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BARREL FOR FIREARMS

The invention relates to a barrel for projectiles of firearms, in particular lightweight hand-held firearms.

A barrel for projectiles is exposed to high mechanical and thermal loads during practical use of the firearm. A sudden gas pressure load of the barrel or a tensile load of the barrel wall upon shooting requires a high yield point or a high strength of the barrel material with good toughness properties. According to the prior art, proven, high-strength heat-treated steels are used as barrel materials which are also commercially available. As material hardness of this thermally-treated barrel part, a material hardness of 47 ± 1 HRC is usually required which corresponds to roughly a tensile strength in the range 1030 to 1125 N/mm^2.

A steel alloy is known from JP 2000-80444 for a barrel for projectiles with a hardness of 28-36 HRc and a toughness at -40° C of at least 20 J/cm^2.

Moreover, EP 0 939 140 A1 discloses a hot-working steel in which the reduction in the mechanical properties at higher temperatures is reduced by narrow limitation of the impurities and accompanying elements.

In the context of a performance increase, quality improvement and increase of safety, increased requirements are placed on the barrel for projectiles of firearms and in such a manner on the material of the barrel parts. This results mainly from increased gas pressure loads due to new munition designs and lower barrel wall thicknesses to reduce the weight of modern weapons.

The object of the invention is, based on the prior art, to provide an improved barrel for projectiles of firearms made of a new material for said barrel which is balanced out by alloying and following thermal treatment, has a required strength or minimum hardness of greater than 47 ± 1 HRC, a high toughness in the temperature range of -50 to +500° C and greater and in such a manner has a safety potential against brittle fracture even with a minimised wall thickness.

This object is achieved according to the invention when the barrel for projectiles is made from a deformed material having a chemical composition of in weight-%

Content	C	Si	Mn	P	S	Cr	Mo	Ni	V	W	Ti	As + Sn + Sb	Fe
Min	0.28	0.08	0.15			3.6	1.2		0.42				Rest
Max	0.36	0.26	0.35	0.005	0.002	4.4	1.8	<0.5	0.5	0.15	0.08	0.007	

as well as impurities due to fusion, which thermally treated barrel for projectiles material has a hardness of 46 to 48 HRC.

In comparison to an alloy for a barrel for projectiles primarily used up to now with a composition formed within wide limits of in weight-% C = 0.42, Si = 0.3, Mn = 0.7, P max. 0.025, S max. 0.01, Cr = 1.1, Mo = 0.2, Ni = 0.25, V max. 0.1, W max. 0.1, Ti max. 0.1, the new weapon barrel material has highly-effective differences in the concentrations of the elements C, Si, Mn, P, S, Cr, Mo, Ni and V, wherein the steel parasites As, Sn, Sb are notably reduced in their max. concentration.

The main observation with the new alloy according to the invention for a barrel for projectiles was an increase of tensile strength or yield strength at temperatures above approx. 300° C. With a short shot sequence, an advantageously thin or lightweight barrel for projectiles is heated at least in the region of the inner surface to above 400 to 450° C, whereby the material strength and the wear resistance of barrel materials used up to now strongly reduces and general problems emerge with the increased quality requirements at increased temperatures on these materials.

If, however, instead of usual hot-working steels, which, in the heat-treated state, often have high material hardness values up to 500° C and even notably higher, are used for weapon barrels, their high temperature properties are very favourable, but the toughness values are comparatively low and the transition temperature from tough fracture to brittle fracture of the material (FATT) is substantially in the range of ± 60 to 0° C.

The disadvantages of the heat-treated steel, on the one hand, and those of a hot-working steel on the other hand are overcome by the composition of the barrel material according to the invention.

In comparison to the mentioned alloys, said barrel material has a lower C content, which favourably influences the hardness properties and provides sufficient hardness values with standard heat treatment technology.

For reasons of material toughness in the low temperature range, the Si content is limited to low values which at most cause a deoxidation of the melt for certain.

Low values of Mn are advantageous under the condition of low S contents.

A Cr and Mo content increased with respect to the heat-treated steel acts favourably on the heat treatment properties of the material and on its high temperature properties.

Low Ni concentrations for improved hydrogen-induced low temperature properties of the alloy are crucial, as has been found.

In the case of the nickel content of the alloy according to the invention directly under 0.5 weight-%, it may be advantageous for a vacuum treatment of the melt to be performed in the production process of the material. The degassing of the liquid steel usually takes place at a pressure of less than 5 mbar (500 Pa), preferably of 1 m bar (100 Pa) and below.

Low nickel concentrations of less than 0.18 weight-% and in particular of 0.1 weight-% of the alloy render expensive vacuum treatment unnecessary in any case.

The low content of As, Sn and Sb of the material is also significant for its high toughness.

