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PROCESS OF CUTTING STAINLESS STEEL AND THE LIKE

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This invention relates to improvements in cutting of metal bodies, such as stainless steel and the like, which can not be effectively cut by conventional flame cutting procedures. Specifically, the invention provides an improvement in the metal surface resulting from the cut by eliminating or reducing scale that is otherwise formed and which adheres tightly to such surfaces.

Many metal bodies are difficult or almost impossible to cut by the ordinary flame cutting procedures in which a stream or jet of oxygen is directed against a preheated portion of the metal. Typical of the metals normally immune or resistant to ordinary flame cutting are the austenitic stainless steels, such as those containing approximately 18% chromium and 8% nickel or manganese, as well as other chromium-bearing alloy steels, and the nickel base alloys, such as those containing principally nickel and molybdenum with only minor proportions of iron or chromium. Certain alloys of copper also fall in this group, and the most important of these are those that contain around 95% copper and about 5% silicon. It is known that these metals can be cut by the action of a stream or jet of oxygen directed against the preheated metal if a suitable flux-forming material in finely divided form is delivered concurrently with the cutting oxygen stream to the preheated site of the cut. The flux-forming materials that may be thus employed are, in general, those which are themselves oxidized or burned in oxygen with the generation of intense heat, and the action of the flux-forming material to make possible flame cutting of the metals named may be due to the fact that the material burns to produce much higher temperatures than would be attained in its absence, or may be due to the combination of the oxidation products of the flux-forming material with those of the metal body being cut to produce an easily removable slag, or the action may be due, in part, to both of these effects.

The flux-forming materials useful for the purpose just described preferably are metals or alloys in powdered form. One of the most effective flux-forming materials is finely divided, substantially pure, iron powder having a particle size such that all of it will pass through 100 mesh screen and most of it will pass through 150–200 mesh screen. Other metal powders useful for this purpose include powdered aluminum; manganese; ferromanganese alloys, such as those containing about 80% manganese; and mixtures of iron with any of these in various proportions. In some cases, nonmetallic materials, such as sodium carbonate, may be used, and these are most effective if they are modified by admixture with iron powder or with one of the other metallic powders mentioned above.

Various ways have been proposed for delivering the flux-forming powder to the part to be cut. This has been done both with and without a carrier gas for the powdered material. Where a carrier gas for the powdered material has been used, it has been proposed to employ the stream of cutting oxygen (or a portion of it), the combustible gas mixture that is burned to preheat the metal to be cut, or a separate stream of another gas, such as compressed air or nitrogen.

Suitable apparatus for carrying out cutting operations employing a flux-forming powdered material as described above, and in which this material is supplied to the site of the cut by means of a separate carrier gas, is shown in Chouinard & LaPota co-pending application, Serial No. 749,412, filed May 21, 1947, now Patent No. 2,657,650, granted November 3, 1953, and in LaPota co-pending application, Serial No. 758,736, filed July 3, 1947, now Patent No. 2,608,446, granted August 26, 1952.

The surface of a metal body, such as stainless steel, that has been formed by flame cutting employing the methods outlined above, ordinarily is found to be covered with a tightly adhering scale that is very difficult to remove. This scale has been found to be formed on the cut metal surface under virtually all conditions, regardless of the particular flux-forming powder employed and regardless of the method by which the powder was delivered to the cut.

Protective atmospheres consisting of hydrogen alone, nitrogen alone and mixtures of these gases are known in the related but non-analogous art of heat treating metals, where they are employed to prevent scale formation due, primarily, to oxidation. These gases serve their purpose chiefly by replacing air in contact with the metals being treated, and this normally requires a suitable enclosure for the entire work. In the art of flame-cutting metals however, high pressure oxygen is directed upon the work and the maintenance of an artificial atmosphere is impractical, and one that is oxygen free is impossible. Also, in heat treating of metals, the principal object is to affect the total metal treated, or at least, large areas, for refining grain structure or the like, whereas in flame cutting, the desideratum sought is not to affect, or to affect as little as possible, the metal other than the exact location of the cut. Therefore, it is apparent that both the degree and the extent of heating and their purposes are radically different in the heat treating art as compared to flame-cutting of metals.

Accordingly, the principal object of the present invention is to improve the metal surface resulting from the cutting action of a stream of oxygen and a flux-forming material applied concurrently to the preheated metal, and particularly to reduce or to prevent the formation of tightly adhering scale on the cut metal surface. Additionally, the present invention makes possible a method in which such scale as may be formed upon the cut metal surface is of a different character from that heretofore encountered, and may be easily removed. Other objects will hereinafter appear.

