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BEHAVIOR OF A537 STEEL GRADE IN CARBURIZING IN FLUIDIZED BED WITH ENDOTHERMIC ATMOSPHERE

Sorin Dobrovici, Nelu CAZACU
Dept.of Metallurgy and Materials Science, „Dunarea de Jos" University of Galati
Sorin.Dobrovici@ugal.ro, Nelu.Cazacu@ugal.ro

ABSTRACT

Fluidized bed allows one to easily change from the chemical composition of the working atmosphere. The paper is based on experiments of carburizing in fluidized bed with endothermic atmosphere made from gases resulting from decomposition of the initial air-methane mixture. Samples made from A537 steel (HSLA class) are subjected to carburizing experiments. Samples were tempered at 860°C in water and then were tempering to 180°C. The results were investigated by hardness test and metallographic analysis and showing influence of the the air/methane ratio over structures and properties of A537 steel grade.

KEYWORDS: HSLA steel, carburizing, fluidized bed, endothermic atmosphere

1. Introduction

In gas carburizing applications, endothermic atmosphere is prepared in an adjacent facility (endo generator) carburizing oven, and inserted after preparation in a working space to avoid oxidation reactions decarburizing at a temperature treatment:

$$2CO = C + CO_2 \quad (1)$$

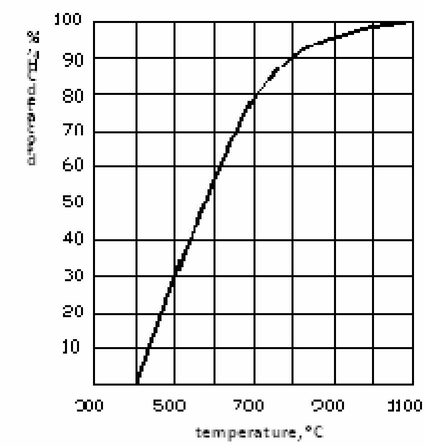

Fig. 1. *Dissociation curve of methane gas with temperature [4].*

Usually, endothermic atmospheres are obtained using specialized equipment (endothermic generators) by the contact of hydrocarbon gases and air in certain conditions of temperature, pressure and maintaining a certain ratio air/hydrocarbon gas.

As a gaseous hydrocarbon, usually uses a gas stream, containing over 95% methane, and are introduced simultaneously with a precise air flow in an indirectly heated reactors (electric or gas fired) at temperature 980 ... 1010 º C.
Reaction occurs partial combustion of methane with oxygen available:

$$2CH_4 + O_2 \rightarrow 2CO + 4H_2 \quad (2)$$

Practically, this reaction follows two stages:

-first, a part of the methane burns in O_2 found after heat-generating reaction, the formation of $C0_2$ and H_20 (vapor) and then

-reacts with $C0_2$ in CH_4 and H_20 (vapor), endothermic. So to ensure that the amount of CH_4 to react and that % $C0_2$ and % H_20 (vapor) to be as small as is necessary to maintain the reaction temperature. Also accelerating reactions may be using a pure Ni porous catalyst. It considers the reaction CH_4 ending residual 0,4-0,8%.

If the temperature is not sufficient dissociation of methane gas and C is deposited form of carbon black including the catalyst reducing its chemical activity. Chemical composition, in this case is amended unfavorable increase% CH_4,% CO increase,% H_20 increases. Methane gas in large quantities in non-differentiated penetrate heat treatment furnace and decomposition here, also with adverse effects. Catalyst purity is very important to adjust the dew point. (% H_20) and carbon potential. NiO catalyst is used on a porous refractory support.

Molar is considered the main reaction:

$$2CH_4 + O_2 + 3{,}8N_2 \rightarrow CO + 4H_2 + 3{,}8N_2 \quad (3)$$

That reaction out a greater number of gas moles than in (at atmospheric pressure and temperature regime). If natural gas is then 100% CH_4 resulting 1.44 times more gas. The chemical composition of the mixture is 20.4% CO, 40.8% H_2, 38.8% N_2. Of the equation we see that for every 2 moles 4.8 moles of CH_4 are needed air. So the ratio air/gas is 2.4.

