Selection of Nozzles for Flame Cutting and Gas Welding

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The object of this article is to give some hints to people involved in flame cutting and to people who are primarily concerned with such processes in terms of the correct flame-cutting nozzles.

In current metalworking practice, flame cutting is frequently performed manually and, to an increasing degree, using high-technology flame-cutting machines. However, the question often arises as to which is currently the correct type of flame-cutting nozzle for the various cutting tasks which arise and which is the most efficient nozzle for the operation in question. The cutting nozzle is by far the most important part of the cutting equipment, since the cutting performance and the quality of cut are primarily dependent on it. In the text , more attentions are paid to mechanised flame cutting, since manual cutting involves simple cutting operations, with no stringent requirements when it comes to the quality and properties of the cut.

Different Type of Nozzle Design

Nozzle manufacturers offer a wide range of flame cutting nozzles. However, both the nozzle and the cutting torch count as part of the cutting tool; the latter, limited by the design of the burner head construction, divides nozzle and torch into two completely different types of construction.

Gas Mixing Nozzles

Fuel gas and combustion oxygen are led separately to a gas-mixing nozzle. The mixing zone is in the burner nozzle itself. The geometry of the combustion oxygen and fuel gas channels in a gas-mixing nozzle is arranged so that no oxygen/fuel gas mixture can ignite back through the gas bore in the torch if a strike-back occurs.

Their constituent materials, block construction and mixing system enable gas-mixing nozzles to support very high thermal loads. Such high thermal loads occur in conjunction with edge preparation for welding, particularly if this is carried out using so-called 'three burner units' on flame-cutting machines. Burner nozzles and torches which are close to one another are heated to a very high degree as a result of radiated heat.

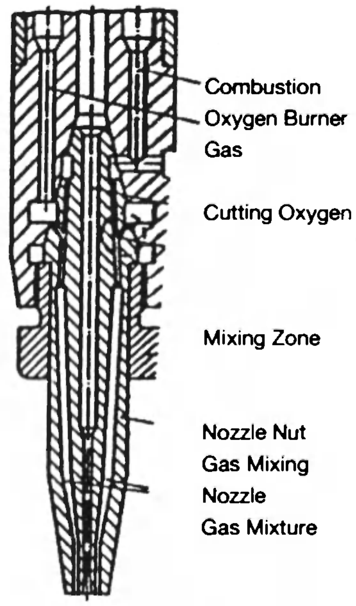

Fig. 1 : Cutting System for Low-Pressure Torch (two piece)

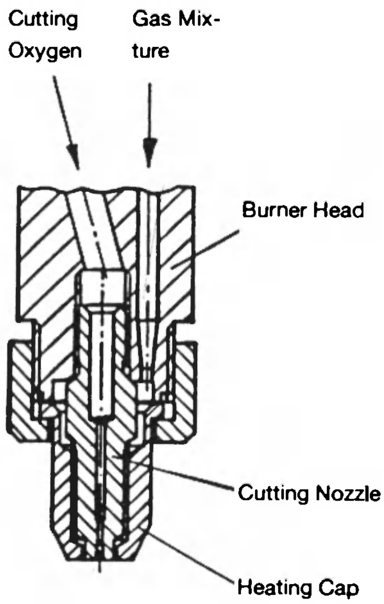

Fig. 2 : Gas-Mixing Nozzle System (one piece)

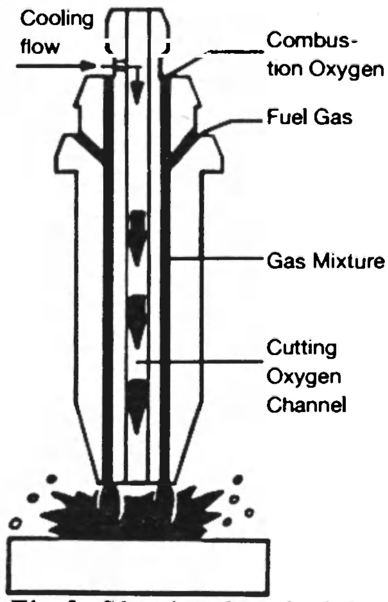

Fig. 3 : Showing the principle of a Gas-Mixing Nozzle with a Cooling Stream Value

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A further typical application for gas-mixing nozzles is when a rough cutting operation generally predominates and no permanent monitoring of the burner nozzle system is possible. The use of this type of nozzle is also recommended if holes larger than 100 mm are frequently cut in thick material; this results in a high thermal load.

