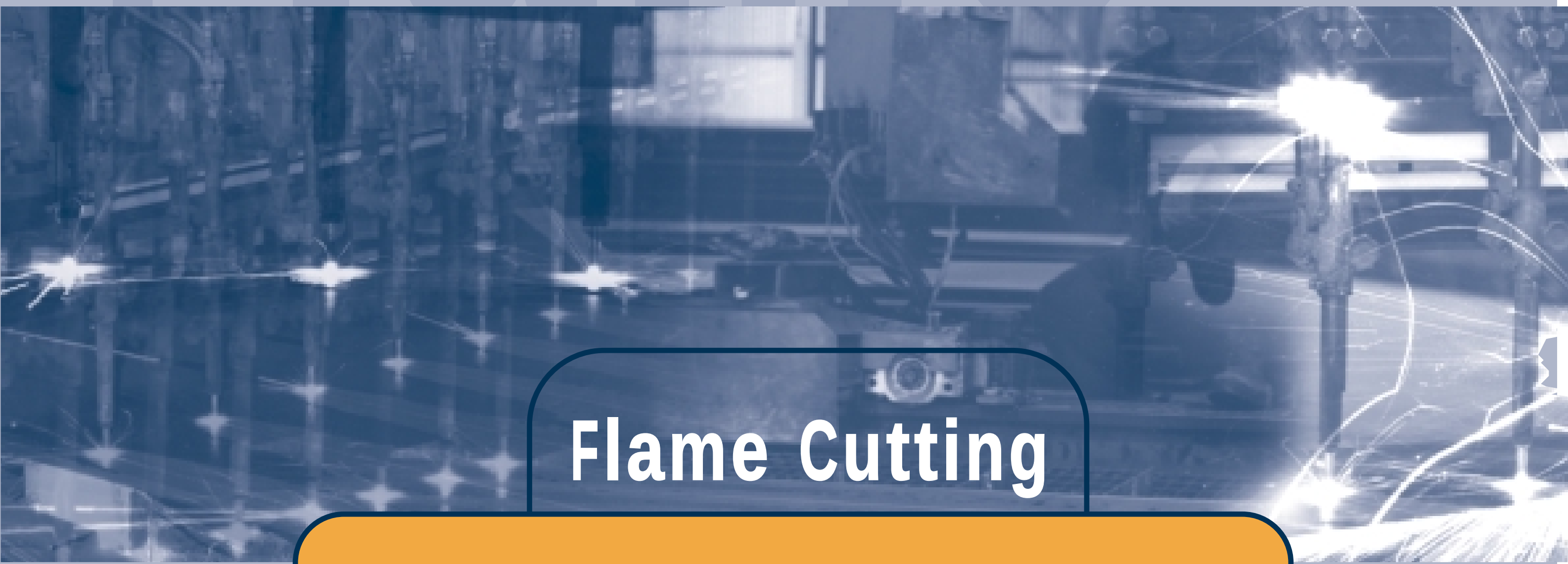
Flame



Flame Cutting

Useful Fabrication Information

Cutting

Flame Cutting

Flame cutting, using a combination of a fuel-gas and oxygen, is a commonly used method for both cutting and edge preparation of a range of steel plate qualities. Conventional flame cutting utilises a cutting torch equipped with a tip which enables the dual functions of

1. preheating the steel to ignition temperature; and

2. directing a stream of high pressure oxygen through a centrally located orifice to perform the cutting.

Acetylene and LP gas are the most commonly used fuel gases for the preheating flame, although natural gas and town gas are also used.

Oxygen is fundamental to the process as it chemically combines with the preheated steel (at around 700°C). This chemical oxidation reaction liberates considerable amounts of additional heat which melts the steel.

The high pressure oxygen jet has the combined functions of reacting with the steel, generating heat, and sweeping away molten products of the reaction from the cut section (kerf).

