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POSSIBILITIES OF IMPROVING PROPERTIES OF MICROALLOYED STEEL WELD METAL BY CHOICE OF WELDING PROCESS AND TECHNOLOGY

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ABSTRACT
In this paper is shown the influence of welding process and technology on the weld metal properties. Microalloyed steel, low alloyed by Ti, Nb and V, is welded by MMA process and MIG/MAG process in the shielding atmospheres 5%CO_2+Ar and 15%CO_2+Ar. The testing results of weld metal toughness, hardness and microstructural analysis are presented. It was shown that weld metal obtained by MIG/MAG process in shielding atmosphere 5%CO_2+Ar has the best properties.
Keywords: microalloyed steel, MMA, MIG/MAG, toughness, microstructure

1. INTRODUCTION
The choice of welding process and technology significantly affects on the weld metal properties. Beside conventional MMA process, welding by metal arc process with mixture of shielded gases has been increasingly popular in recent years. A compound of gas mixture significantly affects weldment properties, especially weld metal toughness. Namely, increased presence of oxide inclusions in weld metal, promotes nucleation of acicular ferrite, which is well-known for its beneficial effect to both weld metal toughness and strength [1,2,3]. In welding in protective gas mixture atmosphere, as a rule, comes to droplet refinement [4,5]. Welding in protective gas mixtures Ar + CO_2 provides better weld forming and less spattering then those obtained by welding in pure CO_2, and comparing with welding in protective atmosphere of pure argon provides better penetration [6].

2. EXPERIMENTAL PROCEDURE
Hot rolled sheets of microalloyed steel, 7.18 mm thick, were used for welding. Welding is performed by MMA process using EVB Ni electrode, Ø3.25 mm, and by MIG/MAG process, using VAC 60Ni, Ø1.2 mm, with protective atmosphere 5%CO_2+Ar i 15%CO_2+Ar. Chemical composition and mechanical properties of base metal and filler material are given in Table 1 and 2.

Table 1. Chemical composition of microalloyed steel and filler material

material	Chemical element, %											
	C	Si	Mn	P	S	Cu	Al	Nb	Ti	Cr	Ni	V
Micro-alloyed steel	0.05	0.32	1.28	0.012	0.005	0.03	0.049	0.045	0.02	-	-	0.054
VAC 60Ni	0.08 - 0.10	0.70 - 0.85	1.40 - 1.60	<0.025	<0.025						1.00-1.20	
EVB Ni	0,07	0,5	1,4								1,1	

Table 2. Mechanical properties of microalloyed steel and filler materials

material	Re, [N/mm^2]	Rm, [N/mm^2]	A_5, [%]	KV(-20°C), [J]
microalloyed steel	510-537	571-595	37-42	152-197
VAC 60Ni	440-510	560-630	22-30	30-35 (at -40°C)
EVB Ni	>500	560-720	>22	>47(at -40°C)

The microstructure of microallyed steel is ferritic-pearlitic (Figure 1), fine grained with uniform grain size 14 (ASTM scale).

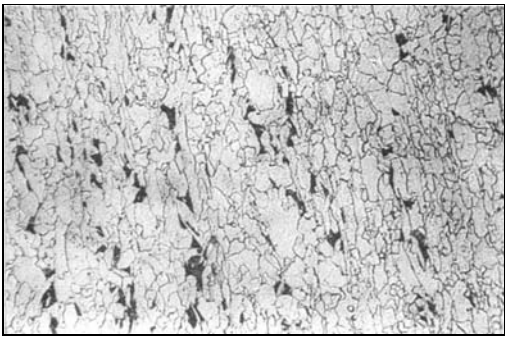


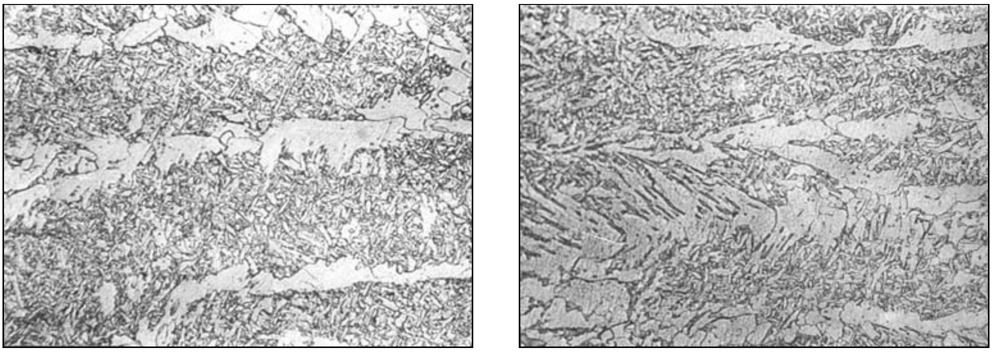
Figure 1. Microstructure of microalloyed steel (x400).

