NEW HIGH STRENGTH TECHNOLOGICALLY ECOLOGICAL AND EXPEDIENT ECONOMICALLY ADVANTAGEOUS ALLOYS ON Fe-C BASE

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Abstract: The paper presents framework a part of by now obtained results of the authors studies in the period 1967(68) - 2002 about possibilities for obtaining new high-strength and wear resistant cast alloys on Fe-C base (complex alloyed steels and cast irons of different systems with different structure, reflected in over 125 articles, 15 inventions (patents) and other scientific studies. The paper includes summarized results and discussion.
Key words: new austenite steels and cast irons , mechanical characteristics, wear resistance.

1. INTRODUCTION

The intensive progress of world science imposes the necessity to create new materials and alloys with high physical-mechanical and exploitation characteristics with simultaneous decrease in material energy and other expenses for achieving high quality. Development of machine building as a strategic sector is inevitably connected to the creation of ever newer and more effective technological and ecological processes in foundry. Bulgarian methods with gas counter pressure (MOMGP) presents a fundamental innovation for great potential possibilities to develop and solve actual-priority Global problems of Mankind; creation of technological and ecological as well as economically profitable machines and devices, new materials (alloys) and their products [1-4]. One of the most perspective directions of MOMGP is creation of new machine-building materials (steels and cast irons), alloyed with volatile elements [1-5]. N is the most common in Nature gas and residual product of a number of industrial production, processing the unique property to substitute expensive and deficit elements like: Ni, Cu, Co, (Mn) etc. and to improve some physical - mechanical and exploitation characteristics in times, not in percentage, completely corresponds to some of the challenges and the outlined Global problems of Mankind for the present and future. This shows that possibilities for obtaining of new N-containing alloys aimed at casts are many times bigger than defformable steels [5-6]. In the Institute of Metal Science - BAS are carried out profound studies not only on possibilities for obtaining new N alloyed deformable steels, but new cat steels and cast irons as well.[5].

2. SUMMARISED RESULTS AND DISCUSSION

The published data are related mainly to stainless deformable steels. Information on cast alloys with high C concentrations over 0,1-0,4wt.%C of Fe-Cr-Mn-C-N system with and without N and over equilibrium N concentration is practically non-available [5]. We studied (%wt): 0,1 to 3,5-4.2%C; 0,3-2(4)%Si; 0,4(7)-28%Mn; 0 to 32-35%Cr; 0,01 to 1,2-2,1%N. (Author's Patents RB: 31141;23369; 24330; 24883;49451;51734;48283;24141;24142;24881;26110;21917)

2.1. MECHANICAL PROPERTIES AND WEARRESISTANCE OF NEW CAST ALLOYS

Austenite is the most economical basis for creation of new alloys with special properties: non magnetism, wear resistance, heat resistance, corrosion resistance, etc., combined with high mechanical characteristics and plasticity. The systems Fe-Cr-Mn-C-N and Fe-Cr-Mn-C as a whole and as a basis for creating new alloys with special properties are not studied enough. Below we present results of some economicall alloys.

2.1.1. MECHANICAL CHARACTERISTICS OF WEAR RESISTANT CAST ALLOYS OF THE SYSTEMS Fe-Cr-Mn-C-N AND Fe-Cr-Mn-C:

The problem linked to obtaining of cast nonmagnetic alloys of the austenite class with high values of the yield strength (σ_{02}) is very topical. The values of σ_{02} of classic austenite wear resistant steels of Hatfield type (C110Mn13) are low (to 35-40.10^7Pa)[5], Values of σ_{02} in classic Cr-Ni austenite steels of the type C10Cr18Ni9Ti are lower [5]. We studied cast austenite alloys in wide range of variation of the basic components; securing after high temperature austenitization (1100-1200 °C) austenite and austenite - carbide structure [5]. C=0,09-3,5wt.%, below 1%wt .Si, to 10-30% wt. Mn, to 0,1-14%wt.Cr, 0,05-1%wt.N, below 0,09% wt.P and S. Some of the steels and cast irons are additionally alloyed with V,Mo,Al,Pb at general sum to 2,5% austenitization and quenching in water of 1100-1200°C.pdtents RB 31141, 49451, [5]. IT is established that austenite can be strengthened with N and C separately or together with both elements. N increases the strength tensile under equal other conditions with 4-6.10^7Pa every 0,1 wt. %N. Some interesting results are present in tabl.1.

