Materials and technologies for the development of modular self-sharpening elements

I. Voiculescu[1], E. Binchiciu[2], V. Geantă[1], N.-A. Sîrbu[2], H. Binchiciu[3]

[1] Politehnica University of Bucharest, Romania

[2] National R&D Institute for Welding and Material Testing – ISIM Timişoara, Romania

[3] S.C. Sudotim S.R.L., Timişoara, Romania

E-mail: ebinchiciu@isim.ro

Keywords

Self-sharpening, modular elements, tubular wire, fabrication line, plow

1. Introduction

In agricultural practice, it is known to increase the working life of active elements from the plows by loading them in the wear affected zone with materials type Fe-25% Cr - (1-2)% Ni alloys, also called sormait [1,2]. Currently, applications consist in depositing by oxy-gas melting of casted rods. This method has the disadvantage of reduced productivity.

Lately, due to the need for a pronounced increase in the life of plows in large aggregates, the process of deposition anti-wear coatings using oxy-gas flame was replaced with that of cladding with coated electrodes, [3,4,5] that depositing suitable alloys for the specific conditions of wear from different soil categories in which they operate.

The paper aims to increasing productivity when cladding and replace the anti-wear layers from the active surface the plow with welding on their surface of modulated additions that are capable of self-sharpening, removable and can easily be replaced after wear. The analysis of possibilities to increase layer deposition productivity, [6] while maintaining a low dilution has highlighted that it is possible to do this using MIG, MAG welding, with tubular wires that have a high potential for uniform distribution of the welding current.

Specialized documentation study in the field of cladding materials has highlighted the existence of Fe-25% Cr alloy wires that have a high grain size as well as dilution. In this situation, the team of authors developed an innovative solution to obtaining self-sharpening modular elements [7] by MIG welding with a wire made in such a way that the distribution of the welding currents in the wire section, including the section of the electric arc, will be as uniform as possible. To this purpose, a new product [8,9] was researched, developed and tested, it was tried to produce cladding technology for metal strips that are suitable to manufacture modulated elements.

The technology of cladding the anti-wear layers on the plow knife body [3,6] is appropriate in the conditions of use of the process in agricultural farms where welding equipment is scares. In the case of industrial manufacturing of modular elements, the new technology is suitable because it ensures their quick acquisition and installation.

The last hour data shows that in order to reduce stress and deformations that remain in the modulated elements, there is the possibility of using ultrasound in order to relief the stress, the future direction of research.

2. Experiments

The experimental program was developed to elaborate self-sharpening modular elements followed two distinct scientific directions, namely:

To develop, by adapting patentable product recipes of tubular wires that have high potential of even current distribution in the welding ark area;

Designing and manufacturing the self-sharpening elements that have a good compatibility to welding using the manual electric process and base materials used in the construction of plow, on which they are mounted on.

In the cladding material (that deposit Fe-25%Cr-(1-2)%Ni) development stage it was taken into consideration the recipes of some tubular wires [6,9], that were adapted by modifying the composition structure in order to suit cladding by MIG welding of thin layers, with harness of aprox. 55-60 HRC.

In order to obtain an even distribution of welding current, respectively of high purity deposits, the composite core of the tubular wires was made out of an alloying system of ferromanganese and metallic nickel, namely a refining-oxidation system [10], made up of ferromanganese, ferrosilicon, and colloidal graphite.

Homogenizing the alloying systems ad = s well as refining-oxidation was made in a homogenizer with plows and chicanes. Tubular wire coat is made up of steel plate of deep embossing. The product recipe of the new composite core tubular wire is presented below, in table 1.

Table 1. Product recipe

Constitutive materials	$FeCr_6$	Ni	$FeSi_{45}$	FeMn	Graphite	FeTi
Mass participation [%]	80	4	4.5	5.5	5	1

The filling coefficient used to manufacture tubular wires was 0.5. Drawing the closed strip – composite core was done using a reduction coefficient of max. 18% in the presence of graphite silicon lubrication. Production was achieved using the fabrication line in figure 2.

Figure 1. Homogenizer with plows and chicanes.

