SURFACE HARDENING OF 40Cr10 STEEL AFTER SHORT TIME NITRIDING IN FLUIDIZED BED

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ABSTRACT

The paper is based by nitriding in fluidized bed experiments over laboratory plant. Fluidization applications are characterized by high values of mass and heat transfer coefficients. For experiments were used 40Cr10 (Romanian standard) steel specimens. The fluidization and nitriding processes are simultaneously. The results of experiments were investigated by micrograph, hardness and XRD. Micro Vickers investigated micro hardness profiles in section.

KEYWORDS: nitriding, thermochemical treatment, steel

1. Introduction

Fluidized bed is dispersing media (granular solid/gas or granular solid/liquid) that working in a close or open space. Fluid flow having usually an ascending passes 0 0. Relative moving of solid granular and very large exchange relative surface giving all important properties of this media: high values of mass and heat transfer coefficient, high temperature uniformity, high thermal mobility

For majority application of fluidized bed in technologies a solid granular /gas is used.

The complex disperse system is usually depending by two independent phases:

- a continues phase that is formed by granular solid uniform dispersed in a gas
- a dilute phase that appears in anomaly functional stages that represent fine suspension that floating in gas (bubble stage).

Fluidization applications (FBT) in surface engineering (and particularly in heat and thermochemical treatments) are depending by correct functionally of fluidization for resulting global favorable properties 0. A classical application is patented stage for steels wire technology, where fluidized bed is a viable media that changes classical melting lead bath 0. High temperature uniformity and the non-polluting media are the important properties for FBT applications 0. High values for mass and heat transfer coefficient are usually recorded by short time for heat and thermochemical processes, 0.

2. Experimental conditions

Some particularities and limits are important when fluidized beds are used:

- open furnace reducing total time treatments by decreasing time for heating and cooling
- open furnace conduce to simple installation concepts and working procedures with advantage in structure and properties of materials
- combustible gases (hydrogen, rests of ammonia) are burned in air and result normal gasses (water vapour)

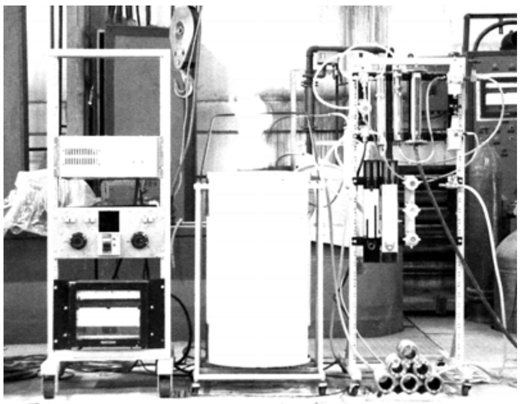

Fig. 1. *Fluidized bed furnace for thermochemical treatments*

For fluidized bed nitriding some functional characteristics are important:

- active nitriding media are functionally identical with fluidization bed

- all basic properties of fluidisation phenomenon having influence over nitruidig processes
- ammonia are source of nitrogen atoms for nitriding

Tab. 1. *Experimental nitriding in fluidized bed regimes.*

Exp.no.	Chemical composition of gas mixture	nitriding temperature	nitriding time
m.u.	%	°C	h
1			1
2		520	2
3			3
4			1
5	33%NH_3+67%N_2	550	2
6			3
7			1
8		580	2
9			3

In Fig. 1 and in

Tab. **1**, are showing fluidized bed furnace and experimental regimes.

Because nitriding is a final treatment, 40Cr10 steel samples has all anterior heat treatments (quenching and tempering) 0. Solid dimension was 0,10…0,16mm, 0. All anterior nitriding in fluidized bed regimes show 00 three groups of influence factors over nitriding process and finally over nitriding structures and properties for layer:

- nitriding factors (nitriding temperature, nitriding time, and nitrogen media activity)
- materials factors (chemical compositions, dimension and shape pieces, surface quality, etc.)
- nitriding media factors (chemical activity, heat and mass transfer coefficients, toxicity, environment impact, etc.)