Mechanic characteristics after homoganisation+queching of some N–alloyed steels **tabl.1**

No in order	Chemical composition in %							Mechanical characteristics					
	C	Si	Mn	Cr	S	N	Other	σ_B 10^7 Pa	σ_{02} 10^7 Pa	δ_5, %	A_K, 10^5, J/m^2	ψ, %	HB
1	0.15	0.81	12.77	5.00	0.029	0.733	V - 1.90 Mo - 0.53 Al - 0.45	73.99	55.05	18.40	4.30	23.00	262
2	0.23	0.74	20.00	6.20	0.025	0.839	V - 0.83 Al - 0.25	71.96	58.72	22.60	17.90	39.10	236
3	0.32	0.73	14.50	7.70	0.034	0.0488	V - 0.64 Mo - 0.19 Al - 3.00	58.20	39.28	12.00	9.50	23.20	195
4	0.72	1.09	12.70	4.48	0.010	0.417	V - 0.42 Mo - 0.30 Al - 0.54 Pb - 0.30	79.54	56.70	23.20	6.10	29.40	283
5	0.075	1.62	14.34	5.63	0.009	0.010	V - 0.60 Mo - 0.30 Al - 0.45	86.90	57.20	24.00	6.30	31.30	297
6	0.75	0.52	19.00	8.67	0.044	0.322	V - 0.21 Al - 0.30	61.07	46.95	13.30	12.40	24.80	247
7	0.83	0.38	13.86	6.14	0.008	0.557	-	91.30	62.70	18.00	6.75	-	-
8	0.80	0.35	12.85	5.58	0.016	0.599	Al - 0.10	92.60	60.33	25.84	6.00	-	-
9	0.88	0.38	15.00	7.90	0.023	0.729	V - 0.10 Mo - 0.70 Al - 0.45	90.43	60.89	31.00	4.80	84.80	270
10	0.88	0.28	13.03	5.98	0.020	0.146	V - 0.2	116.30	80.10	16.50	2.60	-	-
11	0.99	0.19	22.39	3.91	0.022	0.655	V - 0.60 Mo - 0.30 Al - 0.30	92.47	57.80	26.20	8.60	32.80	275
12	0.88	0.64	4.50	4.27	0.020	0.337	V - 1.67 Mo - 0.30 Al - 0.90 Pb - 0.10	78.08	59.08	9.60	6.20	-	-
13	1.05	0.56	22.19	4.02	0.240	0.339	V - 0.50 Al - 0.20 Pb - 0.40	79.86	60.55	28.00	8.60	33.4	274
14	1.13	0.81	12.75	3.46	0.200	0.630	V - 0.93 Mo - 0.33 Al - 0.70 Pb - 0.11	85.47	61.14	13.60	11.60	23.40	304
15	1.02	0.29	5.84	5.84	0.009	0.548	Ni - 2.46	93.88	54.80	40.20	17.50	-	-
16	1.26	2.20	-	8.14	0.012	0.191	-	79.44	51.98	18.11	4.85	-	-
17	0.98	0.34	14.50	8.28	0.262	0.178	-	77.48	81.54	22.04	8.00	-	-
18	1.45	0.80	21.00	5.84	0.030	0.680	V - 0.85	76.05	65.47	5.20	2.30	9.80	260

