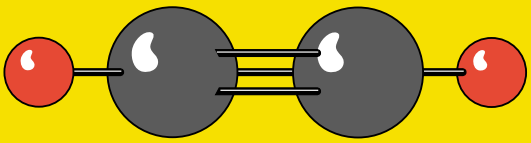
Acetylene ... there is no better fuel gas for oxy-fuel gas processes



H — C ≡ C — H

The acetylene molecule comprises 2 carbon atoms linked by a triple bond and 2 symmetrically arranged hydrogen atoms

The high efficiency of acetylene is easy to explain: The energy released during combustion, the high flame temperature, and the flame propagation rate of the oxy-acetylene flame are due to the favourable molecular structure of the acetylene. Even during decomposition of the acetylene molecule energy is being released, in contrast to other hydrocarbons; this is the so-called energy of formation or formation enthalpy. In the case of acetylene 8,714 kJ/kg of utilisable energy are released. More heat is added by the partial combustion of the oxygen in the gas stream. - And since in oxy-fuel gas processes the first combustion stage only, that is the primary flame, is of practical importance, the favourable combustion properties of acetylene offer a big advantage that is inherent in the product itself.

Conversion data:

m^3 of gas (1.013 bar, 0 °C)	m^3 of gas (1 bar, 15 °C)	kg
1	1.068	1.175
0.936	1	1.100
0.851	0.909	1

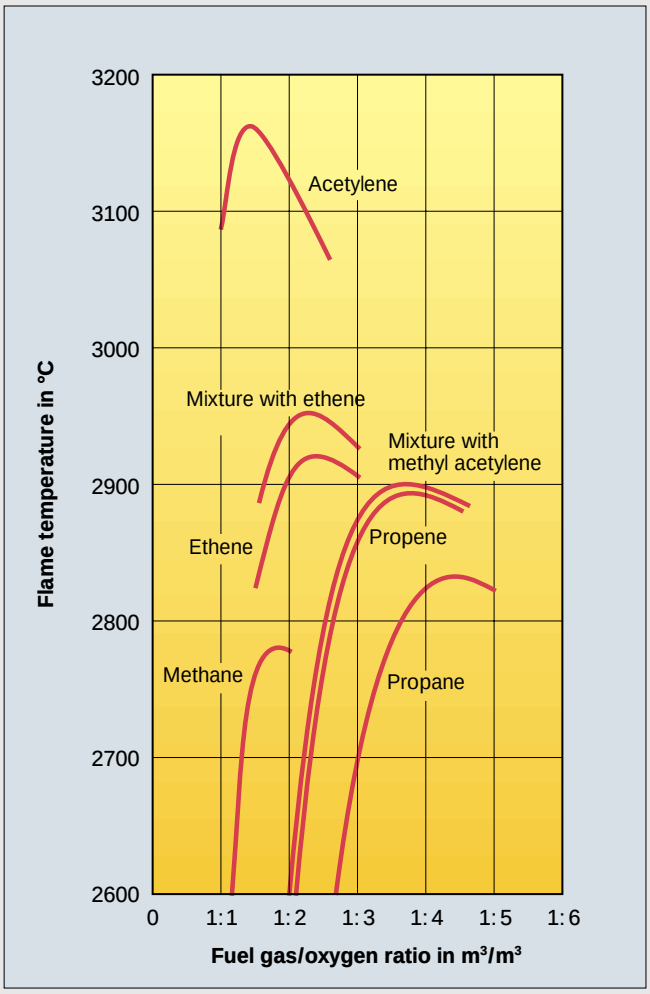
Properties:

