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# MODERN APPROACHES IN DESIGN OPTIMIZATION OF PARTS AND THE DEVELOPMENT TREND OF SURFACE TREATMENTS

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## ABSTRACT

*This paper summarizes the surface engineering technologies having a substantial contribution to increasing operational performance of the parts as well as current trends in the implementation of surface processing technologies that imply technical benefits and minimum negative impact on the environment The experimental results illustrate the influence of during superficial thermal treatment by high frequency current heating and thermochemical treatment (ionic nitriding) on the structural and physic - mechanical characteristics of heat treatable steel pieces. Also experimental results allowed conclusions on optimal regimes of surface processing and comparative analysis of properties obtained through different methods of processing.*

KEYWORDS: surface, high frequency current heating, steel, mechanical characteristics, ionic nitriding

## 1. Introduction

For a more efficient recovery of materials and in order to achieve functional parameters and sustainability in service products, a judicious analysis of the functional conditions highlight most accurate quantification of the nature and intensity of demands is now an essential condition in the design of parts. The correlation of the surface functionality of the parts (provided by an appropriate choice of the method to ensure properties) with requests from its operation in a defined environment is a key factor in surface engineering [1]. Superficial heat treatments are procedures that can contribute to achieving success and improving surface properties, the base material (core or substrate) does not hold. These properties are obtained by structural or chemical structural modifications (thermo chemical treatments) in superficial layer of the work piece and/or by depositing a coating (Fig. 2).

