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Robotized GMA surfacing of cermetalic layers

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ABSTRACT

Purpose: Purpose of these researches was to investigate of influence of heat input in robotized surfacing on quality and properties of cermetalic layers.
Design/methodology/approach: The quality of single and multilayer, stringer and weave beads was assessed by abrasion resistance tests according to ASTMG65 standard, erosion resistance tests according to G76 standard, metallographic examinations and hardness tests.
Findings: Due to the fact that the it was used robotized surfacing stand, the analysis of properties of the deposits was performed for single and multilayer, stringer and weave beads.
Research limitations/implications: For complete information about tested wear plates it is needed to compare theirs properties with others presented technologies of wear plates producing.
Practical implications: Results of this paper is to optimal range of parameters of surfacing of single and multilayer, stringer and weave beads of cermetalic layers.
Originality/value: The researches (hardness tests, abrasion and erosion resistance tests) were provided for surfacing of single and multilayer , stringer and weave beads, and the results were compared. The influence of heat input on layers properties and theirs structure was defined.
Keywords: Welding; Robotized surfacing; Wear plates; Abrasion and erosion resistance

1. Introduction

High requirements for industry equipment results in using modern engineering materials in manufacturing and regeneration processes of this parts [1-3].

As an example of these materials can be cermets. These materials link properties of ceramics (corrosion resistance, erosion resistance, heat resistance) with properties of metals (mechanical properties) [2,11]. Theirs name gets from connection of words: ceramics and metal and it is a best definition of these materials. Cermet is a material which contain crystalline parts of ceramics (carbides, borides, oxides, nitrides) in metal alloy matrix (cobalt, titanium, nickel, molybdenum, chromium) [1-3].

At the beginning these materials were applied in machine cutting tools production [1-3]. At present with development of production technology of additional materials for surfacing theirs application was expand on wear, erosion and high temperature resistant layers manufacturing [4, 12].

Thanks to applying robotized welding stands considerably expands possibility to surfacing layers often on complicated shape elements [5-7]. It is possible to get arbitrary dimensions of cermets layers with high operational properties. It provides to decrease costs of using these parts. In addition the possibility of

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control of all surfacing paramteres allow to precisely steering of surfaced layers properties [5-8,10-13].

The main purpose of investigations was to define the influence of robotized MCAW surfacing parameters with cored wire EnDOtec DO*11 on quality, hardness and wear resistance of stringer and weave beads.

2. Researches

To determine the effect of welding parameters of Metal Cored Wire Arc Surfacing (MCAW) on the quality of deposits, using EnDOtec DO*11 metal cored wires 1,6 [mm] dia., Table 2, single, two and three layer stringer and weave beads deposits were MCAW surfaced on the dry and metallic clean surface of carbon steel plates S355NL - EN10113, 12 [mm] thick, by 120 [mm] wide and 150 [mm] in length, Table 1.
Robotized MCAW pulsed-arc surfacing was conducted on the welding stand equipped with synergetic programmable power source TotalArc^2 5000 and REIS SRV6 welding robot, Fig. 1.

To study the quality of multilayer stringer bead and weave bead deposits MCAW EnDOtec DO*11 wires surfaced at the range of low to high heat input surfacing parameters, Tables 3-4. Results of quality assessment of stringer and weave beads deposits MCAW EnDOtec DO*11 wires surfaced in the wide range of surfacing parameters were tested by visual inspection, magnetic particle-MT and macrograph examinations, Tables 3-4, Figs 2-4.

Table 1.
Chemical composition of materials used as the base plates for surfacing of EnDOtecDO*11 wire dia. 1,6 [mm] deposits (EN 10113-2:1993)

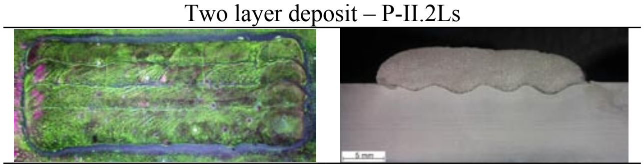
Grade of steel	Chemical composition, % by weight				
	C	Mn	Si	P	S
S355NL (C_e=0,424	0,18	1,36	0,45	0,02	0,02
	Cr	Ni	B	Mo	
	0,09	0,10	-	-	