On statistical basis we obtained mathematics models which help evaluate the influence of the sum Σ C+N in the range 0,18-1,8 wt.% on the strength tensiler and yield strength *(σ_{02})* in cast alloys containing (wt.%): 12-14%Mn, 4-6%Cr, 0,4-0,6%V, 0,25-0,5%Mo, 0,15-0,2%Al. Carbon has been changed within the range 0,09-1,15% and N=0,08-0,9%. The following regression equations have been obtained after 47 - 48 experiments: 1. For the strength tensile $\sigma_B=36,66+45,28\ (C+N)\ -\ 10,24\ (C+N)^2$; for the yield strength $\sigma_{02}=17,035\ +\ 50,95\ (C+N)\ -\ 13,97\ (C+N)^2$. The elongation δ_5 varies within the range 10-13% up to 30-35%, impact strength *(a_k)* from 4-6 to 17-20.10^5Pa j/m^2. The hardness varies within the range 200-300HB. The influence of plastic characteristics higher than that of N [5]. In N, C+N austenite alloys (steels) can be reached higher plastic characteristics compared to only carbon steels. This reveals possibilities and perspectives for regulation of strength and plastic characteristics when introducing C and N in the melt separately or together in *ΣC+N* at different ratios *C/N* or *N/C* [5-6]. We obtained high and medium - alloyed with Cr cast austenite steels, which after high temperature homogenisation and quenching possess yield strength up to 3-4 times higher than that of classic austenite Cr-Ni steel of the type C10Cr18Ni9Ti and up to 1,5-2 times higher than that of the famous Hatfield steel C110Mn13, patent claim RB31141. Cast alloys of the system Fe-Cr-Mn-C-(N) with austenite-carbide structure after high temperature austenitization and quenching possess high mechanical properties (σ_B reaching 80-90.10^7Pa, hardness to 500-600*HB*) and lower plasticity (δ_5 and a_k) depending on quantity, shape, size, distribution and type of residual carbide phase. Decreasing Mn quantity first come the unstable under deformation steels, then we reach martenzite (ferrite) class, at Mn content below 1-3wt.%.Table 2 presents some generalised data on strength tensile *(σ_B)*, yield strength *(σ_{02})*, elongation *(δ_5)*, impact strength *(a_k)* and hardness of N-free and N-containing cast austenite alloys from the different phase areas of the systems Fe-Cr-Mn-C-N and Fe-Cr-Mn-C. The advantages of alloys in the respective phase areas (γ, $\gamma+k$, k -carbide) are obvious-steels and cast irons, containing N in comparison with alloys of the same phase areas with C, without N [5] - patent claim RB31141 and RB49451. At one and the same sum *ΣC+N* for steels of γ - area, better strength characteristics and especially plasticity have those containing less C.

This shows that N creates conditions for obtaining better plastic characteristics towards C, and up to higher content, irrespective of the fact that both elements form solid solutions of introduction. The mechanism of influence of both elements on strength and plastic characteristics has been theoretical presented in [5-6]. It is determined by the similarities and differences in the influence of C and N [5]. For example: at the sum *ΣC+N =1,5-1,6 wt.%* and 4-7wt.%Cr, σ_B is 1,55-1,65 times better than N free steels with the same sum ΣC+N, i.e. containing 1,5-1,6 wt.%C; σ_{02} is 1,35-1,5 times better and δ_5 under the same conditions is 9-14 times better than that of alloys not containing N or at 1,5-1,6 wt.%C. Impact strength *(a_k)* under the same conditions is 3-5 times better. The differences in hardness are minor. Hardness of high carbon steels without N at 1,5-1,6%C is with 45-87 HB higher, than that of N containing with sum *ΣC+N =1,5-1 wt. %*.. This means that N increases hardness to a smaller extent which is not equal to strengthening. Nitride phases are thermo dynamically more unstable than carbide ones. Under austenization (1150°C) N is completely in the solid solution and C can remain under the form of residual carbides [5].

Comparative results from table 2 show that when introducing only C in the melt high σ_B and high σ_{02} can be reached unlike the introduction of (C+N*)* but at considerably lower plastic characteristics. High values of σ_{02} in austenite alloys of the system Fe-Cr-Mn-C-N without N are obtained at lower C content (0,18 - 0,55 wt.%C) and higher Cr content. This is significant from economic point of view, with advantage towards N containing. Irrespective of the fact that C increases σ_{02}, N - containing alloys have certain advantage, having higher values in this characteristics (σ_{02}) even at higher values of plastic characteristics (δ_5 and a_k) . With one and the same composition and equal C and N content the extent of strengthening is higher in N-containing cast austenite steels, tabl.1,2.