***Fig. 1***. *Steel parts whose surface properties can be improved by different methods [9.10]*

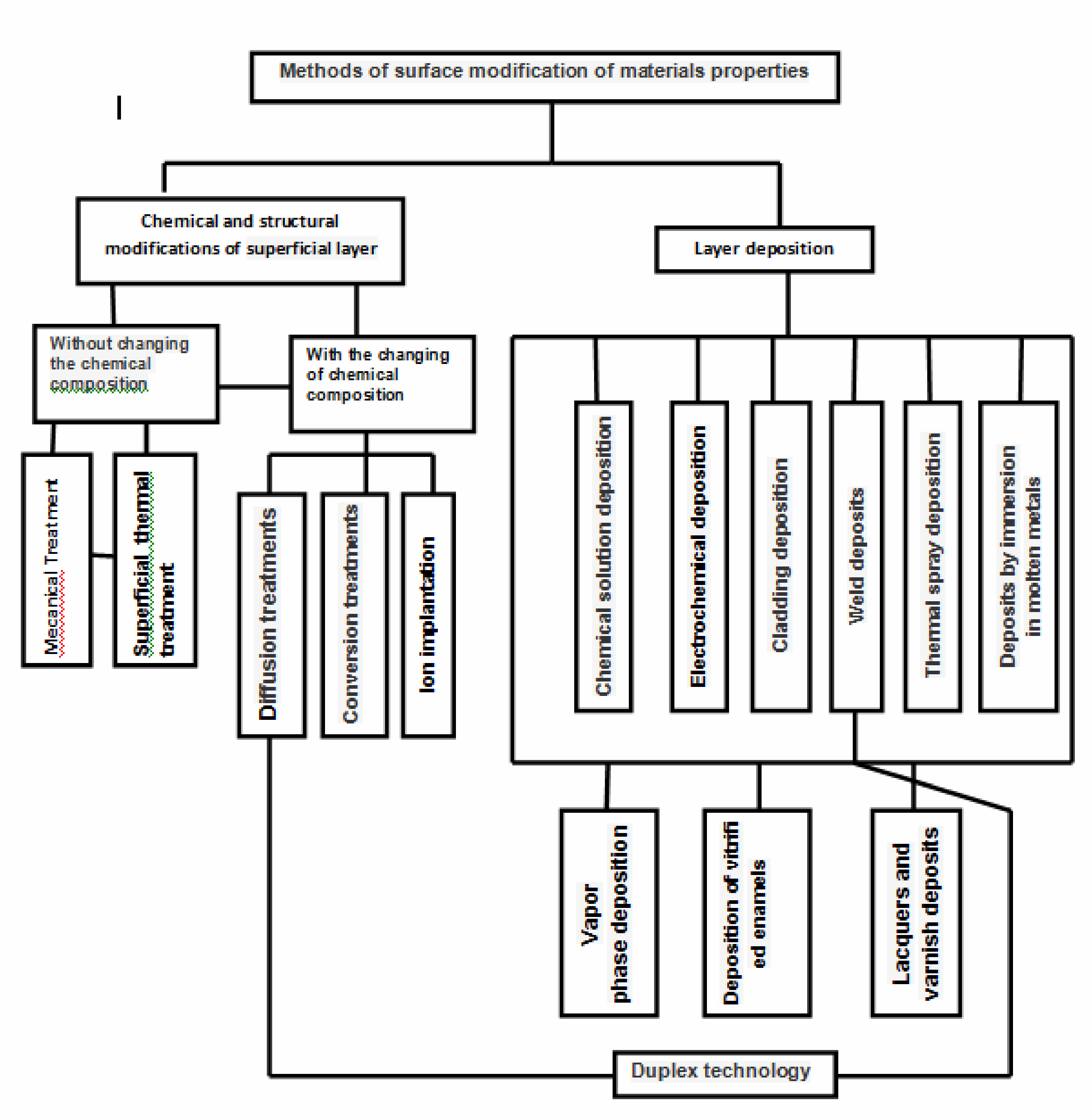


***Fig 2.*** *Classification methods amending superficial properties of materials [1]*

Traditional treatments and therapies thermochemical surface hardening are still the main ways of improving surface properties of the parts, especially the resistance to wear and fatigue.

The development of thermochemical treatments, especially of those made in vacuum and plasma, lead to a more rigorous control of the depth and properties of the modified layer, increasing productivity and reducing adverse environmental effects.

## 2. Experimental conditions

Experimental investigations were performed on samples of steels to improve the quality of 41MoCr11 OLC45, to which different thermal or thermochemical treatments were applied in order to observe structural changes and properties.

The chemical composition of steel qualities is presented in Table 1. Further, in some samples were tested regimens surface tempering with heating currents of high frequency plasma nitrating regimes and specialized equipment.

