INFLUENCE OF NIOBI ON QUALITY HIGH-FREQUENCY WELDED PIPE

S. Rešković[1], M. Balenović[2], B. Grizelj[3], M. Duspara[3]

[1] University of Zagreb, Faculty of Metallurgy, Aleja narodnih heroja 3, 44000 Sisak

[2] Rohrwerk Maxhütte Sisak d.o.o, Braće Kavurić 12, 44000 Sisak,

[3] Josip Juraj Strossmayer University of Osijek, Mechanical Engineering Faculty in Slavonski Brod, Trg Ivane Brlić-Mažuranić 2, 35000 Slavonski Brod

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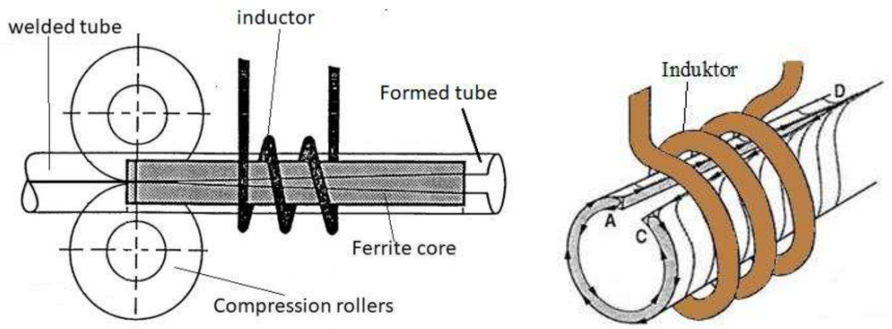
Abstract

In order to investigate the cause of the appearance of Lüders lines on cold drawn pipes, studies of welded pipes were carried out, which were subsequently formed by cold-drawn to the final dimensio. Studies were conducted on low carbon steel without niobium and low carbon steel with the same base chemical composition but with 0,047% addition of micro-alloying element niobium. The pipe are welded using a high-frequency process. The mechanical properties of the pipe were tested. Structural tests were carried out on the weld, the the zone of heat affected and the base material of pipe. Niobium microalloyed pipes have significantly better mechanical properties than niobium-free pipes. Luders band have been found to occur only in niobium microalloyed steel.

1 INTRODUCTION

It is a known fact that the addition a small amount of the microalloyd element is niobium of steel and proper selection of parameters of rolling can get significantly better properties of steel [1]. Only 0.05% Nb can increase the strength of steel by up to 30%. The mechanism of improving the properties the consists of precipitation the fine, deformation of induced niobium precipitates and their interaction with dislocations [2,3]. The niobium precipitate consists of niobium nitrides, niobium carbides and niobium carbonitrides. During thermomechanical treatment they are excreted in the form of densely complex arrays. The size of the precipitate is about 10 nm [4]. They make a strong barrier to the movement of dislocations. In the final thermomechanical treatment, they stop the recrystallization. Therefore, the hot-rolled strip has a fine-grained ferrite pearlite structure and significantly better mechanical properties over a strip of the same base composition without the addition of a microalloying element of niobium [1-4].

From the hot rolled strip are produced longitudinally welded pipes, that retain the same properties as the hot-rolled strip[5,6]. Pipes are produced in continuous processes whereby they are used welding technologies in which the welded joint is the molten material of the edge of the strip. Today, pipes are usually welded with a high-frequency process [7]. The technology of pipe production using high frequency welding process consists in cutting the strip to a specific width, transversely welding the strip to obtain infinite length, forming a strip into the pipe, high-frequency welding of the pipe, calibrating the pipe and cutting the pipe to the appropriate length. Subsequently, different diameters pipe and thicknesses of the wall relative to the initial one are obtained by hot or cold deformation. [7,8].High-frequency welding technology is based on the Kelvin effect, Figure 1



a b

Figure 1. Principle of high frequency pipe welding [9,10]