2.1.2. WEAR RESISTANCE OF COMPLEX ALLOYED HIGH-STRENGTH AUSTENITE CAST ALLOYS

The basic factors determining wear resistance are phase, respective chemical composition. Various processes of wearing reflect in different ways on formation of structure, respective on wear resistance [5-6]. According to enhanced wear resistance criterion the phases and structure components graduate as follows: ferrite, perlite, sorbite, troostite, martenzite. Austenite is contradictory evaluated because of insufficient research. Austenite of steels of the type C10Cr18Ni10 is corrosion resistant but poorly wear resistant even in conditions of wear and corrosion. Austenite of steels of the Hatfield type (C110Mn13) is highly wear resistant under strike pressure and poorly corrosion resistant and heat resistant which makes them inappropriate for work in complex conditions of wearing. The attempt to improve wear resistance of steels of type C110Mn13 by additional alloying with carbideforming even with stabilising austenite elements of substitution or by diminishing the austenite stability in cold deformation conditions (strike pressure) has not given any positive results. Improvement of some properties (σ_B, HB etc.) is accompanied by decreasing of other (plasticity, strike elasticity- resistance against fine destruction under strike pressure or repeated plastic deformation etc.). Obviously until

Mechanic characteristics of wear-resistant alloys; 12-16 % Mn, with and without N

Table 2.

N	Type Alloy	Phase area	C, %	N, %	C+N, %	Cr, %	Tensile strength σ_B 10^7 Pa	Yield strength σ_{02} 10^7 Pa	Elongation δ_5 %	Impact strength a_k 10^5 J/m^2	Hardness HB
1	Steels	γ	0.80-0.90	0.70-0.73	1.50-1.60	4.00-7.00	91-93	63-66	35-28	18-12	270-300
	with N		0.15-0.18	0.74-0.84	0.89-1.02	5.00-6.20	72-74	55-59	28-18	17.9-4.5	236-262
2	Steels	γ	0.90-1.00	-	0.90-1.00	6.50-7.00	43-47	32-39	6-5	-	248-268
	without N		1.50-1.60	-	1.50-1.60	4.00-5.00	55-60	45-49	4-2	5-3	315-387
3	Steels	γ+	0.77-1.10	0.38-0.50	1.45-1.55	12.0-13.0	68-77	-	20-10	4-2.5	-
	with N	k	0.78-1.20	0.43-0.50	1.35-1.60	18.0-19.0	84-91	-	16-8	2.5-1.5	-
4	Steels	γ+	1.00-1.17	-	1.00-1.17	12.0-13.0	55-62	47-50	6-2	-	-
	without N		0.90-1.00	-	0.90-1.00	18.0-19.0	55-65	54-62	1.5-0.5	-	277-296
		k	1.40-1.50	-	1.40-1.50	12.0-13.0	73-78	63-67	2-1	-	362-412
			1.55-1.66	-	1.55-1.60	18.5-19.5	65-74	57-62	-	-	369-415
5	Casts	γ+	2.40-2.80	0.30-0.20	2.70-3.10	12.0-14.0	65-81	-	<2.5-1	1.15-0.45	405-500
	with N	k	2.40-2.60	0.21-0.47	2.70-3.10	18.0-20.0	60-72	-	<2-1.5	0.80-0.42	415-520
6	Casts	γ+	2.50-3.20	-	2.50-3.20	12.0-13.0	23-53	-	-	-	520-598
	without N	k	2.40-3.20	-	2.40-3.20	18.0-19.0	48-59	-	-	-	495-593

