Magnetism

Martensitic stainless steels

All martensitic stainless steels are ferromagnetic below their Curie temperature of typically 720 – 750°C. The Curie temperature is the temperature at which ferrite transforms allotropically into austenite and vice-versa. Above it, these steels are paramagnetic. Below, their magnetic properties depend on their effective metallurgical condition. In the soft annealed condition they are soft magnetic. Then, the magnetic properties can vary from fairly soft magnetic in the annealed, and quenched-tempered below ≈ 250°C, up to hard magnetic above it. The hard magnetic condition is similar to those of permanent magnets.

The magnetic properties of some martensitic stainless steels

Steel	Condition	Magnetic saturation (emu/g)	Coercitive Force (Oe)	Remanence (emu/g)
1.4034	soft annealed	180	3.9	0.25
AISI 420	quenched	105	55	7
Chronifer M-13	QT HRc = 50		45	
1.4057 Chronifer M-15 Chronifer M-15X	QT HRc = 50 HRc = 50		55	
1.4112 AISI 420B Chronifer M-15X	QT HRc = 55		64	

Classical machining conditions

The martensitic stainless steels are usually and preferably machined in the annealed, or annealed and cold worked condition. In these conditions, they are fairly soft magnetic.

Hard machining

Hard machining and grinding are usually done in the QT condition. In this condition the martensitic stainless steels are usually hard magnetic. This condition permits the use of magnetic plates to fix the parts. Before machining the parts may also be magnetized to still increase their fixation strength.

How martensitic stainless steels are used?

The martensitic stainless steels should always be used in the QT condition at the requested strength level. In this condition, depending on the applied tempering temperature, they can be hardened up to hard magnetic.

Magnetic hardening

The magnetic hardening take place as follows:

I. Parallel to the martensite formation during quenching
II. During its stress relieving at low tempering temperature < 200 – 250°C
III. Finally, during the progressive transformation of the martensite by precipitation of Cr carbides at tempering temperature > 250°C.

The progressive precipitation of Cr carbides leads to a partial Cr depletion of the matrix. It strengthens the magnetism.

Change of magnetic properties with the tempering temperature

The Figure on page 2 gives the example of the martensitic stainless steel 1.4034 (AISI 420) steel grade. It shows the relative change of the magnetic properties in function of the tempering temperature.
The differences are given in % of their value in the quenched not tempered condition.

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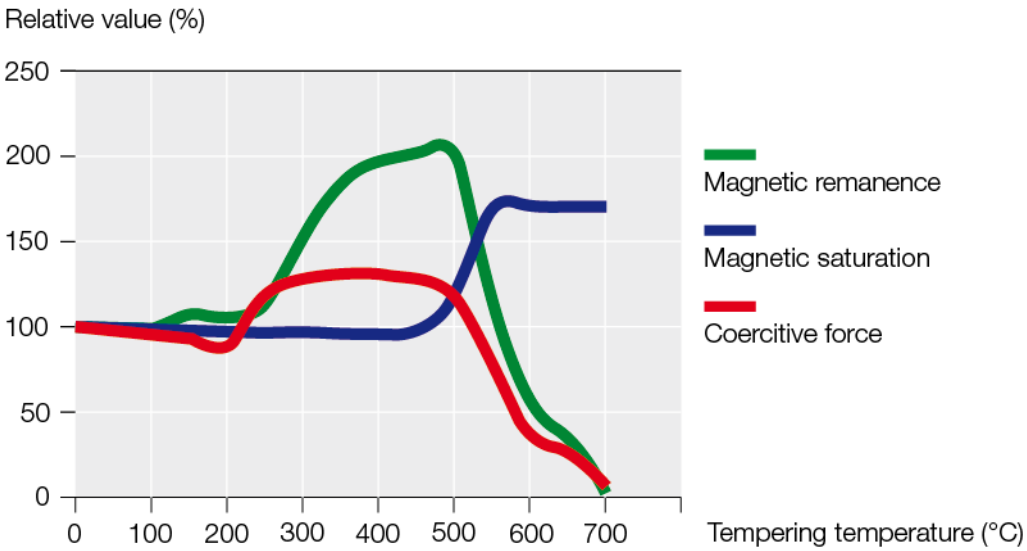
The magnetic properties of the 1.4034 (AISI 420) steel



Demagnetization

The remanence, or retentivity, of martensitic stainless steels quenched and tempered < 500°C, is at its maximum.
Once magnetized, these steels are somewhat difficult to demagnetize. It is necessary to use special demagnetization techniques and devices.

Cleaning of magnetized parts

Retained chips and magnetic particles may strongly adhere to the surface. These residues must be eliminated by cleaning and/or pickling.

Pickling

Pickling is a key operation. Its importance is unfortunately too often under estimated or even neglected.
It is advisable to pickle all finished machined parts to eliminate all residual chips and magnetic particles contaminating the surface of the parts with an appropriate pickling solution.

The pickling of the free machining martensitic stainless steel grades

As an elementary, basic prevention step, the pickling of all martensitic stainless steels should always be made before the passivation treatment.
The pickling of the martensitic stainless steel machining grades such as 1.4005, 1.4035, 1.4104, 1.4105 und 1.4197, must be correctly pickled with adapted solutions and procedures before any passivation treatment, is it chemical or electrolytic.

Passivation

Magnetic particles can adhere on the surface and be carried into the passivation solution, and contaminate them. Thence, it is necessary to eliminate them before by pickling. Otherwise they may be the source of a “Flash back“ reaction, staining partially, or even totally, the surface, and prevent a satisfactory passivation.

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