It is particularly advantageous for achieving the highest quality values when the barrel for projectiles consists of a material mentioned above, which has at least one element in the concentration in weight-% of

Content	C	Si	Mn	P	S	Cr	Mo	Ni	V	W	Ti	As + Sn + Sb	Fe
Min	0.3	0.1	0.2			3.8	1.4		0.44				Rest
Max	0.34	0.2	0.3	0.005	0.001	4.2	1.6	0.1	0.48	0.1	0.05	0.005	

A method for producing a barrel for projectiles of firearms with the aforementioned chemical composition has been found to be particularly advantageous and efficient according to which a thermal treatment is performed as vacuum heat treatment in which at least one curing takes place with a forced cooling from a temperature of higher than 940° C but lower than 995° C with a holding time at hardening temperature after a partial heating of at least 20 min., and a tempering repeated at least twice of the hardness structure is carried out at a temperature of higher than 575° C.

Further improved quality properties can be achieved when a curing of the barrel for projectiles material takes place at a temperature in the range of 960 to 980° C with a holding time at said austenitisation temperature of more than 25 min., following which a multiple annealing at a temperature of about 600° C is carried out.

Based on test results, which merely constitute one mode of embodiment of the invention, said invention will be explained in greater detail. The measurement values of the tests are represented in diagrams.

They show:

Table 1: chemical composition of the comparative alloys or materials

Fig. 1: temperature strength of the materials as a function of the temperature

Fig. 2: notch impact energy (toughness) of the materials as a function of the temperature

A heat-treated steel V320, a hot-working steel W300 and a steel type W381 according to the invention for weapon barrels are indicated in Table 1 with the content of alloy elements, wherein the rest content is substantially iron:

Quality		C	Si	Mn	P	S	Cr	Mo	Ni	V	W	Ti	As + Sn + Sb
V320	min	0.4	0.2	0.6			1.0	0.15	0.2				

	max	0.44	0.35	0.8	0.025	0.002	1.2	0.25	0.3	0.1	0.1	0.05	0.01
W300	min	0.36	0.9	0.3			4.8	1.1		0.3			
	max	0.4	1.2	0.5	0.025	0.002	5.2	1.3	0.4	0.5	0.1	0.05	0.01
W381	min	0.28	0.08	0.15			3.6	1.2		0.42			
	max	0.36	0.26	0.35	0.005	0.002	4.4	1.8	0.18	0.5	0.15	0.08	0.07

All steels of barrels for projectiles indicated and used for a test have been subjected to a vacuum heat treatment with the same parameters:

- austenitisation at hardening temperature
- holding at the austenitisation temperature of 30 min, and quenching
- tempering twice with 2 hours in each case.

Fig. 1 shows the course of the tensile strength R_m with rising temperature up to 600° C.

The strength R_m is notably reduced with heat-treated steel V320 already at a temperature of over 200° C and from roughly 390° C no longer corresponds to the current requirements for a barrel for projectiles material following frequent heating.

The material W381 according to the invention and the hot-working steel W300, in contrast, exhibit a drop in tensile strength below the required limit only from a temperature of roughly 500° C.

Fig. 2 determines the course of the material toughness over the temperature in the range of -40 and +200° C.

It can be clearly discerned from the course of the curve that the hot-working steel W300 overall has lower toughness values and that from a temperature of less than 20° C, a brittle fracture tendency of the material is dominant.

The heat-treated steel V320 exhibits tough fracture properties in the case of impact stress of parts made of said steel, wherein the material W381 according to the invention has only slightly lower toughness values at the individual temperatures.

In comparison, the barrel for projectiles comprises a material W381 which on the one hand has a notably greater tensile strength and hardness at higher temperatures than the heat-treated steel V320 normally used, said material W381, on the other hand, has a notably higher toughness potential at low temperature up to -40° C.

Patentkrav

1. Løb til projektiler af skydevåben, i særdeleshed letvægt, små skydevåben, lavet af et deformeret materiale, der har en kemisk sammensætning i vægtprocent på:

Indhold	**C**	**Si**	**Mn**	**P**	**S**	**Cr**	**Mo**	**Ni**	**V**	**W**	**Ti**	**As+ Sn+Sb**	**Fe**
Min	0,28	0,08	0,15			3,6	1,2		0,42				rest
Max	0,36	0,26	0,35	0,005	0,002	4,4	1.8	<0,5	0,5	0,15	0,08	0,007	

samt smeltningsbetinget forurening, hvilket termisk behandlet løb til projektilmateriale har en hårdhed på mindst 46 til 48 HRC.

2. Løb til projektiler ifølge krav 1, lavet af et deformeret materiale, der har en kemisk sammensætning i vægtprocent på:

Indhold	**C**	**Si**	**Mn**	**P**	**S**	**Cr**	**Mo**	**Ni**	**V**	**W**	**Ti**	**As+ Sn+Sb**	**Fe**
Min	0,28	0,08	0,15			3,6	1,2		0,42				rest
Max	0,36	0,26	0,35	0,005	0,002	4,4	1,8	0,18	0,5	0,15	0,08	0,007	

samt smeltningsbetinget forurening, hvilket termisk behandlet løb til projektilmateriale har en hårdhed på mindst 46 til 48 HRC.

