VACUUMSCHMELZE is the right partner if high performance materials are what you need.

We are experts in the field of magnetic technology where we develop, produce and market special materials and enhanced products.

We are a leading global manufacturer of high performance alloys and related value-added products. VACUUMSCHMELZE has a workforce of about 3000 employees spread over 40 countries and on all continents.

In 1923 we were the first company to melt alloys under vacuum on an industrial scale. Today our product range comprises of well over 100 special alloys. Alongside the crystalline alloys which are melted under vacuum and the rapidly solidified amorphous and nanocrystalline alloys, we are also producing powder metallurgical materials.

Our strength lies in the development and production of innovative products with a high degree of customer benefit. By utilizing our know-how on defined material properties, and in close cooperation with our customers, we develop tailor-made solutions for a wide field of applications. Research and development play a central role in the company by continuously optimizing our materials.

State-of-the-art production and inspection technologies together with a certified quality management system to DIN EN ISO 9001 assure a consistently high quality standard. VACUUMSCHMELZE is also certified to ISO/TS 16949, respectively EN 9100 for automotive and aerospace applications. Environmental protection aspects in material selection, production and warehousing are naturally an integral part of our company policy (DIN EN ISO 14001).

With our products and service it is our constant aim to give our customers a competitive advantage. At VACUUMSCHMELZE we control the entire production chain from material through to sophisticated components. A speciality is customised, tailor-made solutions.

Further information on our products is available on our website www.vacuumschmelze.com

Illustration Page 5: main spring for mechanical watches made of NIVAFLEX 45/5, by courtesy of Schwab-Feller AG, Büren a.A., Switzerland

Illustration Page 6: pivot pins made of NIVAFLEX 45/5, by courtesy of Schneider-Hegi AG, Oberdorf, Switzerland
MATERIALS AND PARTS

We produce crystalline, amorphous and nanocrystalline materials as well as composite materials. Our alloys play a crucial role in many devices, plants and components.

TYPICAL FORMS OF SUPPLY

- Materials as strip, rods and wire
- Shaped and solid parts
- Stamped and bent parts as well as components
- Glued and interlocked laminated packages
- Magnetic shielding

CUSTOMER BENEFITS

By implementing our material and production experience and know-how we meet our customers’ specific requirements. As a result we make a major contribution to optimizing the end product. Close cooperation with our customers is already initiated at the development stage, this frequently leads to joint development and project work where FEM and CAD are implemented to reach the optimum solution.

MATERIAL GROUPS AND APPLICATIONS

- Soft magnetic materials e.g. for earth leakage circuit breakers and wrist watches, for surveillance (anti-theft) systems for the retail trade and for sensors and injection systems for the automotive industry
- Expansion and glass-to-metal sealing alloys e.g. for reed relays, x-ray tubes and all types of leadthroughs
- Ductile permanent magnets e.g. for relays, electronic article surveillance systems as well as hystereses motors and couplings
- Thermobimetals to measure and regulate temperature e.g. for household appliances and for installation and automotive technology
- Age-hardenable spring materials for high thermal, mechanical and corrosive loads in relays, household appliances and mechanical watches
SPRING MATERIALS

High performance alloys made by VACUUMSCHMELZE offer maximum strength combined with other material specific properties.

1. INTRODUCTION

Owing to the increasing demands on spring elements in almost all fields of application the mechanical properties of the materials have to meet ever more stringent requirements.

Non-age-hardenable materials like spring steels attain their maximum tensile strength after a high degree of cold work. This, however, restricts their formability and machining capability so that maximum tensile strength values often have to be sacrificed in favour of cold workability.

In contrast age-hardenable spring alloys are characterised by the fact that in the non-age-hardened state they are ductile and can easily be formed and machined. This property is becoming increasingly important due to the trend towards miniaturisation and the increasing integration density of spring elements. The required mechanical properties are set in a subsequent heat treatment – referred to as age-hardening.

The age-hardenable spring alloys produced by VACUUMSCHMELZE exhibit high strength values. Depending on the alloy, a number of other beneficial properties are available, e.g.:

- Corrosion resistance
- Use at high temperatures
- Electrical and thermal conductivity
- Temperature independent mechanical properties
- Isotropic behaviour of mechanical properties

The fundamental properties of age-hardenable spring alloys with regard to the state of delivery and heat-treatment are presented in the following. Please refer to the individual data sheets for technical details on our spring alloys.

2. DELIVERY STATES AND DIMENSIONS

As a rule, age-hardening is made possible by prior solution annealing. In this step the typical precipitation hardening elements e.g. titanium, aluminium or niobium, are homogeneously distributed in a solid solution matrix. Through rapid cooling this high temperature state is frozen resulting in the delivery „soft“ state.
Subsequent cold work leads to an increased dislocation density and a substantial rise in tensile strength, yield strength and hardness (see Fig. 1). However, this does reduce the ductility and thus the bending properties. Depending on the customer specific application, the optimum degree of cold work is selected.

Alongside the standard delivery states „soft“, „semi-hard“ and „hard“ VACUUMSCHMELZE offers customized delivery states optimized for a particular application. These also include „mill-hardened“ or „heat-treated“ materials which can be used without subsequent age-hardening. In the latter two states of delivery, the maximum mechanical properties are not attained, but machineability and formability are largely retained.

VACUUMSCHMELZE supplies spring alloys as strip or wire to customer dimensions. Depending on the alloy and the state of delivery the most common strip thicknesses are between 50 µm and 1 mm, maximum strip width approx. 250 mm. Typical wire diameters are from 0.2 to 3 mm (other dimensions on request).

**Fig. 1:** Typical curves of tensile strength, yield strength, hardness and elongation as a function of cold work. The shaded sections mark the standard delivery „soft“, „semi-hard“ and „hard“ states.
After forming the spring elements, the mechanical properties can be further enhanced by heat-treatment. Precipitation hardening is generally used for this purpose; here the precipitation elements which are initially distributed in the matrix, are precipitated in fine particles, restricting dislocation movement.

The steady rise in tensile strength and hardness - the so-called underaging - is followed by a maximum and subsequent slow decrease (overaging).

Fig. 2 shows the hardness as a function of aging duration. The precipitation hardening characteristic depends on the alloy and can be controlled by time and temperature (see Fig. 2a). From the same initial state the required increase in hardness is obtained faster at higher temperatures which, in turn, reduces the time factor. Lower age-hardening temperatures require a longer process but are more reliable for the production (slight time deviations during annealing have almost a negligible effect).

In Fig. 2b the influence of the initial state on the age-hardening behaviour at the same temperature is presented schematically. Maximum tensile strength values are obtained in the „hard“ delivery state.

Fig. 2:
Typical curves during age-hardening as a function of aging temperature (a) or the initial state (b).
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