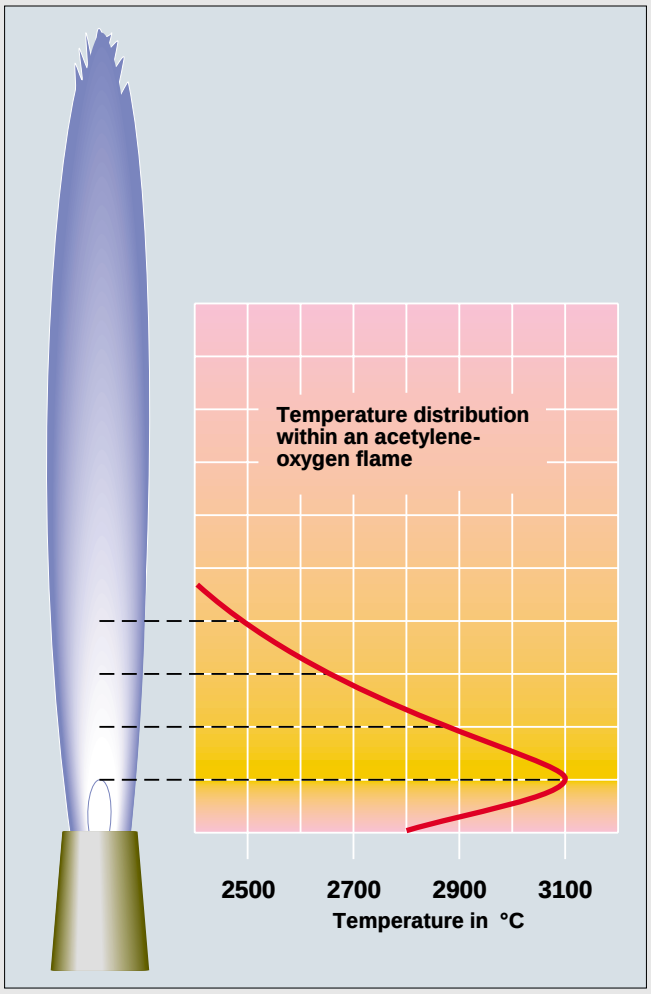
Acetylene is a colourless fuel gas with a slightly ethereal, sweet odour.

Chemical symbol:	C_2H_2
Molar mass:	26.04 g/mol
Triple point:	-80.8 °C/1.28 bar
Critical point:	35.18 °C/61.91 bar
Density (at 15 °C/1 bar):	1.1 kg/m^3
Density (at 0 °C/1.013 bar):	1.175 kg/m^3
Comparison of density:	10 % lighter than air
Ignition temperature:	335 °C in air, 300 °C in oxygen
Flammabiltity limits:	in air 2.3 – 82 % by vol. in oxygen 2.5 – 93 % by vol.

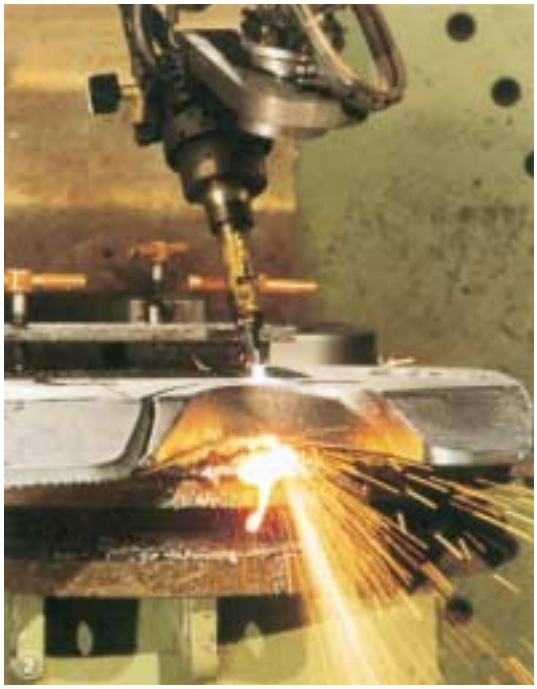
Contents

Acetylene features all the significant properties which really matter in the various oxy-fuel gas processes





Whenever rapid and concentrated heating and preheating of the workpiece is essential, flame temperature is an important factor. Because the higher the temperature, the faster the transfer of heat from the flame into the workpiece.



