Getting Oil Pipes High Strength Quenched And Tempered Condition

CARMEN OTILIA RUSANESCU[1], GHEORGHE VOICU[1]*, MARIN RUSANESCU[2]*, SORIN STEFAN BIRIS[1]
[1] University Polytechnic, Faculty of Biotechnical Systems Engineering Bucharest, Romania
[2]Valplast Industrie, 9 Preciziei Blv., 062202, Bucharest, Romania

The use of the steel with low carbon and fine grain Cr-Mo type is asked by the necessity to fit high strength and plasticity characteristics. The paper emphasizes the quenched and tempered high strength pipes from groups II, III and IV – API 5 CT obtaining. The laboratory experiments followed the establishment of optimum values of the heat treatment parameters. Saying all these to ensure the obtaining of the mechanical characteristics specific to eachs grade that was to be obtained. Were used microalloyied steels with vanadium and columbium, that refined the structure of improved the materials toughness. The paper is determined hardenability and finishing elements influence the use of grain (V, Nb) on hardenability.

Keywords: toughness, corrosion resistant steels microalloyed with vanadium and niobium

The grouth of the oil demand and price led to a continuous growth of the depth of the hole, and the diversification of the extracting areas (severe climate condition or high aggresivity demands for the oil pipes and developing new type of the steel with high strentgh, plasticity and corrosion resistance properties [1].

In this context the API norms are in a continuos improvement by taking the different suplimentary conditions asked by the oil pipes users [21].

The aim of this paper is to obtain quenching an tempering oil pipes from group II-IV API 5 CT [21].

Microalloying steels Cr-Mo type are indicated for the quenching and tempered state, all these having a better behaviour in probing than the C-Mn steels, Cr and especially Mo (elements that generates carbides) stops the transformation in the pearlitic stage and moves it in the bainitic stage with results upon the material characteristics [2].

The use of vanadium and columbium for the finishing graines is more advantageous thanthe aluminium (in comparison with the aluminium), this making not only nitride but also fin dispersate carbide [3]. Vanadium has a stroger action in thee rising of the yield strength because of the fact that vanadium nitrides are forming more quickly and easier than the aluminium [2, 7, 15, 17]. Because of the columbium carbide separation in the austenitic domain the influention of this element very powerful at low temperature from the end of rolling. While through separatrions of nitrides from aluminium and vanadium the toughness is advantageous high influenced, the separation of columbium carbides have a bad effect on the toughness. In this conditions the yield strength bettering is made in the prejudice of the toughness. The growth of the yield strength over the value obtained through the rolling is achieved with the help of the quenching and tempering [6, 12]. The favorabile effect of this treatment is translated through the achievement of one fine grains among one strong subcooling at quenching and through one fine and uniform distribution of the carbides at the further tempering [5, 6, 12, 20]. For low alied steels with a content of 0.20-0.25 % carbon the quenching and tempering heat treatment allows the different values of the mechanical characteristics obtainance through the different selection of the tempering temperature [6]. The group of elements with strong affinity for carbon from carbide with bigger stability at heating than cementite, the decreasing order according their capacity of forming carbides bein the following: Ti, Nb, V, Mo, Cr, Mn [6].

Yield strength can be enlarged through the finishing grain or through the precipitation of same dispersion phase [8, 11, 13]. But it was established the leggier contribution of the finishing grain for witch at a growth with 10 N/mm^2 of the yield strength is obtained simultaneously a growth of the toughness [2]. This growth is equalized with a diminution of the transition temperature with 6^{0}C [9]. For these reasons, lately was emphasized the diminishing of the precipitations phases quantity and the aim to obtain them fine and disperse distributed. For these the content of vanadium was diminished to the inferior limit (0.1 % from 0.2 %) and was registered an a higher stage at the steels with columbium of maximum 0.05 % [3, 9, 10].

Quenching and tempering

The selection of the heat treatment parameters in the case of steels with fine grains and low carbon must have in mind some contradictory factors that are:

-lower quenching because of the smaller content in carbon, but compensated through micro alloying;

-the quenching temperature for complete austenitization but one that doesn't put in to the solution all the particles in order to avoid the growth of the grain;

-the cooling speed after quenching which to ensure the transformation with minimum 50 % marten site [7];

-the tempering temperature for which the precipitation and the particles coalescence and also the structure recristalization in grant the material that properties required for the strength grade wanted [8].

The experiment that were done represent the testing of using Cr-Mo steel with 0.20 % and 0.28 % carbon, and micro alloyed with vanadium and columbium, in order to replace the 33MoCr11 steel used till now to the manufacture of quenching and tempering oils pipes. It is necessary to use recycled, environmentally friendly materials, minimize energy consumption and reduce environmental pollution [4, 9, 14, 18, 19].