Active media for direct carburizing was conducted in two phases in a fluidized bed. Methane molecules in contact with the granular solid is found at high temperatures and their thermal dissociation. Rest of methane through the fluidized bed and is important for carburizing. They come into contact with the surface samples (parts) through adsorption phenomena and generate activated carbon in the "steel-CH_4-H_2" system. For all reactions are formed H_2 and it is the agent of streamlining the carburizing temperature. Gas mixture has a large expansion at this temperature carburizing is instrumental in lowering costs. Specific movements of the solid granular to be useful to remove the amorphous carbon deposition on technologies carburizing in an atmosphere of endothermic gas atmosphere is a major concern for solving complex systems that are necessary to control the chemical composition and carbon potential. Amorphous carbon particles are driven to the top of the oven which burn in contact with atmospheric oxygen. Taking into account the effect of gas expansion at increasing temperature fluidization conditions are obtained at lower overall costs.

2. Experimental conditions

Endothermic atmospheres for use in heat treatment in the fluidized bed to meet basically two situations:

• classic situation of production outside endothermic atmosphere, water retention and then use that carry air

• Producing an endothermic atmosphere directly in the working space for streamlining to reduce gas consumption to streamline and control carburizing by adding hydrocarbon.

Experiments were conducted on an a furnace for carburizing with fluidized bed. The system used for experiments has three parts: a fluidized bed furnace, system for temperature control and gas supply system. Heating method was used for external power but it is possible to use other methods. Samples were taken from the A537. The chemical composition of samples is shown in table 1. Samples were cylindrical shape with 5mm thickness and 15 ... 25mm diameter. The samples were placed in the center of the workspace (fluidized bed) with the aid of a settlement. In Table 2 are shown the carburizing heat treatment regimes tested. Were modified by carburizing temperature and time. Fluidization velocity was constant and corresponds to a rate of 0.2 l/h-gas mixture. Flow was measured with a rotameter. Avoiding an atmosphere very rich in active carbon atoms as a result of high amounts of hydrocarbon that dissociates on the surface parts (black), all adverse effects on the carburizing process, leading to the need to use a carrier gas to participate in the transfer heat but to activized mass transfer.

Endothermic atmosphere is enriched with CH_4 agent of streamlining the sand particles (upper furnaces). In this area is made a fluidized bed which in the circumstances and based on data from major advantages in terms of fluidized bed, uniformity of temperature and global heat exchange coefficients and mass. Theory in this area phenomena release active carbon atoms, adsorption on the surface of activated parts are extra. The movement of particles within a fluid fluidized bed to frequent contacts with the play area which may lead to deplete the carbon black that can form in conditions in which the process is conducted improperly.

Table 1. *Chemical compositions of A537steel grade samples.*

State	C	Mn	P	S	Al
Liquid	0,18	1,31	0,31	0,02	0,03
Solid	0,2	0,31	0,23	0,02	-

Critical point values: Ac1 = 695ºC; Ac3 = 811ºC; Ms = 396ºC; Mf = 146...166ºC.

Usual thickness 9,6; 20,6; 25,4; 38 mm

Table 2. *Experimental regimes and hardness results*

Experiment	Carburizing temperature	Carburizing time	air/methane ratio	Hardness HV_5
um	°C	min	-	daN/mm^2
1	880	10	0	780
2	880	20	0	985
3	880	30	0	244
4	880	10	1	353
5	880	20	1	473
6	880	30	1	274
7	880	10	2	341
8	880	20	2	241
9	880	30	2	268
10	920	10	0	780
11	920	20	0	965
12	920	30	0	644
13	920	10	1	874
14	920	20	1	946
15	920	30	1	509
16	920	10	2	367
17	920	20	2	666
18	920	30	2	909
19	960	10	0	891
20	960	20	0	1006
21	960	30	0	909
22	960	10	1	299
23	960	20	1	396
24	960	30	1	306
25	960	10	2	473
26	960	20	2	524
27	960	30	2	566
			Initial hardness	341

After carburizing samples were successively treated by hardening and tempering. Quenching was performed at 860 °C in water, and tempering to a temperature of 180 ° C.

