Measuring residual magnetism of parts

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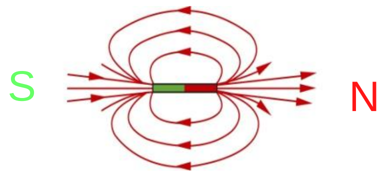
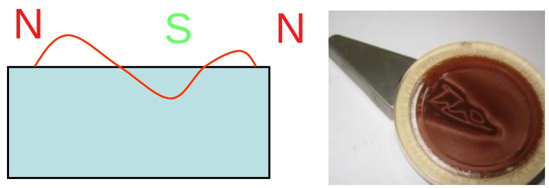
Measuring residual magnetism of parts

- Residual magnetism of ferromagnetic parts
  - Residual magnetism is measured on the surface of a part (magnetic stray flux)
  - The magnetic stray flux strongly decreases with increasing distance from the part surface
  - Parts with dipole N-S magnetization have a relatively high stray flux range
  - Parts with fine pole surface magnetization have often stray flux with short range due to narrow N-S pole transitions
  - The residual magnetism on the surface of a part is responsible for several quality issues in modern manufacturing processes (cleaning of parts, coating, welding...)



dipole N-S magnetization



surface magnetization

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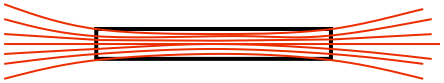
- Magnetic field of earth
  - The magnetic field of earth outside buildings is directed parallel to the N-S axis with an inclination of ~45° to the surface of the earth
  - The intensity of the field of earth outside of buildings is ~0,4 A/cm (~0.5 Gauss)
  - The field of earth is often strongly distorted inside buildings and can reach much higher values than outside

- Induced magnetic fields in ferromagnetic parts
  - The magnetic field of earth induces magnetic fields in ferromagnetic parts
  - Elongated parts induce strong magnetic fields
  - Total magnetic field = residual magnetism + induced field
  - Depending on the orientation in space, the induced field is added or subtracted vectorially to the residual magnetism of the part
  - Reproducible measuring of ferromagnetic parts below ~4A/cm (~5 Gauss) requires shielding of magnetic field of earth (without shielding, measurement uncertainty of 100% or more is not uncommon)



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- Reproducible measurement inside zero Gauss chamber
  - The zero Gauss chamber is shielding effectively the magnetic field of earth or other ambient magnetic fields
  - Inside the zero Gauss chamber residual magnetism is measured without the influence of induced fields due to orientation in space and geographical location
  - In order to eliminate ambient magnetic fields, also 3D Helmholtz coils can be used. Helmholtz coils produce active opposing magnetic fields and are suitable for larger parts.

Ferromagnetic parts are measured inside zero Gauss chamber

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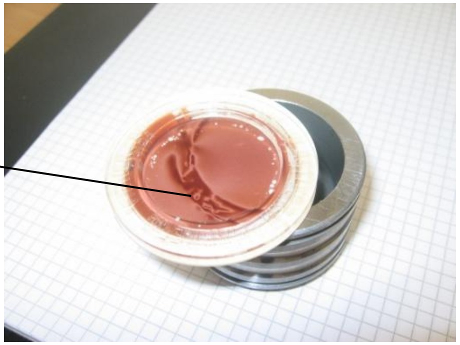
- Fine pole magnetic fields on part surfaces
  - Fine pole magnetism with narrow N-S pole transitions leads to short range stray fluxes (-> small volume of magnetic field, hard to detect without appropriate instruments)
  - The field line density (= field strength) can be very high close to the part surface and can cause strong attraction of ferromagnetic particles, deflect welding beams or influence coating processes
  - Weak magnetic fields and fine pole magnetic fields (even below 2 A/cm or ~2,5 Gauss) are made visible by sensitive magnetic viewers

Fine pole magnetism on part surface



Measuring residual magnetism of parts

- Suitable gaussmeters for measuring residual magnetism
  - Hall effect transducers close to the part surface are enabling the precise detection of fine pole residual magnetism

Gaussmeter M-Test LR.
Hall sensor close to the surface
without flux collector

  - Gaussmeters with flux collector smooth the stray fields and show a average value. Fine pole fields can’t be detected reliably.
  - The calibration of gaussmeters is done with homogenous fields. At this time there are no standards for the measurement of fine pole surface fields. Therefore, measuring results of residual magnetism conducted with inappropriate gaussmeters are often unreliable.

Measuring residual magnetism of parts

- Magnetism units conversion table

Unit	mT	A/m	A/cm		Gauss = Oerstedt
1 mT =	------	796	7,96		10
1 A/m =	0,001256	------	0,01		0,01256
1 A/cm =	0,1256	100	------		1,256
1 Gauss or 1 Oerstedt =	0,1	79,6	0,796		------

Relation between field strength H [A/m] and flux density B [T]:
$B = \mu_r \times \mu_0 \times H$, in air $\mu_r \sim 1$; permeability of vacuum $\mu_0 = 1{,}256\times10^{-6}$ [Vs / Am] (constant)

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Measuring residual magnetism of parts

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  - Troubleshooting in the field of magnetism
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