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(71) Applicants:
- **Fedchun, Vladimir Alexeevich**
  Moscow 111116 (RU)
- **Aslibekyan, Felix Surenovich**
  Moscow 117071 (RU)
- **Prokofiev, Vladimir Konstantinovich**
  Moscow 117419 (RU)

(72) Inventors:
- **Fedchun, Vladimir Alexeevich**
  Moscow 111116 (RU)
- **Aslibekyan, Felix Surenovich**
  Moscow 117071 (RU)
- **Prokofiev, Vladimir Konstantinovich**
  Moscow 117419 (RU)

(74) Representative:
Allen, William Guy Fairfax
J.A. KEMP & CO.
14 South Square
Gray's Inn
London WC1R 5LX (GB)

(54) ALLOYED CONSTRUCTION STEEL

(57) Alloyed construction steel containing carbon, silicon, manganese, chromium, vanadium and iron, and containing in addition a plasticity-enhancing and nitration-boosting chemical element, the relative proportions of components being (wt. %):

Carbon	0.10-0.63
Silicon	0.20-1,20
Manganese	0.40-0.60
Chromium	0.60-3.00
Plasticity-enhancing and nitration-boosting chemical element	0.40-1.50
Vanadium	0.15-0.35
Iron	Rem.

The plasticity-enhancing and nitration-boosting chemical element used is copper or germanium.

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Description

Scope of Application

The invention pertains to metallurgy, in particular, compositions of steels used for fabrication of critical parts for machine-building industry.

Previous Technology Level

The alloyed construction steel with the composition (wt. %) shown below is known:

Carbon	0.4 max
Silicon	0.56-1.5
Manganese	0.30-2.0
Chromium	0.71-3.0
Vanadium	0.21-1.0
Aluminum	0.3 max
Iron	Rem.
(JP, A, # 52-27584)	

This steel does not offer the required complex of properties, especially plasticity, elimination of intercrystalline brittleness and boosted nitration process.

Also known is the alloyed construction steel that has the following components, wt. %:

Carbon	0.30-0.45
Manganese	0.30-0.60
Silicon	0.17-0.37
Chromium	1.50-2.50
Vanadium	0.20-0.50
Germanium	0.20-0.80
Iron	Rem.
(SU, A, # 926060)	

The advantage of this steel is low strength at satisfactory plasticity across the cross section of the part made thereof following both traditional hardening methods and low-temperature nitration. Besides, there is a likelihood of temper brittleness typical of nitrided steels that are currently used.

The alloyed construction steel that contains carbon, silicon, manganese, chromium, molybdenum, nickel, vanadium and iron in proportions shown below (wt. %) is the closest from the point of view of the technological content and result sought:

Carbon	0.27-0.34
Silicon	0.17-0.60

(continued)

Manganese	0.30-0.60
Chromium	2.30-2.70
Molybdenum	0.20-0.30
Nickel	0.12-0.30
Vanadium	0.06-0.12
Iron	Rem.

(Steel 30X3MΦ, GOST 4543-71. Alloyed construction steel, grades and specifications).

The disadvantage of this steel are low yield and hardness, slow rate of saturation during nitrating and presence of scarcely available molybdenum arid nickel that results in high prbduction costs. Besides, there is a likelihobd of temper brittleness typical of nitrided steels that are currently used.

Disclosure Of The Invention

This invention is based on the objective to ensure high physical and mechanical properties of steel combined with high plasticity across the cross section of the part made thereof, following both traditional hardening techniques (quenching, tempering) and low-temperature nitration at 470-520°C, with minimum tendency for temper brittleness, as well as fabrication cost reduction.

The nature of the invention lies in the fact that, besides carbon, silicon, manganese, chromium, vanadium and iron, the alloyed construction steel additionally contains a chemical element that enhances plasticity and boosts the nitration process. The content of components is as follows, wt. %:

Carbon	0.10-0.63
Silicon	0.20-1.20
Manganese	0.40-0.60
Chromium	0.60-3.00
Plasticity-enhancing and nitration-boosting chemical element	0.40-1.50
Vanadium	0.15-0.35
Iron	Rem.