3. Results and discussions

Metallographic analysis showed that after nitriding in fluidized bed for different experimental conditions the specific layer was formed (

Fig. 2).

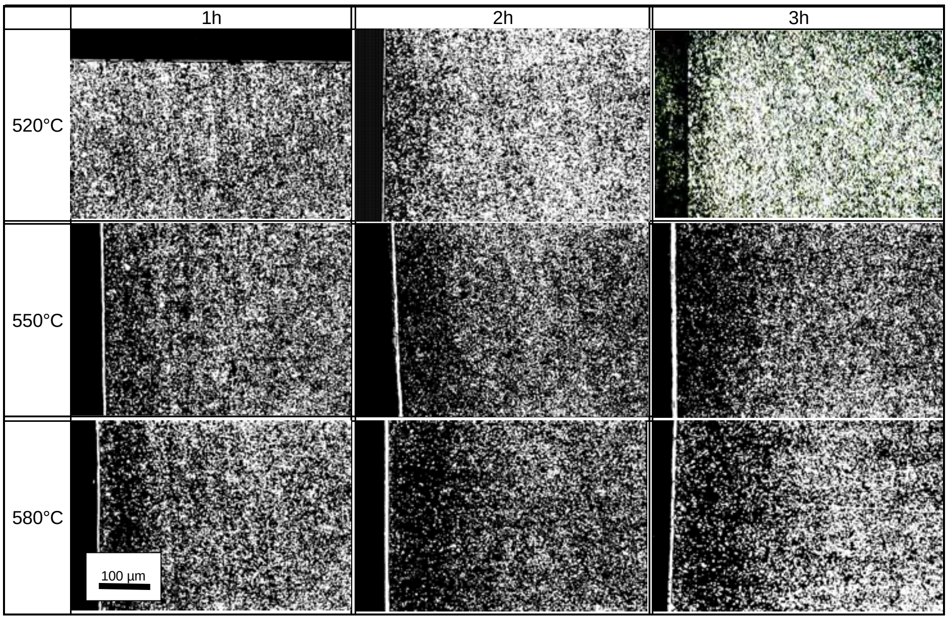

Fig. 2. *Microstructures for 40Cr10 steel specimens after fluidized bed nitriding (etching: nital 2%).*

After etching of all specimens with nital diffusion layer the diffusion zone was formed for all experimental regimes.

Combinations layer (ε+γ') was formed in correlations with high temperature and long time for these treatments. For temperature range 520...580°C the dependence of the total thickness with the process time having a parabolic dependence with nitriding time (Fig. 3). Hardness on the nitride surface of each specimen was measured by Vickers method (MPP-2 with load 5daN). The results are showed in Fig. 4. For all regimes hardness increasing and a maximum values of hardness (HV_5) was obtaining at 550 and 580°C (520...700 daN/mm^2). A parabolic profile of hardness is present.

Measurement of micro hardness (fig) over the thickness of the nitrided layer is usual investigation method for study hardness profile from surface to core of the each specimen. Micro Vickers $HV_{0,05}$ method was used (PMT-3 with load 0.05daN).

