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RESEARCH ON THE DISPOSAL OF HYDROGEN CONTENT FROM THE STEEL DESIGNED FOR MANUFACTURING STEEL PIPES

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Abstract: The paper presents the results of the research conducted in order to reduce the hydrogen content from the steel designed for manufacturing pipes used to transport oil. The steel was produced in an electric arc furnace, type E.B.T. (Eccentric Bottom Tapping) 100t capacity, treated in L.F. (Ladle - Furnace) plants and V.D. (Vacuum -Degassing). In L.F. plants takes place a process of desulfurization and deoxidation with synthetic slag and steel heating plant for processing in vacuum without heat input (V.D.). This research was particularly aimed at explaining the influence of vacuuming parameters (during vacuuming, pressure vacuum system, and temperature of steel) over the hydrogen removal efficiency and hydrogen final content. The obtained data was processed in Excel program, the obtained correlations were analyzed from a technological standpoint and consequently the vacuum optimum parameters were established.
Keywords: Steel pipes, hydrogen content, electric arc furnace, E.B.T. (Eccentric Bottom Tapping), L.F. (Ladle-Furnace), V.D. (Vacuum-Degassing)

INTRODUCTION

Hydrogen and nitrogen are impurities for steel products, but their negative influence is manifested especially in steel.

The negative influence of the hydrogen is manifested by the fact that:

≡ is one of the causes of sulphides in ingots and calmed steel castings;
≡ contribute to the occurrence of the defect called "flakes" (very small cracks) in steels alloyed with chromium and nickel, which substantially reduces fatigue strength of steel parts;
≡ decreases the elasticity and toughness of the steel;
≡ affects the electrical and magnetic properties of steels.

The primary sources of hydrogen are air and moisture.

In steel making processes, hydrogen comes from:

≡ metallic and nonmetallic cargo (iron cargo, scrap iron cargo, mining cargo, limestone cargo, chalkstone cargo etc.);
≡ the aggregate development atmosphere (air, fuel combustion products, oxygen blew in steel etc);
≡ ferroalloys used for the deoxidation and alloyage of steel.

To prevent the ingress of hydrogen in the steel is indicated to be taken a number of technological measures from raw and auxiliary materials, such as:

≡ to not be used in the cargo scrap iron with oil remnants or rust;
≡ the burned limestone should be as fresh as possible, and, unless has its own limestone factory, the limestone transport has to be carried out in closed containers;
≡ the iron ore has to be calcinated;
≡ calcinated ferroalloys used for deoxidation and alloying.

During the decarburization of the metal bath, a part of the hydrogen is eliminated by the carbon monoxide bubbles. Decarburization speed compliance provided in the technological instructions reduces the hydrogen absorbtion in the steel bath. Currently, in most steel mills, to intensify the elimination of hydrogen, bubbling with argon method is used in L.F. facilities and when prompted very low hydrogen contents it is used the treatment of steel under vacuum (desirable for at least 15 min. under high vacuum).The processing parameters in the casting ladle shows a particular importance in order to reduce the gas content in the steel.

THE STUDY PROBLEM

Oil industry requests high quality steel for manufacturing the steel pipes that carries oil, resistant to corrosive oil components, the external environment acting on pipelines, the temperature variations, etc.

In what concerns the quality of the steel, one of the factors influencing the behavior of steel in use is the hydrogen content that exists in the steel, respectively in the finished product (rolled pipe).

For this research we watched the process of steel making in an electric arc furnace, type E.B.T. (Eccentric Bottom Tapping) 100t capacity, treated in L.F. (Ladle - Furnace) and V.D. (Vacuum -Degassing) facilities. In the L.F. facility a process of desulfurization and deoxidation takes place with synthetic slag as well as heating the steel in order to be processed in the vacuum plants without heat input (V.D.).

This research was particularly aimed at explaining the influence of the vacuuming parameters (during vacuuming, pressure vacuum system, and temperature of steel) over the hydrogen removal efficiency and hydrogen final content. 35 charges of were followed and after analyzing the parameters values due to technological deviations, 30 charges was selected. All the obtained data was processed in Excel program.