Fig. 1. A view of robotized stand for welding and surfacing equipped in programmable power source TotalArc^2 5000 and REIS SRV6 welding robot

Table 2.
Chemical composition and hardness of EnDOtec DO*11 wire dia.1,6 [mm] desposits [13]

Metal cored wire	Content of alloy components – [%] by weight and deposits hardness				
	Ni	C	Si	Cr	B
EnDOtec DO*11	Bal.	0,4	2,5	3,0	1,5
	WC	Deposit	Tungsten carbides (WC)		
	50	55 HRC	2400 HV0,3		

MT examinations	Macrographs
Two layer deposit – P-II.2Ls	



Two layer deposit - P-II.2Lw

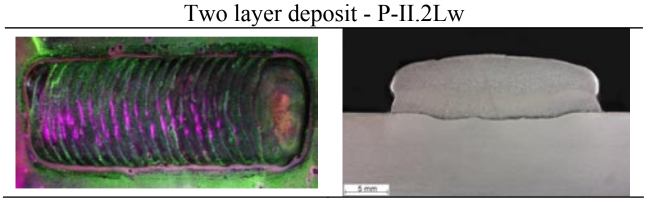


Fig. 2. A view of face during MT examinations and macrographs of two layers stringer and weave beads deposits. Table 3, MCAW EnDOtecDO*11 wire dia.1,6 [mm] surfaced

Heat input: 0,22 – 0,26 kJ/mm   Heat input: 0,81-0,97kJ/mm

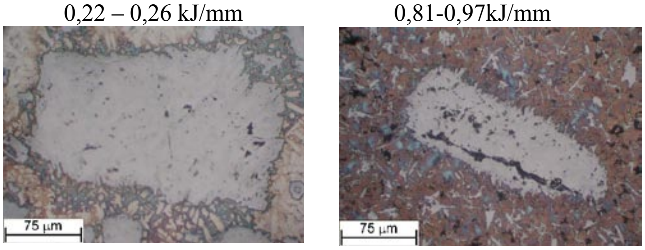


Fig. 3. Microstrucutre of tungsten carbides in stringer beads deposits surfaced with low and high heat input

Hardness was measured on surface and cross section of deposits, Tables 3-4. Measurements were provided to determine an influence of heat input on surface hardness and matrix microhardness, Table 3-4.

To determine quantitatively the wear resistance of MCAW EnDotec DO*11 wire surfaced one and three layers weave beads deposits, Table 5, in comparison to HARDOX 400 wear plate wear resistance, the tests of abrasive wear type metal-ceramic were conducted in accordance to standard ASTM G65 - Standard Test Method for Measuring Abrasion Using the Dry Sand/Rubber Wheel Apparatus. Mass loss was reported directly and relatively in comparison to the mass loss of the reference HARDOX 400 wear plate, Table 5. Conversion of a mass loss into volume loss is described as: Volume loss, [mm^3] = mass loss [g] **:** density [g/cm^3] x 1000.

Table 3.
The effect of MCAW EnDOtec DO*11 wire dia. 1,6 [mm] surfacing parameters on single, two and three layers stringer bead deposits quality and deposits hardness

Deposit designation**	Wire feed speed [m/min]	Arc current [A]	Arc voltage [V]	Heat input [kJ/mm]	Quality of deposits assessed by visual inspection and MT examinations	Deposits hardness HV30	Average matrix microhardness HV0,3
P-I.1Ls	1,9	99÷125 (95)*	14,5÷17,5	0,29÷0,44	Good quality, smooth face, no undercuts, transverse cracks	500÷630	475
P-I.2Ls						530÷680	501
P-I.3Ls						540÷700	480
P-II.1Ls	3,3	148÷168 (155)*	17,5÷20,0	0,52÷0,67	Good quality, smooth face, no undercuts, transverse cracks	480÷510	612
P-II.2Ls						510÷570	658
P-II.3Ls						520÷560	655
P-III.1Ls	4,7	203÷225 (220)*	20,0÷21,5	0,81÷0,97	Good quality, smooth face, no undercuts, transverse cracks	420÷470	628
P-III.2Ls						460÷500	609
P-III.3Ls						450÷540	-