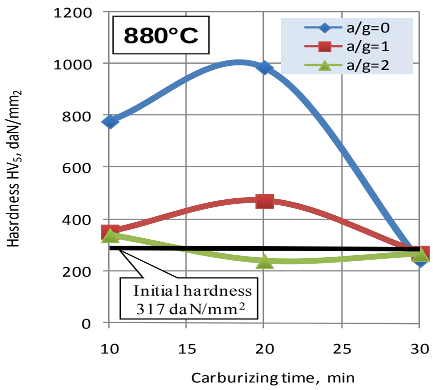

***Fig.2**. Influence of duration on the final hardness of steel samples A537 after carburizing in fluidized bed at 880 °*

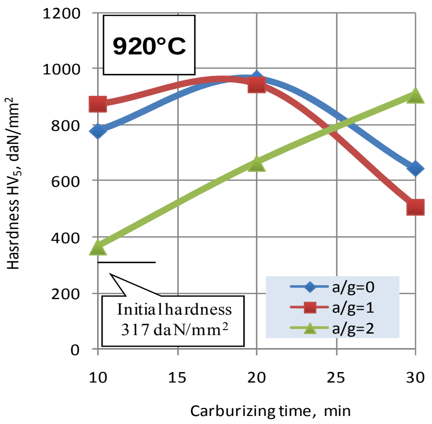

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***Fig.3**. Influence of duration on the final hardness of steel samples A537 after carburizing in fluidized bed at 920°C*

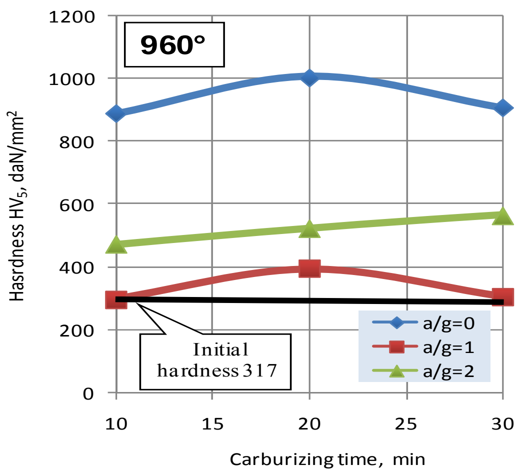

***Fig.4**. Influence of duration on the final hardness of steel samples A537 after carburizing in fluidized bed at 960°C*

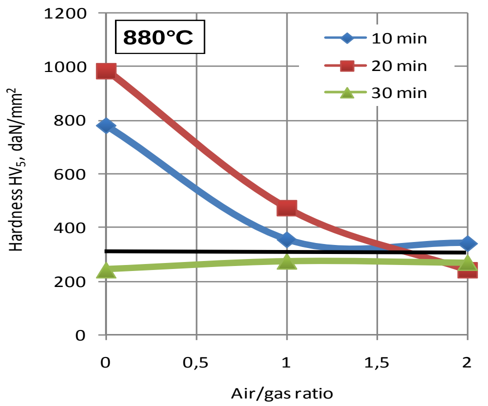

***Fig.5**. Air/gas ratio influence on the final hardness of steel samples A537 after carburizing in fluidized bed at 880 °C*