Flame cutting

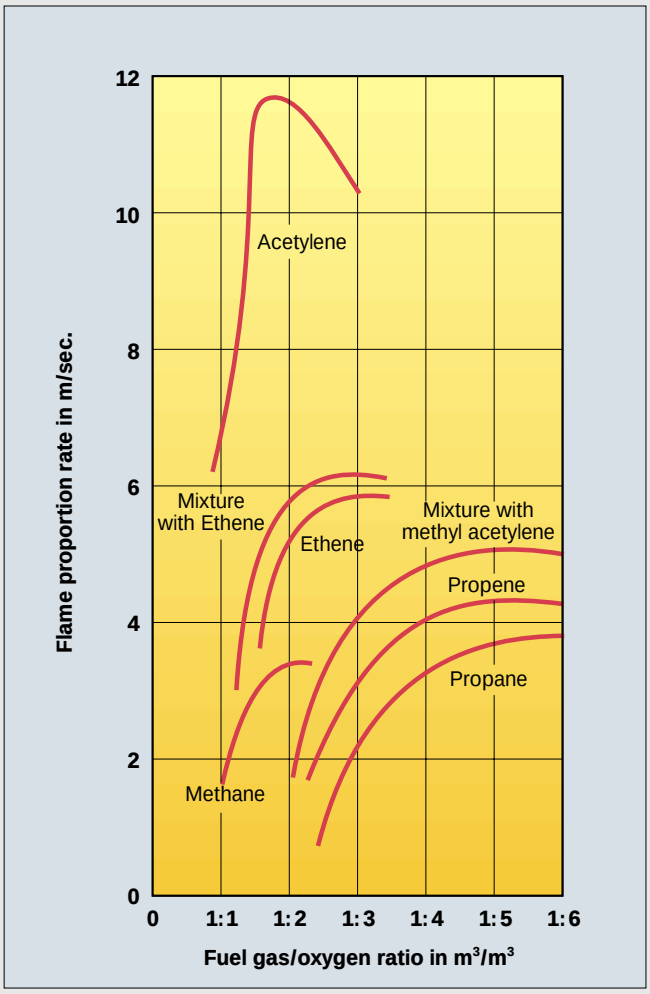
Flame cutting, whether by hand or by machine, is one of the main fields of application for the highly effective oxy-acetylene flame. Flame cutting is a labour intensive process. 80 to 90% of total costs are costs for labour and equipment. So in this respect, the high flame efficiency of the acetylene gas pays off extremely well: rapid pre-heating for starting or cutting holes. Optimal cutting speed even with rusty, scaled or primered sheet. Cutting quality leaves nothing to be desired. Sharp cut edges, smooth cut surfaces, and easily removable scale are

guaranteed. Regardless of the type of cut, and even with extreme bevel cuts.

The latest types of flame cutting machines and technically advanced tips contribute to high cost-effectiveness in flame cutting with acetylene.

① ***Different types of welding seam shapes produced by oxy-fuel gas flame cutting***
② ***Flame cutting by industrial robot***
③ ***Flame cutting in routine manufacturing***
④ ***Simultaneous flame cutting with multiple torches***
⑤ ***Flame cutting involving computer-supported cost control, based on cutting parameters determined on-line***

Acetylene provides the highest flame temperature and propagation rate



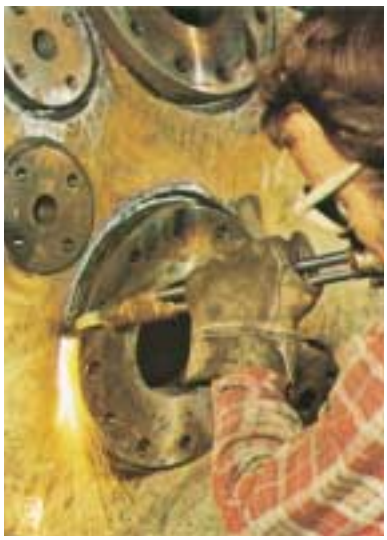
Acetylene is also the fuel gas with the highest flame propagation rate. After all, thermal efficiency is the better the faster the hot combustion products meet the workpiece. This requirement is particularly important when heating metallic materials of high thermal conductivity like steel, copper or aluminium.