DATA INTERPRETATION

After processing the data, correlations between vacuuming parameters were obtained, considered independent parameters and dependent parameters, hydrogen removal efficiency and final hydrogen content. The correlations are expressed by polynomial functions of grade II and III, exponential and logarithmic, analyzed from a technological point of view and based on those data the optimal vacuum parameters were established.

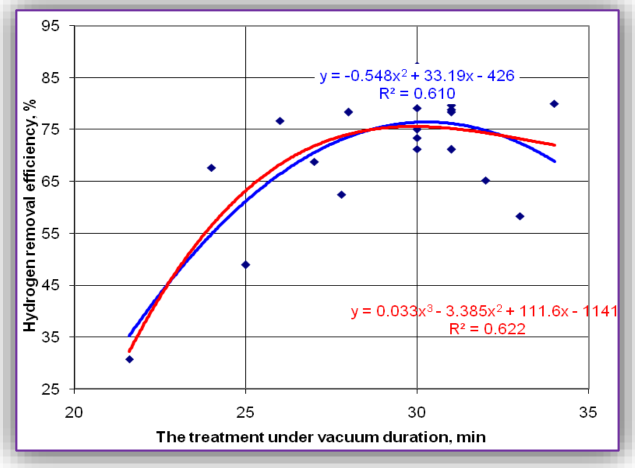

Figure 1. Hydrogen removal efficiency depending on the treatment under vacuum duration

From the graphical representation shown in Figure 1 it appears that with increasing duration of vacuum, hydrogen removal efficiency increases. Once the duration of the vacuum switch 30 min, the hydrogen removal efficiency begins to decrease slightly. Technologically this increase is explained by the fact that in these circumstances there is appropriate time for the hydrogen diffusion from the steel bath in an argon bubbles and thus to the vacuum atmosphere. Within 30-34 minutes there is a slight decrease in the hydrogen removal efficiency, due to lower rate of hydrogen diffusion caused by lowering the temperature. It can be considered that treatment durations of 30-34 minutes are great.

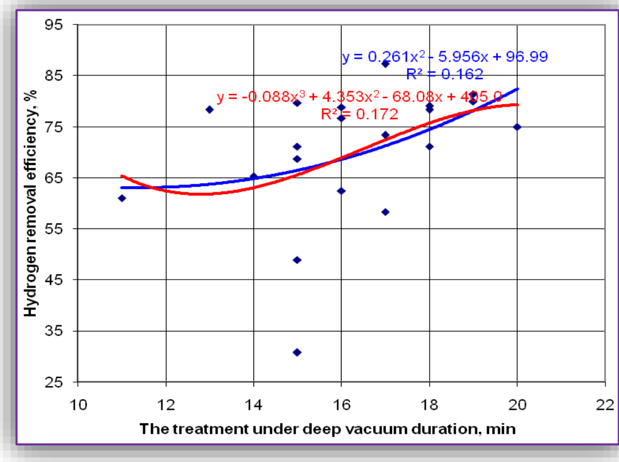

Figure 2. Hydrogen removal efficiency depending on the treatment under deep vacuum duration