REMARKS: Surfacing current pulsed, polarization – positive DC(+). Speed of surfacing 0,3 [m/min]. Vertical wire position. Wire stick out 20,0 [mm]. Shielding gas 97,5%Ar+2,5%CO_2, flow rate 16,0 [l/min]. Stringer beads overlap 25-30%. Interpass temperature 200-250 [^{o}C]. * - set current (on current source) ** - P-I.1Ls means: P-I – arc current 95 [A], 1Ls – one layer, stringer bead deposit

Table 4.
The effect of MCAW EnDOtec DO*11 wire dia.1,6 [mm] surfacing parameters of two and three layer weave bead deposits on the deposits quality

Deposit designation**	Wire feed speed [m/min]	Arc current [A]	Arc voltage [V]	Heat input*** [kJ/mm]	Quality of deposits assessed by visual inspection and MT examinations	Deposits hardness HV30	Average matrix microhardness HV0,3
P-I.2Lw	2,6	118÷134 (125)*	17,0÷18,5	0,46÷0,57	High quality, smooth face, no undercuts no cracks	450÷540	503
P-I.3Lw						530÷590	520
P-II.2Lw	3,3	142÷158 (155)*	19,0÷21,0	0,62÷0,76		450÷520	646
P-II.3Lw						450÷500	620
P-III.2Lw	4,0	176÷189 (185)*	19,5÷22,0	0,79÷0,96		480÷520	625
P-III.3Lw					Strong third layer overlap due to overheating	450÷490	590

REMARKS: Surfacing current pulsed, polarization – positive DC(+). Shielding gas 97,5%Ar+2,5%CO_2, flow rate 16,0 [l/min]. Vertical wire position. Wire stick out 20,0 [mm]. Interpass temperature 200÷250 [^{o}C], weave bead deposits at constant velocity zig-zag oscillation technique at the frequency 0,2 [s^{-1}].
* - set current on power soruce, ** - P-I.1w means: P-I – arc current 125 [A], 1w – weave beads, amplitude of oscillation – 15 [mm],
*** - heat input of MCAW surfacing of one layer weave bead deposit

Table 5.
Results of low-stress abrasion resistance to metal-ceramic scratching by means dry quartz sand as the abrasion material of HARDOX 400 wear plate and MCAW surfaced two and three layer deposits of EnDOtec DO*11 wire dia. 1,6 [mm]

Deposit designation	Average heat input [kJ/mm]	Average despoits hardness HV30	Mass loss [g]	Average mass loss [g]	Average volume loss [mm^3]	Relative* abrasion resistance
HARDOX 400-1	-	-	1,4734	1,4617	185,7306	1,00
HARDOX 400-2	-	-	1,4501			
PI.3Ls	0,365	620	0,3623	0,3722	32,7641	5,67
			0,3821			
PIII.3Ls	0,89	495	0,4521	0,4314	37,9753	4,89
			0,4108			
PI.3Lw	0,515	560	0,5259	0,5139	45,2377	4,11
			0,5019			
PIII.2Lw	0,875	500	0,6704	0,6561	57,7553	3,22

REMARKS: Density of EnDOtec DO*11 wire - 11,36 [g/cm^3] and HARDOX 400 7,87 [g/cm^3],
* - abrasion resistance relative to HARDOX 400

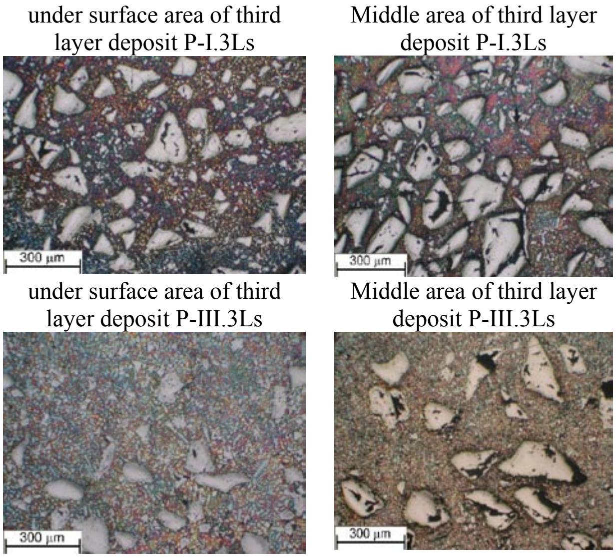


Fig. 4. Microstrucutre of third layer of deposits, Table 3, MCAW EnDOtec DO*11 wire dia.1,6 [mm] surfaced