When it comes to the manual cutting of scrap, the possible uses are also being limited increasingly to gas-mixing nozzles. Manufacturers are currently offering a special type of construction for this application, with an integrated cooling stream valve; this cools the nozzle and extends the service life. In this case, a small quantity of combustion oxygen flows through the cooling stream valve into the cutting oxygen channel during heat-up and thus exerts a cooling effect (see Fig. 3). By mixing the gases in the nozzle, damage to the burner caused by the strike-back of the flame is eliminated.

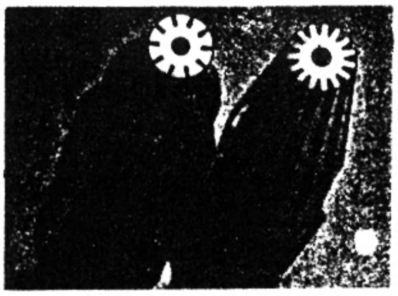

Fig. 5 : Different Heating Flame Outlets for Dry Cutting Nozzles

Cutting Nozzles for ALow-Pressure Torches

In a low-pressure torch the fuel gas is drawn in by the combustion oxygen and mixed in the torch. A ready-to-use fuel gas/oxygen mixture is therefore led to the cutting nozzle system.

Flame cutting with a low-pressure torch and its component cutting and combustion nozzles is the most frequently used cutting system. The nozzle systems shown in Fig. 4 form part of a system of this type.

In the case of two-piece nozzles, the subsequent acquisition of spare parts is inexpensive, since only the cutting nozzle normally needs to be replaced. The formation of the heating flame, which can be quite finely adjusted and reduced, offers a major advantage.

Fig. 4 : Cumbustion nozzle (left), combustion cap (centre), cutting nozzle (right)

It enables this sheet and smaller parts to be cut with negligible distortion.

An additional technical advantage provided by cutting nozzles for low-pressure torches is the shape of the heating flame in relation to its ideal design. The openings for the heating flame outlet take the form of several fine, right-angled slots, fine wedge-shaped slots or an annular gap (see Fig. 5). Their main feature is that they provide a closed heating flame envelope when a section is taken through the shape of the flame in every direction. The heat is evenly distributed around the cutting flame which is brought to the surface of the sheet. This is not always the case when it comes to drilled heating channels, such as those used for gas-mixing nozzles.

Let us now take a look at concentric nozzles. Non-centralised concentric nozzles often have a one-sided flame configuration. This reduces the heating performance and subsequently the cutting performance and increases the tendency of the burner to strike back. This type of concentric is no longer used for mechanised flame cutting. Modern concentric nozzles have a guide section between the combustion cap and the cutting nozzle to produce the most accurate centering of the heating flame cross-section (annular gap) (see Fig. 6).

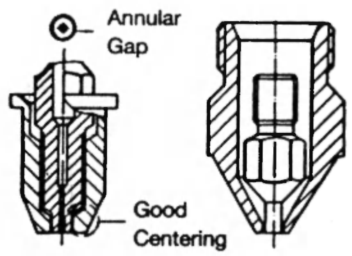

Fig. 6 :
Right : Cutting Nozzle Seated in the Heating Nozzle withoutGuide
Left : Cutting Nozzle is Accurately Located in the Combustion Cap

The shape and intensity of the heating flame has a decisive effect on the cutting performance of a nozzle and on the operational safety of the cutting torch. Maximum protection must also be given to the cutting gas jet before it mixes with the atmosphere. In Germany, ☞

nozzles for low pressure torches form the basis of each new development of cutting nozzles.

Construction of the Cutting Oxygen Channel

The central feature of each flame cutting nozzle, regardless of its type of construction, is the shape of the cutting oxygen channel. Its performance and dimensions have a decisive effect on effect on cutting quality, cutting speed and the shape of the cut. The issuing oxygen jet needs to be a sharply-defined closed cylinder; any scatter, divergence or constriction must be avoided, since these.impair the surface of the cut. This requirement is fulfilled if the total pressure energy outside the mouth of the nozzle is converted to velocity.

Higher Cutting Speeds

In recent years development work on flame-cutting nozzles — particularly for mechanised flame cutting has focused on achieving high outlet velocities (above the velocity of sound) by means of systematic analyses based on a predetermined shape of nozzle. The resultant high kinetic energy enables liquid oxides to be carried away rapidly, produces a high jet velocity and makes more pure oxygen available for combustion at the reaction zone per unit of time. This has led to nozzles with smaller, specially-formed cutting oxygen channels. These channels are constructed in the form of a so-called Laval Nozzle, using which very high jet velocities for the cutting oxygen are obtained. The cutting oxygen pressure has been increased from a maximum of 5 bar to 10 bar. This has enabled to cutting speed to be increased by 20 to 30%, producing a better quality of cut than before. Such devices are therefore termed 'rapid cut' or 'high performance' nozzles. The quantities of cutting oxygen, heating oxygen and fuel gas used per metre of cut have not increased.