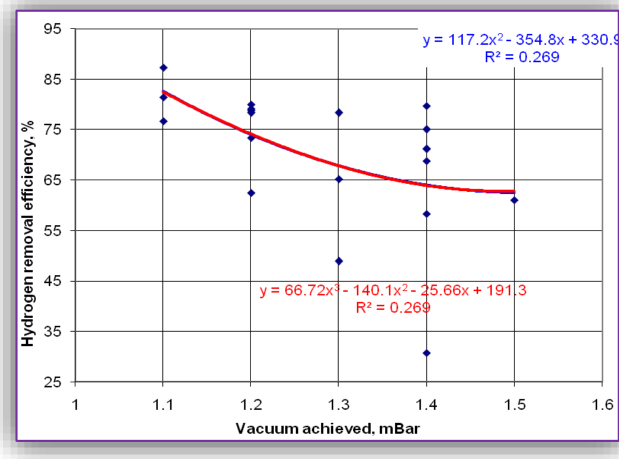

Figure 3. Hydrogen removal efficiency based upon the vacuum achieved

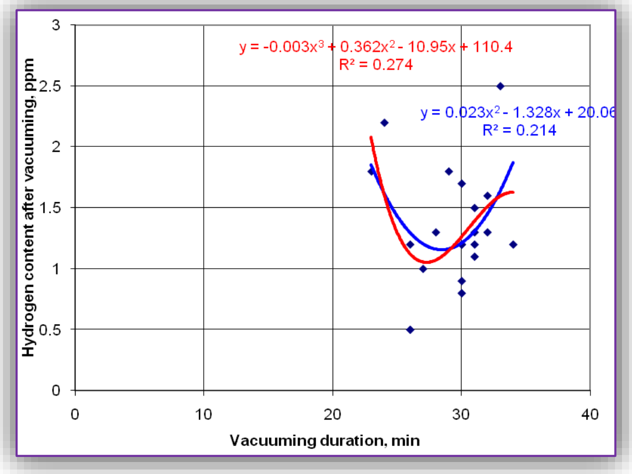

Figure 4. Hydrogen content after vacuuming depending on the vacuuming duration

Figure 2 notes that increasing duration of treatment under deep vacuum (advanced) leads to increased hydrogen removal efficiency. Technologically this is explained by the fact that there is an increase of the hydrogen diffusion speed, dependent on the hydrogen partial pressure from the system. Decreasing the total pressure above the metal bath (from vacuum space) clearly decreases the hydrogen partial pressure. At a vacuum of 30-34 minutes duration, treatment duration under deep vacuum of 18-20 minutes is representative.

Analyzing the graphical representation in Figure 3, it can be noted the treatment under high vacuum efficiency, resulting in increasing the efficiency of hydrogen removal. Therefore, under a vacuum of 1.1-1.2 mbar are obtained, for the efficiency of hydrogen removal, values within the range of 75-85%. Decreasing the pressure over the metal bath (in the vacuum system) also causes the decrease in the partial pressure of hydrogen, so it creates favorable conditions for reactivating the diffusion of hydrogen.

The technological analysis of the graph shown in Figure 4 shows that an increase in the duration of the treatment under vacuum, up to 26-30 minutes, leads to a reduction of hydrogen content from the liquid steel as a result of the favorable conditions (temperature, time) of degassing. If achieving high values for the treatment under vacuum duration, then the hydrogen content no longer decreases, on the contrary, it increases slightly due to lower bath temperature and the ingress of hydrogen from slag (the diffusion speed from slag in the bath is higher than the diffusion speed from bath to slag). The results shown are correlated very well with those shown in Figure 1.

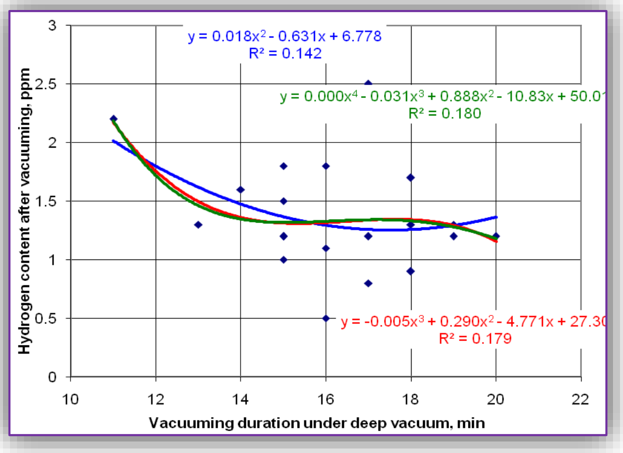

Figure 5. Hydrogen content after vacuuming based upon the vacuuming duration under deep vacuum

The results shown in Figure 5 confirm that the treatment under high vacuum leads to the reduction of hydrogen content from the metal bath. The treatment duration was up to 20 minutes, the decrease being intense until duration of 16 minutes, after which remains steady. The obtained results are correlated very well with those shown in Figure 2.

Analyzing the results shown in Figure 6 it can be noted an advanced reduction of hydrogen content from the metal bath to less than 1ppm. The results are correlated very well with those shown in Figure 3.