By passing a formed pipe through an inductor, a high frequency current is induced in the pipe, Figure 1. It concentrates in area A-C-D, Figure 1b, and heats the edges of the formed pipe. U točki D čelik je rastaljen [9]. Compression rollers, Figure 1a, the molten edges are joined and the molten metal extruded. To reduce current losses, a ferrite coreis placed in the formed pipe [10]. Changes in the structure, size and arrangement of niobium precipitates it is possible that can arise the djuring welding process at the weld site and in the zone of heat affected [11]. These changes can affect the properties of the pipe. In high-frequency pipe welding, the steel is heated to a temperature of up to 1400°C at the weld site. This area is very narrow. The molten and very soft material is pressed out by the pressure rollers. In the zone of heat affected, the temperature drops from the place of welding to the base material. Although the process takes a very short time, changes may occur as to the structure, size of the niobium precipitates and their interaction with dislocations. Therefore, it is important to obtain a well-welded pipewith a narrow area of the zone of heat affected in a high-frequency process [7,10,11].

In order to obtain different pipe dimensions, targeted mechanical properties and better surface quality, the pipes is cold drawing. Cold e drawing technology consists of the chemical preparation of the pipe and the pipe passage through matrices of different dimensions[9]. The degree of reduction in the diameter and thickness of the pipe depends primarily on the steel. The final, is obtained much smaller pipe dimension by drawing in more phase of cold-drawn pipe. In order to achieve a high degree of deformation, the pipes must be heated between phase of cold-drawn pipe. This reduces internal stress.

Cold drawing of longitudinally welded pipes that have not been heat treated after welding shows the appearance of Luders bands Luders bands are in fact inhomogeneous deformations that occur at the beginning of the plastic flow of the material. Although discovered long ago, it is still not fully understood why they occur, the mechanism of their propagation through the deformation zone, and what factors and how they affect their formation and propagation [12, 13].

The aim of this paper is to investigate the behavior in zone weld material and base material in high-frequency pipe welding, examine the effect of niobium on pipe quality, and to determine the appearance of Luders band during cold-drawing pipes of niobium microalloyed steel.

2 MATERIAL AND EXPERIMENTAL

Studies were conducted on low carbon steel without niobium (A) and low carbon steel with the same base chemical composition but with 0,046% addition of micro-alloying element niobium (B), Table 1.

Table 1. Chemical composition of steel / wt %

Steel	C	Mn	Si	P	S	Al	Nb	N
A	0,12	0,78	0,18	0,0010	0,0013	0,02	0,000	0,0048
B	0.12	0.77	0,18	0,0008	0,0012	0,02	0,047	0,0068

From both steel, rolled the strip dimensions 370x3,0 mm. Longitudinally welded pipes dimensions ϕ 57x3,0mm were rolled out of the strip. The technological process of forming and welding pipes rolling is given in Figure 2.

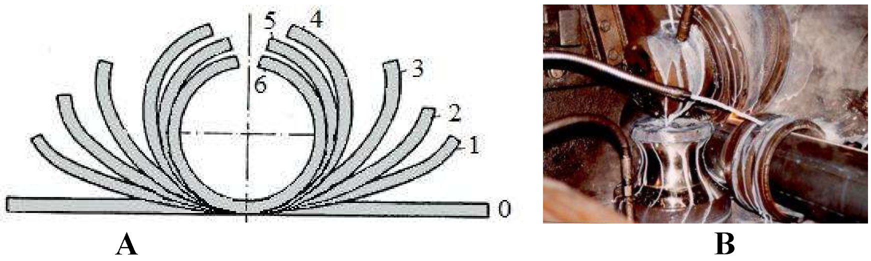


Figure 2. Technological process of A) pipe formation and B) pipe welding

The lamella was gradually formed into a pipe, Figure 2A and welded by a high-frequency process, Figure 2B. The welding parameters are shown in Table 2.

Table 2. Pipe welding parameters

Steel	V, m/min	I, A	U, kW
A	32	12,8	14,3
B	32	12,5	14,1

When choosing welding parameters, care was taken to obtain the optimum width of the heat affected zone. [3]. After welding, detailed testing of the mechanical properties of the pipe was performed. The mechanical properties of the pipe were tested on test mashine ZWICH 50kN. Pipes of both steels are chemically prepared and cold drawn in one span to a dimension of ϕ 42x2,0mm mm.

