



REVIEW ARTICLE

THE FORMATION OF THE ENVIRONMENT FOR GASEOUS CARBONIZING WHEN USING SOME DIFFERENT GASES

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ARTICLE DETAILS

ABSTRACT

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In this paper, the results of an overview of the formation of carbon permeability when using a number of different permeable gases are presented. The most common permeable gases are "endo" gas and methanol. However, with conditions in Vietnam with an extremely abundant gas source, the use of imported gases will cause enormous waste. Therefore, in this study, we introduce the formation of the permeability medium of two "endo" and methanol gases. In addition, the authors also presented an analysis of the formation of seepage environments from Vietnamese gas sources. Research results show that the formation of permeability medium is suitable for imported gases. Experimental results show that the use of Vietnamese gas for permeability is of the same quality as imported gases.

KEYWORDS

laser technology, application technology, the machine manufacturing industry, an overview study.

1. INTRODUCTION

Carbon permeability is a heat treatment process in which iron or steel is heated in the presence of another material (below the melting point of iron) that can release carbon when it decomposes. The outer surface will have a higher carbon content than the original. When iron or steel is cooled quickly by me, the outer surface area with high carbon content becomes hard, while the core remains soft and tough[1]. This production process can be identified according to the following key features: for low carbon content; details in contact with gas, carbon-rich liquids or solids; produces a hard detailed surface; The core of the part remains virtually durable and flexible; and depth of hard surface layer up to 6.4 mm. Carbon permeability for steel includes heat treatment of metal surfaces using carbon in solid, liquid, gas or plasma. Previously, carbon permeability was done by direct exposure to coal on metals, but modern techniques use gases or plasmas that produce carbon (such as carbonic or methane). The process depends mainly on the composition of the surrounding gas and furnace temperature[2]. These factors need to be carefully monitored because heat can affect the microstructure of the material. When there is a requirement for controlling gas composition, carbon permeability can be performed at low pressure in the vacuum chamber[3]. Carbon-permeable plasma is being widely used in the industry to improve the surface properties of some metals, especially stainless steel, because it is environmentally friendly (compared to using gas or substance). liquid) and can work evenly on a complex surface (plasma can penetrate holes and narrow slits)[4]. The process of carbon permeability is based on the implantation of carbon atoms on the surface of a metal. The metal consists of metal atoms closely linked together in a metal lattice, carbon atoms inserted into this lattice can be mixed into solid (low temperature) or anti-liquid solutions. Metal substrates form ceramic carbide (at high temperatures)[5]. Both of these mechanisms increase the durability of the metal surface but have different effects: The first mechanism, called solid-state stabilization, increases the metal's resistance to corrosion but increased insignificant hardness; the second mechanism, called precipitation, increases hardness but often affects the corrosion resistance of metals. Which mechanism is chosen depends on the requirements. A major requirement for carbon permeability is to ensure maximum contact between details and carbon sources[6]. When using gas or liquid, details are kept on a basket by net or hung by wire. When using a solid, detailed

source and carbon to be added to a container to ensure that contact occurs to the maximum possible surface area, the container is usually of aluminum or alloyed carbon steel. Nickel-chromium heat and lid are sealed with clay[7]. Carburizing is a method of carbon saturation on the surface of the part and penetrates deep into the interior by diffusion. After finishing the process of absorbing carbon content on the surface of steel, it can increase from $0.1 \div 0.25\% \text{ C}$ to $0.8 \div 1.2\% \text{ C}$ with a thickness of millimeters. Carbon permeability is often applied to machine parts that need to have anti-wear work surface, still need toughness in the core, such as gear, shaft and ring, split shaft, latitude and camshaft ... Steel used to absorb In addition to ordinary carbon steel, people also use alloy steel containing Cr, Ni, Mn, Ti, Mo ... to increase mechanical properties, increase permeability and keep small particles when permeable[8]. The carbonization temperature is usually higher than the A3 temperature (usually from $900 \div 950^\circ\text{C}$), ie single-phase Austenite permeability is the solid solution with the largest carbon solubility.

