

VSMPO PROCESSES OF SEAMLESS TITANIUM TUBES MANUFACTURE

V.V.Tetyukhin, V.G.Smirnov, A.N.Gavrilov
VSMPO, 1, Parkovaya st., V.Salda, Russia, 624600

Nowadays, VSMPO tube manufacture possesses the set of equipment, production practices and specialists ensuring the manufacture of seamless and welded tubes as per the requirements of Russian Federation and international standards [1].

The equipment includes: 120 MN and 30 MN rated capacity horizontal hydraulic presses, 6.6 MN vertical hydraulic press, PVP 40-80 helical rolling mill equipped with piercing and rolling-off stands, lathes for boring and turning of tubes and tube hollows, roller mills HPT 90, HPT 55, HPT 32, HPTC 8-25, roller mills HPTR 30-60, HPTR 15-30, HPTR 8-15, drawbench. Heat-treatment of tubes is carried out in the electric resistance furnace with sliding hearth and vacuum furnace.

Tubes are delivered with surface as hot-strained, as machined and pickled.

The extruded tubes for subsequent machining are manufactured in different titanium alloys. The range of hot-strained extruded tubes not machined is under table 1, mechanical properties of tubes in several titanium alloys are under table 2.

Extruded and hot-rolled long tubes for oil production, drill water-separating pipe strings, dynamic pipe-lines of floating operation systems are manufactured from high-strength titanium alloys of the kind of VT6c, VT 6, Ti-6Al-4V alloyed with palladium or ruthenium, and wrought alloys of the kind of Gr1, Gr2, Gr 9 to ASTM

B-337/338 and Ti-3Al-2.5V-1.3Mo-1Zr.

The internal diameter of extruded tubes "4...12" (102.2-304.8) mm, wall thickness 14...25 mm, length up to 8000 mm. The tubes are subject to machining and chemical treatment [2,3].

The long hot-rolled tubes in titanium alloys for oil and gas production on land and sea shelf are manufactured by VSMPO together with ChPTZ per the developed practice and include the specified forging of ingot and hot rolling [3,4]. The range of tubes is under table 3 [3,4].

Hot-rolled tubes and tube hollows with inner and outer surface as machined are manufactured on 3-high mill PVP 40-80 and allow to obtain the tube hollows of the increased precision [1]. The range of tubes is under table 3.

The cold-rolled seamless tubes in titanium alloys are manufactured from hot-rolled extruded stock with hydraulic and ultrasonic tests as per the requirements of Russian and international standards. The range of tubes is under table 4.

THE NEW PRODUCTION TREND OF VSMPO TUBE MANUFACTURE

It is cold-rolled tube hollows obtained from hot-extruded tubes at 1 or 2 passes with the intermediate heat-treatments. This allows to manufacture and deliver tube hollows with high quality indices per geometry and specified microstructure intended for hydrosystems of airspace application. The cold-rolled tube hollows TREX are delivered with outer diameter from 35 up to 86 mm, with wall thickness from 2.8 up to 20 mm and length 1800-5000 mm to the domestic and international standards or customer-approved specifications.

The tube hollows are delivered as regards outer and inner diameter with diameter tolerance $\pm 0.8\%$...1.5%, wall thickness tolerance $\pm 7.5\%$...10% and eccentricity(e) determined as follows:

$$e = \frac{T_{\max} - T_{\min}}{2T_{\text{nom}}} \cdot 100 = \leq [e]$$

$T_{\max}$, $T_{\min}$ - max and min tube wall thickness in the controlled section;

T_{nom} - nominal wall thickness;

$[e]$ - allowable eccentricity $[e] \approx 3-5\%$.

Microstructure of alloys of the kind of VT 1-0, PT -7M, Gr2, Gr 9 to ASTM is characterised by equiaxial α -phase, grain size 6-7 per ASTM E 8 in alloys VT1-0, PT-7M, Gr2 and 8-9 for Gr 9 (Ti-3Al-2.5V).

Typical microstructure of Grade 2 and Grade 9 alloys is under Fig. 1 and 2.

Table 1.

Hot-extruded tubes not machined

outer diameter, mm	wall thickness, mm	length max, m	outer diameter, mm	wall thickness, mm	length max, m
50	7	1.5	85	8-20	0.4-0.7
52	7-8	1.2-1.3	88-89	11-20	0.35-0.6
54-55	7-9	1.1-1.2	92	-	0.3-0.4
56	7-10	1.0-1.2	94	-	0.3-0.4
58	7-11	0.8-1.1	70-75	10-18	3.0
60	7-12	0.8-1.1	80-85	12-18	3.0
62	7-13	0.8-1.0	90-95	14-22	2.5
65	7-14	0.8-1.1	100-105	15-25	2.0
68	7-16	0.8-1.1	110-115	15-30	1.8
70	7-17	0.7-1.1	120-125	15-32.5	1.7
72-73	7-18	0.65-1.0	130-135	15-32.5	1.6
74	7-19	0.65-0.9	140-145	15-32.5	1.5
75-81	7-20	0.5-1.0	150-155	25-32.5	1.2
83	7-20	0.4-0.9	160	20-35	1.0