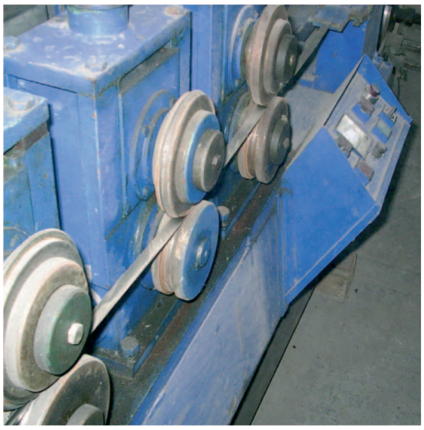

Figure 2. Tubular wire fabrication line.

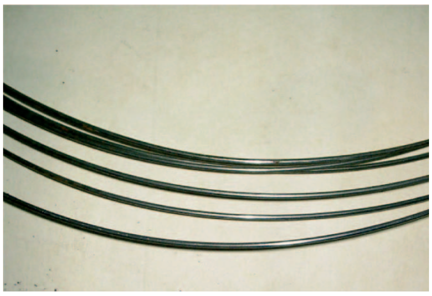

Figure 3. Drawed tubular wire.

The resulting tubular wire, figure 3, was tested in order to highlight it's physical-chemical, technological characteristics, and used to develop modular elements and mount them through manual electric welding on plow knife supports.

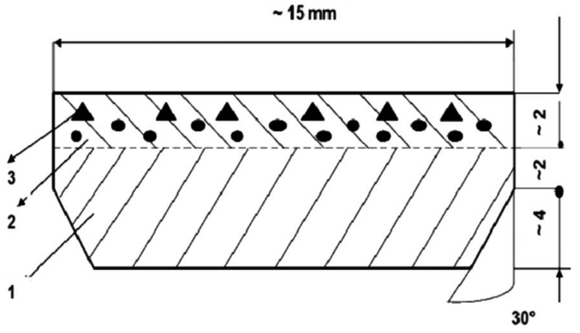

Figure 4. Design self-sharpening composite strip.
1 - suport; 2 - matrice; 3 - complex carbides of Cr and Ti

Figure 5. Plow equipped with self-sharpening modulated elements.

The design of the composite strip blank from which the self-sharpening elements are cut, as shown in the innovative literature [9] figure 4, is thus conceived in that the lateral areas present, from fabrication, facilities to self-sharpen and chamfer in order to weld them to the plow holder. The anti-wear layer deposited by MAG welding on the composite tape support consists of an austenitic matrix rich in complex carbides of Cr and Ti. The composite strip is a slim rod, which has determined the deposition of anti-wear layers, residual stresses and large deformations partially diminished by a pre-positioning with an experimentally determined arrow.

Welding the modulating element equipped with anti-wear layers and self-sharpening system, mounted on the plow pillar, was accomplished by using electric manual operated process with basic electrodes, presented in figure 5.

The thus achieved plow pillars have been tested in order to determine the physicochemical characteristics, respectively to draw up their technical documentation, as well as, under real operating conditions, to highlight the service life expansion, under optimal fuel consumption conditions.

In-service experiments have shown an increase in durability compared to standard coulters by 300%, with the possibility of multiplying it by up to 3 times, by re-rolling with modulated self-sharpening elements.

3. Results and discussions

Tubular wire with composite core, that deposit by welding alloys type Fe-25%Cr-2%Ni-Ti were used to achieve through MAG welding samples of deposited metal. In advance the wire was tested from a dimensional and characteristic point of view so it will be compatible with MIG/MAG welding processes.

Technological test results, figures 6, 7, 8 highlighted the match of the new product with specific requirements of MIG/ MAG processes.

Deposited metal sample was used to determine the elemental chemical composition, table 2, using spectral analysis with programs Fe and tool steels.

Tabelul 2. Elemental chemical composition, in mass %.

C	Mn	Si	Cr	Ni	Ti	Base
1.35	0.93	0.3	24.3	1.9	0.7	Fe

After processing through welding the deposited material, according to metallographic and sclerometric requirements [11], we proceeded to investigate it. The detected structure, figure 9, highlighted an austenitic matrix with a grain limit well known, in which sphere type complex carbides are incorporated, they assure a good resistance to wear, medium and high abrasion pressure.