In cutting nozzles for manual cutting torches, simple channels of cylindrical shape are used almost exclusively.

Another possible way of increasing cutting performance still further involves the use of oxygen blanket nozzles. To protect the oxygen jet from prior contamination, it is surrounded by an additional oxygen blanket; this ensures that almost pure oxygen is supplied to the reaction zone. In the case of sheet metal with a thickness of up to 70 mm, nozzles of this type produce a very high quality of cut, with the cut surface taking on an almost polished appearance. However, working with a nozzle of this type always requires the exact distance between the nozzle and the upper surface of the sheet to be maintained, since the effect of the oxygen blanket on the cutting process is otherwise reduced and virtually no advantage is obtained from this type of nozzle. As a result, installation is generally restricted to flame-cutting machines with a maximum of 3-4 torches. If a very wide cut is required, this restricts the use to a few specific applications. In addition, such cases lead to a higher nozzle price and a relatively high oxygen requirement.

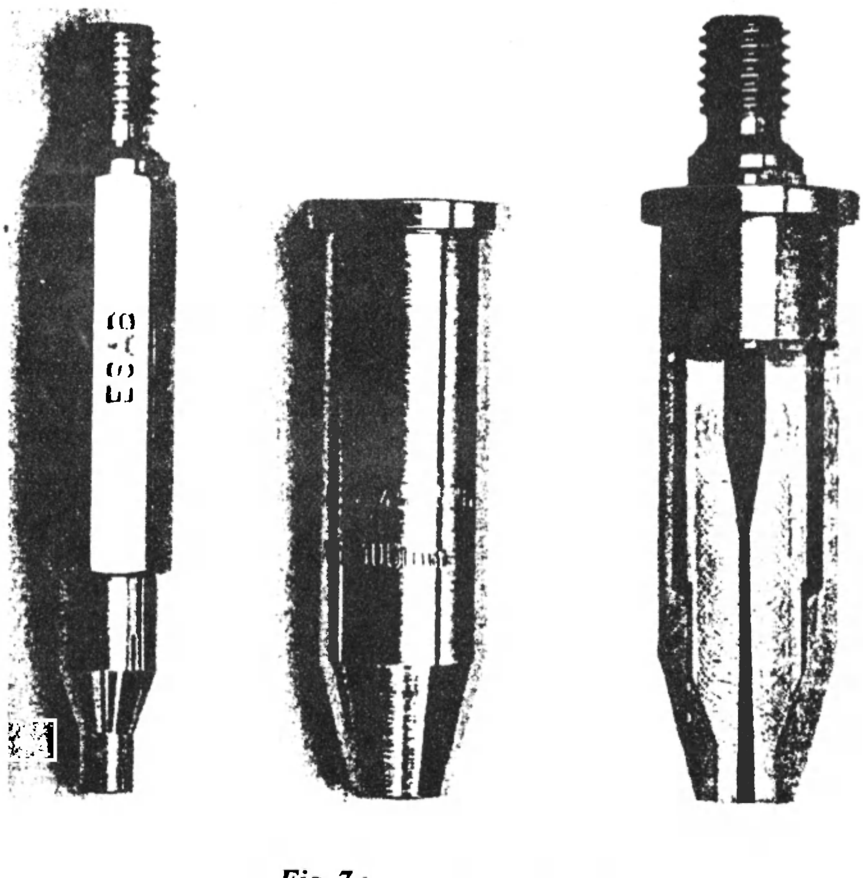

Fig. 7 :
Right : Section through a High Performance Nozzle (Laval Channel).
Left : High Performance Nozzle — System for Low-Pressure Torch

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Operation with rotatable three-torch units is not possible.

The appearance of the cut and the flame-cutting machine which is used are important criteria for the selection of the correct burner nozzle system. If cutting is performed on modern, numerically controlled equipment associated with long operating times and if the sheets to be cut are less than 100 mm thick, a high-performance nozzle is recommended. These machines are high-value machine tools and a higher cutting speed then results in increased productivity from the machine, thereby making significant annual cost savings possible. If numerically-controlled machines are acquired, the use of high-performance nozzles or rapid-cut nozzles should be a fundamental consideration.