Flame-cleaning

Flame-cleaning with acetylene is used wherever clean sheet metal surfaces are required for further processing. Rust, mill scale and other scale are efficiently removed by low-cost flame-cleaning. Flame-cleaned surfaces ensure excellent adhesion of paint finishes and coatings. Thereby, also corrosion-resistance is improved. Flame-cleaning procedures are also used for thermal treatment of concrete and natural stone surfaces. In particular for cleaning and preparatory treatment of concrete carriageway surfaces. Also old paint and coatings, oil contamination, and abraded rubber can be removed in an environmentally friendly way. The concrete thus exposed gives optimal adhesion for synthetic resin coatings.

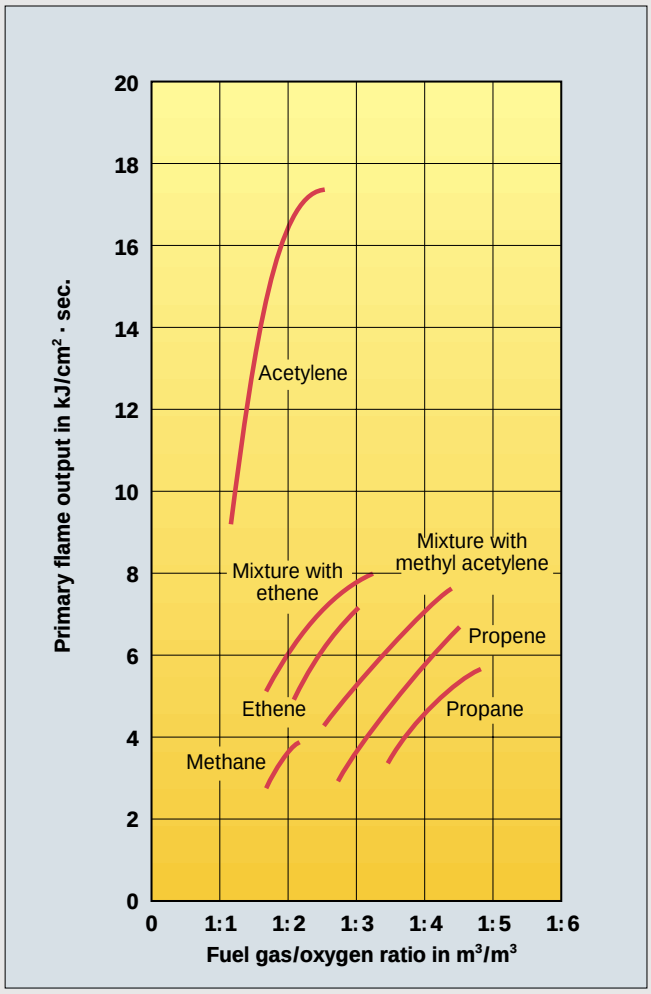
Gouging

Gouging is used to remove weld defects or to prepare welds for root runs. Proper guidance of the torch tip gives a perfect weld channel.