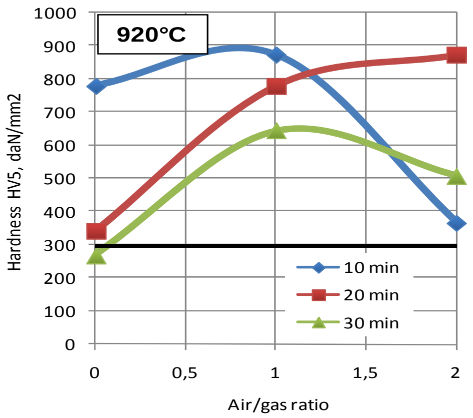

***Fig.6**. Air/gas ratio influence on the final hardness of steel samples A537 after carburizing in fluidized bed at 920°C*

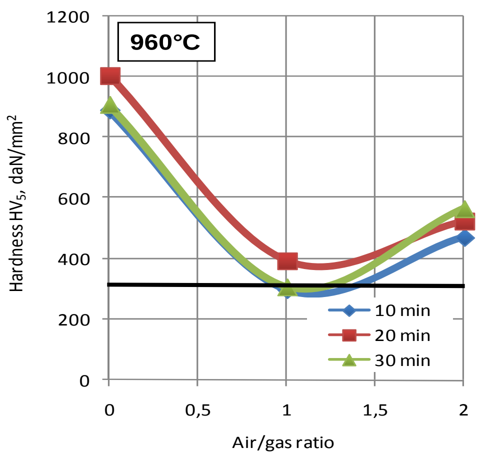

***Fig.7**. Air/gas ratio influence on the final hardness of A537 steel samples after carburizing in fluidized bed at 960°C*

3. Results and discussion

Final hardness variation is shown in Figures 2 ... 4. to emphasize the influence of duration of time on carburizing. Remarkable low carburizing times are chosen according to environmental performance as vigorous fluidized bed mass and energy transfer coefficients. There is a time of 20min for maintaining the trend to maximize the hardness and decreased with increasing the hardness ratio air/gas, which is consistent with significant changes of chemical atmosphere composition in the working space.

A similar situation happens in the other two temperatures used in the experiment, namely 920 °C and 960 ºC, in a report that air/gas = 0 provide the carburizing working atmosphere. In this situation carburization is made of waste methane gas through a fluid layer by thermal decomposition phase homogeneous contact of hot granules. Figures 4 ... 6 are useful in interpreting the influence of gas-air ratio on the process of carburizing and the structure and properties of A537 samples. A report air / gas = 0 leads to the higher surface carburizing at higher costs. Ratio air / gas =1 at 920 °C provides the final hardness values of the best, which is close to normal temperatures in the carburizing layer structure depending on the diffusion of carbon in the material structure. Carburizing processes are negatively affected by increasing ratio air/gas at 2, due to strong decreasing of carbon potential.

4. Conclusions

Carburizing process proposed takeover seeks favorable elements in carburizing atmosphere of endothermic and fluidized beds. Endothermic atmosphere separately produced in the vicinity of the carburizing furnace is expensive and increases the costs of treatment.

Creating directly into the furnace, endothermic atmosphere is a far less expensive and if controlled oxidizing effect of water vapor can achieve the following objectives: optimal fluidization with a mixture of cheap gas (air + methane) which contain hydrocarbon components in a proportion large enough to achieve carburization

Since the potential of carbon is difficult and expensive to measure process can be based on the repeatability and process control through its effects. It can carry out real-time chemical gas composition results that can highlight both carrying chemical reactions and their kinetics.

Mainly, the carbon potential of the fluid layer can be changed by adjusting the addition of methane in the fluidization chamber. Fluidized bed has one most important property: by continuous movement of bed, solid particles have frequently contacts with surface parts and that phenomenon prevent black amorphous carbon deposition and carburizing process inhibition.

Surface mechanical properties are significantly modified by thermal treatment application successive carburizing, hardening and recovery. Surface hardness is the main method of investigation of mechanical properties and is strongly influenced by air/gas ratio...

It is even possible that the vertical kinetics of chemical reactions to be changing by changing chemical composition of the atmosphere. The resulting gases have different thermal properties and therefore, strongly influence ground processes, compared with carburization only to the hydrogen gas that is formed is recognized as a powerful gas heater, very good.

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