Experimental part

Materials and methods

The chemical composition of the experimental steels are shown in table 1.

* email: ghvoicu_2005@yahoo.com; rusanescum@yahoo.com

Table 1
CHEMICAL COMPOSITION

Steel	Mark Steel	C	Mn	Si	P	S	Cr	Mo	Nb	V
21NbMoCr10	A	0.21	0.88	0.18	0.02	0.017	1.07	0.30	0.04	-
21VMoCr10	B	0.22	0.76	0.27	0.021	0.022	0.97	0.28	-	0.14
28NbMoCr10	C	0.28	0.84	0.23	0.022	0.020	0.98	0.30	0.05	-
28VMoCr10	D	0.32	0.64	0.20	0.015	0.015	1.00	0.28	-	0.18

(Chemical elements, [%])

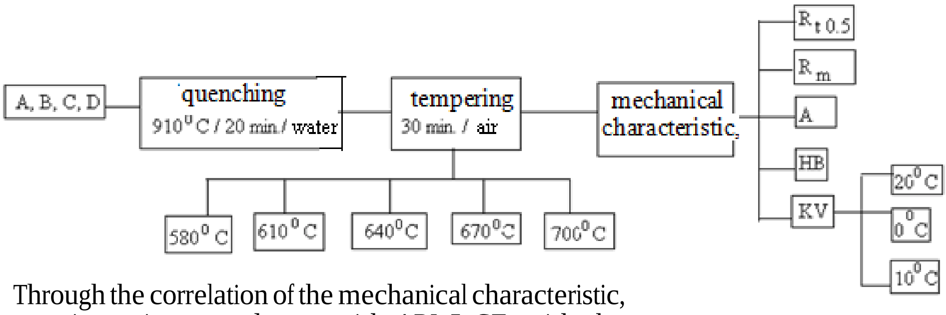

Fig. 1 Experimental schedule and determined characteristics [3]

Where: R_t 0.5 - is - the limit of conventional extension [N / mm^2]; A - elongation under maximum force [%]; R_m - tensile strength [N / mm^2]; HB - Brinell hardness; KV - resilience [J]

Through the correlation of the mechanical characteristic, determinate in accordance with API 5 CT, with the parameters of heat treatment were chosen the optimum variants of quenching and tempering for certain strength grade.

Results and discussions

Hardenability is tempering steel capacity martensitic structure in a surface layer within a certain hardness and height. Hardened layer hardness depends on the chemical composition of steel. It grows with the content of carbon and alloying elements.

Hardening height is the distance from the surface to the structure semimartensitica (50% + 50% martensite Troost). Critical diameter hardened section indicates the maximum size of the volume, maximum hardness entire section [3].

Semimartensitice structure hardness (HRC) depends on the carbon content of steel: 0.13 to 0.22% C shows 25 to 30 HRC; 0.28 -0.32% C, 35-40HRC; 0.43 to 0.52% C, 45-50HRC; From 0.53 to 0.62% C, 50-55HRC, the minimum for carbon steel, alloy steel the maximum.

If the austenitization temperature is higher than the temperature for finishing the granulation solubilizing compounds, they are dissolved in austenite and this increases the hardenability of either the stabilization or by enrichment of carbon. On the other hand, the dissolution of the particles in the austenitization temperatures too high, increase the grain and as it is known, after tempering, the steel will have a low toughness. A higher carbon content 0.10 - 0.40% is beneficial leading to slower growth and tempering critical hardenability. Also austenitic grain size growth leads to slower critical quenching hardenability growth and increasing the amount of martensite transformed from maintaining isothermal. The only adverse effects are increasing trend of deformation and cracking temper and tenacity achieve lower. From this last reason use growth trend of the austenitic grain with a high temperature of austenitising tempering in order to increase hardenability it is not advisable because a grain great austenite leads to hardening to obtain a martensite with large needles, which in return leads to a structure unfit for hard material.

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They were calculated and plotted versus steel hardenability curves 33MoCr11 21NbMoCr10 experimental steels, 21VMoCr10, 28NbMoCr10 and 28VMoCr10 (fig. 2).

It is noted that for the same carbon content, the better hardenability of microalloyed steels have vanadium, and these strips and the like as compared with the steel 33MoCr11.

First was made the checking of the materials hardness after quenching. The norm API 5 CT [21] required a minimal value of the hardness, depending on the carbon contents, that ensure the obtaining of a minimum 50 % marten site after quenching.

$$HRC_{min} = 52 \times (\% C) + 21 \qquad (2)$$

The hardness obtained after quenching compared with the minimal values calculated show a proper hardenability of the materials (table 2).

