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(54) **RESSORT D'ACIER RESISTANT AU RELACHEMENT**
(54) **RELAXATION-RESISTANT STEEL SPRING**

(57) L'invention concerne un ressort d'acier très résistant qui présente une surface exempte de pailles et de poussières résiduelles et qui résiste également au relâchement à des températures de fonctionnement élevées. Ce type de ressort d'acier est obtenu à partir d'un fil d'acier ayant la composition suivante: entre 0,45 et 0,85 % en poids de carbone, entre 0,2 et 1,60 % en poids de silicium, entre 0,3 et 1,50 % en poids de manganèse, entre 0,4 et 1,20 % en poids de chrome, le reste étant constitué de fer et d'impuretés inévitables. Le fil est austénisé, puis soumis à un traitement isothermique dans une plage de températures comprises entre 450 et 650 °C. Ledit fil est ensuite étiré jusqu'à avoir une résistance à la rupture comprise entre 1600 et 2300 N/mm^2, pour une striction d'au moins 40 %. Ledit fil est ensuite formé à froid pour donner lieu à un ressort et est ensuite soumis à un recuit léger de détensionnement dans une plage de températures comprises entre 200 et 350 °C.

(57) The invention concerns a very strong steel spring having a bright surface which is free from residual dirt, the spring also being resistant to relaxation at high operating temperatures. A spring of this type is produced from a steel wire of the following composition: between 0.45 and 0.85 wt % carbon; between 0.2 and 1.60 wt % silicon; between 0.3 and 1.50 wt % manganese; between 0.4 and 1.2- wt % chromium; the remainder being iron and unavoidable impurities. The wire is austenitized and then treated isothermally at temperatures ranging from 450 to 650 °C. The wire is then drawn to a tensile strength of between 1600 and 2300 N/mm^2 at a contraction in area when breaking of at least 40 %. The wire is cold formed to produce a spring and is then stress-free annealed at temperatures ranging from 200 to 350 °C.

(57) Abstract

The invention concerns a very strong steel spring having a bright surface which is free from residual dirt, the spring also being resistant to relaxation at high operating temperatures. A spring of this type is produced from a steel wire of the following composition: between 0.45 and 0.85 wt % carbon; between 0.2 and 1.60 wt % silicon; between 0.3 and 1.50 wt % manganese; between 0.4 and 1.2- wt % chromium; the remainder being iron and unavoidable impurities. The wire is austenitized and then treated isothermally at temperatures ranging from 450 to 650 °C. The wire is then drawn to a tensile strength of between 1600 and 2300 N/mm² at a contraction in area when breaking of at least 40 %. The wire is cold formed to produce a spring and is then stress-free annealed at temperatures ranging from 200 to 350 °C.

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PCT/DE 96/00935

Relaxation-rigid steel spring

The invention relates to a steel spring possessing a good relaxation rigidity at relatively high operating temperatures.

Springs of patented drawn spring steel wires consisting of unalloyed carbon steels are known. Such springs are basically free of scales and residual impurities, however, they can be used at operating temperatures above 80°C only to a limited extent. They are used under highly reduced operating tensions, which can be compensated by a bigger mass of the spring only, which again will cause considerable economical and constructive disadvantages as is well known. With regard to the relaxation behaviour at higher operating temperatures, springs of oil-annealed unalloyed spring steel and valve spring wires show the same disadvantages. In addition, scales or other residuals attach due to the oil finishing to the surface of the spring and will come off during the spring function thus possibly causing in sensitive operating areas, e.g. automatic gearboxes and fuel injection systems in motor vehicles, severe misfunctions or complete failure of such aggregates.

The application of springs made of steel spring wires alloyed with CrV, SiCr and SiCrV is already known in the practical application for increasing the relaxation behaviour at higher operating temperatures. Boundary temperatures up to 160°C can be realized. These alloyed steels also require an oil annealing treatment. Thus, the same disadvantages as with the springs made of unalloyed spring steels will arise, i.e. residual scales attach to the surface, which - when coming off as a consequence of the spring function - can result in failure of highly sensitive technical systems. A further essential disadvantage consists in the fact that the martensic structure resulting from the annealing procedure reacts extremely sensitive to acids and surface treatments connected with hydrogen diffusions into the material. The so-called hydrogen brittleness caused by acid treatment or electrolytic coating results in an early failure of the spring element and thus leads to functional fatigue of complex and expensive mechanisms. Besides these functional disadvantages, the springs of this material group have an essential technological disadvantage. After being reshaped, such spring elements must be immediately subjected to stress-release annealing (tempering). If there is any time delay, internal tension cracks will result which cause early breaking of the spring element(s).

