# Properties of Cold Compressed Steel Tubes

W. Carl Anderson

# PROPERTIES OF COLD COMPRESSED STEEL TUBES

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This presentation is to show and explain a different type of steel tube and its processing. The history and legend of steel is most fascinating and has been one of first experiment and then of explanation, often mysticism or superstitions. For instance, the legend of the Damascus Sword was that to be any good, the final process of heat treating was to heat the sword to a dull cherry and then plunge it through a slave's abdomen; and not suspecting any other way, the sword makers pursued this custom for many generations.

We are now a little more sophisticated, but there is still much to discover about how steel processes affect steel properties.

Getting to the subject to be covered, the process to be described was originated to accurately size and shape tapered tubes. A battery of pressure rolls press a tapered tube blank on a hardened steel mandrel which travels through circles of rolls. Various shapes of cross sections were made: square, fluted, octagonal, or round, with round proving to be the most popular. Subsequent testing showed unanticipated results, completely in contrast with cold rolling of sheet steel. Cold rolled sheet, if not annealed has increased yield strength but very decreased toughness as evidenced by bend properties. If cold rolled sheet is annealed it has increased toughness but the yield strength is even lower than it was after hot rolling. However, the cold compressing process showed greatly increased yield strength and <u>improved</u> toughness or bend properties. Ultimate tensile strength increased

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and reduction of area stayed about the same. Elongation was confined to a length of about twice the sample width (or about 1") and consequently showed up as a smaller percentage in an 8" long test specimen. Whereas the grain structure of cold rolled sheets showed elongated grains, the cold compressing process showed no difference at 600 magnifications and it was only at 65,000 magnifications with an electron microscope that the change was evident which was a breaking up of the grain boundaries. Since the process pressed the blank as it was held in place, the process resembles hydraulic compression and practically no thinning of the material occurs.

In order to be able to predict properties, it is necessary that mill rolling processes as well as chemistry are carefully controlled and these have been readily worked out.

As to the future, new chemistries of steel and the resulting metallurgies are being appraised. Bending tests of thin wall tubes are continuing to show higher allowable stress limits before local buckling than those established by tests on pipes as columns. The effects of various chemistries have permitted control which lead to better galvanizing. Welding and further fabrication techniques have been established and are continuing to be researched.

Following Figure 1 shows chemistry, yield and tensile properties of steel as received from several mills, and also in comparison, the properties of the same heats after processing into ASTM A-595 tubes.

Figure 2 shows photomicrographs of sample before and after the process both at 400 diameters.

Figure 3 shows photomicrographs at 65,000 diameters both before and after the process. Note the fracture of the grain boundaries.

Figure 4 shows a typical bent specimen. This specimen happens to be 5/16" thick, with a yield strength at 70.5 ksi and an ultimate tensile strength of 79.3 ksi.

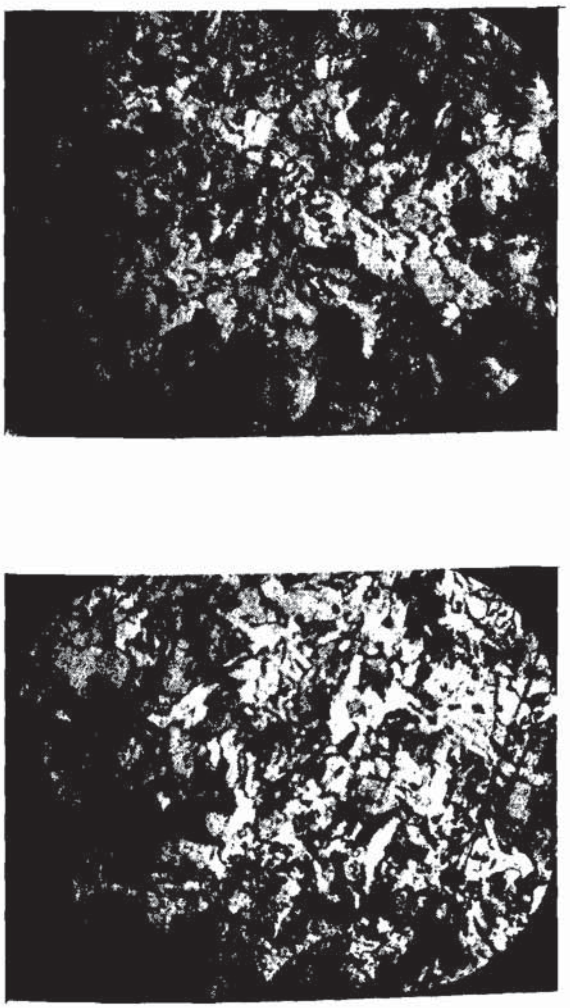
Figure 5 shows the longitudinal welding of the tapered blanks.