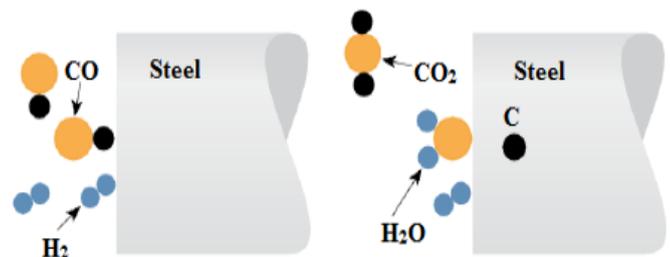


Figure 1: Diagram describing the process of carburizing into mechanical parts[9]

In the process of permeability, when the substances are absorbed into the environment at high temperature, decomposition reactions will take place to form an over-saturated carbon environment[10]. This permeability environment, has a determinant of organization and properties of the

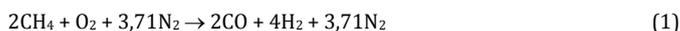
permeability layer as well as the mechanical properties of the mechanical parts after infiltration[11].

Currently, in the world and in Vietnam, often use gas-permeable environment with a number of different gases. Therefore, the study of the formation of permeability is an especially important factor. From this research helps us in gaseous permeability conditions with the use of gas in Vietnam to achieve the quality of permeability is equivalent to imported mechanical parts.

2. USING "ENDO" GASEOUS FOR CARBONIZING

Currently developed countries mainly use carbon sources such as natural gas, industrial gas (blast furnace gas, coke gas) and some other liquefied gases (LPG)[12]. In addition to the above gas sources, gas generators are also used for seepage[13]. This device is called - Endogas generator and this gas gives the same composition as the endogas gas so it is called endo gas-generating gas for carbon-absorbing gas[14]. This gas is also used in combination with another gas such as natural gas, propane and air. In many places exothermic gas or other industrial gases are used. In general, most still use endo gas, because endo gas can give better processing quality. However, if industrial endo gas used from coke ovens is cheap, it is more expensive to produce them on their own. Most endo gas is a reaction product of air with natural gas at a high rate (2.5 to 5.5 times) or inside the coke oven. When heating takes heat, it will have endothermic terminology, meaning heat absorption[5].

With Endo gas is a product of air and methane gas. At the specified temperature, the reactor occurs:



The ratio of air required for 2 volumes of methane is 4.8. Since 2 volumes of methane need 1 volume of oxygen, only 21% of oxygen in the air and 2 methane requires $1 / 0.21 = 4.8$ air. In general, the endo gas composition itself is similar: about 20% CO, 40% N₂, 40% H₂ is a very small amount of CO₂ and other impurities have been ignored. In order to increase the production of endogas, in addition to using heat, people also use catalysts to speed up the reaction and adjust the desired composition[9].

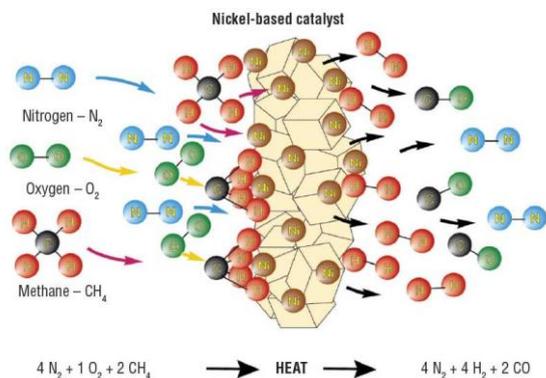


Figure 2: Endothermic gas for carbonizing based on catalyst of nickel[15]

CO is the gas that acts as the main absorbent. H₂ is the gas involved in seepage. When H₂ is present, the permeability rate increases significantly, so that the permeability process takes place faster. However, the presence of H₂ also has some disadvantages: H₂ crunches some materials, is easy to cause explosion, causing pollution when discharged into the environment. N₂ acts as a filler, it helps stabilize the gas environment and expels oxidized gases so it protects the product. Just like H₂, N₂ are also uninvited guests, they cannot be absent when using hydrogen and air carbides during seepage. $\text{C}_n\text{H}_2\text{n} + 2$ is a C-supply and carries both H₂ when decomposing.

