Niobium Nb

NIOBIUM FOR HIGH CARBON WIRE PRODUCTS: HIGHER PRODUCTIVITY AND COST EFFECTIVE

SUPERIOR WIRE PRODUCTS WITH NIOBIUM

High carbon steel wire rod is a semi-finished product. Further processing, by techniques including cold drawing, cold rolling, cold upsetting, then produce several different end products such as wire ropes for bridges and prestressing steel wires for prestressed concrete in civil engineering construction and structures.

For some applications they have to reach very high tensile strength levels, higher than 2,000 MPa, that can be reached by dry wire drawing from diameters around 5.00 to 7.94 mm to final diameters from 0.15 to 0.40 mm. Due to this intensive steel work hardening during drawing, the material has to be submitted to intermediate patenting treatment, getting back its capacity to be cold drawn again. These wires are submitted to strong stresses during drawing, that can cause breakage with a strong decrease of productivity and the reduction of final wire quality. The addition of up to 0.025% niobium for these products helps to improve the so called drawability of wire, reducing these breakages and minimizing the need of the intermediate patenting treatments.

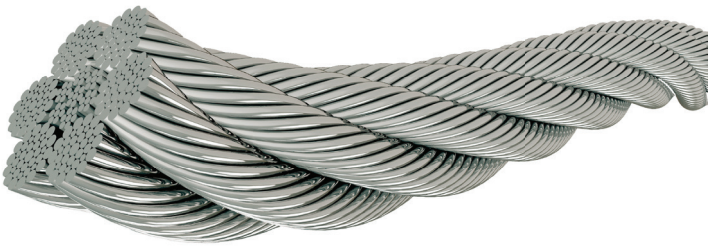


Figure 1: Example of high carbon steel wire rod finished product

NIOBIUM INCREASES THE DRAWABILITY OF WIRE ROD: REDUCING OR EVEN ELIMINATING THE NEED FOR INTERMEDIATE ANNEALING HEAT TREATMENTS AS DEMONSTRATED IN INDUSTRIAL HEATS

An industrial heat was produced at an integrated BOF melting shop operation for 0.83% C wire rod steel. Steels with and without 0.018% Nb were compared during operational wire rod drawing.

Table 1: Chemical composition of high carbon with and without niobium tested during an industrial heat

	C-Mn	Nb-containing
C (%)	0.83	0.83
Mn (%)	0.76	0.77
Si (%)	0.22	0.24
Cr (%)	0.14	0.27
Nb (%)	- 0 -	0.018

The wire rod from the niobium heat demonstrated exceptional properties, providing ultimate tensile strength (UTS) of 1,247 MPa and a reduction of area (RA) of 42%.

MicroNiobium Steelmaking Alloy Approach in 1080 Wire Rod. S. G Jansto; Association for the Iron and Steel Technology - Oct. 2014.

A wire rod with 7.5 mm was drawn to 2.4 mm in different wire manufacturers and no annealing was required to reduce 90% of its cross-sectional area.

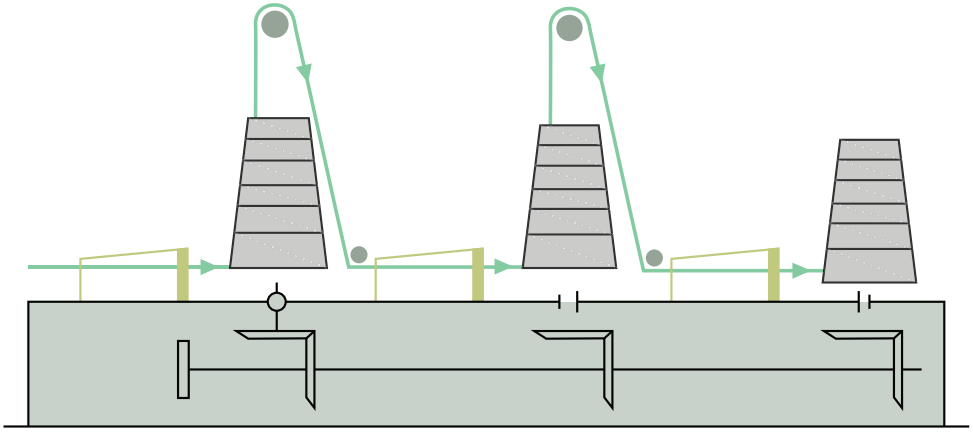


Figure 2: Scheme of a tandem drawing machine
Adapted from http://www.idc-online.com/technical_references/pdfs/mechanical_engineering/Wire_and_bar_drawing.pdf