To remedy these disadvantages, springs of austenitic non-corroding spring wires, e.g of the type X 12 CrNi 17.7 have been developed. However, due to the considerably higher alloying requirements and the technological particularities, unacceptably high material costs result for the spring elements.

JP-A-2057637 discloses a wire which is austenitized and isothermally held at 250 to 500°C, and which is then shaped into a spring. The arrest temperature of 250 to 500°C results in a so-called bainite tempering with a bainite structure of low ductility. A subsequent drawing procedure, as would be desired for obtaining an increased tensile strength, is accoding to this prior art impossible.

GB-A-2210299 and EP-A-368638 further disclose the manufacture of springs made of oil annealed spring steel or tempered steel, or the tempering of springs formed of unhardened wire.

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The invention is based on the problem to provide a highly strong wire spring which is - at increased temperatures - relaxation rigid, with a surface free of scales and impurities, involving relatively low material costs.

This problem is solved according to the invention with the features of claim 1.

Advantageous embodiments result from the subclaims.

The invention is explained in more detail in the following by means of two embodiments.

Embodiment 1:

A relaxation rigid and heat resistant tension spring having the following dimensions:

wire diameter		3.6 mm
spring body diameter		41.5 mm
length relaxed	L_0	268 mm
length under tension	L_1	384 mm
	L_2	570 mm

is produced from rolled steel with a diameter of 8 mm and the following composition:

0.68 weight percentage of carbon
1.48 weight percentage of silicium
0.52 weight percentage chromium
0.65 weigth percentage manganese and accompanying elements typical in steel.

This rolled steel is austenitized at 900°C, isothermally transformed at 540°C and subsequently cold drawn to 3.6 mm. Thereby, a rigidity Rm of 1900 N/mm² is obtained. This wire is completely automatically shaped to a tension spring with the above-mentioned dimensions and then, in order to eliminate tensions, annealed at 300°C for one hour.
Relaxation loss after examination at L_2 at 145°C in one hour: 4.8%

Embodiment 2:

A further example refers to the manufacture of a helical pressure spring. The tension spring of rolled steel with a diameter of 5.5 mm and a composition as in embodiment 1 is subjected to an analogue heat and cold drawing treatment thus producing a pressure spring for a fuel injection pump with the following spring data:

wire diameter	1.4 mm
outer diameter	7.3 mm
length relaxed	25.4 mm

relaxation examination at L_2 = 15.4 mm and 150°C for twelve hours: 3.5%

Nürnberg, August 4, 1998
Reg.-Nr. 30102 PC

(New) patent claims

1. Relaxation rigid steel spring with high rigidity, characterized in that it is produced from a steel wire with the composition of

a) 0.45 to 0.85 weight precentage carbon
0.2 to 1.60 weight percentage silicium
0.3 to 1.5 weight percentage manganese
0.4 to 1.2 weight percentage chromium,

as well as optionally in addition

b) 0.05 to 0.30 weight percentage vanadium addition and/or

c) 0.005 to 0.05 weight percentage titanium,
0.01 to 0.2 weight percentage niobium and/or tantalum,
0.05 to 0.5 weight percentage molybdenum

and/or

d) the complete or partial replacement of the elements chromium and silicium with 0.003 to 0.01 weight percentage boron

e) as well as iron and unavoidable additions,

wherein said steel wire

f) is autensitized and then isothermally heat-treated in the temperature range between 450 and 650°C,

g) then drawn to a tension rigidity of 1600 to 2300 N/mm² at a breaking reduction of at least 40%,

h) cold shaped to a spring, and

i) finally annealed such as to release stresses within a temperature range from 200 to 350°C.

2. Steel spring according to claim 1, characterized in that said spring has a helical shape.

3. Steel spring according to claim 1 or 2, characterized in that the average spring core diameter is equal to or smaller than four times the wire diameter.

4. Steel spring according to any one of claims 1 to 3, characterized in that said spring is shot-peened in order to increase its durability.

5. Steel spring according to any one of claims 1 to 4, characterized in that said spring is preloaded*by excessive elastic shaping optionally at room temperature and/or at temperatures up to 400°C.

*) hot set

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