

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

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## 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 scarce. 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 arc 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 hardness of approx. 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 as 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 <sub>6</sub>	Ni	FeSi <sub>45</sub>	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.

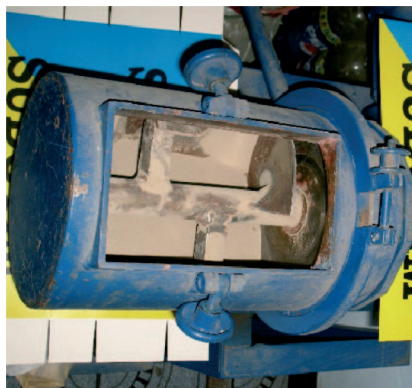


Figure 1. Homogenizer with plows and chicanes.

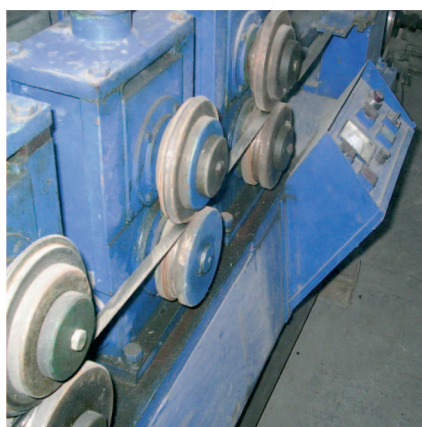


Figure 2. Tubular wire fabrication line.

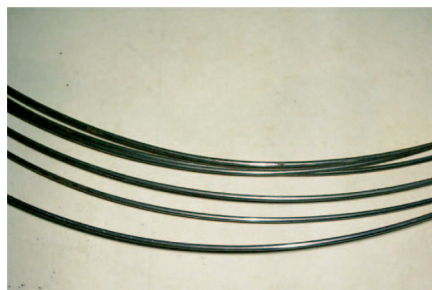


Figure 3. Drawn tubular wire.

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

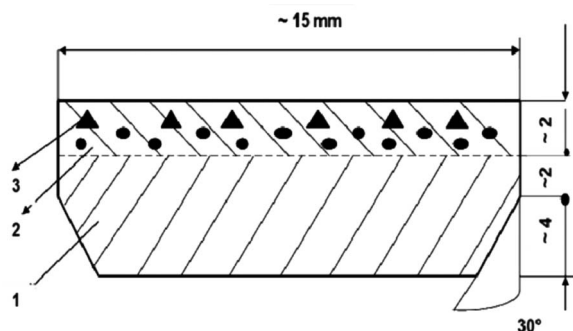


Figure 4. Design self-sharpening composite strip.  
1 - suport; 2 - matrice; 3 - complex carbides of Cr and Ti



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.

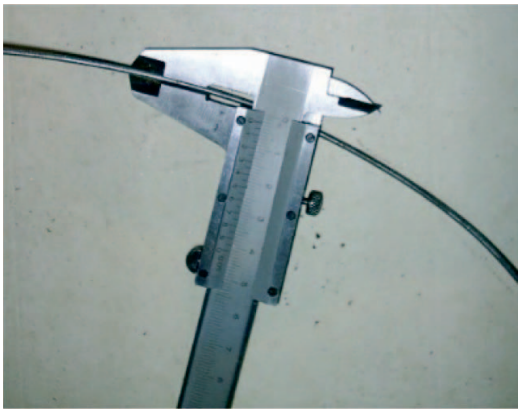


Figure 6. Dimensional test.

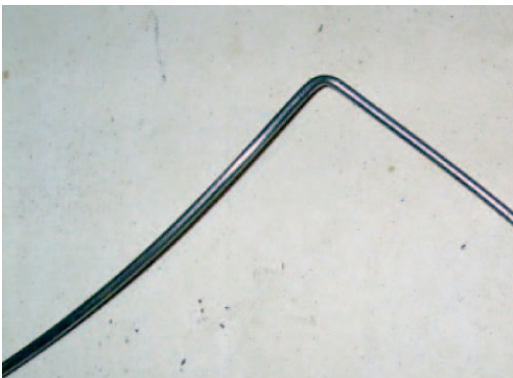


Figure 7. Bending test at 90°.

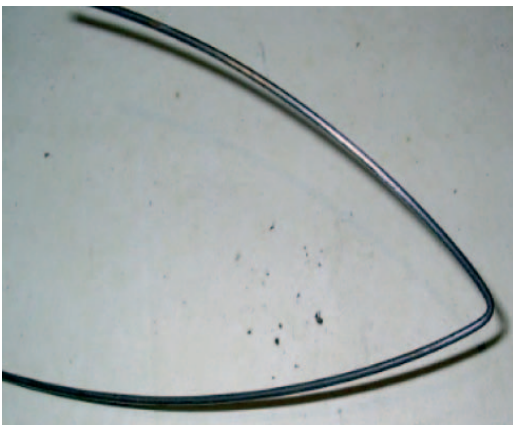


Figure 8. Profile opening test.