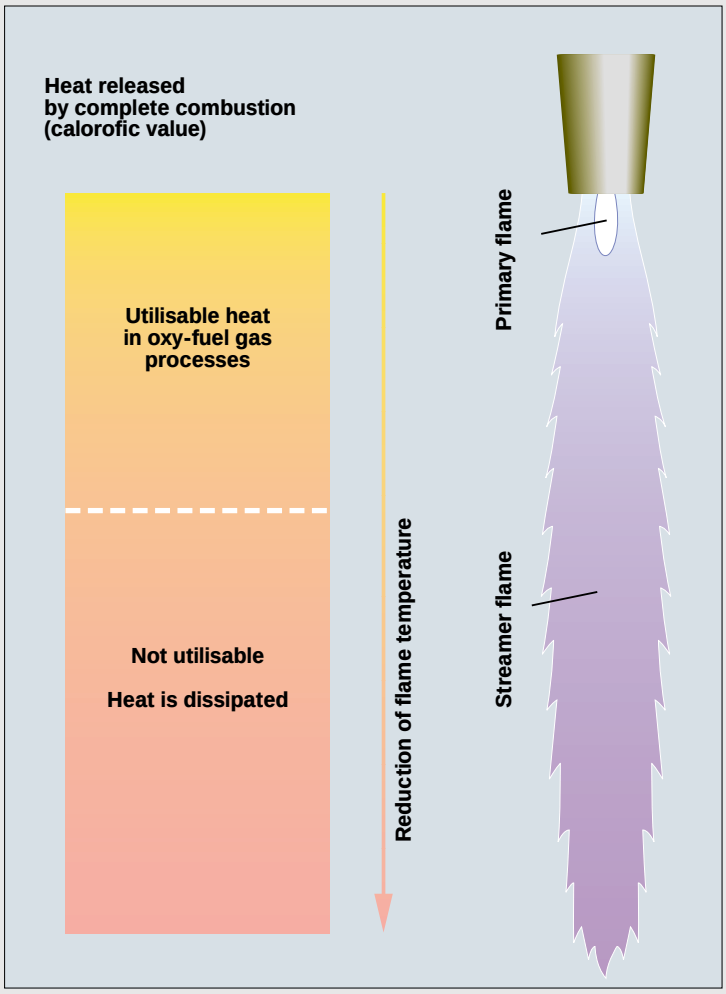


① ***Flame-cleaning of a steel surface***
② ***Flame-cleaning of concrete***
③ ***Gouging of the root for reverse side welding***
④ ***Gouging a welding defect in shipbuilding***

The primary flame output in oxy-fuel gas processes



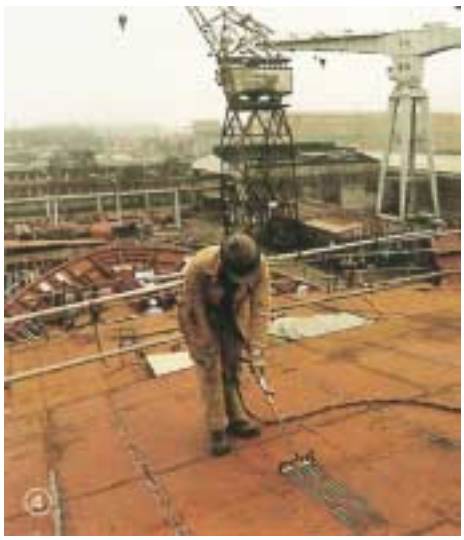
The resultant referred to as the primary flame output (related to unit volume) is the product of the flame propagation rate and the heat evolved in the primary combustion stage in the flame cone. This alone provides the heating capacity.
And, since in oxy-fuel gas processes the primary combustion stage only, i.e. the primary flame, is of practical importance, the favourable combustion properties of the acetylene flame offer a big advantage which is simply inherent in the product itself.



The calorific value of a fuel gas is not the decisive factor. This value includes also the heat output released in the secondary combustion stage in the streamer flame, which cannot be utilised in oxy-fuel gas processes.

Flame straightening

In flame straightening the high efficiency of acetylene is of particular value. The high flame temperature combined with the high combustion velocity of the oxy-acetylene flame ensures rapid and precise positioning of the straightening points. Due to the variable oxy-acetylene flame and easily interchangeable torch tips, any desired heat output can be set, enabling optimal and economical treatment of the workpiece.



① ***Shaping a girder for shipbuilding by flame straightening***
② ***Flame straightening in large-diameter pipe production***
③ ***Flame straightening in mechanised production of box girders***
④ ***Flame straightening in shipbuilding***

The heating rate of the oxy-acetylene flame ensures concentrated heat input

Locally defined flame heating to forging temperature by oxy-acetylene torches arranged on both sides.

There is a direct relationship between flow velocity and flame propagation rate. The higher the flame propagation rate, the higher the flow velocity can be set. The higher the flow velocity, the higher the gas volume burned per unit of time on the area of the workpiece to be heated. The more gas is burned, the higher the concentration of heat released.