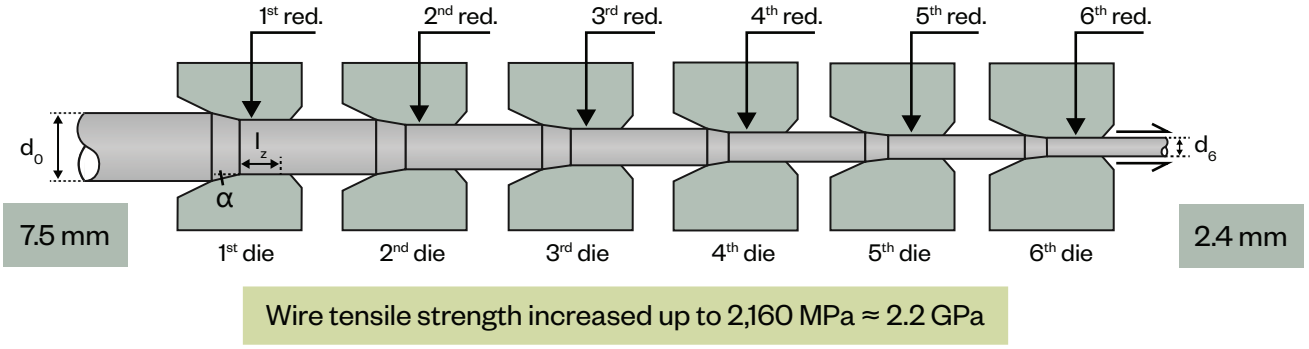


Figure 3: Schematic presentation of the cold drawing process from 7.5 mm to 2.4 mm with multiple passes through the dies.
Adapted from Structural integrity of progressively cold-drawn pearlitic steels: from Raffaello Sanzio to Vincent van Gogh. Science Direct - Procedia Structural Integrity 3 (2017) 3-10.

During the drawing operations, the niobium wire rod presented higher ductility if compared with non niobium wire rod.

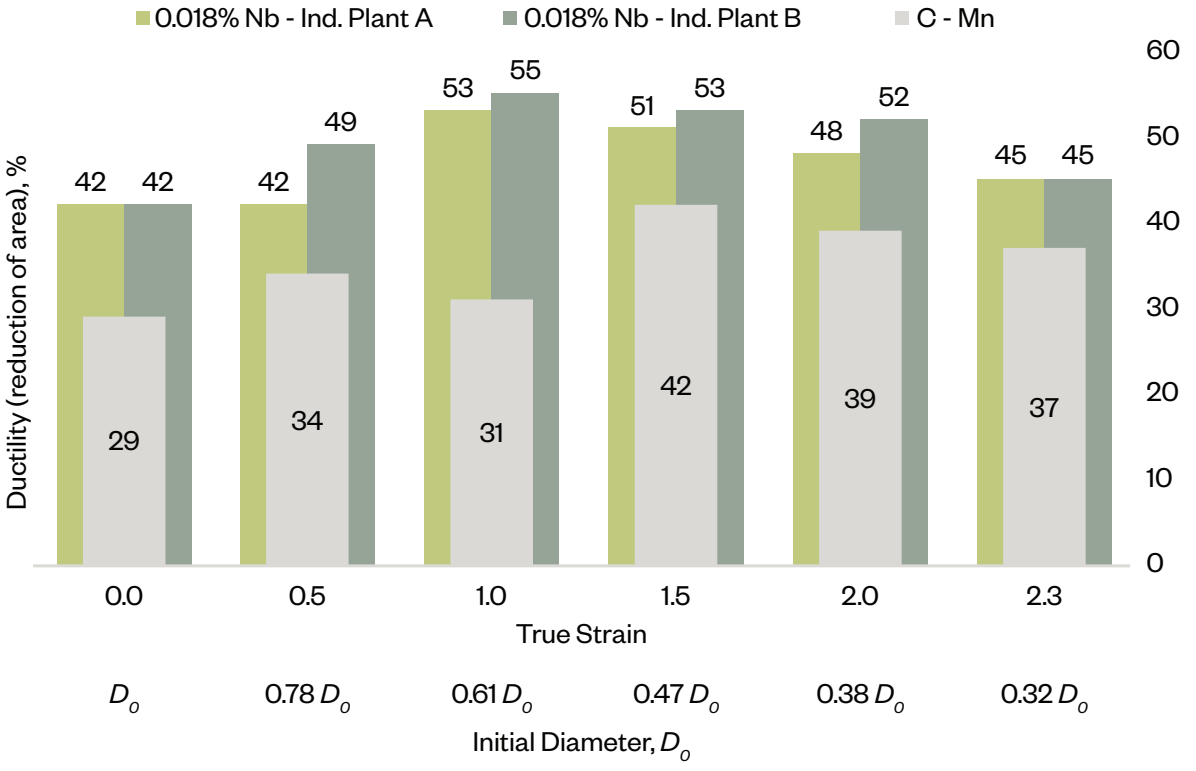


Figure 4: Relation of reduction as a function of strain applied during drawing process, pointed by the reduction of diameter of wire. For instance, the 1.5 true strain represents the value as 0.47D_0 expressed as a function of the initial diameter.
Adapted from MicroNiobium Steelmaking Alloy Approach in 1080 Wire Rod. S. G Jansto; Association for the Iron and Steel Technology - Oct. 2014.