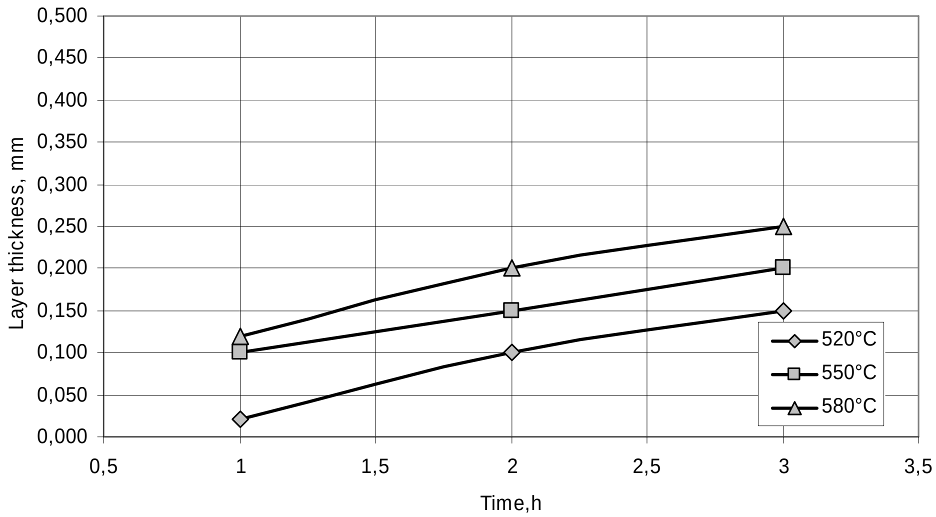

Fig. 3. *Total layer depth for 40Cr10 steel specimens after fluidized bed nitriding and for different temperature.*

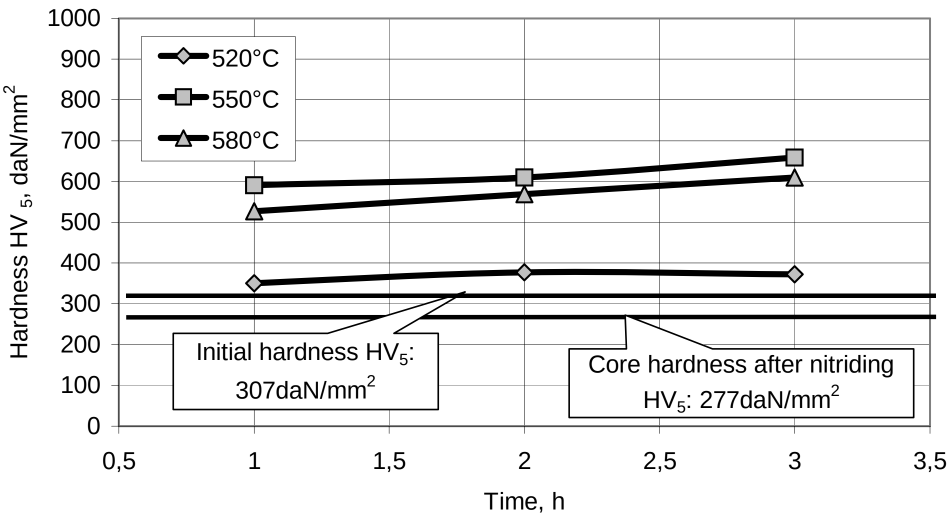

Fig. 4. *Hardness HV_5 over 40Cr10 steel specimens surface after fluidized bed nitriding.*