3 RESULTS AND DISCUSSION

A detailed examination of the mechanical properties and structure of the hot-rolled strip and longitudinally welded pipes was carried out. The results of mechanical tests are shown in Table 3, and showed that niobium microalloyed tape and pipes had better mechanical properties than niobium-free tape.

Table 3. Average mechanical properties of hot-rolled strip and longitudinally welded pipes

Steel	Hot rolled strip			Longitudinally welded pipe		
	Re, MPa	Rm, MPa	A_5, %	Re, MPa	Rm, MPa	A_5, %
A	398	460	17	416	475	19
B	511	598	32	520	610	31

Significant differences were observed on the pipes during cold drafting. Pipes made of niobium microalloyed steel after the first pase coold drawing, had Luders band on the surface, Figure 3, while niobium-free steel pipes no have Luders bands. Considering that the welding zone area was very narrow could not be distinguished whether Luders band exist on the welding zone or only on base material, Figure 3. The recorded surface was grinding and polishing with various gadding sandpaper before recording

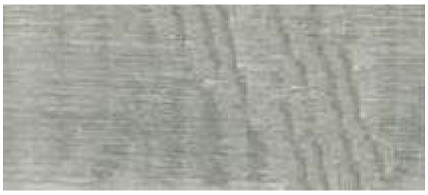


Figure 3. Luders bands on the surface of cold drawn pipe of niobium microalloyed steel

In Figure 3, Luders bands on the pipe surface are clearly observed. Previous tests of niobijem microalloyed steel strips [14] have shown that cold stretching of the strip causes inhomogeneous deformation to occur at the beginning of the plastic flow of the material. The extent to which the process during stopping occurs when inhomogeneous deformations occur on the test specimens, Luders bands are clearly visible, Figure 4. In the test specimen, at the point C, Figure 4, the observed Luders band are almost identical to those in Figure 3.

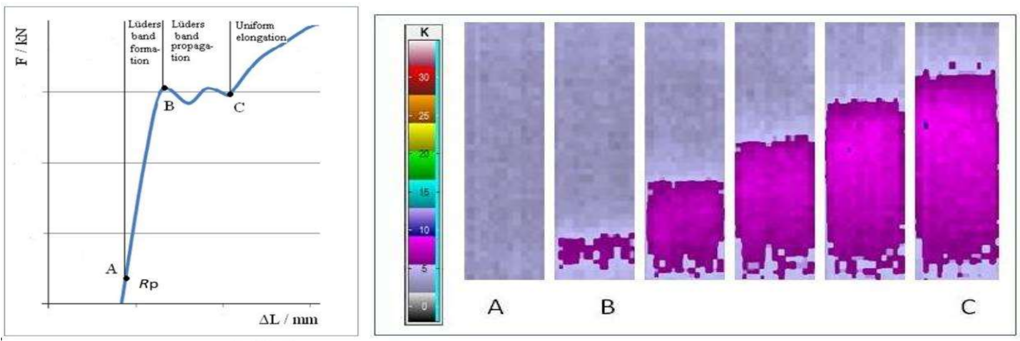


Figure 4. *Thermograms at the start of plastic flow of material [14]*

Figures 4 show that Lüders band is present only in steel with micro-alloyed niobium. In the area of A-B Lüders band is formed. In the B - C Lüders band area it propagates through the deformation zone. This phenomenon has not been noted in low carbon steel. Detailed microstructure analysis was performed on the longitudinally welded pipes. The macrostructure of welds of steels A and B is shown in Figure 5. It can be clearly seen that the pipes are well welded with the optimum size of the heat intake zone

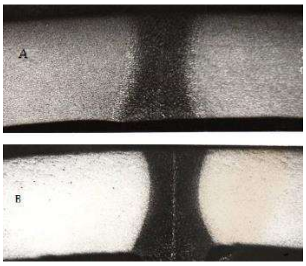


Figure 5. Macro structure of weld, A) low carbon steel, B) niobium microalloyed steel increase 50x

A detailed analysis of the welds of the microalloyed Nb pipes, Figure 6, shows the influence of temperature in the weld and its immediate vicinity, Figure 6a. The structure of the base material, Figure 6b, is homogeneous and fine-grained.