WHY DO NIOBIUM STEELS HAVE HIGH DRAWABILITY?

The most important parameters for evaluating the wire's ability to be drawn are:

- Reduction of area in tensile test;
- Structural homogeneity, being free from centerline segregation;
- Fine pearlite interlamellar spacing (λ). Niobium refines interlamellar spacing, Figure 5.

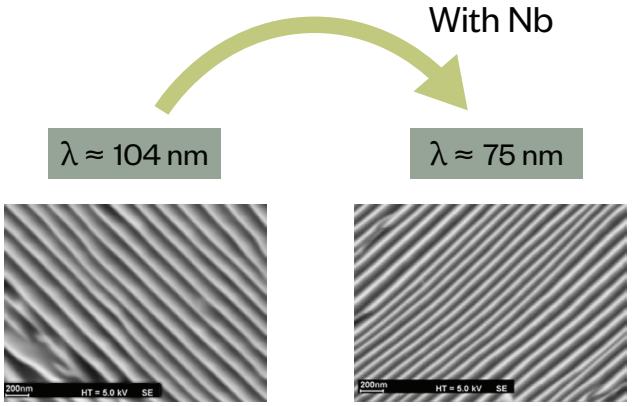


Figure 5: Refinement of pearlite interlamellar spacing by adding 0.018%Nb at 0.83%C steel wire rod. Adapted from MicroNiobium Steelmaking Alloy Approach in 1080 Wire Rod. S. G Jansto; Association for the Iron and Steel Technology - Oct. 2014.

The refinement of pearlite interlamellar space can be estimated assuming that both ferrite and cementite plates undergo the same strain and the interlamellar spacing is reduced proportionally to the wire diameter during wire drawing, as per equation:

$$\lambda(\varepsilon) = \lambda_0 exp\,(-\varepsilon/2)$$

λ - Pearlite interlamellar space after drawing

λ_0 - Initial pearlite interlamellar space

ε - Strain by drawing

Figure 6 shows the refinement of pearlite interlamellar space during the drawing process. The steel with niobium has finer pearlite during the process, explaining its better capacity to be drawn. The finer pearlite reduces the need for intermediate heat treatments, in order to recover the steel capacity to be drawn, which then guarantees the high productivity of the process.