Also, either copper or germanium are used as the chemical element that enhances plasticity and boosts the nitration process.

The copper content is 0.40-0.80 wt. %, provided the silicon/copper ratio is 1.5-2.5.

The germanium content is 0.60-1.50 wt. %, provided the silicon content is 0.20-0.40 wt. %.

The combination of essential features described above is aimed at achieving the technical result sought and is related to it through cause and consequence, as it makes it possible to:

- ensure superior strength and hardness properties of the alloyed construction steel that has high plasticity across the entire cross section of the part made thereof, due to the chemical composition of the steel, shown above;
- boost the nitration process and ensure high plasticity across the cross section of parts;
- bring the steel making cost down by eliminating scarcely available components.

Besides, the invention may be used commercially in various industries for fabrication of critical parts and components.

Thus, a conclusion may be drawn that the technical invention claimed meets the requirements of its patentability.

The Best Way to Exercise The Invention

An experimental batch of alloyed construction steel is produced in an induction furnace. This experimental batch is then used to fabricate blanks that are to be exposed to quenching for 20 minutes at 890°C and to oil cooling and tempering for 3 hrs at 200°C and air cooling.

Standard mechanical properties are to be determined, i.e.: ultimate tensile strength σ_B, yield point $\sigma_{0.2}$, elongation δ, reduction ψ, impact strength KCV^{+20} and Rockwell hardness, HRC, as well as surface hardness HV, layer thickness up HV-400, comparative wear resistance, fatigue strength of nitrided samples σ_{-1}, endurance strength of nitrided samples σ^k_{-1} and impact strength of nitrided samples KCV^{+20}.

Table 1 shows steel compositions which use copper as the plasticity-enhancing and nitration-boosting the element; Table 2 contains steel compositions in which germanium is used as the plasticity-enhancing and nitration-boosting element. Mechanical properties of steels listed in Table 1 are shown in Table 3; operational properties of steels included in Table 1, after nitration, are described in Table 4; mechanical properties of steels listed in Table 2 are summarized in Table 5 and operational properties of steels included in Table 2, after nitration, are included in Table 6.

Commerical Use

Use of the alloyed construction steel in question will help to ensure superior physical and mechanical properties combined with high plasticity across the entire cross section of the part made thereof, with minimum tendency for temper brittleness, and reduce the steel making cost by 30-40%.

Table 1

Component	Composition, mass %			
	1	2	3	Prototype
Carbon	0.10	0.35	0.63	0.30
Silicon	0.80	0.90	1.20	0.27
Manganese	0.40	0.50	0.60	0.45
Chromium	0.60	1.80	3.00	2.50
Chemical element that enhances plasticity and boosts	0.40	0.50	0.80	-
nitration - copper	0.15	0.25	0.35	0.09
Vanadium	Rem.	Rem.	Rem.	Rem.
Iron				
$\frac{\text{Silicon}}{\text{Copper}}$	2.0	1.8	1.5	-

Table 2

Component	Composition, mass %			
	1	2	3	Prototype
Carbon	0.10	0.35	0.63	0.30
Silcon	0.20	0.29	0.40	0.27
Manganese	0.40	0.50	0.60	0.45
Chromium	0.60	1.80	3.00	2.50
Chemical element that enhances plasticity and boosts	0.60	1.02	1.50	-
nitration - germanium	0.15	0.20	0.35	0.09
Vanadium	Rem.	Rem.	Rem.	Rem.