3. USING METHANOL FOR CARBONIZING

Unlike endo gas, it is a gas that has a very stable composition before being supplied to a permeable furnace but must be produced so the price is high. Methanol is used for carburizing because it is supplied in liquid form[16]. This is one of the absorbent gases that creates an absorbent environment directly in the furnace. When decomposing methanol, it directly produces CO by reaction:



When permeability only needs to use Nitrogen - Methanol mixture can be easily controlled by gas flow meter, can solve the problem and improve the permeability quality. With gas flow control device, one can change the ratio of CO in the furnace. The very basic advantage of a group of bioethanol used for carburizing is that it makes less soot when absorbing. Currently the use of bioethanol is being strongly developed under the advanced technology name MOCVD. The permeability medium using methanol CH₃-OH can be adjusted according to the following principles:

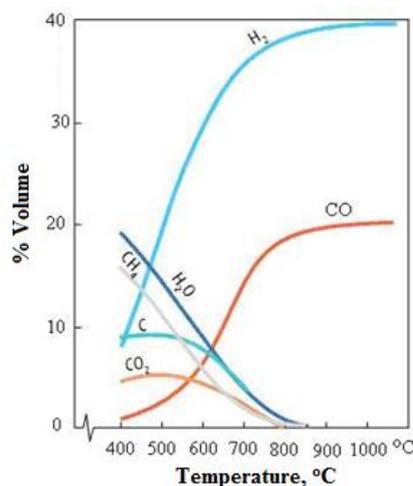


Figure 3: Methanol decomposition results in 40% N₂ and 60% methanol gas mixtures[17]

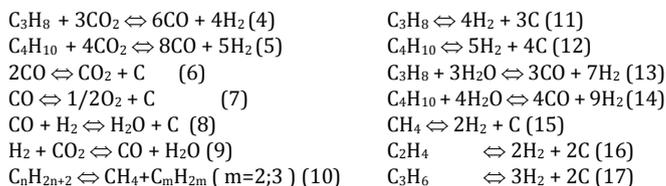
With the above gas mixture can produce 20% CO equivalent to the amount of CO in endo gas. However, one can produce up to 33% CO with methanol /N₂ mixture by changing the amount of N₂. In addition, there are some other types of permeable gas mixtures such as toluene, methanol and N₂ mixture, mixture of ethanol and N₂, kerosene, some of Vietnam's facilities have studied carburizing gas on Vietnamese gas platform. Male combined with some oxygen and gas-filled gas[18].

4. USING VIETNAMESE GAS FOR CARBONIZING

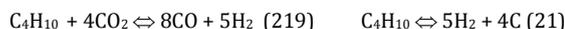
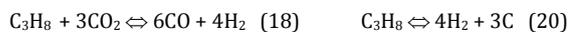
Currently, a number of companies in Vietnam have purchased foreign equipment lines for gaseous carburizing using permeable gas such as: Endo gas, natural gas (CH₄), liquefied gas (methanol and Toluene), but the most common is seepage with a mixture of Toluene and Methanol[19][20]. These devices give much better performance than before. However, the cost of investment in equipment and fuel, technology transfer is very expensive, so the cost of products is relatively high and if you want good quality, you must use the original fuel of the supplier, so you must enter air permeability[21]. Due to the current situation, Vietnam has not been able to produce absorbent gas like foreign countries, so it is difficult to take initiative in the production process and master the technology, causing waste and cost. Therefore, finding a type of permeability gas that is available and suitable for the conditions of Vietnam but still ensuring the permeability standards is a very urgent and practical thing.

In Vietnam, gas is a fairly common fuel. The gas has a very high carbon content, so it can be used as a good permeability gas, besides the gas price is not too high so it can reduce production costs. But with gas used as an absorbent gas, the control of the composition, the ratio of mixing with other gases to achieve good results is a problem. If this problem is solved, this is a new direction for heat treatment technology - permeability in Vietnam, permeate C, C-N using gas in Vietnam[22].

Vietnam gas only includes 50% C₃H₈ and 50% C₄H₁₀, so Petro Vietnam Gas has a large carbon content. Therefore, it can be used as an absorbent if there is a ratio of mixing with oxygen supply gas (to create CO) and air filler (to regulate the permeability of gas concentration and to protect the environment against oxidation). When we introduce the permeable gas mixture including Vietnam gas + CO₂ + N₂ with a certain ratio into the kiln, the following reactions will occur:



As shown above, there are many reactions that can occur in the furnace environment. However, the main reaction is:



When a gas mixture is provided into a furnace at a high temperature (900°C ÷ 950°C), a reaction (18), (19), (20), (21) may occur. Reaction (20), (31) produces carbon black which interferes with the permeability process so it is not desirable to react (18), (19) to create permeable gas so it is beneficial. From (18), (19), it can see that both gas and CO₂ are involved in reacting to each other to create a permeable environment. Depending on the ratio of Gas / CO₂, temperature, catalyst, there will be certain CO, excess gas or CO₂ in the oven. At this time, the furnace consists mostly of CO, H₂, N₂ and a very small amount of CO₂, O₂, H₂O, excess gas. But in reality under permeability conditions, gas residual gas is very small and is considered to be almost completely decomposed. On the other hand, looking at the reactions that can occur in the permeability environment, the amount of H₂ produced in the permeability environment is entirely due to the decomposition of gas. Thus, the amount of hydrogen gas generated directly reflects the amount of gas supplied to the seepage process. By using a hydrogen sensor to accurately measure the H₂ content in a permeable environment, it is possible to use a hydrogen sensor to control the infiltration process. In the carbon carburizing technology, the carbon transporter is CO, at the temperature of about 900°C ÷ 950°C carbon, the reactive CO decomposes to C occurs when the catalyst is Fe or Ni. Therefore, on the steel surface, there is the following reaction:



Because the reaction decomposes CO into carbon on the steel surface, the amount of CO will continuously decrease so we must regularly supply new absorbent into the furnace. With good mixing and diffusion conditions, the CO component on the steel surface cannot be changed and is equal to the CO component in the environment.

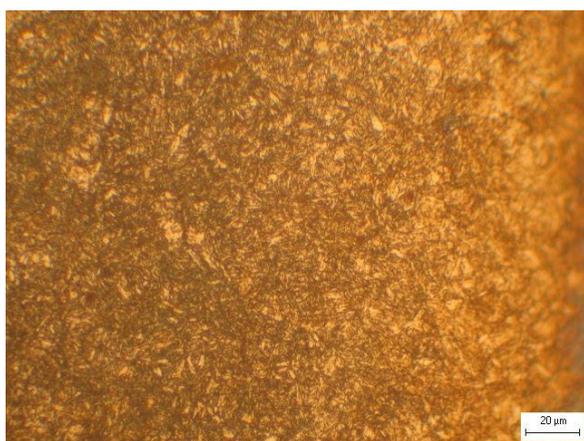


Figure 4: Microstructure of 20CrMo after carbonizing and steeling (X500)[23]

After the carbonizing and steeling, martensite and residual austenite (bright colors) are appeared[18]. On the surface of the sample, because the amount of carbon on the back surface is higher than that in the core, the amount of austenite is more abundant in the core. According to simulation results, residual austenite content in the surface layer is about 21%[24].

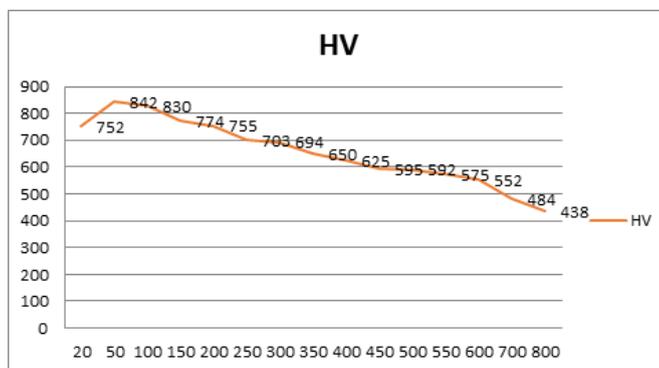


Figure 5: Distribution of hardness of the permeability layer from the surface to the core[25]

Looking at the distribution of hardness of the permeability layer shows that: right next to the surface (a few tens of μm from the surface, lower hardness), the cause is austenite surplus. Hardness is distributed in the permeability layer evenly, there is no sudden change. According to Vietnamese standard 5747, the effective depth of permeability layer is the distance from the surface to the position with corresponding HV hardness = 550kg/mm². Thus, in this case, the permeable layer has an effective thickness of about 600μm.

5. CONCLUSION

The process of forming the permeability environment when using Vietnam gas is completely the same as the process of forming absorbent environment when using endo or methanol gas. The quality of permeability when using Vietnam gas is uniform and similar to the quality of permeability when using imported gas. The hardness distribution line is suitable for the hardness distribution line when using the above imported gases.

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