I have discovered that these objects may be attained, and that improved flame cutting of metal bodies ordinarily resistant or immune to conventional flame cutting may be carried out by the aid of a flux-forming powder delivered to the site of the cut in a carrier gas which is composed of a mixture of a gas which is non-oxidizing under the above referred to flame cutting conditions with an effective amount of hydrogen, and in which mixture the proportions of the gases are such as to result in a composition that is non-inflammable in air. The gases defined and contemplated as being non-oxidizing under the particular flame cutting conditions here involved include nitrogen, carbon dioxide, argon and helium. The resultant cut metal surfaces thus obtained are found to be substantially free of tightly adherent scale, and such scale as may be present on these surfaces is loose and may be easily removed. This is an important advantage in precision shape cutting of stainless steel and the like, especially where the cut surface of the metal must be cleaned in advance of subsequent operations employing the cut part.

Tests have demonstrated that to be effective for practical purposes, the non-inflammable mixtures in air of the non-oxidizing gas and hydrogen used in the practice of this invention must contain at least 5% by volume of hydrogen. I prefer to use between about 10% and about 20% by volume of hydrogen in the carrier gas with optimum results being attained at about 20% by volume of hydrogen. The maximum amount of hydrogen that can be safely used has been determined to be about 38% by volume. The remainder of the carrier gas may be any gas of the group named above.

Mixtures of nitrogen with hydrogen are preferred as a matter of convenience and economy, although as stated above, helium, argon or carbon dioxide may be substituted for the nitrogen. Nitrogen alone when used as a carrier gas for the flux-forming materials does not enable the desired effect of scale prevention or the formation of a loose scale to be attained, and no other single gas of the group named is practically effective for this purpose. Mixtures of hydrogen with any one of the gases named in the specified proportions are, however, extremely effective.

Metallurgical studies of the heat-affected zone and of the metal surfaces resulting from cuts made in austenitic stainless steels using the carrier gas mixtures of this invention have shown distinct ancillary advantages. Specifically, the heat-affected zone is less than is the case when carrier gases proposed prior to this invention are used, and within this reduced heat-affected zone there is a further reduction in the proportion of it within which undesirable grain growth occurs. These improvements most probably are achieved because the less dense and non-adherent scale formed in the practice of this invention admit of a more rapid cooling of the cut surfaces and contiguous areas through the critical range. Moreover, the physical properties of the metal cut are not materially impaired nor are its corrosion-resistant properties diminished. While these metallurgical benefits are obtained through the use of any of the carrier gas mixtures within the scope of my invention as described above, they are most pronounced and the maximum advantages in all of the respects set forth are obtained through the employment of the preferred carrier gas composed of mixtures of nitrogen with from 5% to 38% by volume of hydrogen.

The upper limit of hydrogen in admixture with the non-oxidizing gases for the purpose of this invention, as stated above, is around 38% by volume. This represents the dilution limit of inflammability in air of the preferred mixtures of hydrogen with nitrogen, and is, in effect, a border-line composition for this mixture of gases. Any increase, even as little as 1% or 2% by volume, in the hydrogen content, renders the mixture inflammable in air. Furthermore, a higher hydrogen content necessarily increases the cost of the mixture, in addition to increasing the hazards involved in its use.

In tests conducted with hydrogen-carbon dioxide mixtures, the upper limit of hydrogen in admixture with carbon dioxide representing the dilution limit of inflammability in air was about 37% by volume. As was the case with nitrogen-hydrogen mixtures, it was found that at least 5% by volume of hydrogen must be used with carbon dioxide. Also, the preferred range for use with carbon dioxide is between about 10% and about 20% by volume of hydrogen in the carrier gas, and optimum results were obtained with mixtures of about 23% by volume of hydrogen and 77% by volume of carbon dioxide. The improvements in the condition of the metal surfaces using this latter gas mixture compare favorably with those obtained through the use of a mixture of 20% hydrogen with 80% nitrogen by volume as the carrier gas.

Argon and helium in admixture with hydrogen in the proportions previously set forth are also effective for the purposes of this invention, but the relatively higher cost of such gases as argon and helium probably would preclude them from all but special uses, and for this reason, detailed discussion of such mixtures is omitted here.

The action by which this invention prevents or reduces the formation of tightly adhering scale on cut metal surfaces cannot be stated exactly. It seems probable that the gases, particularly the hydrogen, are absorbed on or dissolved in the molten metal as the cut is made and thereafter are expelled beneath the scale-forming surface when the molten metal solidifies and cools, with the result that the action in eliminating scale or preventing its tight adherence to the cut metal surface is more or less mechanical. It seems unlikely that the action is predominantly a chemical one involving reduction of the scale-forming materials by hydrogen, but this possibility cannot be ruled out entirely. There is a further unexpected result in that it has been found that mixtures of hydrogen with the specified other gases in the carrier gas does not detract from the ability of the carrier gas to prevent premature oxidation of the flux-forming material as it emerges into the cutting oxygen stream and before it reaches the point at which its ignition is desired in the cutting operation. In any event, the use of the mixtures of gases specified above as a carrier gas to convey the flux-forming materials supplied to facilitate cutting of metal bodies normally immune or highly resistant to conventional flame cutting makes possible a distinct improvement in the quality of the cut metal surface.