The process of flame cutting therefore involves both chemical oxidation and the physical removal of molten metal. It is the interrelation of these two factors which dictates the gas flow rates, nozzle design, cutting speed, etc. appropriate for satisfactory flame cutting. Equipment manufacturers can provide information on cutting procedures for a wide range of applications. The Welding Technology Institute of Australia (WTIA) - Technical Note 5 "Flame Cutting of Steels" provides a comprehensive coverage of the subject.

It will be apparent from the foregoing that the combination of the heat liberated during the oxidation/melting reaction, and the heat influence of the preheat flame results in the localised heating of a narrow zone of the parent plate adjacent to the cutting edge. After the passage of the flame, cooling of this zone occurs and metallurgical changes take place. This heat affected zone, resulting from the heating and cooling cycle of the plate, is similar in many respects to the heat affected zone formed adjacent to the fusion zone of a weld.

In the case of flame cutting, the microstructural changes at the edge due to these thermal gradients depend primarily on the cooling rate (or quenching severity) although some preferential element oxidation and diffusional changes also occur as surface phenomena. The overall cooling rate, however, is the most significant factor and is dictated in the case of flame cutting by a number of conditions, the most important of which is cutting speed. Accordingly, the amount of heat generated is greater, for a given length of cut, for a slow cutting speed than for a fast cutting speed and the cooling rate, or rate of heat dissipation, is correspondingly slower for a slow cut.

The response of the steel being cut to this thermal cycle dictates the extent of which metallurgical changes occur and, as in the case of welding (and indeed heat treatment), affects the degree to which hardening of this heat affected zone occurs. The proportion of bulk hardening elements such as carbon, and to a lesser extent manganese, in steels is important in this context as these and other elements increase the hardenability of the steel, and thereby increase the tendency to hardening of the flame-cut heat affected zone. Alloy steels containing additional elements which promote hardenability do require special procedures for flame cutting, and are outside the scope of this brochure.

Factors other than merely the heat affected zone hardness are relevant in respect of the service performance of flame cut plate. Surface roughness, gouging, and edge profile may all influence the degree to which stress raising influences are present on the flame cut edge and these may contribute to reduced fatigue performance or to brittle fracture in service or during cold forming.

Allied processes such as flame gouging, flame washing (or scarfing), rely on principles similar to those outlined above and the thermal effects described for the heat affected zone apply equally for edges subject to plasma and laser cutting.

Mild and Medium Strength Grades

Steels in this category are typified by the structural grade AS/NZS 3678-250, and the AS 1548-7-460 grade used in pressure vessel manufacture. These grades exhibit relatively low hardenability by virtue of the deliberate low carbon equivalents used on these grades. Flame cutting of "mild" steels presents little difficulty regardless of cutting method despite the abovementioned thermal cycle to which the heat affected zone adjacent to the edge is subject. Marginal hardening of this area may occur, although this is usually only of significance where subsequent, severe cold forming of the edge is envisaged, or in particularly critical applications where a risk of brittle fracture or fatigue exists.

High Strength Grades

Higher strength structural grades such as AS/NZS 3678-350 and 490MPa tensile pressure vessel grades are also readily flame cut without the need for special precautions in most applications. The increased hardenability of these grades means they are more susceptible to hardening of the cut edge, and this may be unacceptable for certain critical applications.
Reduced edge hardening may be facilitated by either
1. reduction in cutting speed, and/or
2. initial preheating of the plate.
Both of these procedures serve merely to slow down the cooling rate at the cut edge.

Medium to High Carbon Grades

Where carbon content exceeds about 0.3%, plates may require both preheating and reduced cutting speeds in order to obtain acceptably low hardness levels in the heat affected zone.

Preheating is particularly important for heavy sections where uniform preheating will assist considerably in reducing the chilling effect of the surrounding steel as well as ensuring a consistent cut.

Machining of the cut is also facilitated by the softer edge produced by adherence to the above procedures. Post heating immediately after cutting may be desirable to ensure even slower cooling of the flame cut edges of heavy thickness, hardenable steels. Furnace cooling or insulation after cutting may be appropriate in such cases.

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