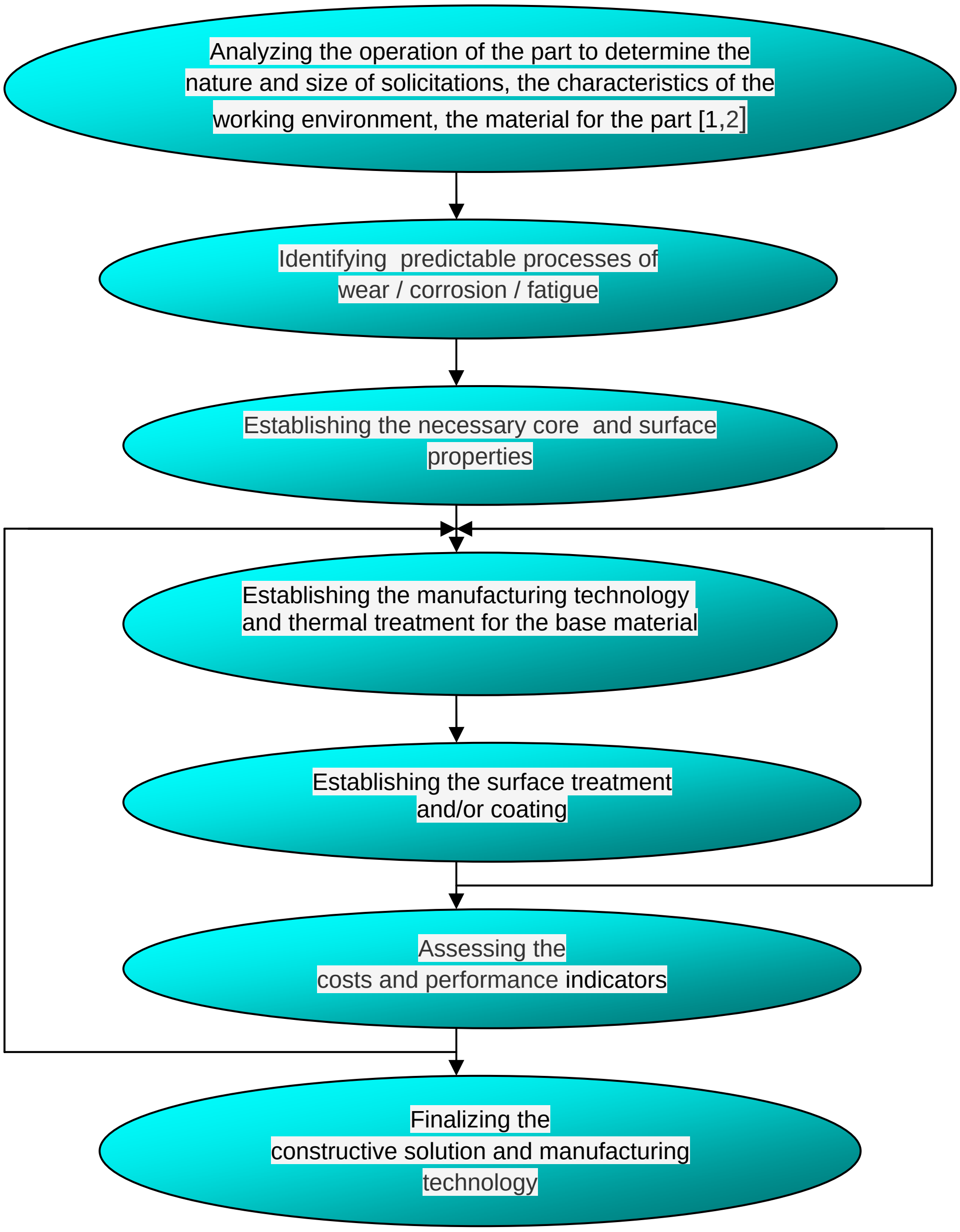


***Fig. 3***. *Sequences of a the product design of a given part [9.10]*

## 2. Experimental conditions

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***Table 1***. *Chemical composition of samples*, %

| Steel quality | C | Mn | Si | S | P | Cr | Mo |
|---|---|---|---|---|---|---|---|
| OLC45 | 0.42-0.50 | 0.50-0.80 | 0.17- 0.37 | 0.020-0.45 | max. 0.04 | - | - |
| 41MoCr11 | 0.38-0.45 | 0.60-0.90 | 0.17- 0.37 | max. 0.035 | max. 0.035 | 0.90- 1.20 | 0.15- 0.30 |

There have been conducted experiments on determining the optimal process parameters to improve heat treatment (quenching and high tempering Fig. 4 followed by surface treatments. Further, in some samples were tested regimens surface tempering with heating currents of high frequency plasma nitrating regimes and the specialized equipment.

***Table 2.*** *Experimental heat treatment regimes in volume (41MoCr11)*

| Sample/ experimental regime | Hardening temperature [$^0$C] | Cooling environment | Comeback Temperature [$^0$C] | Cooling environment | HB |
|---|---|---|---|---|---|
| 1 | 840 | oil | 200 | air | 381.2 |
| 2 | 840 | oil | 250 | air | 369 |
| 3 | 840 | oil | 300 | air | 341 |
| 4 | 840 | oil | 350 | air | 300.2 |
| 5 | 840 | oil | 400 | air | 288.6 |
| 6 | 840 | oil | 450 | air | 335.5 |
| 7 | 840 | oil | 500 | air | 269.6 |
| 8 | 840 | oil | 550 | air | 250.6 |
| 9 | 840 | oil | 600 | air | 253 |
| 10 | 840 | oil | 650 | air | 204.55 |
| 11 | 880 | oil | 200 | air | 358.8 |
| 12 | 880 | oil | 350 | air | 375.6 |
| 13 | 880 | oil | 500 | air | 299.6 |
| 14 | 880 | oil | 650 | air | 215.8 |
| 15 | 850 | air | - | - | 217 |