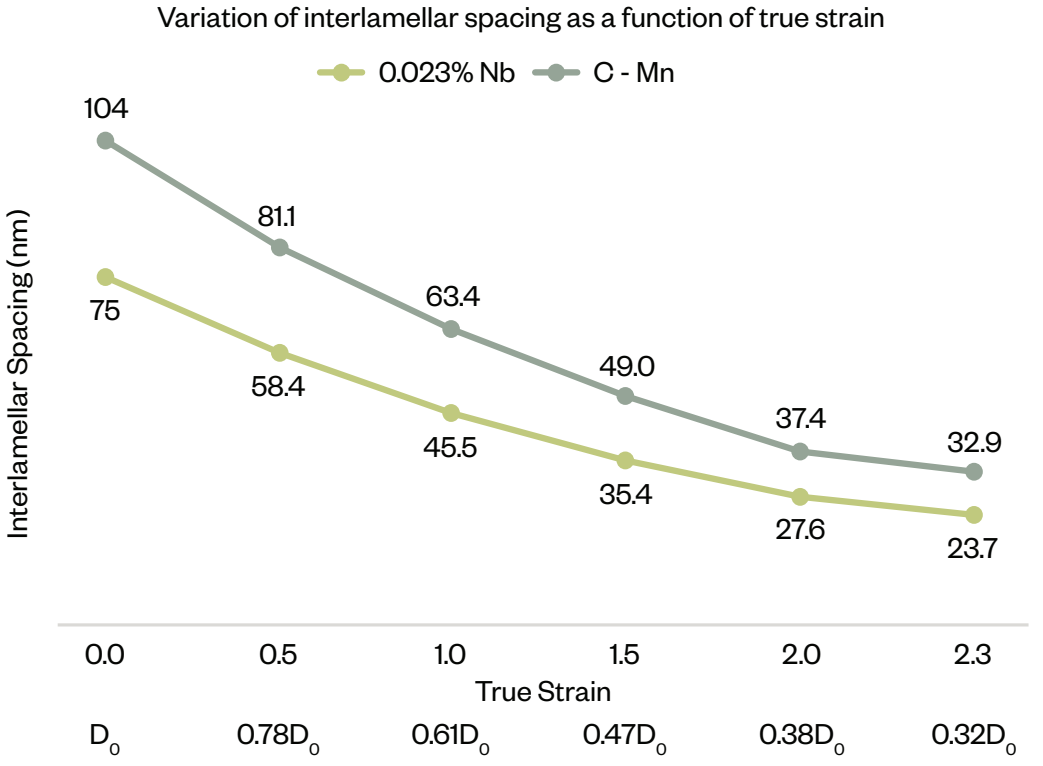
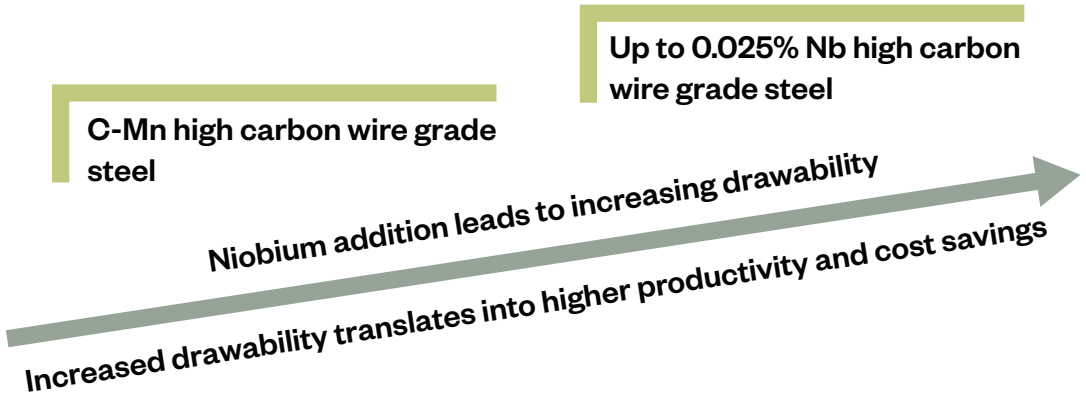
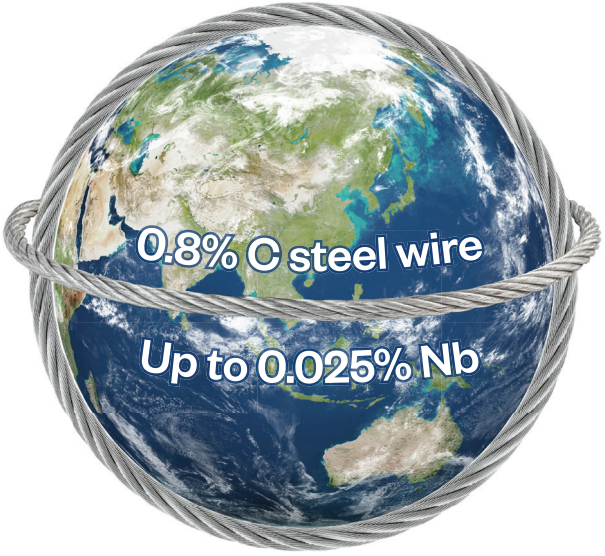


Figure 6: Refinement of pearlite interlamellar spacing during drawing for niobium and non-niobium 0.83%C wire rod. Adpated from Effect of microstructural features on ductility of drawn pearlitic carbon steels. Won J. Nam, Hyung R. Song and Chul M. Bae; ISU International, vol. 45 (2005) no.8, 1205-1210.

HIGH CARBON WIRE WITH NIOBIUM IS A CHOICE YOU CAN RELY ON



MicroNiobium Steelmaking Alloy Approach in 1080 Wire Rod. S. G Jansto; Association for the Iron and Steel Technology - Oct. 2014.



HIGH CARBON WIRE WITH NIOBIUM DELIVERS SUPERIOR PRODUCTS TO A GLOBAL MARKET

CBMM technical experts are available to advise on how the metallurgical concepts involved can be applied to your individual steelmaking, thermomechanical processing and drawing techniques. Our staff and consultants are keen to help our clients with all aspects of wire rod fabrication to ensure that you, and your customers, gain the maximum benefit from applying the latest knowledge to produce the best quality high carbon wires microalloyed with niobium.

CBMM | Niobium Nb

World leader in the production and commercialization of Niobium products, CBMM has customers in over 40 countries. With headquarters in Brazil and offices and subsidiaries in China, Netherlands, Singapore, Switzerland and the United States, the company supplies products and cutting-edge technology to the infrastructure, mobility, aerospace and energy sectors. CBMM was founded in 1955 in Araxá, Minas Gerais, and relies on a strong technology program to increase Niobium applications, growing and diversifying this market.

Further information can be obtained at **www.niobium.tech**