Heat input during welding was 7 kJ/cm, to exclude its influence since the weld metal toughness has been shown to be sensitive to input energy for used steel.

3. RESULTS AND DISCUSSION

The better arc stability and less spattering was noticed during MIG/MAG welding with protective atmosphere of Ar+ 5% CO_2, than with protective atmosphere of Ar+ 15% CO_2.

Figure 2 is presented microstructure of weld metal cover pass obtained by MIG/MAG process. The weldments microstructural analysis indicates presence of different morphological forms of ferrite. The microstructure of weld metal obtained in protective atmosphere Ar+5%CO_2 consists of acicular ferrite and proeutectoid ferrite, separated by boundaries of original austenitic grains (white regions). The microstructure of weld metal obtained in protective atmosphere Ar+15%CO_2 portion of acicular ferrite is less, on the account of increasing proeutectoid ferrite and ferrite with secondary phase. In the weld metal microstructure obtained by MMA process prevails proeutectoid ferrite.



5%CO_2+Ar 15%CO_2+Ar

Figure 2. Microstructure of weld metal cover pass (x400)

These facts are confirmed by hardness measurements in the cover pass[7]. Decrease of portion of acicular ferrite directly affects on hardness decrease, Figure 3.

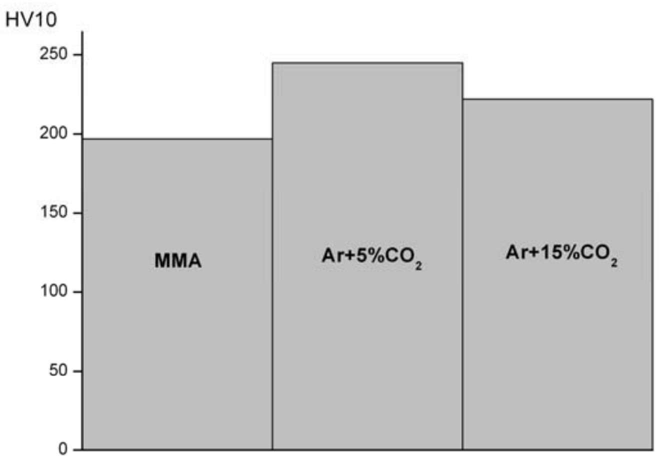


Figure 3. Weld metal hardness vs. mixture and welding process

Weld metal hardness of MMA joint is lower than weld metals hardness of joints carried out in both protective atmosphere.

Besides of noticed influence of protective gasses on the arc stability and weld appearance, it is important to emphasize that the welding process effects a metal weld toughness as well. The influence of welding process on the weld metal toughness at +20°C, - 40°C and -55°C was analyzed, as it is presented in Figure 4.

The highest toughness is achieved by welding in protective atmosphere of Ar+5%CO_2 (186 J at 20^0C), and the lowest toughness is achieved by MMA welding (83 J at 20^0C). The same dependence is characteristic for lower temperatures. At all testing temperatures, weld metal toughness obtained by MMA process is lower than weld metal toughness obtained in both protective atmosphere.

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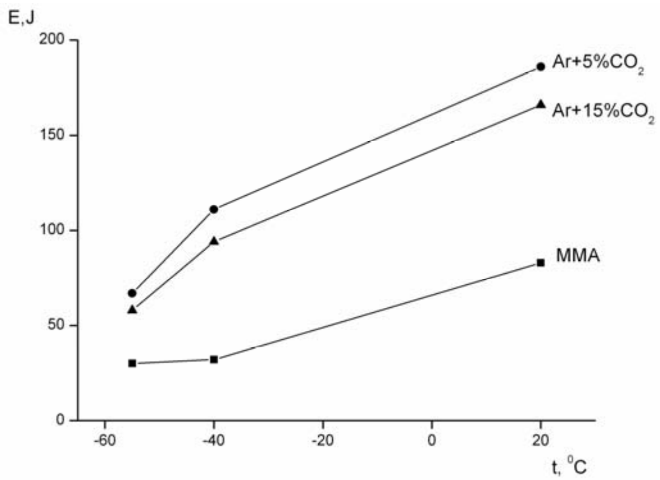

Figure 4. Weld metal toughness of microalloyed steel vs. temperature

4. CONCLUSIONS

Considering performed examinations the following is concluded:

1. The better arc stability and less spattering was noticed during MIG/MAG welding with protective atmosphere of Ar+ 5% CO_2, than with protective atmosphere of Ar+ 15% CO_2.
2. Welded joints carried out in protective gas atmosphere have better weld metal toughness at all temperatures in compare with MMA process.
3. Welded joints carried out in protective gas atmosphere have higher weld metal hardness in cover pass in compare with MMA process, as a result of the oxygen influence on final microstructure (formation of acicular ferrite).

5. ACKNOWLEDGEMENT

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