Figure 6 shows the cold compressing operation into a 16 fluted tube.

Figure 7 shows cutting a round finished tube to length.

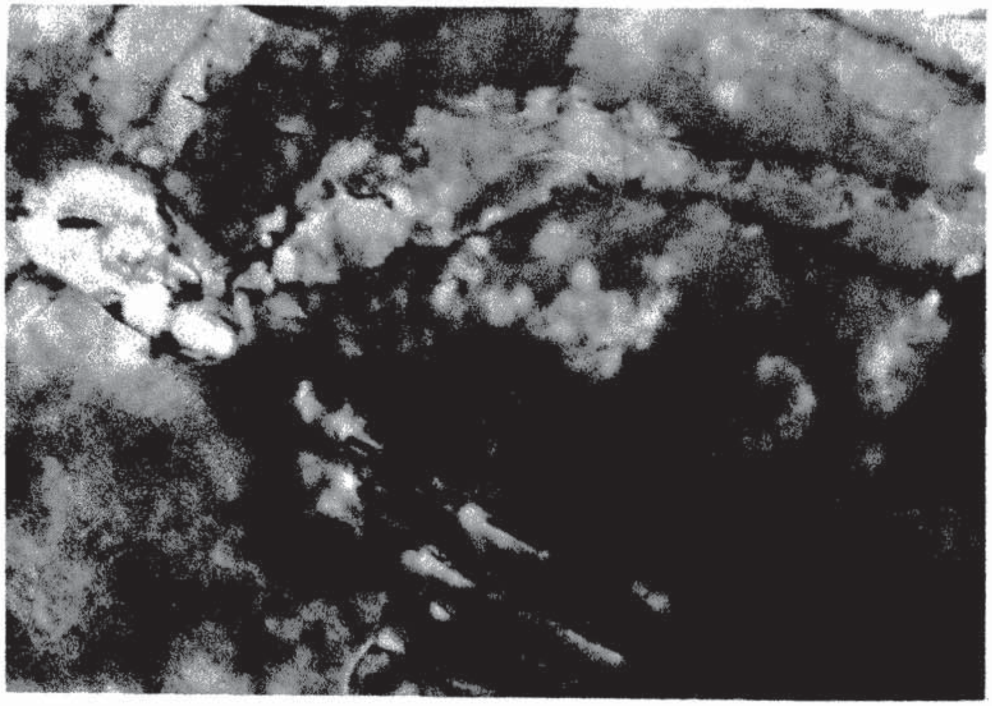
FIGURE I

| As Shipped from Steel Manufacturer | | | | | | | | | Tube After Manufacture | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Heat No. | Thick | C | MN | S | P | Si | Al. | Yield | Test No. | Yield | % Incr. | Bend 0" Rad. |
| 167 | .18" | .22 | .78 | .022 | .01 | .03 | .008 | 48.2 | 4974A | 76.1 | 58% | OK |
| " | " | " | " | " | " | " | " | " | 4974B | 76.3 | 58 | " |
| 105 | .18 | .20 | .72 | .029 | .007 | .03 | .005 | 46.2 | 4975A | 71.7 | 55 | " |
| " | " | " | " | " | " | " | " | " | 4975B | 73.6 | 59 | " |
| 338 | .12 | .19 | .73 | .024 | .008 | .03 | .005 | 45.4 | 4983A | 73.7 | 62 | " |
| " | " | " | " | " | " | " | " | " | 4983B | 70.3 | 55 | " |
| 868 | .12 | .18 | .80 | .027 | .007 | .04 | .008 | 49.0 | 4985A | 79.2 | 62 | " |
| " | " | " | " | " | " | " | " | " | 4985B | 75.0 | 53 | " |
| 168 | .312 | .22 | .50 | .035 | .01 | .01 | .027 | 38.2 | 5024Ai | 63.5 | 66 | " |
| " | " | " | " | " | " | " | " | " | 5024Ao | 62.8 | 64 | " |
| " | " | " | " | " | " | " | " | " | 5024Bi | 63.1 | 65 | " |
| " | " | " | " | " | " | " | " | " | 5024Bo | 60.4 | 58 | " |
| 313 | .25 | .20 | .74 | .021 | .03 | .012 | .012 | 44.2 | 4805A | 65.9 | 49 | " |
| 362 | .25 | .19 | .70 | .03 | .01 | .03 | .004 | 44.9 | 4805B | 66.7 | 49 | " |
| 552 | .12 | .21 | .48 | .024 | .008 | .03 | .01 | 47.3 | 4945A | 72.3 | 53 | " |
| " | " | " | " | " | " | " | " | " | 4945B | 76.8 | 62 | " |
| 831 | .312 | .20 | .80 | .032 | .01 | .01 | .003 | 43.8 | 4956Ai | 72.5 | 66 | " |
| " | " | " | " | " | " | " | " | " | 4956Bi | 72.4 | 65 | " |
| " | " | " | " | " | " | " | " | " | 4956Ao | 70.5 | 61 | " |
| " | " | " | " | " | " | " | " | " | 4956Bo | 69.9 | 60 | " |
| 332 | .312 | .20 | .77 | .031 | .008 | .04 | .02 | 42.0 | 4933A | 64.3 | 53 | " |
| " | " | " | " | " | " | " | " | " | 4933B | 62.6 | 49 | " |
| " | " | " | " | " | " | " | " | " | 4963A | 71.9 | 71 | " |
| " | " | " | " | " | " | " | " | " | 4963B | 72.8 | 73 | " |
| " | " | " | " | " | " | " | " | " | 4964A | 63.2 | 50 | " |
| " | " | " | " | " | " | " | " | " | 4964B | 68.6 | 63 | " |
| 465 | .25 | .20 | .74 | .015 | .009 | .04 | .02 | 41.8 | 4934A | 60.9 | 46 | " |
| " | " | " | " | " | " | " | " | " | 4934B | 61.3 | 47 | " |
| " | " | " | " | " | " | " | " | " | 4936Ai | 62.8 | 50 | " |
| " | " | " | " | " | " | " | " | " | 4936Bi | 60.1 | 44 | " |
| 981 | .25 | .22 | .72 | .023 | .009 | .02 | - | 43.4 | 4936Ao | 60.3 | 39 | " |
| " | " | " | " | " | " | " | " | " | 4936Bo | 61.3 | 41 | " |
| " | " | " | " | " | " | " | " | " | 4950A | 66.3 | 53 | " |
| " | " | " | " | " | " | " | " | " | 4950B | 65.5 | 51 | " |