Table 2

Mechanical properties of tubes

alloy	tensile strength, kg/mm ² (MPa)	relative elongation, %
VT1-00	30-45(294-441)	20.0
VT 1-0	40-55(392-539)	15.0
OT 4-0	50-65(490-637)	15.0
OT 4-1	60-75(588-735)	12.0
OT 4	70-85(686-833)	10
VT 22	110-130(1078-1274)	8
VT 14	90(882)	10
VT 3-1	90(882)	8
VT 6C	85(883)	10

Table 3

Hot-rolled tubes with outer and internal diameter as machined

outer diameter, mm	wall thickness, mm	length, mm
70-90	9-12	3000-4000
90-100	13-20	2000-3000
279-508*	13-102	up to 8000

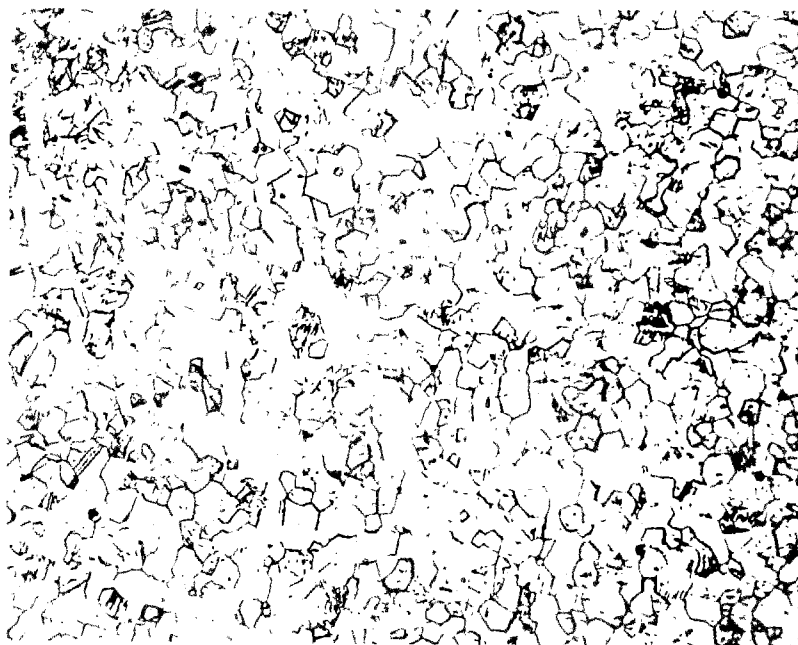
* jointly with ChTPZ

Table 4

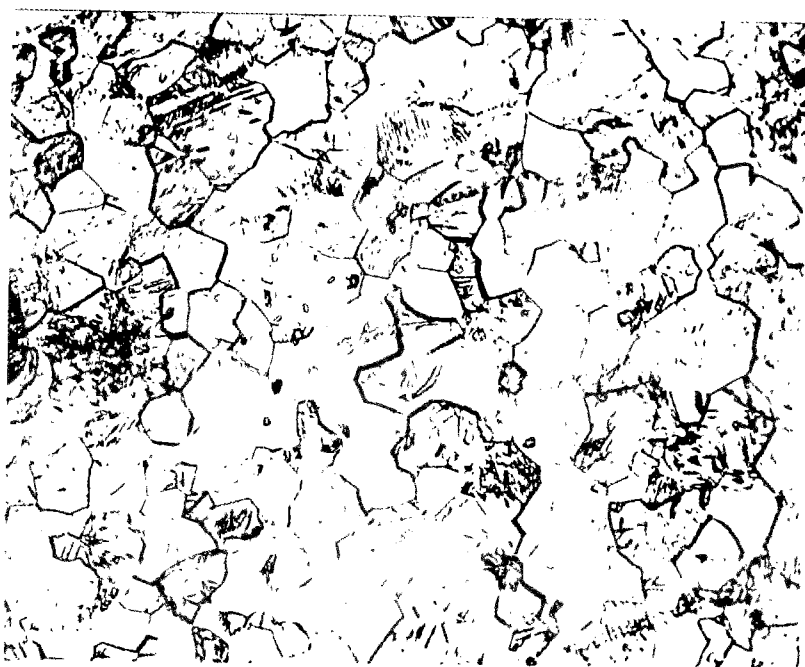
Cold-rolled tubes of VSMPO manufacture

outer	maximum tube length at wall thickness, mm						
diameter, mm	0.9-1.0	1.2-1.5	1.6-2.0	2.2-3.0	3.2-4.0	4.2-8.0	4.0-12.7
6-10	4000	-	-	-	-	-	-
12-15	4000	5000	-	-	-	-	-
16-22	5000	6000	6000	-	-	-	-
24-28	6000	6000	6000	6000	-	-	-
30-38	6000	6000	6000	6000	6000	-	-
38-76	-	-	-	-	-	-	4000
40-52	6000	6000	6000	6000	6000	4000	-
52-60	-	6000	6000	6000	6000	4000	-
89-355*							11400