To summarise

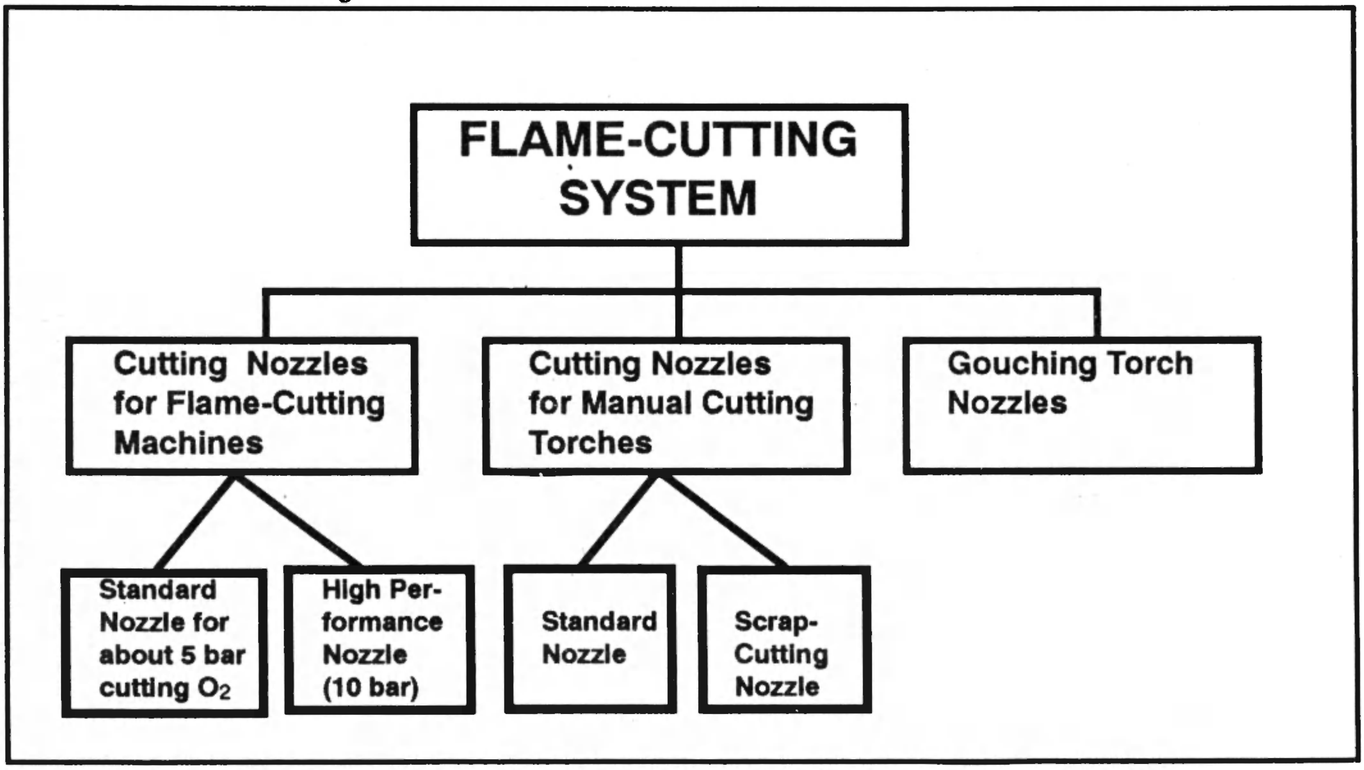
It is not possible to give any general advice on the nozzle which should be installed for each application. The choice also depends on the operating conditions prevailing in each case.

The following points are to be applied .

- High-performance nozzles are installed for low-pressure torches and the gas-mixing type of construction for use with modern NC machines for thicknesses of up to 100 mm. When the sheet thickness exceeds 100 mm, high-performance nozzles provide no significant advantages and standard systems are then installed. Manufacturers normally stock high-performance nozzles of this type for thicknesses of up to 100 mm.
- Gas-mixing nozzles are installed predominantly for sheet thicknesses of more than 100 mm, or if many holes have to be cut causing high thermal loads.
- Low-pressure torches with the corresponding nozzle systems are preferred for sheet thicknesses of up to 100 mm as it is so much easier to adjust the heating flame. It is particularly important to remember that only low-pressure torches should be used for thicknesses of up to 10 mm. ■

Hints for Selecting Nozzles

The following diagram gives an overall picture of the cutting systems most frequently installed in flame-cutting machines and manual cutting torches.



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