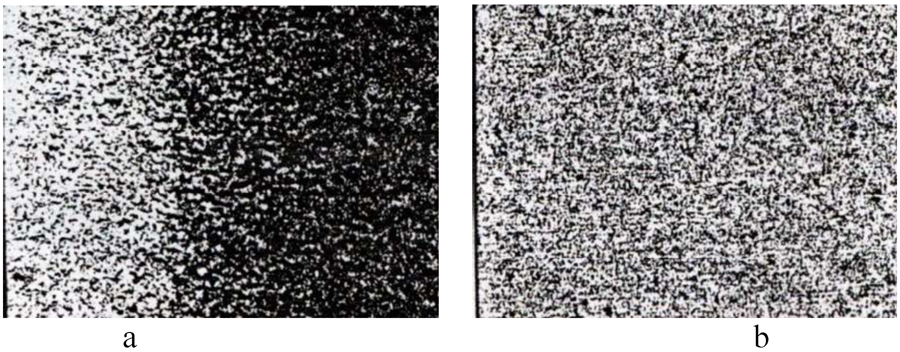


Figure 6. Microstructure of welded niobium microalloyed steel pipes, A) var, B) base material

Characteristic samples of niobium microalloyed pipes examined with a scanning electron microscope. In The basic material of a longitudinally welded pipe from the niobium microalloyed steel, Figure 7a, , revealed several series of fine precipitates of niobium. At the site of the weld and the zone of heat affected, niobium precipitates are larger, Figure 7b. No sequences of niobium precipitates were found as in the base material.

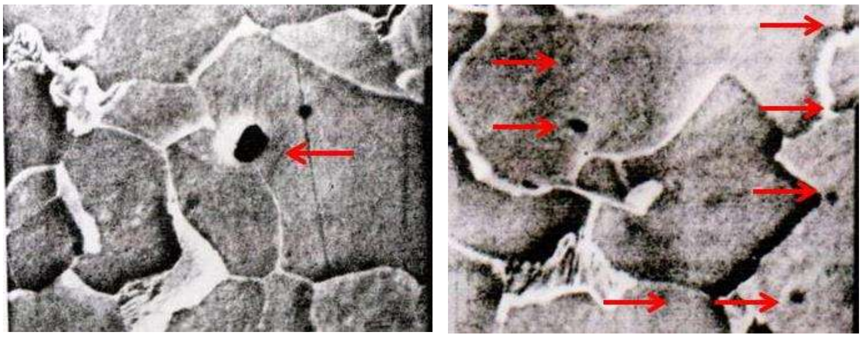


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Figure 7. Niobium precipitates a) in var, b) in base material

This means that due to the high temperatures it is on the weld and in the zone of heat affected there was some solubility of niobium precipitates (carbide, nitride and carbonitride). The diffusion of carbon atoms, nitrogen and niobium resulted in an increase in the size of niobium precipitates. Cotler's atmospheres of carbon and nitrogen atoms in steel have been shown to influence the appearance of Luders lines [15].

4 CONCLU SION

The tests performed clearly showed that the longitudinally welded pipe made from niobium microalloyed steel have significantly better mechanical properties than the same pipes made from steel which have almost identical chemical composition but do not contain the microalloying element niobium.

It has been found that in high-frequency welding of niobium microalloyed steel tpipe, the size and arrangement of niobium precipitates are changed at the weld zone. At the location of the weld and in the zone of heat affected due to the high temperature that occurs during high-frequency welding there is some dissolution of niobium precipitates. The re-cooling causes the previpatites to thaw in the zone of heat affected.

Subsequent cold drawing of the pipes from microalloyed steel with niovium results in Luders lines. Due to the very narrow the zone of heat affected and the weld itself, no difference was observed in the appearance of Luders lines on the weld and on the base material. The Luders lines did not originate from niobium-free pipes that were cold drawn through the same process parameters.

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