resistance of steels of type C110Mn13 by additional alloying with carbideforming even with stabilising austenite elements of substitution or by diminishing the austenite stability in cold deformation conditions (strike pressure) has not given any positive results. Improvement of some properties (σ_B,, HB etc.) is accompanied by decreasing of other (plasticity, strike elasticity- resistance against fine destruction under strike pressure or repeated plastic deformation etc.). Obviously until recently (patent RB31142, RB49451, RB51734 etc.) scientists considered C (along with Mn) for the only and most important element determining wear resistance of steels of the Hatfield type, resp. possibilities for strengthening and reaching of optimum combination between strengthening and plastic characteristics. Hens we should expect that strengthening of austenite under the influence of C and N should lead to improvement of wear resistance. Under interaction between abrasive particles and details surface, there is processes of surface plastic deformation, microcutting or surface microdistruction. Similar processes take place under friction wearing. Under strike pressure there is a surface settling which according to the extent of stability leads to strengthening and obtaining of surface deformation martenzite. Because of this the increase in strength, hardness extent of deformation strengthening and resistance towards fine destruction leads to improvement of wear resistance of Cr-Mn austenite containing C and N separately and together. For testing of wear resistance we used two methods; 1) of friction- by laboratory machine ''Schoda-Savine'', 2) weight method-wearing under abrasive, hidroabrasive and strike abrasive pressure, combined with certain strike pressure (Personally developed laboratory machine). Basic studies are after austenitization and quenching in water. We made an attempt to test wear resistance of alloys of both studied systems after following ''ageing''. Summarised results of the studies on wear resistance of cast austenite alloys of the system Fe-Cr-Mn-C-N boil down to; [5] (patents Claim RB31141, RB49451 etc. 1. Increasing the content of C, N, ΣC+N, Mn, Cr and the pressure of crystallisation, wear resistance of austenite cast alloys containing 1-8(12,) wt.% Cr improves. It is obtained the following regression equation for wearing (W, μm^3) by'' Shcoda-Savine'' method; 45.10^5Pa; 0,6-1,2 wt.%Si; 1150°C/H_2O: a)W*-wear resistance, P-pressure; $W^*=f(C,wt\%)=179{,}204C^4-1524{,}604C^3+4591{,}278C^2-5865{,}909C+3222{,}174$ ($0{,}15\leq C\leq 3{,}2$ wt.% N=0,4-0,6wt.%, Mn=16-18wt.%,Cr=6-7,5wt.%), b)$W^*=f(Cr,N,\ wt.\%)=-78{,}486.Cr+441{,}932N+1124$ ($0{,}5\leq Cr\leq 13{,}5$wt.%; $0{,}04\leq N\leq 1$wt.%N; Mn=16 -18 wt%, C= 0,7-0,8wt.%), c) $W^*=f(Mn,N,wt\%)=10{,}167Mn^2-225{,}65Mn+6159.10^3N^2-1313.10^3N-355{,}87Mn.N+3{,}889.10^3$ ($10\leq Mn\leq 28$wt.%, $0{,}2\leq N\leq 1$wt.%, C=0,55-0,7wt.%, Cr=4-5wt.%), d)$W^*=f(N,wt\%)=999{,}811N^2-2579N+2255$ {$5\leq P.10^5Pa\leq 45$. $N=f(P)=0{,}019P+0{,}048$}. The alloys (steels and cast irons) with austenite-carbide structure after austenization [5] have better wear resistance than steels with monophase austenite structure but have worse plastic characteristics. Increasing Cr content up to 12-14wt.% in alloys containing 16-18 wt.% Mn, 0,7-0,8 wt.%C. Wear resistance is slightly improved. The slight influence of Cr, Mn and pressure is explained with the determining action of the absorbed under their effect N. We obtained medium and low alloyed with C cast austenite alloys with $\Sigma C+N\geq 0{,}8$-1*wt..%,* which after austenitization and quenching possess higher yield strength and better wear resistance than the classic austenite Hatfield steel (C110Mn13); up to 1,5-2 times (separate parts up to 3-5 times) in alloys with austenite structure and up to 4-6 times (separate parts even more) in cast iron and many times better wear resistance than classic Crt-Ni austenite of the type C10Cr18Ni10. We determined the ratios between the component at which after high temperature austenization and quenching is obtained optimum combination between mechanical characteristics and wear resistance and good corrosion resistance (to grade 4 according to RB standard BSS17043-89).

