/m] and the magnetic flux density  $B$  [T] (magnetic induction). If we look at the entire bundle of all existing field lines and relate them to the respective area, the result is the magnetic flux density. The flux density  $B$  is the higher, the higher the field intensity  $H$  is [3].



**Fig. 1:** Hysteresis loop [3]

If  $N$  turns of a copper cable are wound around an iron specimen and a current  $I$  flows through the cable, the iron specimen can be magnetised. In this way, the field intensity  $H$  is also easy to understand, as it is the product of the number of turns  $N$  and the current  $I$  (Fig. 1).

In the example of a completely demagnetised iron specimen without external magnetic fields or magnetomotive forces, the flux density is  $B=0$ , and, likewise, the field intensity is  $H=0$ . The continuous rise of the field intensity  $H$  causes an increase of the flux density  $B$  until the iron's saturation limit is reached. When the field intensity is reduced again, the flux density declines not along the rise curve but along a curve branch which is located above the rise curve. When  $H$  becomes zero, a residual flux density remains due to this fact [4]. This "residual magnetism" is the reason why the arc cannot burn stably during welding, the arc weaves and is deflected, droplets are not evenly de-

taching, sidewall fusion is improper and the welding result is insufficient altogether.

## 2 Ferromagnetic materials

Ferromagnetic means that a material is magnetic without the influence of an external field. The reason for this can be looked at in different ways. While, at the atomic level, electron shells interact via orbital and spin angular momenta to create a parallel alignment of the atomic magnetic moments (and hence cause magnetisation), the physicist Pierre-Ernest Weiss in 1907 came up with the idea of interpreting the phenomenon as due to the existence of magnetic areas [3]. Each Weiss domain has all magnetic moments within it pointing in the same direction and has a neighbour of identical size within which they point in the opposite direction. This can be illustrated in experiments using an ultra-fine magnetite suspension on a polished workpiece surface, where the ultra-fine magnetite particles deposit at the borders of the Weiss domains and make them visible. Basically, primarily the alloying elements iron, nickel and cobalt exhibit ferromagnetic properties.

Magnetic fields in semi-finished products made of ferromagnetic materials neutralise each other in the semi-finished product after production and cooling because the Weiss domains are in equilibrium. When producing sheet and pipe cuttings from a continuously cast semi-finished product, the Weiss domains are separated from each other and no longer are in equilibrium. For example, disequilibrium states which influence the arc during welding may occur at joint sidewalls to be welded. Another possibility of influencing the arc is mentioned in [5]. There, it is assumed that magnetically hard spots, caused by a lack of homogeneity and impurities in the material, create permanent magnetic properties which need to be degaussed prior to welding (Fig. 3). Other sources [6] point out that magnetic crack testing carried out in particular at the beginning and ends of pipes using direct current may cause magnetism in the pipe sections.

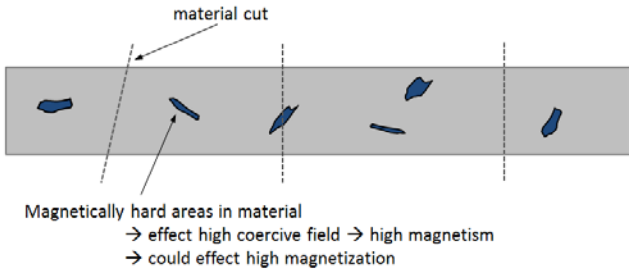


Fig. 3: Magnetically hard areas in the material [5]

### 3 Consequence of magnetism during welding

During welding, a high-temperature plasma causing the materials to be welded to heat extremely and melt is created between a cathode and an anode due to the ionised gas and freely moving charge carriers. The plasma column is infinitely mobile and behaves like an electrical conductor towards electrical and magnetic fields, which is why it is sensitive to electrical and magnetic interference. If a critical magnetic flux density  $B$  exists in the material to be welded, the plasma column is attracted or repelled, depending on polarity. The arc is then deflected, irrespective of the welding torch position, and behaves unstably. The consequences may be insufficient sidewall fusion during weld preparation and hence lack of fusion in the welding result. Droplet detachment is negatively affected, the arc weaves and moves on the workpiece. The energy cannot be applied where it is needed. From the user's point of view, all this leads to insufficient welding results and much finishing work, up to scrapping of the workpiece, and hence to serious qualitative and economic loss.