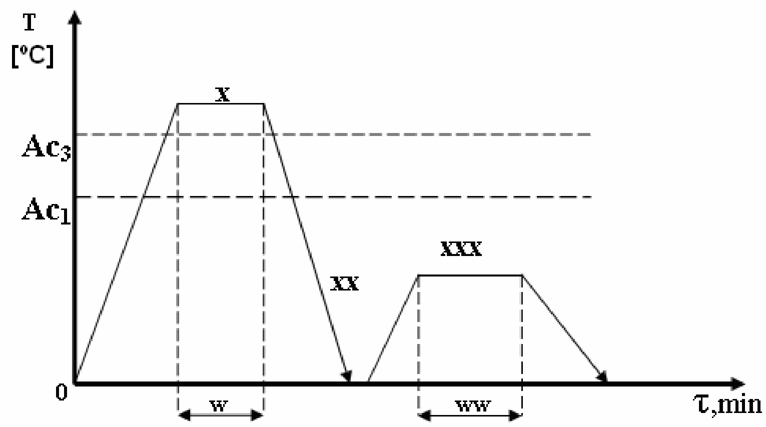



***Fig. 4.*** *Experimental heat treatment regimes for determining optimal parameters of improvement. Annealing temperature X: XX-Cooling medium: XXX-temperature recovery: W term maintenance the annealing temperature (2min/mm) ww-temperature maintenance during recovery*

a

b

***Fig. 5.*** *Experimental equipment*
*a). Ion nitriding facility, b). Installation for high frequency heating quenching CIF)*

The thermochemical nitriding treatment was performed in gas dissociate demonian, by heating to 550$^{o}$C and maintaining 1 the ion nitrating for 16 hours in a special facility (in Arcelor Mittal SA, Figure 5).

Further experiments aimed at establishing the correlation between the structural state of the core due to the heating treatment (by volume) and the method of surface treatment to achieve maximum efficiency in the design of the improved steel to parts.

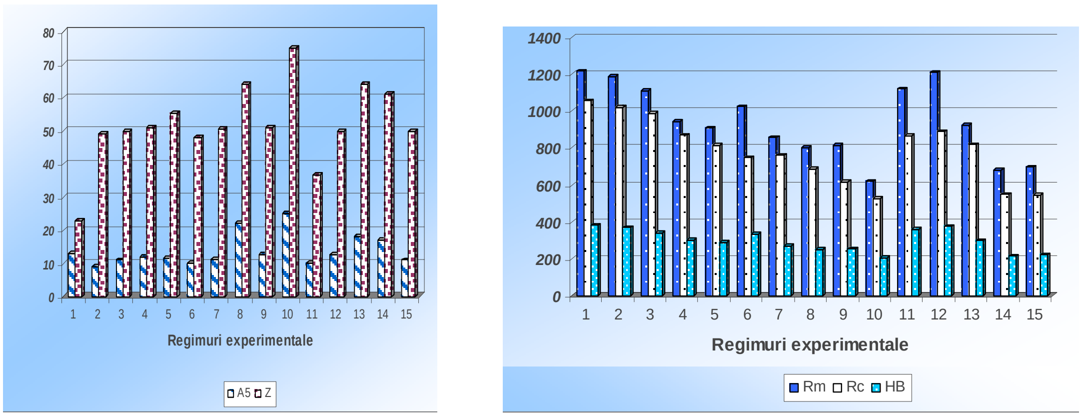
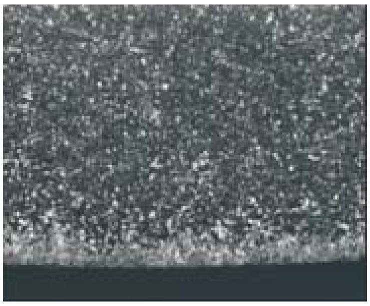


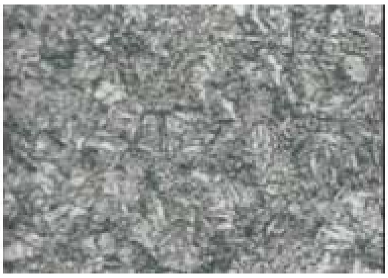

***Fig. 6**. Mechanical properties of 41MoCr11 steel samples*

***Microstructural aspects. X100, 2% natal attack***

*Core*



*Nitrided layer*



*Center hardness: 329 HV*

*Middle layer hardness: 412 HV, 516 HV, 549 HV*

***Microstructure feature layer***

*Layer hardness: 713 HV, 739 HV, 745 HV*

## 4. Conclusions

This paper presents the study of the new approach in designing optimal surface engineering technologies, but is also part of the research results on some superficial heat treatments applied to improve steel parts. Experimental results illustrate the influence of the main technological parameters specific surface heating with high frequency currents of nitride ion on the properties of the surface layer of steel parts of the improvement. Moreover, experimental results allowed conclusions on the optimum processing volume to obtain optimal characteristics in all the parts by applying light heat processing methods.

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