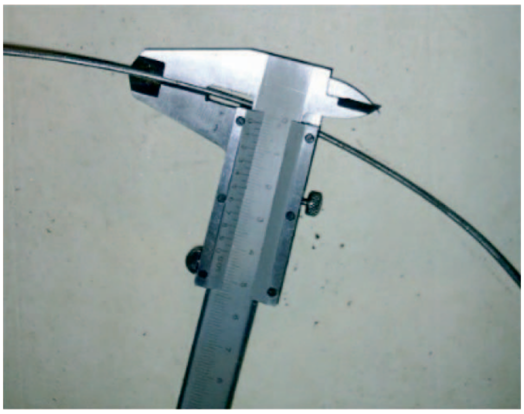

Figure 6. Dimensional test.

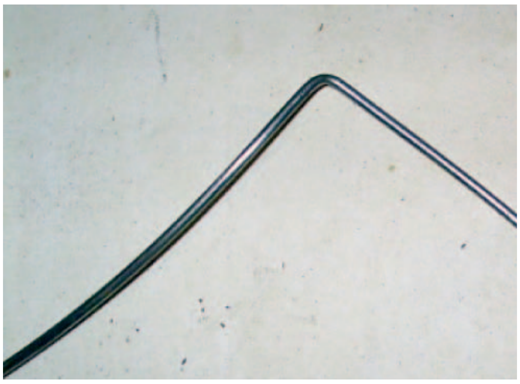

Figure 7. Bending test at 90°.

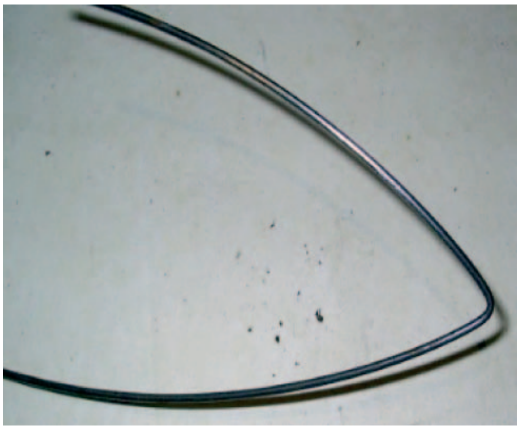

Figure 8. Profile opening test.

Structural analysis was accompanied by sclerometric tests, table 3, that confirm the detected structure.

Table 3. Hardness

Test type	Hardness values
Deposited metal	58; 56; 59; 62; 61 in welded state
Fusion area in deposited metal – base metal	218; 230; 225; 210; 218 HB

Deposited material tests highlighted the possibility of using then in order to develop self-sharpening strips through MAG welding. They were tested in the fusion area of the base material with the deposited material through spectral analysis, figure 10 and sclerometric tests in the HAZ, table 3, in order to show the processes feasibility. Analyses above mentioned did not show defects or hardness anomalies in the tested area, fact that validates the fabrication process of the composite rod with self-sharpening. The thus obtain product was used to equip plow pillar supports by manual electric welding, figure 5, which were introduced, after a vibration stress relief procedure, [12] into real industrial conditions.

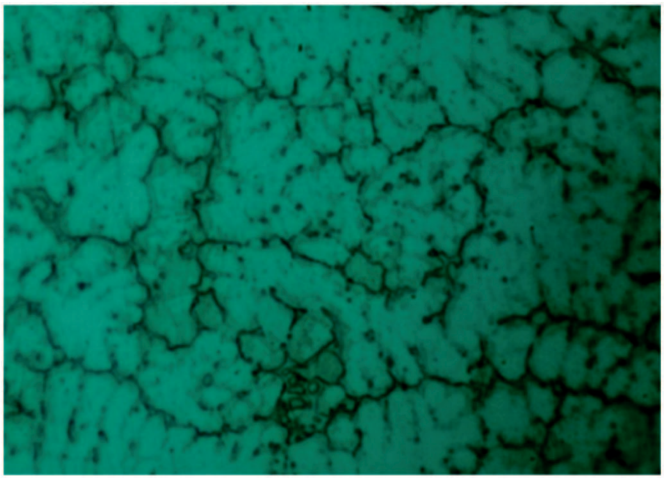

Figure 9. Deposited metal [500X].