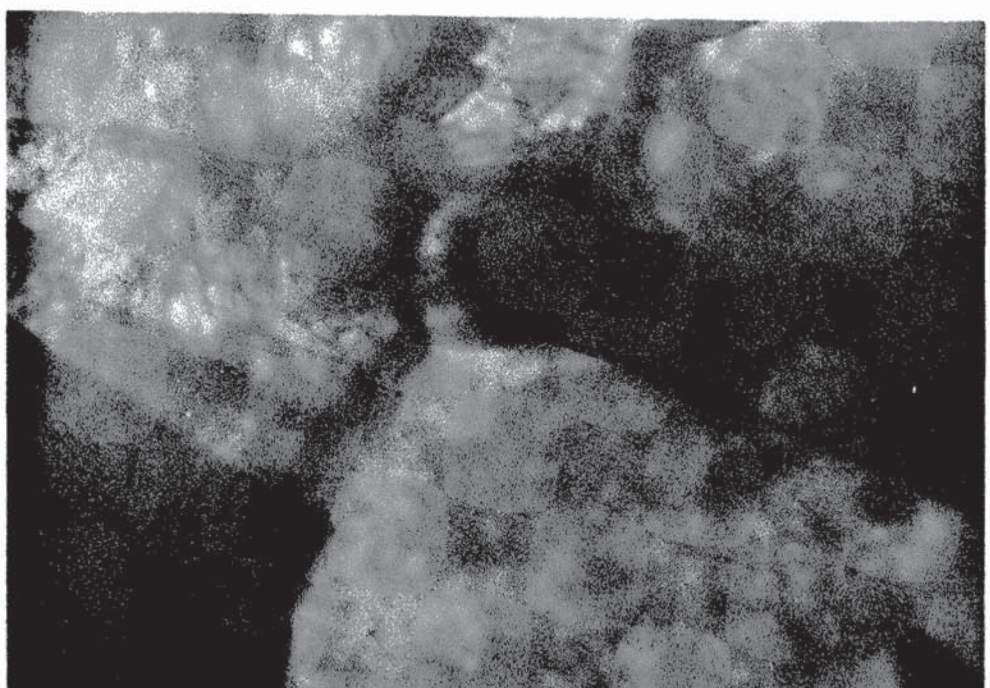


Before Process After Process

FIGURE 2 Micrographs (x400) of Grain Structure
(Longitudinal Section)