### 4 Degaussing of ferromagnetic materials

The above preliminary considerations make it clear that ferromagnetic materials can be degaussed by flooding them with alternating current. In the example of the pipe, a copper cable needs to be wound around the pipe ( $N$  turns). A current  $I$ , which after a certain time changes its direction of flow and also its amplitude towards a lower value, is sent through the windings around the pipe. The amplitude of the current is reduced each time it passes through the cable. Due to this process, the magnetic field intensity  $B$ , and hence also the residual magnetism in the material, are reduced to near zero, as shown in Fig. 4

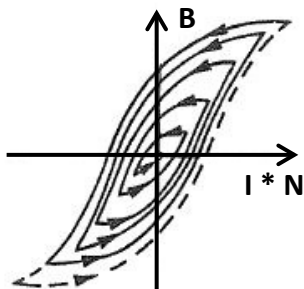


Fig. 4: Degaussing process [3]

### 4 Application-specific solution – Pico 350 cel puls pws dgs

As a manual metal arc welding machine, the EWM Pico 350 cel puls pws dgs power source (Fig. 5) is actually designed for extreme situations, especially in pipeline construction. 100% reliable vertical down welding with up to 6 mm thick cellulose electrodes anywhere in the world characterise the machine. Operating temperatures between  $-25\text{ }^{\circ}\text{C}$  and  $+40\text{ }^{\circ}\text{C}$  and mains voltage tolerances of up to 25% are no obstacles to operation. In addition, the power source includes a function to carry out a continuous degaussing process. For the user, this means: no instability of the arc, low-spatter and high-quality welding results, no finishing work and hence cost-efficient working without compromises.



Fig. 5: EWM Pico 350 cel puls pws dgs

In addition to the power source with degaussing function, EWM offers the *degauss 350* as a power source exclusively for degaussing (Fig. 6). Both machines are delivered with all aids required for degaussing.

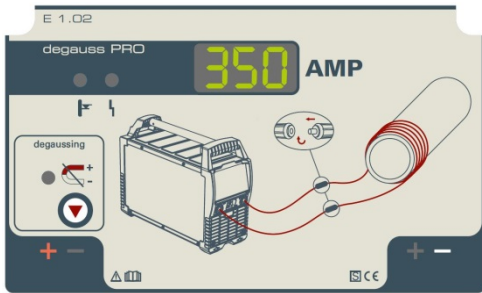


Fig. 6: EWM degauss 350

### 5 Degaussing of a creep-resistant pipe made of alloy P91 (X10CrMoVNb9-1)

At the start of the experiment, a gaussmeter was used to determine the magnetic flux densities  $B$  in a pipe with a diameter of 400 mm and a wall thickness of 38 mm. In a subsequent weld test it was found that the arc is strongly deflected especially in the upper area of the sidewalls of the weld preparation because there the magnetic field is positive on one side and negative on the opposite side.

To degauss the pipe, grounding cables were attached to the pipe halves (Fig. 7). The grounding cable was wound in the form of a single-layer coil with ten turns per pipe half. The degaussing process was then performed using the *EWM Pico 350 cel puls pws dgs*. Starting at 350 A, the degaussing process is carried out automatically as described at section 4. Due to the even degaussing with changing current flow direction and decreasing amplitude, the Weiss domains can be turned and aligned continuously, so that the pipe is degaussed and can be welded without disturbance.

