Niobium Nb

ADDING UP TO 0.10% NIOBIUM TO API LINEPIPE STEELS INCREASES PRODUCTIVITY AND DECREASES COSTS IN YOUR HOT STRIP ROLLING MILL

MEETING THE REQUIREMENTS OF PIPE MANUFACTURERS

This publication explains how steelmakers can use small levels of niobium, up to 0.10%, in linepipe steels providing pipe manufacturers with a product that meets the desired quality at a competitive cost.

It is important for steel producers to work together with the pipe manufacturers to agree the properties of the steel used to produce the pipes. This ensures that the properties of the pipes can then meet the specific pipeline project requirements.

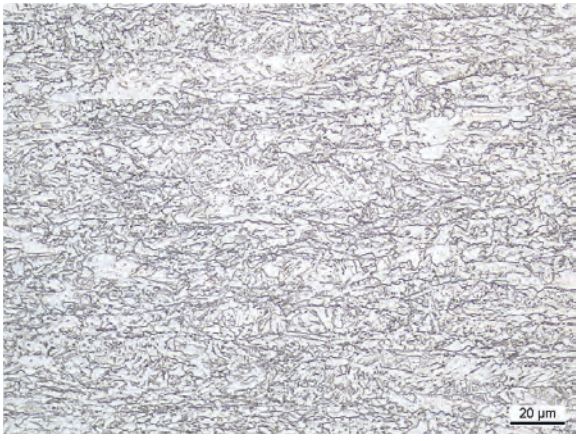
In essence, the pipe manufacturers require steelmakers to provide:

- Competitive steel prices;
- Delivery time to meet the specified schedule and volumes;
- Reliable products that consistently meet the required quality standards, ensuring a smooth and efficient pipe manufacturing process.

HOW CAN THE STEELMAKERS FULFIL THESE REQUIREMENTS?

The key to achieving comptetitive costs, production capacity and product reliability is through robust processes, using an appropriate alloy design:

Niobium increases the T_{nr} (non-recrystallization temperature), hence retarding recrystallization. This allows hot rolling at higher temperatures without the risk of recrystallization and growth of the deformed grains. The result is a fine, homogenous austenitic grain size and an austenite with more strain accumulation at the end of the hot rolling process. This finer and deformed austenite transforms, to a desired acicular ferrite microstructure compatible with API requirements. The plates or coils produced by this process, with this refined and homogeneous uniform microstructure, will guarantee that the best possible product will be supplied to pipe manufacturers. It enables them to produce their products to meet the required standards, without any kind of defect that results in a downgrade or material cut away.



Acicular ferrite, bainite and carbide precipitates

Volker Flaxa, Franz M. Knoop, Hot-rolled strips of up to 19 mm in thickness and their processing to helically welded large diameter pipes of grade X80, BAC2010, China, 2010.

REDUCING COSTS AND IMPROVING HOT STRIP ROLLING MILL PRODUCTIVITY

Not only does adding up to 0.10% niobium improve the steel properties, it also brings cost savings and increased productivity to the rolling mill. The figure below summarises how this alloying approach brings advantages through enabling rolling at a higher temperature.

Where in the rolling mill?	Advantages of rolling at higher temperatures	Maintenance	Energy Required	Water Required	Quality	Productivity
Roller table	Does not need to stay at roller tables waiting for the temperature to decrease	↓	↓	=	↑	↑
Descaler	Does not need a large amount of water	=	↓	↓	↑	=
Sizing unit	Lower loads due to higher plasticity of material	↓	↓	=	↑	=
Roughing	Roughing can be done with less passes and the rolls don't need to have rotation reduced	↓	=	=	=	↑
Crop shear	Increased plasticity means less damage to the shear blade	↓	=	=	=	=
Finishing stands	Higher material plasticity means less roll wear and lower electric motor power	↓	↓	=	=	=

