

heat treatment

FeNi50

1. Heat treatment of finished parts

The optimum magnetic properties for the SUPRA 50 and SUPRA 510 alloy families are obtained by high temperature heat treatment on the finished components.

The heat treatment is first of all designed to re-crystallize the metal. The treated parts must be handled with great care, since even the slightest amount of plastic deformation will degrade the magnetic properties.

2. Atmosphere

A protective atmosphere is essential to avoid oxidizing the metal. The role of the atmosphere is extremely important. The use of a reducing atmosphere composed of pure dry hydrogen is recommended, since it promotes the elimination of certain residual impurities in the metal, such as carbon, particularly on thin components.

All necessary precautions must be taken to guarantee the purity of the atmosphere. The parts to be treated must be degreased and cleaned before annealing. The inert powder (alumina, magnesia) often used to insulate the parts from one another must be perfectly anhydrous.

During the heating ramp, a 1 to 2 hour hold should be performed at around 400°C, if necessary, to improve the dew point in the furnace chamber. The dew point should be less than -40°C during the high temperature heat treatment.

Aperam Alloys Imphy 47.5% Ni grades are little sensitive to the heating and cooling rates. Common industrial heating and cooling rates from a few tens to a few hundreds of °C/h are perfectly satisfactory.

3. Oxidation treatment

For certain applications, the finished parts must be coated with a thin layer of oxide (for example, to electrically insulate rotor sheets or profiles). This can be achieved by holding the parts at around 500°C in an atmosphere with controlled oxygen partial pressure (e.g. : 1 hour in air).

Supra50 T

Heat treatment at a high temperature (1'150 - 1'170°C) is essential to ensure satisfactory secondary re-crystallization

Aperam Alloys Imphy

B.P. 1
Avenue Jean Jaurès
F- 58160 Imphy

Tel + 33 3 86 21 30 00
Fax + 33 3 86 21 31 00
nickel.alloys@aperam.com
www.aperam.com/alloys-imphy

FeNi80

1. Heat treatment of finished parts

The optimum magnetic properties of the Mumetal, Permimphy and Supermimphy grades are obtained only after high temperature heat treatment of the finished sheets or parts. The principal aim of this treatment, which is essential, is to re-crystallize the material. The final heat treatment must imperatively be performed under appropriate conditions, according to the recommendations given below.

2. Atmosphere

Hydrogen, which helps to reduce certain residual impurities, is the best protective atmosphere. However, cracked ammonia and vacuum are alternative possibilities. All necessary precautions must be taken to eliminate the risk of contamination, particularly by oxygen and water vapour. The parts to be treated must be thoroughly cleaned and degreased. The inert powder (alumina, magnesia) often used to isolate the parts must be perfectly anhydrous.

In all cases, the dew point inside the furnace must be less than -40 °C.

3. Temperatures

Aperam Alloys Imphy recommends holding for 2 to 6 hours at 1'100 - 1'170°C. The heating rate has little influence on the magnetic properties. In contrast, a lower heat treatment temperature will adversely affect the permeability level.

4. Cooling rate

The cooling rate determines the degree of short range ordering of the atoms and therefore has a marked influence on the permeability of the Fe-80% Ni alloys. In the majority of ordinary cases, simple furnace cooling is sufficient, provided that the cooling rate is of the order of 100 to 300°C/h between 600 and 300°C. However, to optimize certain magnetic properties, such as the initial permeability or the rectangularity of the hysteresis cycle, or to reduce variations in permeability around ambient temperature, it may be necessary to accurately adjust the cooling conditions between 600°C and 300°C.

A good practical solution is to allow the parts to cool slowly into the furnace down to a holding temperature situated between 400 and 520°C, followed by holding for about 1 hour, then to rapidly remove them from the furnace in order to finish the treatment with a high cooling rate (of the order of 1'000°C/h). The value of the holding temperature depends on the desired magnetic properties. Another possibility is to perform a second treatment, typically of 1 hour at about 500°C, followed by rapid quenching (1'000°C/h), after the initial high temperature treatment (2 to 6 hours at 1'100 - 1'170°C).

5. Oxidation treatment

For certain applications, the parts must be covered with a thin layer of oxide (e.g. electrical insulation of Supermimphy/Permimphy profiles). In this case, during the final stage of the heat treatment, the protective atmosphere is replaced by an atmosphere with a controlled oxidizing potential (for example, holding in air for 1 hour at about 500°C).

FeCo

1. Heat treatment of finished parts

The aim of the heat treatment, which must be performed on the finished parts, is to eliminate internal stresses due to cold work and to give the metal the required balance between magnetic and mechanical properties.

2. Part preparation

It is recommended, particularly for thin components, to thoroughly degrease the surfaces before heat treatment to avoid all risk of surface contamination. Furthermore, to prevent the components from sticking together during heat treatment, it is preferable to coat them with a film of inert anhydrous material, such as talc, magnesia or alumina. For heavy parts, it is necessary to provide flat supports adapted to the shape and weight of the components, in order to avoid distortion during heat treatment.

3. Atmosphere

The treatment must be performed out of contact with oxygen, either in pure dry hydrogen or under vacuum. Cracked ammonia atmosphere is acceptable only for AFK 1 and AFK 18, but not for AFK 502R, in which nitriding is observed, leading to a marked impairment of the magnetic properties.

4. Temperatures

It should be pointed out that the temperatures indicated below must not be exceeded, since otherwise the properties will be irretrievably degraded. This occurs immediately on attaining the temperature of the α and γ allotropic transformation, situated at around 900°C for AFK 502R and AFK 1, and around 940°C for AFK 18.

In the heat-treated condition, all magnetic materials must be handled with care, avoiding shocks and plastic deformation. These precautions are particularly recommended for AFK 502R alloy, whose deformation capacity is limited. After heat treatment, the metal shows a dimensional expansion of the order of 1 to 1.5 x 10⁻³. This must be allowed for in particular cases where the components must respect tight tolerances.

AFK 502 R

Treatment for optimizing the magnetic properties: 2 to 3 h at 850°C in pure dry hydrogen or under vacuum, followed by cooling at 250°C/h in the same atmosphere. To reduce the treatment time, cooling can be performed in air below 300°C.

Treatment for optimizing the mechanical properties: 2 to 3 h at 725°C in pure dry hydrogen or under vacuum, followed by cooling at 250°C/h in the same atmosphere. To reduce the treatment time, cooling can be performed in air below 300°C.

AFK 1

Treatment for optimizing the magnetic properties: 2 to 3 h at 850°C in pure dry hydrogen or cracked ammonia, followed by cooling at 250°C/h in the same atmosphere.

Treatment for optimizing the mechanical properties: 2 to 3 h at 725°C in pure dry hydrogen or cracked ammonia, followed by cooling at 150°C/h in the same atmosphere.

AFK 18

1 to 4 h at 900°C-920°C in an atmosphere of pure dry hydrogen, or under vacuum or in an inert atmosphere (rare gas), followed by cooling in the same atmosphere.

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F- 58160 Imphy

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Remarks

Custom heat treatment

When the magnetic property requirements are particularly demanding, Aperam Alloys Imphy can place its extensive experience in the heat treatment of magnetic alloys at the user's disposal. Moreover, Aperam Alloys Amilly have a range of high performance heat treatment equipment devoted to magnetic alloys, and can perform heat treatments for customers on any parts whose magnetic properties must be optimized.

The data enclosed in this document are only given as indicative values and correspond to our standard product. Different specific requirements are subject to discussion and formal approval by Aperam Alloys Imphy. For further information or special request, please contact us.

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