* tubes manufactured jointly with ChTPZ

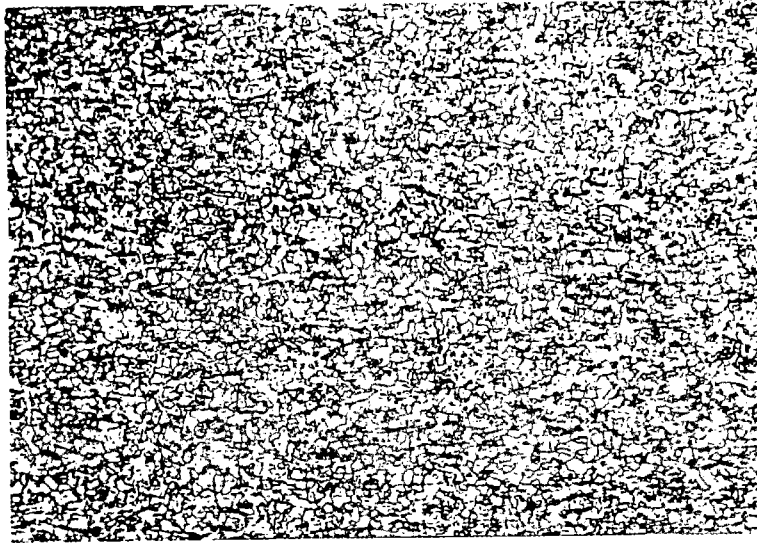


a) L direction (x100)

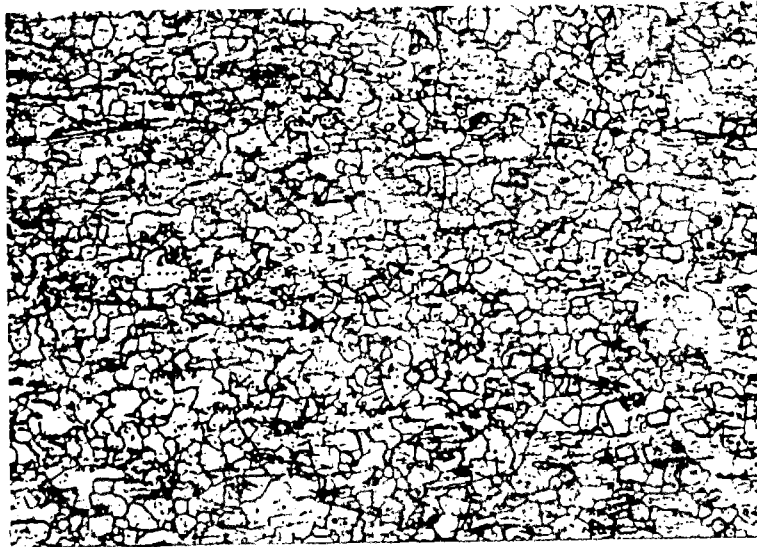


b) L direction (x200)

Fig.1 Microstructure of $\varnothing 51 \times 11$ cold-rolled tubes in Gr. 2, heat 8-27-1750



a) L direction (x100)



b) L direction (x200)

Fig.2 Microstructure of $\varnothing 51 \times 11$ cold-rolled tubes in Gr. 9, heat 8-27-1750

Surface roughness not exceeds $Ra\ 3.2\ \mu m$.

Each tube hollow through the whole length is checked for eccentricity, max and min wall thickness, 100% of tubes are subject to inspection for freedom from defects per standard notches with depth not more than 3 % of wall thickness, positioned in L and T directions on outer and inner tube surface.

To ensure quality of tube hollows the extrusion method is introduced with mandrel centering on the billet container axis during direct and indirect extrusion, with removable mandrel included[5]. The new lubricants and tool designs for tube extrusion, inner surface and wall sand blasting unit, band grinding of outer tube surface [6,7,8] are also introduced.

Summary:

1. VSMPO has the set of equipment, practices and inspection means allowing to manufacture seamless tubes in Ti alloys to international and Russian standards.
2. VSMPO together with tube manufacturers of Russian Federation is able to manufacture hot-rolled and hot-extruded tubes from 508 mm in dia and up to 8000 mm in length.
3. VSMPO developed the manufacture of tube hollows (TRES) in titanium alloys for manufacture of hydrosystem tubes of airspace application.

References:

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