After Process



Before Process

FIGURE 3 65,000 Diameters

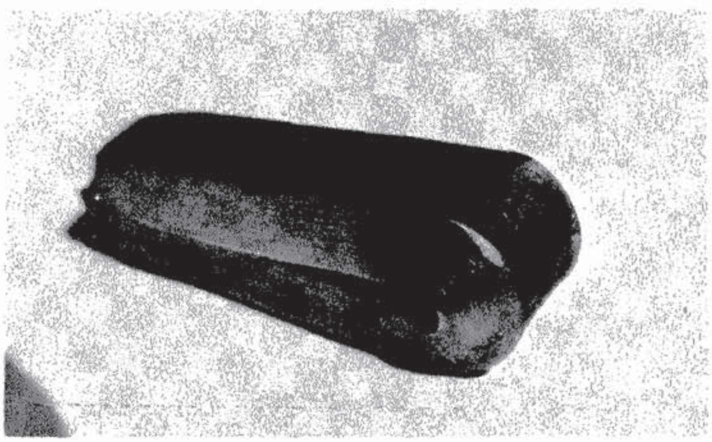


FIGURE 4

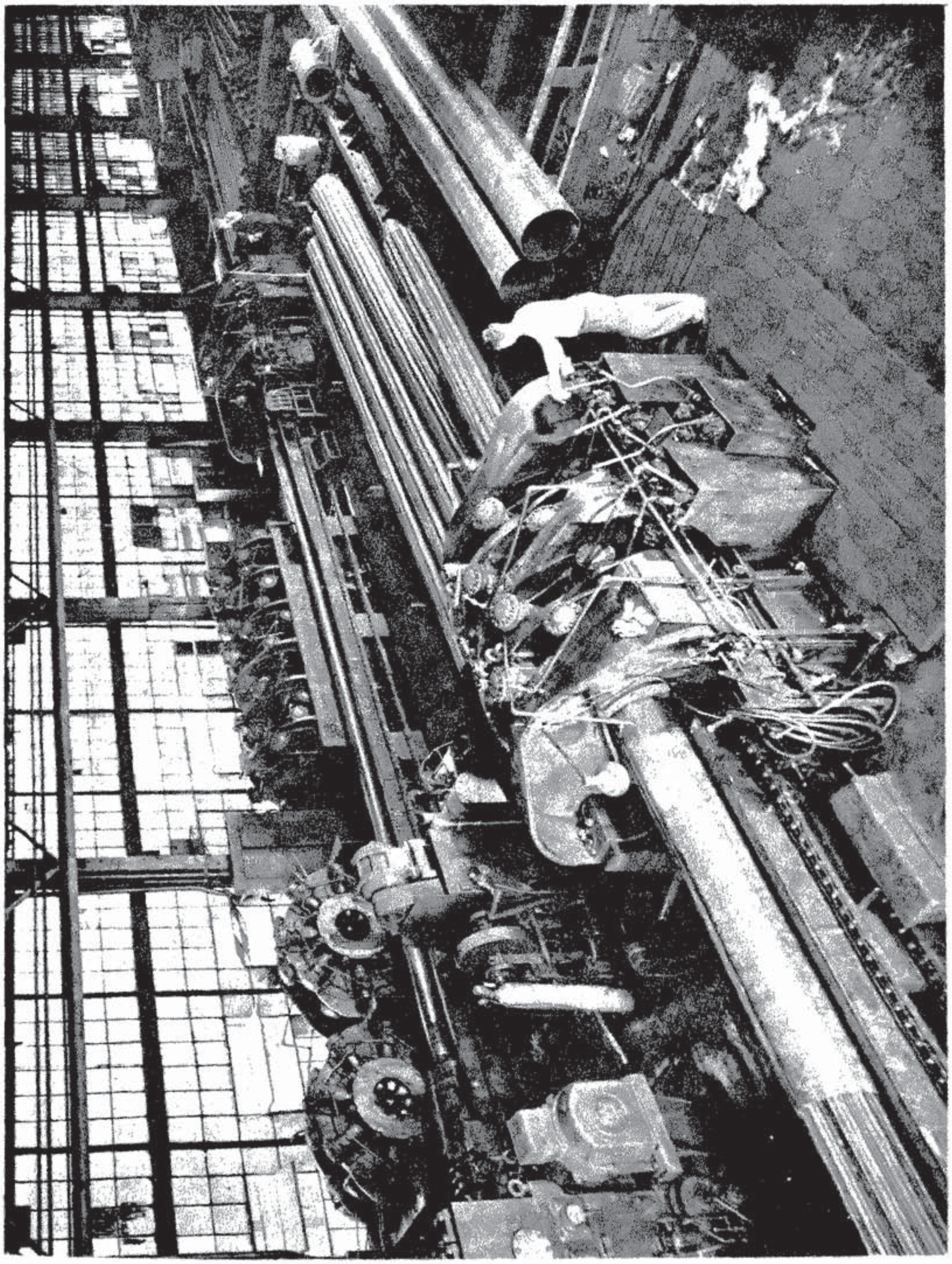


FIGURE 6 Tubes in Near Machine are "Fluted"; In Far Machine are Round