Flame heating

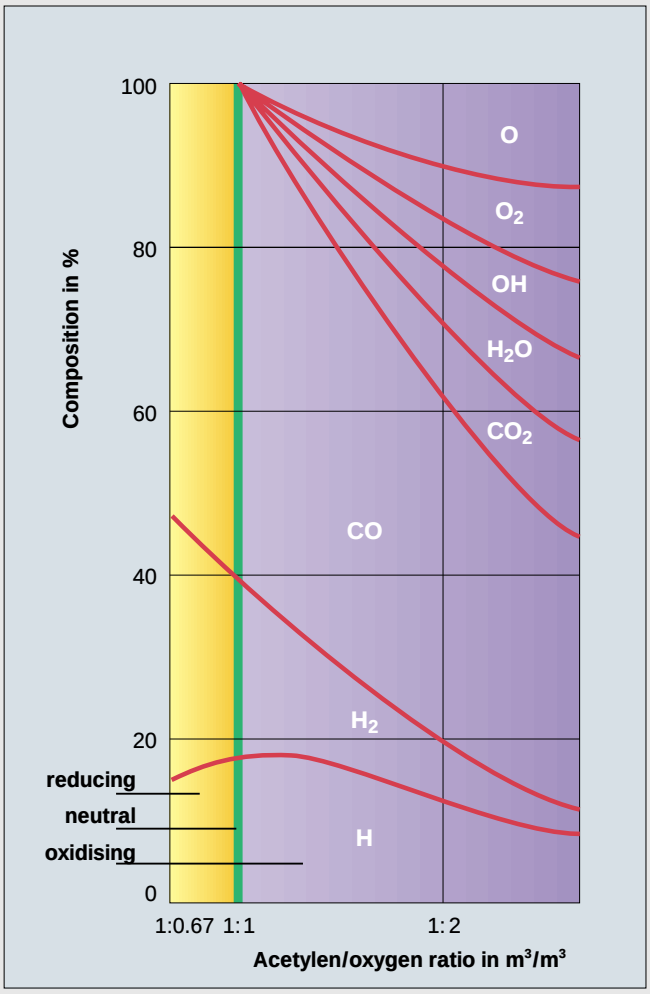
Flame heating means local heating preparatory to hot forming, e.g. bending of pipes, necking of distributors, dishing of vessel bottoms, or for pre- and reheating in welding and flame cutting. Both, normal welding torches and specially developed high-output oxy-acetylene torches are used for these heating procedures. The use of high-output heating torches is recommended in particular when large quantities of heat are to be applied to the workpiece with the highest speed and concentration possible.

Flame hardening

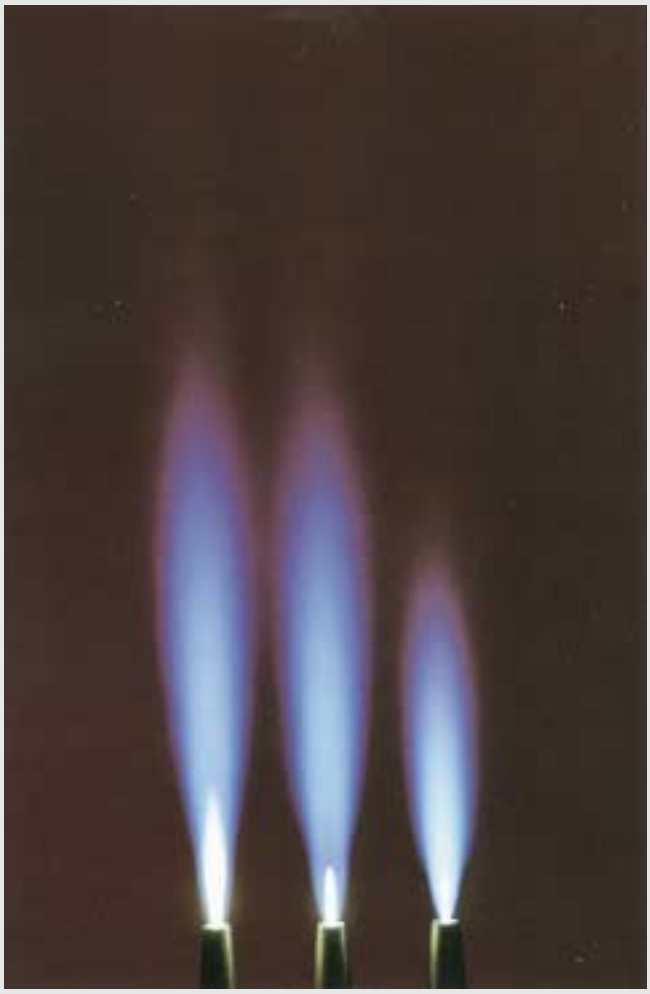
Flame hardening of ferrous metal workpieces is used to improve resistance against wear. Particularly in the case of components for driving assemblies like gear wheels or ball raceways service life is increased substantially. In the process hardened layers are produced by locally heating and quenching defined surface areas without any adverse effects on the core material. For flame hardening mainly mechanised methods are used in job and batch production. Here also the workpiece surface layers are heated so rapidly by the high-output oxy-acetylene flame that a sharply defined zone of heat concentration is formed down to the desired depth without heat penetrating into the lower layers. By immediate subsequent quenching with water the heat is removed from the workpiece. The inherent compressive stress forms the hardened structure. Because the material below the resultant hardened layer is not involved in the structural transformation processes, accuracy of shape and the mechanical properties of the workpiece remain unchanged.