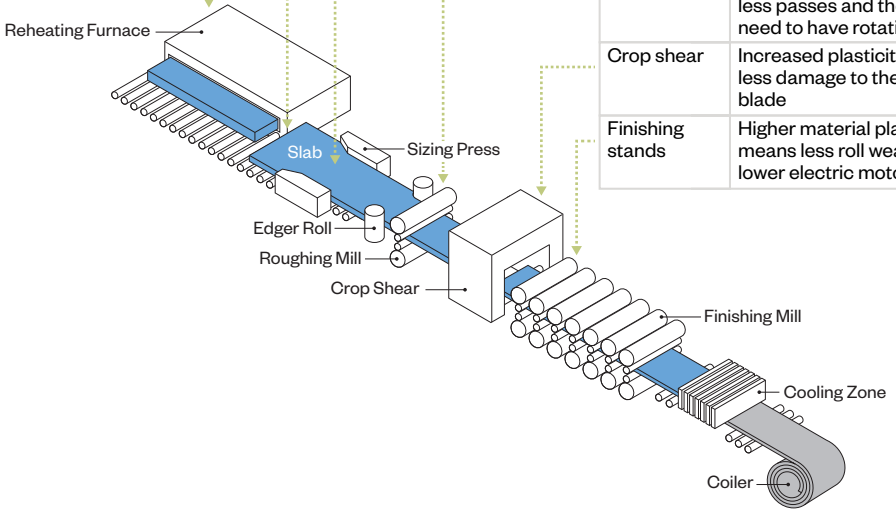
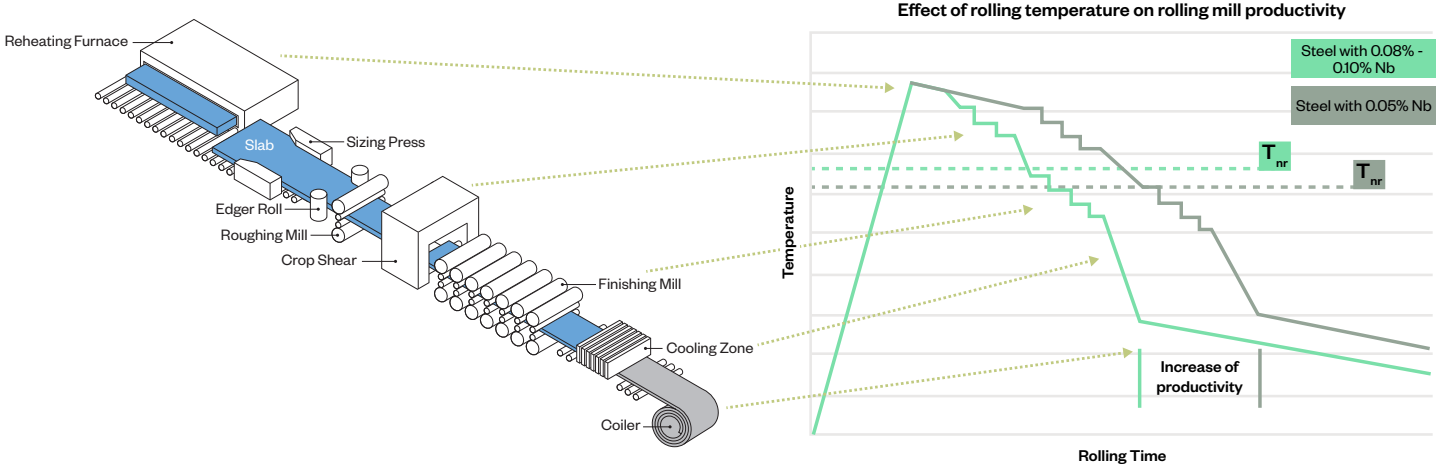


Table adapted from Flaxa, V., Comparison of productivity, maintenance and system load for hot strip rolling ofpipeline steels using TM and HTP, CBMM Internal Correspondence, 2019

Rolling mill adapted from Lee, Kyunghun & Han, Jinqyu & Park, Joonhong & Kim, Byungmin & Ko Dae-Cheol. (2015). Prediction and control of front-end curvature in hot finish rolling process. Advances in Mechanical Engineering. 7.10.1177/1687814015615043