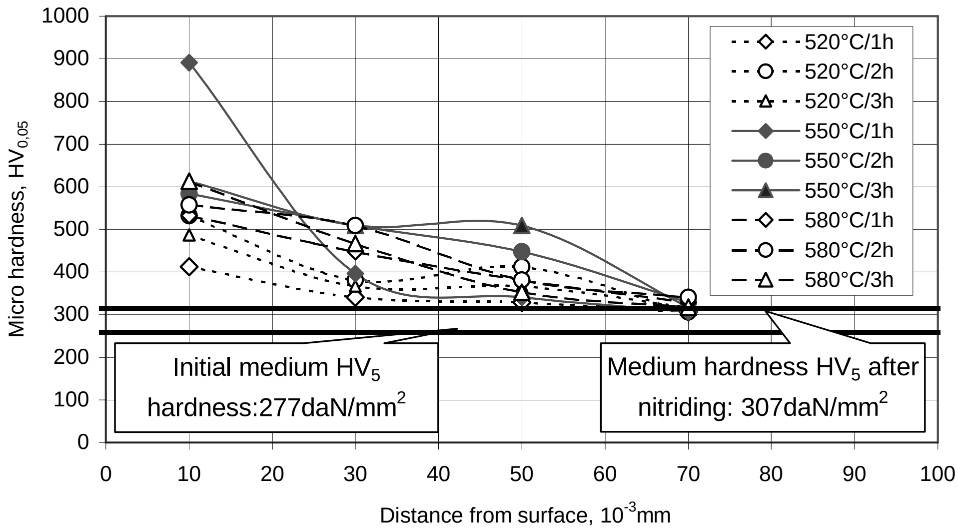

***Fig. 5.** Micro hardness $HV_{0,05}$ for 40Cr10 specimens after fluidized bed nitriding..*

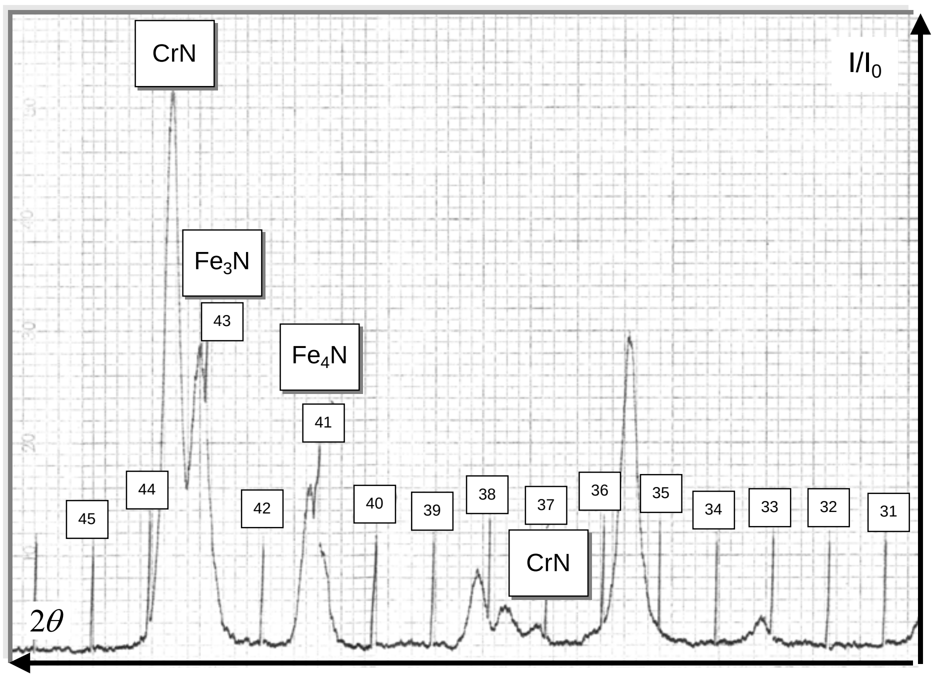

***Fig. 6.** Difractogramm for 40Cr10 steel specimens after nitriding in fluidized bed (550°C/3h)*

The measurement results are showed in Fig. 5. Nitrided layer depth obtaining by micro hardness measurements showing:

- 50µm at 550°C temperature a maximum values is obtaining for 3h maintaining
- 70…75µm for 3h maximum titriding time (3h) at 550/580°C nitriding temperature.

XRD measurements (DRON 3.0, Bragg-Bentano method, 30kV and 24mA) showed that the iron and chrome nitride with specific structure were formed (Fe_4N, Fe_2N, CrN). In Fig. 6 is showing difractogramm for 550°C nitriding temperature and 3h nitriding time.

4. Conclusions

Fluidized bed is recognized that active media for thermochemical treatments characterized by high values for mass and heat transfer coefficients 0. For that total time of processes are reduced with maintaining the result values for superficial structures and properties.

For all nitriding experimental regimes was obtained nitriding layers and structure and superficial properties is in direct depending with values of experimental factors.

- The maximum values for hardness was obtaining for 550 and 580°C temperatures
- Hardness increasing can be associated with carbon and chrome contents of steel
- Microstructure and XRD are direct correlated with surface HV_5 hardness and micro hardness $HV_{0,05}$ profile for each regime
- Nitrogen desorbtion are eluded by rapid cooling after treatment

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