3. Løb til projektiler ifølge krav 1 eller krav 2, lavet af et deformeret materiale, der har mindst ét element af koncentrationen i vægtprocent på:

Indhold	C	Si	Mn	P	S	Cr	Mo	Ni	V	W	Ti	As+ Sn+Sb	Fe
Min	0,3	0,1	0,2			3,8	1,4		0,44				rest
Max	0,34	0,2	0,3	0,005	0,001	4,2	1,6	0,1	0,48	0,1	0,05	0,005	

4. Fremgangsmåde til fremstilling af et løb til projektiler af skydevåben ifølge et af kravene 1 til 3, hvor en termisk behandling udføres som en vakuum-varmebehandling, i hvilken mindst én hærdning finder sted ved en temperatur på højere end 940 °C, men lavere end 995 °C med en holdetid ved hærdningstemperatur efter en delopvarmning på mindst 20 min, og hvor en temperering gentages mindst to gange af hårdhedsstrukturen udføres ved en temperatur på højere end 575 °C.

5. Fremgangsmåde ifølge krav 4, hvor en hærdning af løbet til projektilmateriale finder sted ved en temperatur i området på 960 til 980 °C med en holdetid ved nævnte austenitiseringstemperatur på mere end 25 min, følgende hvilken en multipel udglødning ved en temperatur på omkring 600 °C udføres.

6. Fremgangsmåde til fremstilling af et løb til projektiler af skydevåben ifølge et af kravene 1 og 3 til 5, **kendetegnet ved at** en vakuumbehandling af smeltemassen finder sted under fremstillingen af materialet.

DRAWINGS

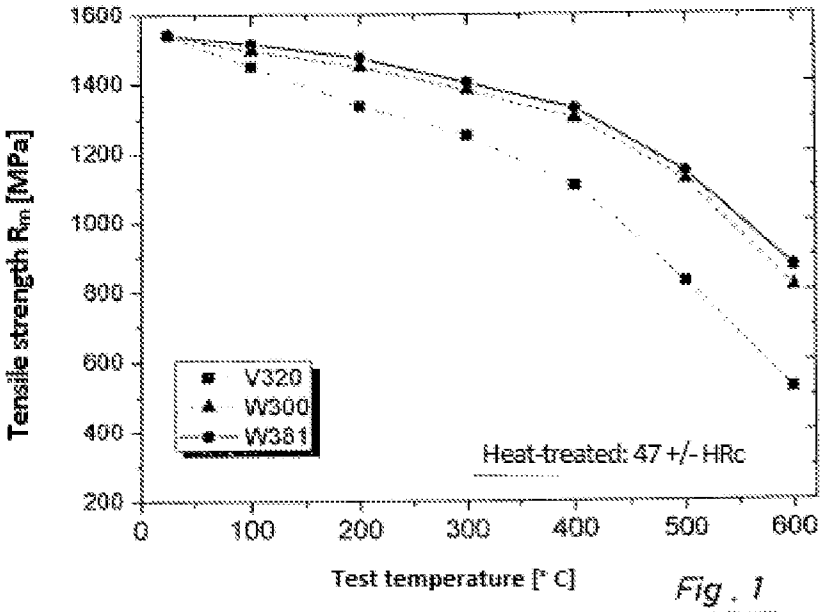


Fig. 1

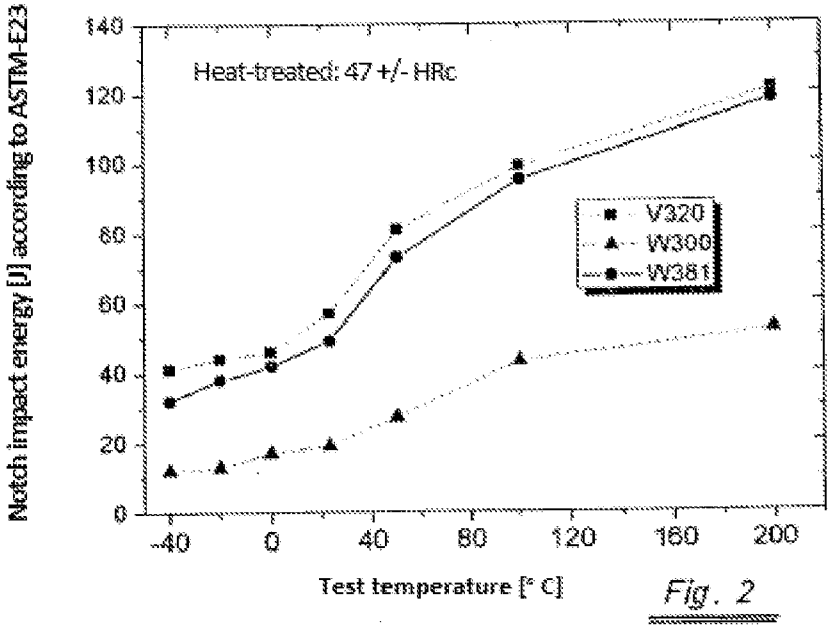


Fig. 2