① ***Rapid locally defined flame heating for hot forming***
② ***Heating in necking procedure in pipe-line construction***
③ ***Flame hardening a shaft***
④ ***Special torch for flame hardening***

Neutral flame setting and its advantages



△ ***Composition in per cent of flame gases at flame cone depending on mix ratio***

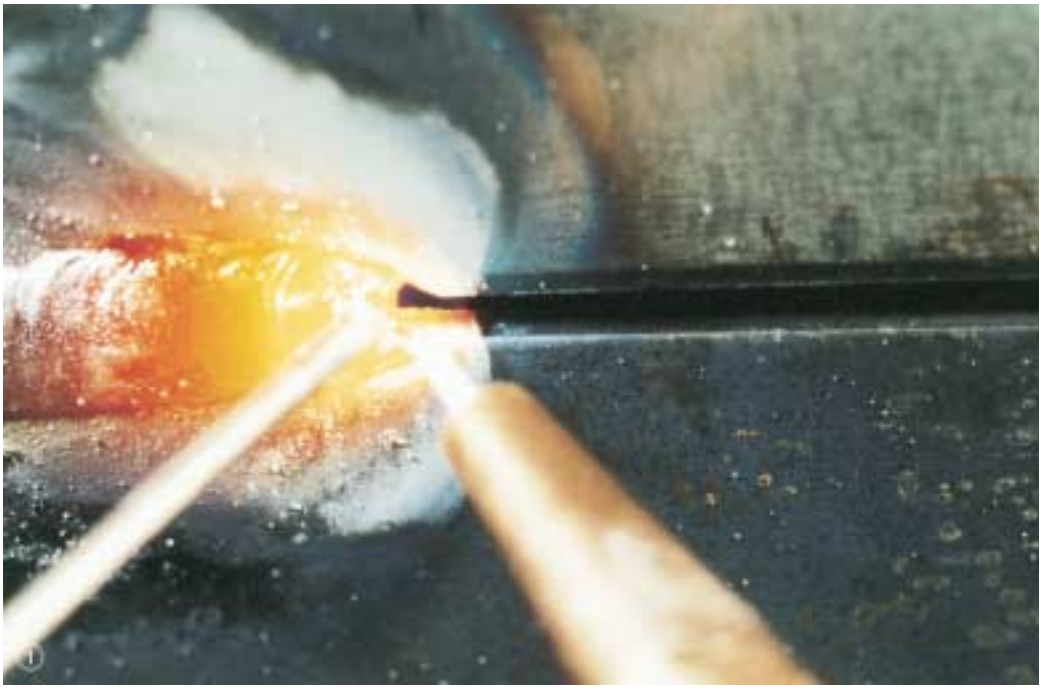


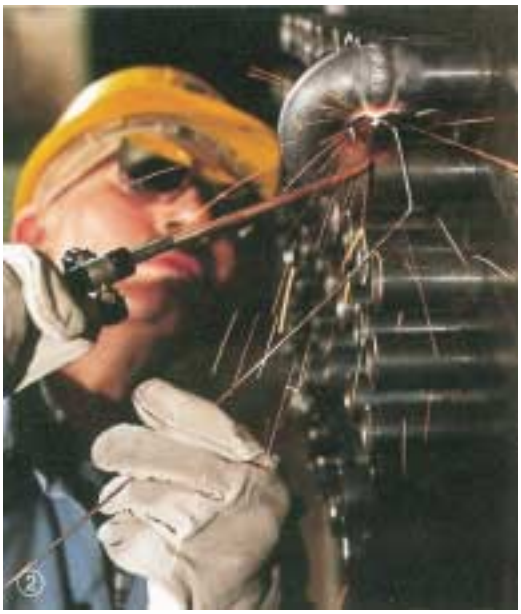
Flame setting
reducing - neutral - oxidising

Only acetylene has the necessary flame temperature and flame output at neutral flame setting for melting and welding steel. A neutral flame setting is essential especially when welding steel in order to avoid undesirable reactions in the molten pool. The oxy-acetylene flame is “neutral” when the acetylene/oxygen ratio is 1:1. The flame is termed “reducing” when there is a surplus of acetylene and “oxidising” when there is excess oxygen.