3. Conclusions

Based on results of investigations of MCAW EnDOtec DO*11 metal cored wire surfacing it was found:

1. Exist a range of optimal surafcing parameters allow to surfacing high quality deposits with smooth face, no undercuts, without internal defects, with high hardness and abrasion resistance, Figs. 2-4, Tables 3-4.
2. Single and mulitlayer stringer and weave bead deposits MCAW EnDOtec DO*11 wires surfaced showed high quality in wide range of arc current (heat input). All deposits are free of any external or internal defects, but in the case of surfacing stringer beads all are transverse cracked, Fig. 2, Tables 3-4.
3. Tungsten carbides size and distribution in nickel alloy matrix of stringer bead deposits is a function of MCAW surfacing heat input. Increase of surfacing heat input is the cause of increasing dissolution of tungsten carbides in nickel alloy matrix, Fig. 3-4. Changes in hardness results corresponds with chnges in the tungsten carbides size and distribution, Tables 3-4.
4. Hardness of multilayer stringer and weave bead deposits is in the range from 420 HV30 of high heat input one layer deposits to 700 HV30 of low heat input three layers deposits, and is a function of the value of heat input of MCAW surfacing, Table 3-4.
5. Three layer weave bead deposits abrasion resistance is a 30÷35% lower than three layer stringer bead deposits and in both case decreases with increase of heat input, Table 5.

References

[1] A. Klimpel: Surfacing and thermal spraying. Warsaw, WNT 2000 (in Polish).
[2] M. Wysiecki: Modern tool materials. Warsaw, WNT, 1997 (in Polish).
[3] L.A. Dobrzański: Physical metallurgy with metal science basis. WNT, Ed. 4, Warsaw, 1999 (in Polish).
[4] A. Klimpel, A. Zając: SSA surfacing examples. Welding Review. 1994. Nr 2-3, s. 5-10 (in Polish).
[5] A. Klimpel, A.St. Klimpel, A. Rzeźnikiewicz: „MCAW robotized weave beads surfacing. 47. National Scientific-Technically Welding Conference „Achievments and perspectives in welding”. Katowice, 18-20.10.2005, s. 71-76 (in Polish).
[6] A. Klimpel, J. Górka: „An influence of parameters of MCAW surfaicing on quality of mulitlayers cermets deposits. Welding Review nr 4-5, 2005, s. 45-49 (in Polish).
[7] A. Klimpel, D. Janicki, A.St. Klimpel, A. Rzeźnikiewicz: „MCAW robotized surfaicing with Ni-WC metal cred wire” COMMENT Worldwide Congress on Materiale and Manufacturing Engineering and Technology. Gliwice-Wisła 16-19. 05. 2005, s. 901-908 (in Polish).
[8] A. Klimpel, L.A. Dobrzański, D. Janicki, A. Lisiecki: Abrasion resistance of GMA metal cored wires surfaced deposits”. COMMENT. 13th International Scientific Conference On Achievements In Mechanical And Materials Engineering. Wisła 16-19.05.2005 s. 311-314.
[9] K.J.A. Brookes: World Directory and Handbook of Hardmetals and Hard Materials. East Barnet, International Carbide Data. Ed. 6, 1996.
[10] A. Klimpel, P. Pierożak, S. Stano: Wear resistance of SSA surfaced layers. Welding Review. 2002. Nr 5, s. 1-6 (in Polish).
[11] Koji Kato Koshi Adachi “ Wear of advanced ceramics” Laboratory of Tribology, School of Mechanical Engineering, 2002.
[12] “Standard Test Method for Measuring Abrasion Using the Dry Sand / Ruber Wheel Apparatures” – ASTM G65-00 (2001)
[13] Castolin Eutectic. Catalogue. Applied-metallurgy products and processes for industrial maintenance and repair