The highest quality of cuts made in austenitic stainless steels of the so-called 18 and 8 types have been found to result from the use of a flux-forming material composed essentially of pure iron powder delivered to the site of the cut in a carrier gas composed of a dry, oxygen-free mixture of 80% nitrogen with 20% hydrogen. The specific composition and particle size of a preferred iron powder for obtaining cuts of the best quality is as follows:

Chemical analysis

Element:	Percent by weight
Fe	99.88
C	0.008
Mn	0.019
Si	0.006
Cu	0.006
P	0.002
S	0.004
Loss in H_2	0.09
Apparent density	2.60–2.70

Screen analysis

Mesh size:	Percent by weight
On 80	None
On 100	Trace
On 200	15–20
On 325	15–25
Through 325	60–70

By the use of this combination of flux-forming materials and carrier gas in accordance with my invention, shape cutting of stainless steel can be conducted with high efficiency and a minimum of metal is consumed since the kerf produced by the cut is very clean and narrow. The cut metal surfaces are substantially free from tightly adherent scale and may be easily prepared for further use or fabrication.

The gas mixtures containing hydrogen employed in accordance with this invention may be and preferably are premixed in advance of their use. However, it is possible to produce at least certain of the desired gases in situ, for example, by the decomposition of ammonia which will occur in the flame. In this case, a gas consisting principally of nitrogen (or other suitable non-oxidizing gas) and containing sufficient ammonia to result, on decomposition of the latter, in a mixture as described above may be used, and it will be understood that reference to mixtures of hydrogen with non-oxidizing gases in the appended claims includes chemically produced mix-

tures as well as those made by combining the gases as such.

Other modifications and variations of details of the invention will be apparent to those skilled in this art, and these are also included in its scope as defined by the appended claims.

This application is a continuation-in-part of and is substituted for my co-pending application Serial No. 154,894, filed April 8, 1950, now abandoned, which, in turn, was a continuation-in-part of my application Serial No. 752,289, filed June 3, 1947, and now abandoned.

I claim:

1. In the method of cutting metals normally immune or resistant to conventional flame cutting with preheat and oxygen alone, such as stainless steels and the like, by the action of a flux-forming material applied concurrently with a stream of oxygen to the preheated metal, the improvement comprising the step of delivering the flux-forming material to the site of the cut in a stream of a carrier gas comprising a mixture of a gas which is non-oxidizing under said specific flame cutting conditions, with at least 5% by volume of hydrogen and not more than will render the mixture inflammable in air, thereby improving the metal surface by reducing or preventing the formation of tightly adhering scale.

2. In the method of cutting metals normally immune or resistant to conventional flame cutting with preheat and oxygen alone, such as stainless steels and the like, by the action of a flux-forming material applied concurrently with a stream of oxygen to the preheated metal, the improvement comprising the step of delivering the flux-forming material to the site of the cut in a stream of a carrier gas comprising a mixture of a gas of the group consisting of nitrogen, carbon dioxide, argon and helium with at least 5% by volume of hydrogen and not more than will render the mixture inflammable in air, thereby improving the metal surface by reducing or preventing the formation of tightly adhering scale.

3. The method of claim 2, in which the mixture contains from about 5% to about 37% by volume of hydrogen.

4. The method of claim 2, in which the mixture contains from about 10% to about 20% by volume of hydrogen.

5. The method of claim 2, in which the carrier gas consists of a mixture of nitrogen with about 5% to 37% by volume of hydrogen.

6. The method of claim 2, in which the carrier gas consists of a mixture of carbon dioxide with about 5% to about 37% by volume of hydrogen.

7. Method of improving the metallurgical properties of the cut surfaces and adajcent areas, of metals normally immune or resistant to conventional flame cutting with preheat and oxygen alone, in the process of cutting them by the action of a flux-forming material applied concurrently with a stream of oxygen to the preheated metal, by reducing the heat affected zone and further reducing the portion within said heat affected zone within which undesirable grain growth occurs, comprising the step of delivering the flux-forming material to the site of the cut in a stream of carrier gas consisting of a mixture of a gas which is non-oxidizing under said specific flame cutting conditions, admixed with at least 5% by volume of hydrogen and not more than will render the mixture inflammable in air.

8. Method of improving the metallurgical properties of the cut surfaces and adjacent areas, of metals normally immune or resistant to conventional flame cutting with preheat and oxygen alone, in the process of cutting them by the action of a flux-forming material applied concurrently with a stream of oxygen to the preheated metal, by reducing the heat affected zone and further reducing the portion within said heat affected zone with which undesirable grain growth occurs, comprising the step of delivering the flux-forming material to the site of the cut in a stream of carrier gas comprising a gas from the group consisting of nitrogen, carbon dioxide, argon and helium admixed with at least 5% by volume of hydrogen and not more than will render the mixture inflammable in air.

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