Hardenability was determined through the front quenching method. The obtained curves overlaped the

Table 2
HARDNESS VALUES AFTER QUENCHING

Steel marking		A	B	C	D
HRC	measured	40	38	45	43
	calculating	31	32	35	38

hardenability curve of the 33MoCr11 steel used now in the same purpose as the experimental steels. From figure 2 results thate the 0.28 % carbon steel is similar from the point of view of the hardenability with the reference steel, the other two steel (with 0.21 % C) being inferior (the most

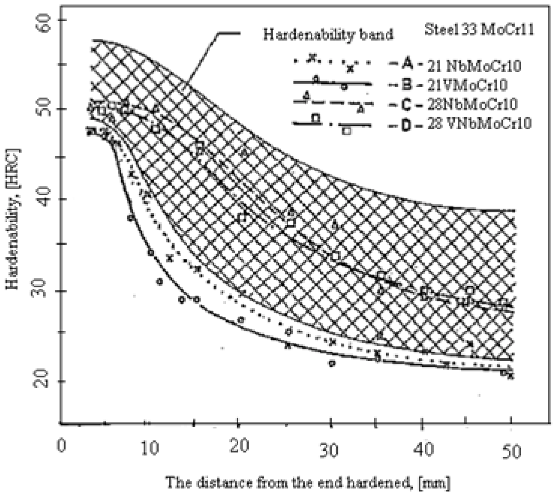

Fig. 2 Hardenability curves of experimental steels and hardenability range of 33MoCr11

probable the proportion between bainite and martensite is different at quenching).

Tempering

The growth of the tempering temperature leads to the lower of the mechanical strength properties, the hargness and the increase of the material toughness, higher resistance grade being obtained at lover tempering temperature (fig. 3, table 3). It is emphasized the fact that in the laboratory testings, the condition of maximum hardness required by API 5 CT for group [21]. It was obtained only at higheer tempering temperature (table 3).

Structure of steel after hardening and tempering

It is observed that in variants a, b, c (hardening at 920^{0}C) due to the size of the austenitic granulation, the helical aspect of the quenching component is retained after return. The corresponding structure was obtained in variant d when the globular constituent after return was finely and uniformly distributed

Conclusions

The use of Cr-Mo steels with low carbon and fine grains, micro alloyed with vanadium or columbium for manufacturing quenching and tempering oil pipes in accordance with API 5 CT norm lead to the improvement of the strength characteristics and to obtaining a higher toughness of the materials.

The heat treatment parameters must be strictly controlled in order to realise imposed requirements regarding the steel's harden ability (characteristic required by API 5 CT) and also the hardness after tempering for the grades from the group II. The steels lower content of carbon, through the influence that it has upon the harden ability, depth of quenching, limits thee steel's use with low content in carbon for lower thickness pipe (under 10 mm). By tempering at lower temperature are obtained higher strength characteristics, the explanation being the lack of the precipitate particle coalescence. The increase of the tempering temperature also leads to the intensification of the recristallization process, lower density of dislocation, the crystal form and their growth that leads to a lower strength and a higher toughness. At tempering temperature between 620 and 670^{0}C are obtained , according to the