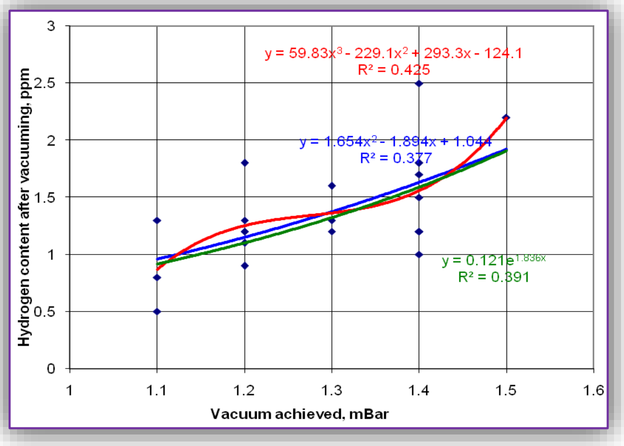

Figure 6. Hydrogen content after vacuuming based upon the vacuum achieved

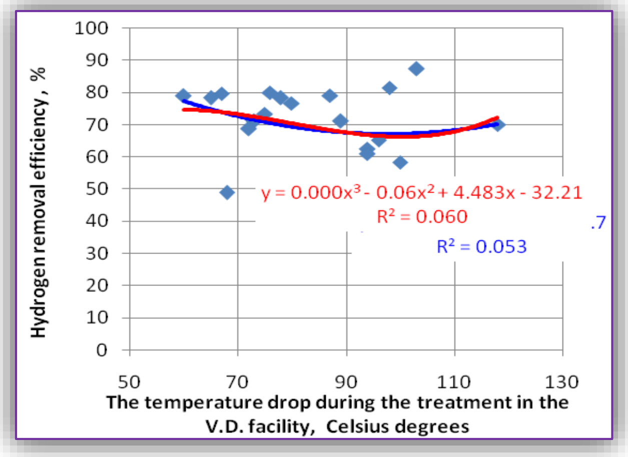

Figure 7. Hydrogen removal efficiency depending on the temperature drop during the treatment in the V.D. facility

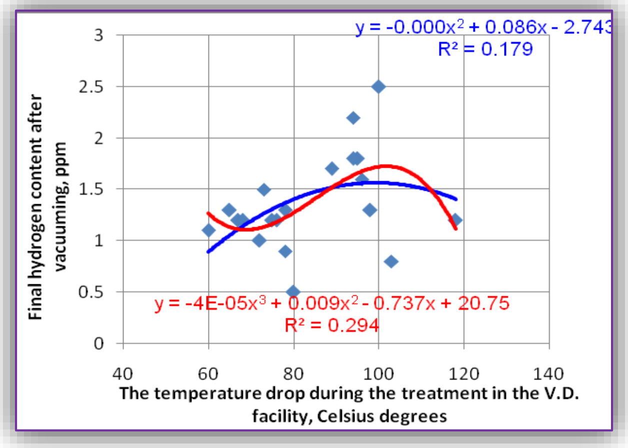

Figure 8. Final hydrogen content after vacuuming depending on the temperature drop during the treatment in the V.D. facility

Referring to Figure 7 and Figure 8 it is found that the values for steel temperature in the vacuum facility are suitable for quality standards imposed on steel pipes.

CONCLUSIONS

From the research made in the industrial phase one can conclude the following:

≡ The main parameters of vacuuming, the total duration, the duration under high vacuum and the vacuum pressure in the system, they all influence both the hydrogen removal efficiency, and the final hydrogen content;

≡ In the technological sense there is a very good correlation between the correlations obtained in EXCEL program relating to the hydrogen removal efficiency and the hydrogen content at the end of vacuuming;

≡ Through the treatment of liquid steel in the LF facility it is ensured a reduction of the sulfur and oxygen contents through the means of synthetic slags, and through vacuum treatment a reduction of the gas content, in particular less than 2.5 ppm hydrogen;

≡ The steel processing in L.F. facility ensures a good overheating of the steel so that the duration of vacuum treatment reaches 30-35 minutes and the high vacuum treatment reaches up to 20 minutes, thereby ensuring the appropriate time for the oxygen diffusion from the liquid steel in the argon bubbles under suitable conditions of heat;

≡ Significant influence over the content of hydrogen at the end of the treatment has a very low pressure achieved in the vacuum facility (1,1mBar);

≡ Due to steel overheating in L.F. facility the treatment duration under vacuum can be increased up to 30 -34 minutes, compared to 18 -20 minutes without the L.F. facility.

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