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[54] METHOD OF PRODUCING QUENCHED AND TEMPERED HOLLOW STEEL STRUCTURAL MEMBERS OF POLYGONAL CROSS SECTION

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[58] **Field of Search** 148/12.4

[56] **References Cited**

UNITED STATES PATENTS

2,222,263	11/1940	Nelson	148/12.4
2,256,455	9/1941	Crawford	148/12.4
2,748,039	5/1956	Adams et al.	148/12.4

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[57] **ABSTRACT**

Method of producing quenched and tempered hollow steel structural members of polygonal cross section includes the steps of hot rolling a hollow steel tube, austenitizing the tube, water quenching it, reheating the tube to a tempering temperature just below the lower critical transformation temperature, and rolling the tube to the desired polygonal cross section while holding the temperature of the member at the tempering temperature.

8 Claims, No Drawings

METHOD OF PRODUCING QUENCHED AND TEMPERED HOLLOW STEEL STRUCTURAL MEMBERS OF POLYGONAL CROSS SECTION

This invention relates to hollow steel structural tubing, and more particularly to quenched and tempered structural steel tubing of polygonal cross section such as square or rectangular. Tubular structural steels processed in this manner developed high yield strengths and high tensile strengths, together with high notch toughness at low temperatures.

Heretofore, structural steel tubing of polygonal cross sections has been produced in one of two ways. In the first method, a substantially round tube is formed by hot rolling in a tube mill, which tube is formed into the desired cross sectional dimensions and shape by passing it through a squaring pass after the round tube has been formed. The squaring or sizing operation is carried out at a temperature of from about 1100° to 1500°F. In the second method, the tube is hot rolled in a conventional manner, then reheated to about 1300°F., and passed through a sizing mill to form the tube into a polygonal cross section. Heat treatment of the finished shapes has resulted in distortion of the flat faces of the shapes beyond acceptable commercial limits. Thus, the physical properties such as strength and toughness of these tubes are limited to those properties which can be attributed to chemical composition alone. US Pat. No. 2,748,039 teaches a method of producing a quenched and tempered pipe of round cross section which requires additional small reductions to be made after the quench and temper process to remove minor distortions caused thereby.

This invention is predicated upon my development of a weldable water-quenched and tempered structural tube of polygonal cross section to meet the demand for higher strength structural materials with superior notch toughness properties.

Accordingly, it is the principal object of this invention to provide a method of producing quenched and tempered hollow steel structural members of polygonal cross section having high yield strengths, and excellent notch toughness and elongation properties.

It is a further object of this invention to provide a method of producing dimensionally correct hollow steel structural members.

The method of the invention consists of:

a. Hot rolling a hollow steel tube with substantially oval or circular cross section by any conventional tube rolling method;
b. Austenitizing the tube;
c. Water quenching the tube to about 150°F;
d. Reheating the tube to a temperature above the stress relieving temperature and below the Ac_1 temperature;
e. Tempering the tube in the tempering temperature range;
f. Rolling the tube to the desired polygonal cross section while holding the temperature of the tube within the tempering temperature range; and
g. Allowing the resulting product to be air cooled.

The chemical composition of the steel in the tube may be any steel which is suitable for the production of quenched and tempered tubes. A suitable composition is a silicon-aluminum killed steel, having a composition of about 0.20% carbon, 1.45% manganese and 0.06% vanadium. This steel composition is martensitic and exhibits good weldability.

Austenitizing is accomplished at a temperature greater than the A_3 temperature of the steel in the tube. For most steels, this means a temperature greater than 1550°F but will usually be from about 1600°F to about 1750°F. Preferably, the austenitization is carried out in a gas-fired furnace in an excess air atmosphere for a sufficient time to assure uniform heating of the tube.

Water quenching is accomplished by passing the tube through a series of spray quench rings to provide 100% surface coverage of the tube circumference. The tube is quenched to a temperature of about 150°F, but may be quenched to any temperature below 200°F.

The tempering temperature is just above the stress relieving temperature and just below the lower critical transformation temperature of the steel, that is, just below the Ac_1 temperature. For most steels, tempering will be carried out at a temperature between about 1150°F and 1225°F. The tube is tempered for a period sufficient to bring the tube to a uniform tempering temperature.

The tube is rolled to the desired polygonal cross section such as a round-cornered square, round-cornered rectangle or any other desired cross section while within the tempering temperature range. This is normally done with a sizing mill having a number of stands with squaring passes.