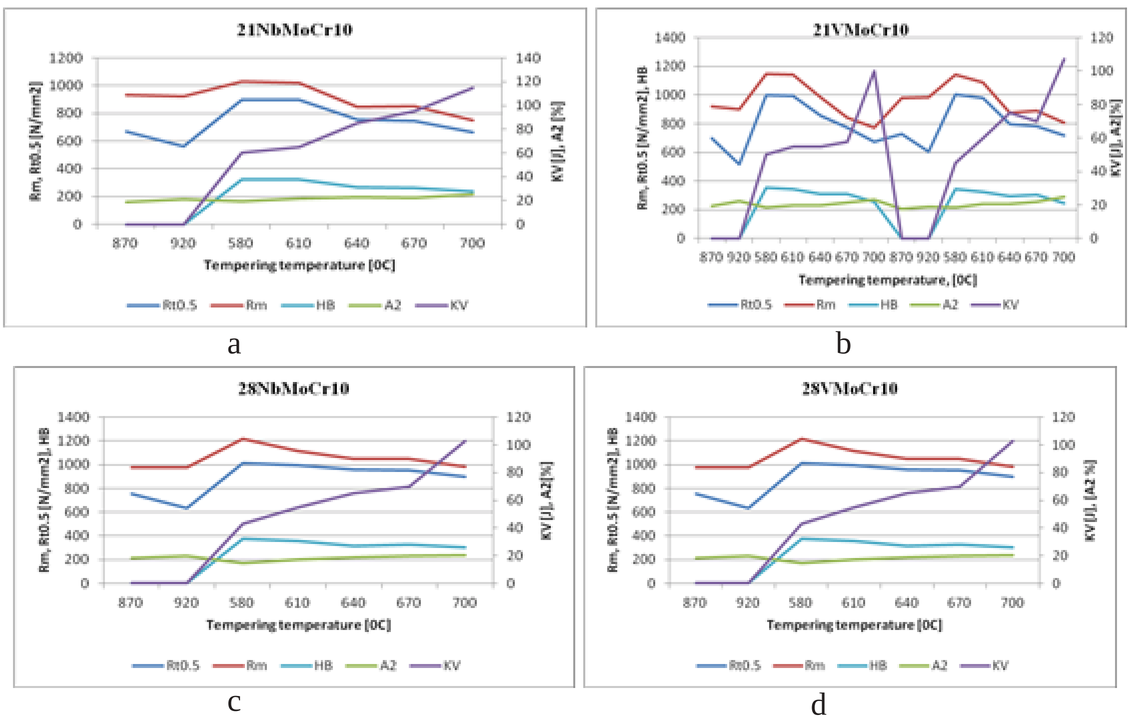

Fig. 3 Mechanical characteristics variation with tempering temperature. a) steel 21 NbMoCr10, b) steel 21 VMoCr10, c) steel 28NbMoCr10, d) steel 28VMoCr10, A_2 - elongation [%], $R_{t0.5}$ yield strength [N / mm2], R_m - Tensile strength [N / mm^2], HB - Brinell hardness; KV - resilience [J]

Table 3
MECHANICAL CHARACTERISTICS (AVERAGE VALUES)

Steel	The state that is material	T [0C]	Mechanical characteristics				
			$R_{t0.5}$	R_m	A_2	KV	HB
21NbMoCr10	L	870	667	933	18.6	-	-
	N	920	562	923	21.1	-	-
	C+R	580	898	1031	19.6	60	325
	C+R	610	896	1020	22	65	325
	C+R	640	754	846	22.9	85	265
	C+R	670	745	853	22.4	95	260
	C+R	700	663	753	25	115	235
21VMoCr10	L	870	699	922	19.5	-	-
	N	920	519	902	22.2	-	-
	C+R	580	1001	1149	18.5	50	355
	C+R	610	996	1143	19.8	55	345
	C+R	640	855	983	20	55	310
	C+R	670	774	844	21.7	58	310
	C+R	700	674	773	23	100	255
28NbMoCr10	L	870	728	979	17.5	-	-
	N	920	604	983	19	-	-
	C+R	580	1002	1142	18.4	45	345
	C+R	610	981	1087	20.5	60	325
	C+R	640	796	876	20.5	75	295
	C+R	670	783	893	22	70	305
	C+R	700	719	806	24.9	107	245
28VMoCr10	L	870	752	978	18.3	-	-
	N	920	637	979	19.8	-	-
	C+R	580	1013	1216	14.9	43	375
	C+R	610	995	1118	17.2	55	360
	C+R	640	957	1051	18.8	65	313
	C+R	670	952	1048	19.7	70	325
	C+R	700	897	983	20.4	103	305

carbon content, strength grade from group II and III (L 80, C 90, P 110).

The results will be tested on many heats fort the results reproduction but also in different conditions of technological flow at different oil pipes manufacturers.

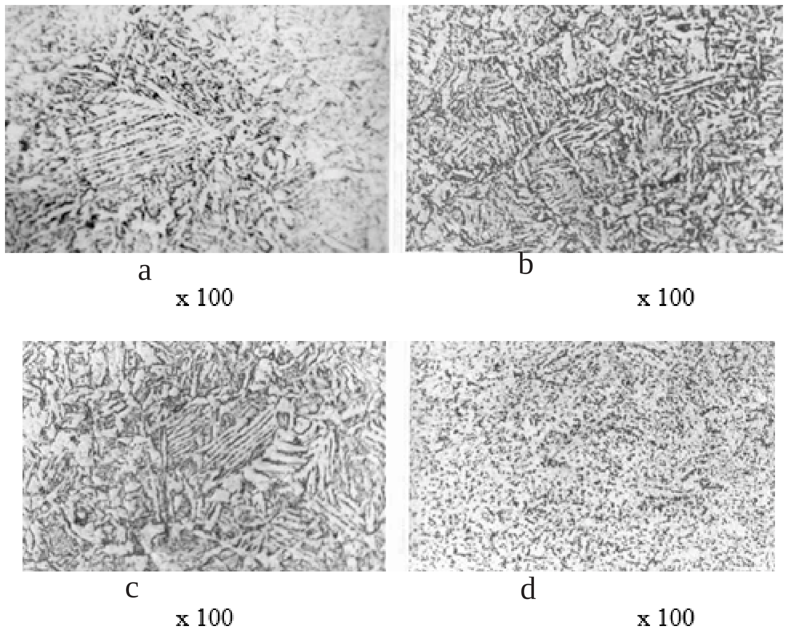

Fig. 4. Aspects of the structure of the material obtained after hardening and tempering

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Manuscript received: 16.01.2018