-Steels with austenite structure (γ -area, wt.%), patents RB31141;RB49451 [5]: a) stable structure (C=1,3-0,5%; N= 0,06-0,9%, Si=0,8-1,2% Mn=28-11%; Cr=8-0,1%; S,P∠0,1.%, b) unstable structure - under deformation; C=0,4-1,2%, N≤0,2%, Cr=0,7-1%, Mn= 6-10%, S, P≤0,1%. The stable, as well as the unstable can be additionally alloyed preserving their monophase structure after austenitization and quenching, with V up to 0,5-1,5%, Mo to 0,5-1%, Al up to 0,5-0,8%, Pb up to 0,4%, W to 0,3-1% etc., separately and in combination to 2-2,5%.Patents RB31141,RB49451. After austenitization and quenching in water they have following mechanical characteristics; $\sigma_B=70\text{-}110.10^7$Pa, $\sigma_{02}=50\text{-}82.10^7Pa$, δ_5 up to 40-30%, a_k up to 25-20.10^5 J/m^2. Improvement of wear resistance towards Hatfield steel C110Mn13 under equal conditions: a) after austenitization and quenching in water at 1150°C up to 1,5-2,5 times (separate part to 3-5 times). b) after following heating and cooling down (ageing) at 700°C - to 2-4 times. c) after cooling down at negative temperature (minus 65°C) up to 1,5 - 2,5 times.

-Alloys with austenite- carbide structure (γ+K - area)-patents RB31141,RB49451[7,12,14-18,23]. Cast irons with composition (wt.%): C=2,8-3,6%; Si= 0,7-2%,Cr=10-15%; Mn=10-15%, N=0,04-0,5%, S,P

≤0,1%. For higher strike depending on certain conditions of exploitation. Mechanical characteristics after austenization and quenching at 1100-1150°C; σ_B=*50-80.10⁷Pa; a_k = 1,4-0,5.10⁵ J/m²; 400-600 HB*. Improvement of wear resistance towards C110Mn13 to 4-6 times separate parts even more. In order to improve the mechanical characteristics and wear resistance these cast irons can be additionally alloyed with carbide and nitride - forming (Mo, V, W, Nb, Ti, Zr etc.), authors patent RB49451, RB31141 etc. and for regulation strength and plastic characteristics can be introduced additionally stabilizators of austenite forming solid solutions of substitution; Ni, Cu etc. and C and Si content can be decreased to 1,5-2,2%C and 0,4-0,9% Si, Patent RB 51734. Ageing (700°C) deteriorates and cooling down at negative temperatures (minus 65°C) improves wear resistance of steels in γ - area [5,6,10]. Low Kr alloyed (1-8wt.%) dispersion hard steels possess better wear resistance than medium or high Cr alloyed ageing on the mechanism of interrupted separation [5]

-*Alloys of system Fe-Cr-Mn-C-without N*, [25,26], patents RB31141,RB49451. It is determined that from N-free cast austenite alloys of the system Fe-Cr-Mn-C obtained cast alloys with better wear resistance in comparison with some traditionally used in practices samples: martensite quenched and tempered, austenite Mn and Cr-Ni steels. We obtained cast austenite alloys of that system having up to 4-9 times better wear resistance than steels C45, containing only 0,45 wt.%C (quenched in oil and tempered at 450°C) up to 4-5 times austenite steel C45Cr20Ni12Mn2Si2. Best wear resistant in combination with good mechanic characteristics shows alloy 1,52%C, 12,5 wt.%Cr and 15 wt.%Mn.