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.

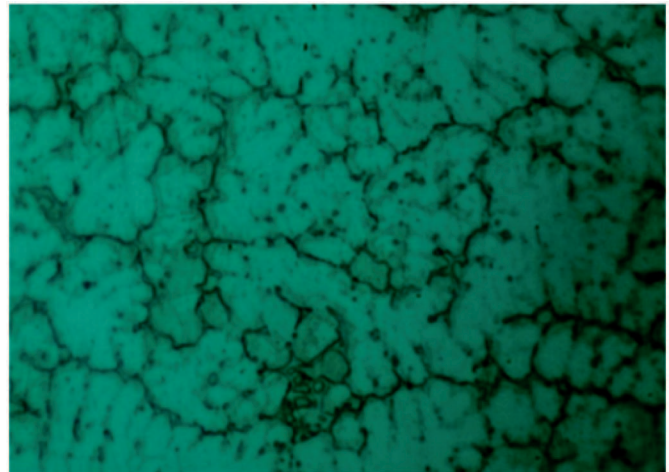


Figure 9. Deposited metal [500X].

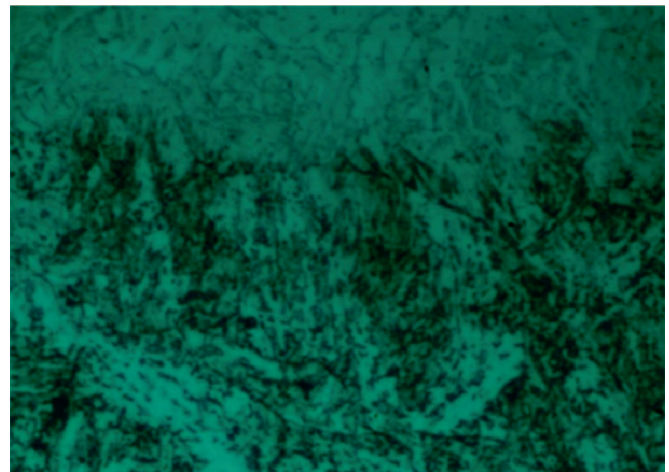


Figure 10. HAZ [500X].

#### 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 properties and a high resistance to wear.

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## PROJECT PN-III-P1-1.2-PCCDI-2017-0332

### Increasing the institutional capacity of bio-economical research for the innovative exploitation of the inland vegetal resources, in order to obtain horticultural products with high added value - BIOHORTINOV

#### PARTNER INSTITUTIONS OF THE PROJECT

##### Coordinator of the complex project

University of Pitești – UPIT

##### Partners of the project

Research-Development Institute for Pomiculture Mărăcineni – ICDP

National Research-Development Institute for Biotechnologies and Horticulture Ștefănești – INCDBH

National Research-Development Institute for Chemistry and Petrochemistry București – ICECHIM

Polytechnic University București – UPB

Research-Development Station for Pomiculture Constanța – SCDP

University of Medicine and Pharmacy Craiova – UMF

National Research & Development Institute for Welding and Material Testing Timișoara – ISIM

#### COMPONENT PROJECTS

**Component Project 1.** Comprehensive electronic system for monitoring the conditions of hydronic and biocenotic stress (SHBH) with intelligent data processing algorithms for warning and preventing it in horticulture

Coordinating institution: UPIT,

Responsible Pr 1 Prof. assist. univ. dr. Alin Gheorghită MAZĂRE

**Component Project 3.** Developing plant extracts and innovative phytosynthetic nanostructured mixtures with phytotherapeutic applications to reduce biocenotic stress in horticultural crops.

Coordinating institution: ICECHIM

Responsible Pr 3, CS I dr. chim. Radu Claudiu FIERĂSCU

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#### OBJECTIVES OF THE PARTNERSHIP

1) Developing human resources from RDI by stimulating the training of young researchers and high-performance research teams.

2) Increasing the involvement of the participating research centers in joint CDI projects in order to attract new collaborators by correlating and coordinating the activities and resources developed in this project.

#### Fulfilling outcome indicators will also improve the quality of life by:

- Improvement of products resulted from fruit and wine crops,
- through standardized nutraceutical products obtained, improving the quality of the environment,
- alternative solutions offered to combat apple and vine diseases,
- modern culture technologies based on multisensory quantification of hydric and biocenotic stress from fruit and vineyards,
- phytomonitoring and early warning under the conditions of climate change,
- the social impact produced by the new jobs generated.

**Component Project 2.** Multi-sensorial quantification of hydric and biocenotic stress in horticulture through phytomonitoring and early warning under climatic change conditions.

Coordinating institution: ICDP

Responsible Pr 2, CS II Florin Cristian MARIN

**Component Project 4.** Innovative advanced processing technologies for native vegetal resources.

Coordinating institution: UPIT

Responsible Pr 4, CS II dr. Cătălin Marian DUCU