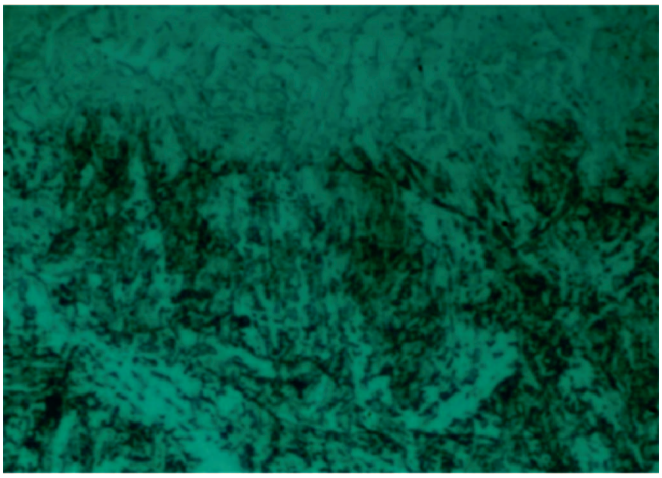

Figure 10. HAZ [500X].

4. Conclusion

Research performed concluded with high potential results that have a wide applicability, as followed:

- A product recipe and a tubular wire that deposit by MAG welding, thin layers, slightly diluted alloys, type Fe-25%Cr-2%Ni-Ti, that have austenitic structure with a high content of complex carbides of Cr and Ti as well as associated hardness's of aprox.55HRC that assure a high resistance to abrasion wear under medium and high pressure, specific to hard soils;
- A fabrication technology by cladding using the MAG process, of the composite strip, that has self-sharpening

properties and a high weld-ability potential with the plow pillar supports through accessible processes in the agricultural farms;

• A manufacturing technology, based on preventive repetitive maintenance, of plow supports equipped with modulated elements that have self-sharpening proprieties and a high resistance to wear.

References

[1]. Iovănaş R. e.a.: Recondiţionarea şi remanierea produselor sudate, Editura Universităţii Transilvania din Braşov, ISBN 973-635-416-4, 2006.

[2]. Binchiciu H., e.a.: Încărcarea prin sudare cu arcul electric, Editura Tehnică Bucureşti 1992.

[3]. ***: HURO: „Cercetări privind oportunitatea creşterii duratei de viaţă şi eficienţa reciclării componentelor active ale echipamentelor din agricultură" Programul CBC HURO 1001/234/2.2.2, Acronim TRANSAGRO, 2012-2016.

[4]. www.esab.com

[5]. www.bohler.com

[6]. DURAG/298: „Innovative materials and technologies to increase the sustainability of the active elements constituting in the technical equipment in agriculture" Contract RESEARCH EXCELLENCE PROGRAM 298/2006-2008

[7]. Ro129877/28.11.2014: "Bandă compozită cu proprietăţi de autoascuţire pentru ranforsarea suprafeţelor active ale utilajelor de prelucrare a solului şi procedeu de obţinere„ Binchiciu E.F, Binchiciu A., Binchiciu H., Voiculescu I., Geantă V., Stefănoiu R.

[8]. MATFREZ: „Materiale şi tehnologii performante destinate realizării cuţitelor de freză pentru asfalt "- Contract PCCA 188/ 2012-2017.

[9]. RO129867/28.11.2014: „Electrod tubular cu miez compozit şi procedeu de obţinere" Emilia Binchiciu E., Voiculescu I., Horia Binchiciu H., Geanta V., Stefănoiu R.,Binchiciu A.

[10]. Stefănoiu R., Geanta V.: Rafinarea oţelurilor prin injectarea gazelor inerte, Editura BREN, Bucureşti, 2008, ISBN 978-973-648-770-5

[11]. Voiculescu I., Rontescu C., Dondea L.I.: Metalografia imbinărilor sudate, Editura Sudura, Timişoara, 2010, ISBN 978-973-8359-58-1.

[12]. O. V. Oancă, N.- A. Sîrbu, I. A. Perianu, (2015), Structural and Functional Characterization of Ultrasonic Joining for Multiwire Conductors for Automotive Industry, International Conference Advanced Materials Research, vol. 1111, Ed. Trans Tech Publications, pP.252-259