This is what show the general comparison between wear resistance and mechanical characteristics of austenite cast alloys of the systems Fe-Cr-Mn-C-N and Fe-Cr-Mn-C: **1.**The best wear resistance after austenitization and quenching in both systems show cast irons with residual austenite chromium eutectic, including carbides of the type Me_7C_3. Wear resistance of steels with monophase austenite structure after austenitization and quenching of both systems is almost one and the same. **2.**After ageing the wear resistance of austenite alloys of the systems Fe-Cr-Mn-C containing N deteriorates and of the N-free alloys improves. This is due to different characteristics of separating phase: carbides and nitrides (carbon-nitrides). Interestedly ageing alloys of both systems have poorer complex of mechanic and exploitation characteristics (wear resistance etc) in comparison with continuously ageing mechanism (diffusion or non-diffusion) [5]. **3.** In austenizated and quenched condition N - containing austenite alloys possess better complex of strength plastic characteristics and wear resistance in comparison with N-free. Plastic characteristics and yield strength in steels of γ - area are better than those in N-free alloys of the same area, tabl.2. This confirms the advantages of N-containing austenite alloys. Nitrogen austenite alloys can be used for stronger pressurised (strike) details, casts or products obtained through plastic deformation as well as for more effective lightening of details, machines and devices. Besides some Mn austenite steels low Cr alloyed (of the type C110Mn13, Mn20 etc.), N-free alloys of the system Fe-Mn-Cr-C can be used basically forcasts. **4.**The advantages of N-free alloys on austenite basis from the system containing above -equilibrium quantities N is that they can be obtained and founded in existing aggregates and devices in atmospheric conditions. This advantage is not big enough, especially having in mind the challenges of today and next century when there will be larger and more severe requirements towards production from ecological point of view [5]. The other advantages of free founded austenite alloys is that they can be strengthened and improved in wear resistance through "ageing"(continuous. ageing) [5]. **a)** Is it determined that from N-free cast austenite alloys of the system F-Cr-Mn-C can obtained founded alloys with better wear resistance in comparison with some traditionally used in practices samples: martenzite quenched and tempered, austenite Mn and Cr-Ni steels. We obtained cast austenite alloys of that system having up to 4-9 times better wear resistance than steels C45, containing only 0,45 wt.%C (quenched in oil and tempered at 450°C) up to 4-5 times better than steels C110Mn13 (quenched) and up to 4-6 times better than that of austenite steel C45Cr20Ni12Mn2Si2. Best wear resistance in combination with good mechanical characteristics shows alloy (wt.%) 1,52%C, 12,5%Cr and 15%Mn. **b)** Optimum combination between mechanic characteristics and wear resistance after austenization and quenching at 1150°C is obtained at following ratios between component in wt%: **a) steels**: C=0,65-1,6 %; Cr=10-20%, Mn=14-16%; σ_B=*45-76.10⁷Pa*; σ_{02}=*33-65.10⁷Pa*; δ_5=*8,5-1,6%*; a_k=*15-3,5.10⁵J/m², 260 - 360HB*. Improvement of wear resistance towards steel C30(0,3%C) up to 2,5 - 4 times (separate parts to 5 times) towards steel C45 (0,45%C) up to 4-5 times), towards C110Mn13-

to 1,5-2,5 times (separates parts to 3-4,5 times) towards austenite steel C45Cr20Ni12Mn2Si2 - to 2-3,5 times; b) **cast irons;** C=2-2,6; Cr=12-18%; Mn=14-16%; Si below 0,3-0,6%; $\sigma_B=36\text{-}60.10^7 Pa$, *400-600HB*. Improvement of wear resistance towards steel C30 up to 3-5 times (separate parts to 9-12 times), towards steel C45- to 4-9 times towards C110Mn13 - to 4-6 times, towards C45Cr20Ni12Mn2Si2 - to 5-6 times. **5.** Experimental results confirm the qualitative and quantitative deference's in influence of C and N on mechanical characteristics and wear resistance [5].