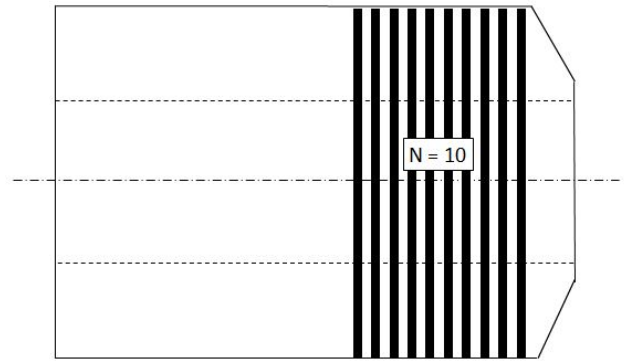


Fig. 7: Coil winding at one pipe half

After degaussing, the magnetic flux densities resulting at the defined markings were measured again and recorded. Another weld test was made to assess the effect of the degaussing on the arc.

The *EWM Pico 350 cel puls pws dgs* reliably degaussed the previously magnetised pipeline tube P91. The comparison between magnetised and demagnetised pipe is shown in Fig. 8.

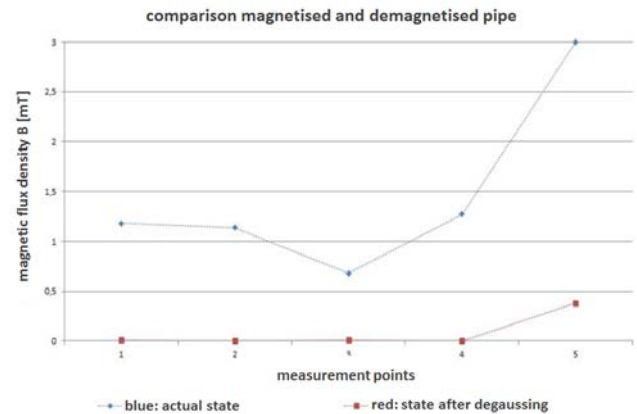


Fig. 8: Comparison magnetised and demagnetised pipe

### 6 Recommendations regarding degaussing

The *EWM Pico 350 cel puls pws dgs* and the *degauss 350* feature a stored sequence program which the user can run to degauss metal sheets and pipes. The current change increments are selected based on trials and permanently stored in the process control unit, so that errors in practical application with respect to the actual degaussing process are ruled out.

However, special attention should be given to the number of windings applied around the workpiece to be degaussed. As a rule, residual magnetism decreases with increasing number of turns following successful degaussing and, as a consequence, the welding result is improved. The tests described were carried out with ten turns per side and yielded very good results regarding the welding behaviour or no detectable deflection of the arc. Examinations with just five turns showed a value of the magnetic flux density  $B$  after degaussing which was about three times high-

er. The lower number of turns had a negative effect especially at the fusion faces.

Therefore, the number of turns should be chosen in such a way that any possible residual magnetism is not expected to affect the welding process but the degaussing work can still be carried out economically.

## 7 List of references

[1] Online source:  
<http://www.weltderphysik.de/gebiete/stoffe/magnete/was-ist-magnetismus/>, retrieved on 13-08-2014

[2] Online source: <http://de.wikipedia.org/wiki/Magnet>,  
retrieved on 11-08-2014

[3] Ilschner, B., Singer, R.F.: *Werkstoffwissenschaften und Fertigungstechnik – Eigenschaften, Vorgänge, Technologien*. 5th edition, Springer Verlag Berlin, Heidelberg, 2010, p. 292

[4] Haug, A.: *Grundzüge der Elektrotechnik zur Schaltungsberechnung*. 2nd edition, Hanser Verlag München Wien, 1985, pp. 274–281

[5] Online source:  
[http://umformtechnikmagazin.de/umformtechnik-fachartikel/ungeliebte-eigenschaften\\_12916\\_de](http://umformtechnikmagazin.de/umformtechnik-fachartikel/ungeliebte-eigenschaften_12916_de),  
retrieved on 06-08-2014

[6] Online source:  
<http://www.ndt.net/article/dgzfp03/papers/p10/p10.htm>  
, retrieved on 06-08-2014

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