The shapes produced by this method are free of distortion, have high notch toughness, high yield strength and high ultimate strength.

To illustrate the present invention, two steels having chemical compositions as shown in Table 1 were melted in an electric furnace and rolled into 10 inch diameter tube rounds which were subsequently rolled into 10 ⅝ inch outside diameter seamless tubes, half of each composition having three-eighths inch walls and half having one-half inch walls. The lower vanadium content tubes were austenitized at 1600°F, and the higher vanadium tubes at 1650°F, in a walking beam furnace for 100 minutes per inch of wall thickness. This was followed by spray quenching with quench water at a temperature of about 92°F. The one-half inch wall tubes were quenched at a speed of 26 ft. per minute and the three-eighths inch wall tubes at 36 ft. per minute. The tubes were regrouped and some were tempered at 1175°F, and some at 1225°F. All tempering was for 72 minutes total furnace time, after which the round tubes were formed into square tubes at the tempering temperature in a five-stand sizing mill having squaring passes. The final tubes were allowed to air cool.

TABLE 1

	C	Mn	P	S	Si	Al	V	Cu	Ni	Cr	Mo	N_2
Ingot No. 1........	.22	1.49	0.011	0.019	0.45	0.064	0.037	0.01	0.16	0.08	0.01	0.008
Ingot No. 2........	.22	1.51	.009	.019	.47	.067	.071	.01	.16	.08	.01	....

Table 2 shows the mechanical properties from two as-rolled tensile tests and tests from each tube quenched and tempered according to this process. From this data, it is clear that 75,000 psi minimum yield strength may be attained in all wall thicknesses to one-half inch.

TABLE 2

Pipe No. and end	Composition	Wall	Austenitizing temperature	Temper tempera-ture (°F.)	Longitudinal strip tensile: Yield strength (psi)	Ultimate strength (psi)	Elong. in 2" (%)	Yield tensile
1E-S	0.04 V	0.500"	As-rolled		68,490	98,480	32.0	0.70
2E-S	0.07 V				74,070	103,790	28.5	.72
1A-N	0.04 V	.375"	1600 °F	1175	88,630	102,980	30.0	.86
1B-S				1175	89,770	103,300	27.5	.87
1C-N				1225	79,400	94,350	34.0	.84
1D-S				1225	80,300	95,460	35.0	.84
1E-N		.500"		1175	86,090	100,680	33.0	.86
1G-S				1225	82,590	94,200	35.0	.88
1I-N				1225	80,800	95,220	35.0	.85
2A-N	0.07 V	.375"	1650 °F	1175	98,070	111,420	30.0	.88
2B-S				1175	102,990	114,480	29.0	.90
2C-N				1225	91,420	104,790	31.0	.87
2D-S				1225	95,440	100,260	32.5	.95
2E-S		.500"		1175	90,670	106,680	31.0	.85
2G-N				1225	84,590	101,200	33.5	.84
2I-S				1225	85,360	102,610	36.0	.83

Charpy V-notch impact properties were excellent with 100% shear and 93 ft./lbs. of energy absorption on a two-thirds size specimen at minus 100°F.

From the foregoing, it can readily be seen that I have invented a method of producing dimensionally correct quenched and tempered hollow steel structural members of polygonal cross section having high yield strength, excellent notch toughness and excellent elongation properties.

I claim:

1. A method of producing hollow steel structural members of polygonal cross-section comprising:

a. hot-rolling a hollow steel tube of substantially round cross-section;
b. austenitizing said tube at a temperature greater than the A_3 temperature of the steel in said tube;
c. water quenching said tube;
d. reheating said tube to a tempering temperature above the stress relieving temperature and below the Ac_1 temperature;
e. tempering said tube at said tempering temperature;
f. rolling said tube to the desired polygonal cross-section while within said tempering temperature range; and
g. air cooling said tube.

2. A method according to claim 1 wherein said austenitizing temperature is above 1550°F.

3. A method according to claim 2 wherein said austenitizing temperature is from about 1600°F to about 1750°F.

4. A method according to claim 1 wherein said tube is water quenched to a temperature below about 200°F.

5. A method according to claim 4 wherein said tube is water quenched to a temperature of about 150°F.

6. A method according to claim 1 wherein said tempering temperature is from about 1150°F to about 1225°F.

7. A method according to claim 1 wherein said polygonal cross-section is a round-cornered rectangle.

8. A method according to claim 1 wherein said polygonal cross-section is a round-cornered square.

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