2.2. NEW N-CONTAINING HIGH STRENGTH AND WEAR RESISTANT CAST ALLOYS IN OTHER METAL SYSTEMS

Alloys can be obtained in atmospheric conditions with and without N and higher pressure with above equilibrium quantities N. We obtained austenite cast irons in the system Fe-Mn-V-(Cr)-C-N with invertible microstructure, having comparable wear resistance and better plastic characteristics (a_k) in comparison with studies austenite alloys of the systems Fe-Cr-Mn-C and Fe-Cr-Mn-C-N we obtained patent for innovation RB48293. The best combination between strength and plastic characteristics and wear resistance come at following ratio components in wt%; C=2,1-2,8%; Si=0,4-0,9%; Mn=10-22%; V=4-11%, N=0,04-1,3%; S, P, below 0,05-0,09%. After austenization and quenching in water at 1130°C-1200°C posses following mechanical characteristics; $\sigma_B=40\text{-}64.10^7 Pa$, $a_k=0,7\text{-}2,810^5\ J/m^2$, *36-51 HRC* [5] RB48293. Improvement of wear resistance towards Hatfield steel C110Mn13 (by the method ''Shkoda-Savin") up to 2,7 times and in conditions of abrasive-hidroabrasive wearing combined with moderate strike pressure up to 3-3,5 times better than that of steel C110Mn13 and to 3-3,2 times towards quenched and tempered steel C45. Successful experiments about attempts of substitute part of the expensive and deficit V for Cr have been carried out. After austenization and quenching in water at 1130°C following characteristics are obtained; $\sigma_B=48\text{-}96.107Pa$, $\delta_5=0,8\text{-}5\%$, $a_k=0,7\text{-}2,4.10^5\ J/m^2$, *33-56HRC*. Improvement of wear resistance under abrasive wearing with certain strike pressures - to 3,5-8 times towards steel C110Mn13 and up to 3-7,3 times towards steel C45. Invertible structure with optimum mechanical properties and impact strength is obtained at sum Σ $Cr+V=13\text{-}17$,[5]. Cast irons of the system Fe-Cr-C-(N) have more rude structure and big quantity of carbide mass increasing the brittle's. Under equal quantity of carbide phase in the cast irons from the systems Fe-Cr-C-(N); Fe-Cr-Mn-C(N) and Fe-Mn-(Cr)-V-C-N advantages are on the side of V cast irons, thanks to more favourable distribution, shape and high hardness in strengthened elastic austenite matrix

2.3. INDUSTRIAL TESTING AND INSTALMENTS OF NEW COMPLEX ALLOYED ALLOYS

Results of long laboratory studies (1967/68/ - 2001) show that cast alloys of investigation systems are characterised basically as high strength and wear resistant.14 patents and innovations have been protected. Those containing 12-14wt.%Cr possess also corrosion properties in some media [5]. They concern new alloys outlining a wide range of the basic components (wt.): from 0,05 -0,1% to 3,5-4,2 %C, 0,4 to 28-30%Mn, 0 to 30-35%Cr, from 0,01 to 1,3-2,1%N. Additional alloying is used separately or together in different combinations with carbide and nitride forming and austenite forming. We carried out continuous seri industrial testing industrial production and consumption of casts working under abrasive wearing, somewhere in combination with *PH=6-8* and definite strike pressure from light to strong variables: spades for fraction - throwing cameras in foundry production, casts for machines, producing ceramics and fireproof materials and details, hammers for parcellation of coal, stones, minerals for high pressurised machines, machines working under variable pressure (links, tracks, teeth for excavators), casts for sectors of mining industry, cement industry etc.(claws for breakers, facing coatings, for mills, hydrocyclones, separators, grinding bodies etc.). Industrial testing confirm results from laboratory research [5].

2.4. DIRECTIONS FOR APPLICATION OF DEVELOPED COMPLEX - ALLOYED ALLOYS

All developed alloys are suitable for work in contact with following abrasives (in dry and wet conditions - *PH=6-8*; soil, sand, coal stones, minerals, asphalt, cinder okaline, middling slime, agglomerate, ores, concentrates, clinker, cement, forming materials and mixtures for metallurgical and foundry product, ceramics ad fireproof materials and mixtures, hidrotransport, pneumotransport, inertmaterials etc. The main direction is substitution of traditionally used; cast iron type "Nihard"; "Climax alloy", austenite steels of the Hatfield type, Cr-Ni steels and piling up in layers, martenzite-quenched carbon steels etc. Steels with monophase austenite structure and most of all N-containing after homogenisation and quenched are appropriate for non-treatable with cutting instruments highly pressurised (strike, variable) cast and details obtained after plastic deformation, working in conditions of wearing, erosion, cavitation, as well as for lightening of details, machines and devices. Steels and cast irons with austenite carbide structure are suitable for non-treatable with cutting instruments, casts working in conditions of abrasive, hidroabrasive, strike abrasive, combined with compression, corrosion mechanical wearing. Vanadium cast iron with invertible structure - for founded and forget products working under variable pressure and wearing. Industries consumers are mainly the sectors of: power engineering, building and constriction Materials mining metallurgy and foundry (dome and rolling production, agglomeration, coal and are mining) as well as general and special machine building [5]

Acknowledgement: The work has been carried out under Republican contracts TH295 and TH717 of the Ministry of Education and Science of Bulgaria with man co-ordinator the author Dr Eng. B.V.Kolev

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