Table 2 (continued)

Component	Composition, mass %			
	1	2	3	Prototype
Iron				

Table 3

Steel	Heat treatment conditions				Mechanical properties					
	Quenching		Temper		Ultimate tensile strength σ_B N/mm²	Yield point $\sigma_{0.2}$, N/mm²	Elongation δ, %	Reduction ψ, %	Impact strength KCV^{+20}, J/cm²	Rockwell hardness, HRC
	Temp., °C	Cooling medium	Temp., °C	Cooling medium						
Offered										
1	890	Oil	200	Air	680	590	18	65	240	22
2	890	Oil	200	Air	1830	1760	13	50	80	52
3	890	Oil	200	Air	2360	2280	8	42	56	62
Prototype	870	Oil	200	Air	1750	1580	6	40	48	50

Table 4

Steel	Nitration conditions	Nitrided layer depth, mm	Surface hardness HV, N/mm^2	Comparative wear resistance,	Fatigue strength σ_{-1}, N/mm^2	Endurance strength σ^k_{-1}, N/mm^2	Impact strength KCV^{-20}, J/cm^2
Offered							
1	500°C 36 hrs	0.82	590	1.01	510	1360	120
2	500°C 36 hrs	0.75	8100	1.28	760	2200	74
3	500°C 36 hrs	0.58	8300	1.24	710	2000	51
Prototype	500°C 36 hrs	0.40	7150	1.18	620	1300	35

Table 5

Steel	Heat treatment conditions				Mechanical properties					
	Quenching		Temper		Ultimate tensile strength σ_B, N/mm²	Yield point $\sigma_{0.2}$, N/mm²	Elongation δ, %	Reduction ψ, %	Impact strength KCV^{+20}, J/cm²	Rockwell hardness, HRC
	Temp., °C	Cooling medium	Temp., °C	Cooling medium						
Offered										
1	890	Oil	200	Air	680	580	24	72	280	22
2	890	Oil	200	Air	1850	1790	15	15	140	52
3	890	Oil	200	Air	2280	2210	11	11	82	60
Prototype	870	Oil	200	Air	1750	1580	6	6	48	50

Table 6

Steel	Nitration conditions	Nitrided layer depth, mm	Surface hardness HV, N/mm^2	Comparative wear resistance,	Fatigue strength σ_{-1}, N/mm^2	Endurance strength N/mm^2
Offered						
1	500°C 36 hrs	0.98	580	1.02	530	1420
2	500°C 36 hrs	0.87	7800	1.31	890	2320
3	500°C 36 hrs	0.74	7950	1.28	780	2200
Prototype	500°C 36 hrs	0.40	7150	1.18	620	1300

Claims

1. Alloyed construction steel containing carbon, manganese, chromium, vanadium and iron, characterized by containing, in addition, a chemical element that enhances plasticity and boosts the nitration process, the component ratio being (wt/%):

Carbon	0.10-0.63
Silicon	0.20-1.20
Manganese	0.40-0.60
Chromium	0.60-3.00
Plasticity-enhancing and nitration-boosting chemical element	0.40-1.50
Vanadium	0.15-0.35
Iron	Rem.

2. Alloyed construction steel according to claim 1, characterized by the use of copper or germanium or as the plasticity-enhancing and nitration-boosting chemical element.

3. Alloyed construction steel according to claims 1 and 2, characterized in that the copper content is 0.40-0.80 wt.%, provided the silicon copper ratio is maintained at 1.5-2.5.

4. Alloyed construction steel according to claims 1 and 2, characterized in that the germanium content is 0.60-1.50 wt.%, provided the silicon content is 0.20-0.40 wt.%.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/RU 96/00184

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl^6: C22C 38/24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl^6: C22C 38/24

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 40604312 (THYSSEN EDELSTAHL WERKE AKTIENGESELLSCHAFT), 29 November 1977 (29.11.77)	1-4
A	GB, A, 1547520 (UDDEHOLMS AKTIENBOLAG), 20 June 1979 (20.06.79)	1-4
A	FR, A1, 2567910 (KANTO SPECIAL STEEL WORKS LTD.) 24 January 1986 (24.01.86)	1-4
A	DE, B2, 2144554 (VEREINIGTE EDELSTALWERKE AG (VEW)), 11 January 1979 (11.01.79)	1-4

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
06 September 1996 (06.09.96)	18 September 1996 (18.09.96)
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Facsimile No.	Telephone No.

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