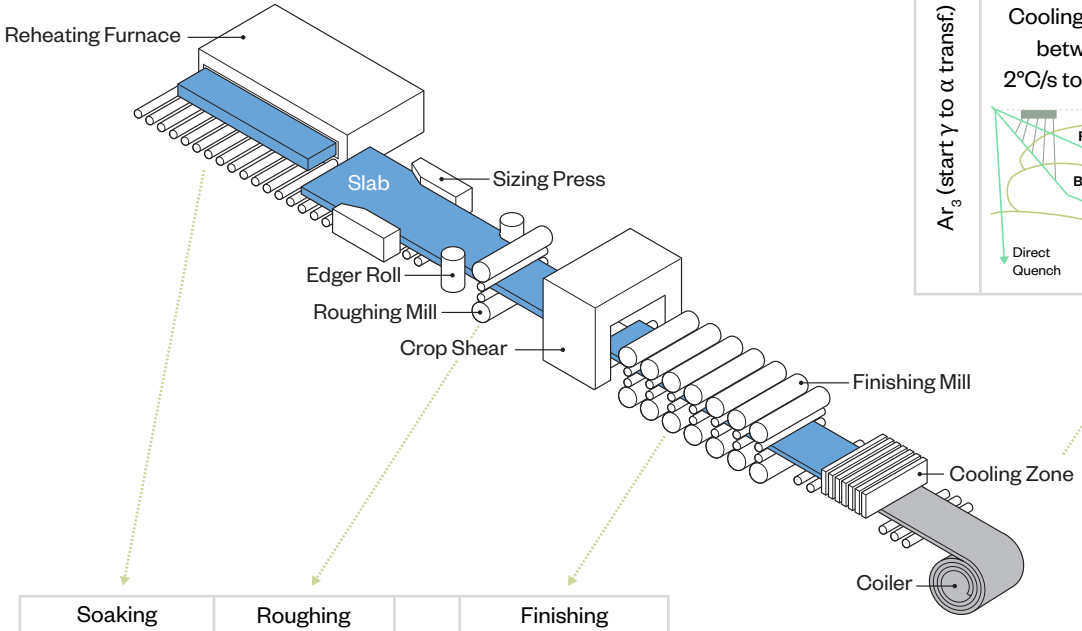
The increase of the T_{nr} temperature, enabling the material to be rolled at temperatures up to 100°C higher than conventional TMCP processing, results in the following advantages:

- Roughing can be done with less passes;
- Crop shears are exposed to a higher temperature steel that has higher plasticity, resulting in better cutting and less wear of the shear components;
- There is less wear on the rolling mill equipment and the electric motors use less energy due to the reduced rolling forces at the higher temperatures;
- The final thickness of the steel is defined by rolling at temperatures around 60°C to 80°C above the temperature at which austenite transforms into ferrite. This makes it easier to select and apply the appropriate cooling rates to the material after it leaves the final finishing stand of the rolling mill. This allows transformation directly into acicular ferrite and bainite, avoiding the strained pancake austenite transforming into ferrite plus perlite, which gives the material the best guarantee of excellent toughness.

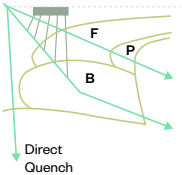
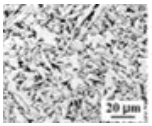


Adapted from Bremer, S.; Flaxa, V.; Knoop, F. M., A novel concept for thermo-mechanical hot-rolled strip for large diameter HTS (Helical Two Step) Line Pipe, International Pipeline Conference, Calgary, 2008.

GRAIN REFINEMENT DURING HOT ROLLING



Soaking 1.250°C	Roughing 1.200/1050°C	T_{nr} (non recrystallization) 1020°C	Finishing 1.000/840°C
Slab thickness 200 mm	Thickness after 40% reduction 60 mm		Strip thickness 22 mm
Ti (C, N) particles plus niobium in solid solution; Austenite grain size 80/90 µm	Nb, Ti (C, N) particles and Nb atoms at grain boundaries; Austenite grain size 20/30 µm		Pancake shaped austenite Nb (C, N) particles and small amount of niobium in solution

Ar_3 (start γ to α transf.) 770	Laminar cooling 840/600°C	Coiling 600/400°C
	Cooling speed between 2°C/s to 20°C/s 	 Acicular ferrite bainite Grain size 2/5 µm

This approach has been successfully applied by steelmakers, transferring considerable benefits to pipe manufacturers. Steels with up to 0.10% niobium have been used extensively in large scale pipeline projects around the world, including the Second and the Third West-East Pipeline in China, the best examples of this concept being used successfully.

Contact our technical experts to find out more about how this concept can be applied in your hot strip rolling mill.

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can be obtained at
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