Gas welding

In oxy-fuel gas metal working gas welding is certainly one of the major processes. The big advantage of acetylene lies in the reducing effect of the welding flame which is easy to adjust and well to control. Gas welding work with acetylene is characterised by good gap bridging capabilities. There is no or very little seam preparation required. Its problem-free application is particularly useful in out-of-position welding. In pipeline construction, for instance, where other welding methods are usually out of the question or not economical, the oxy-acetylene flame is the welder's tried and true friend. Combustion of acetylene with oxygen is characterised by a sharply defined flame cone.



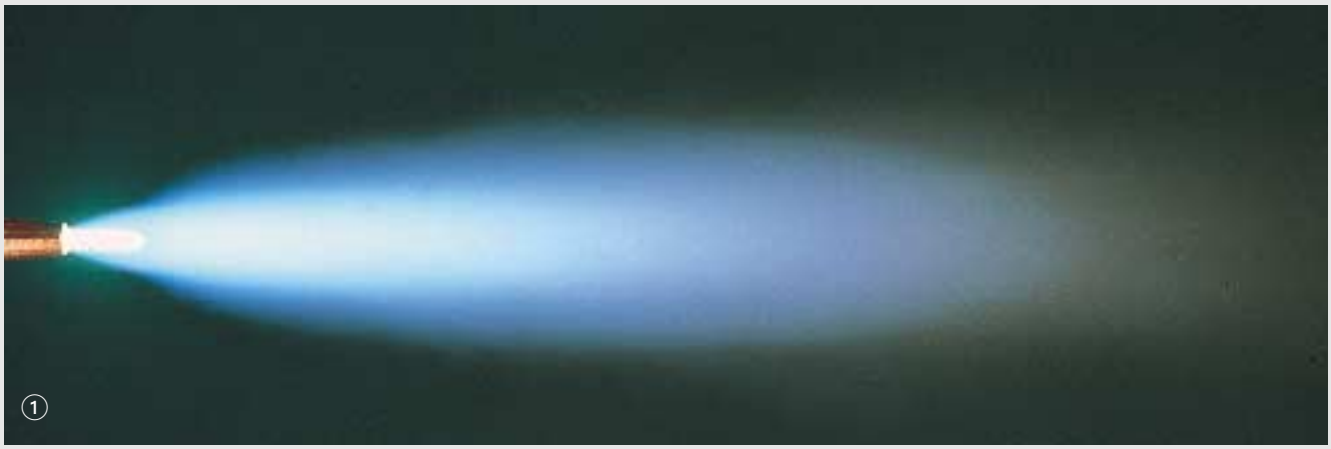


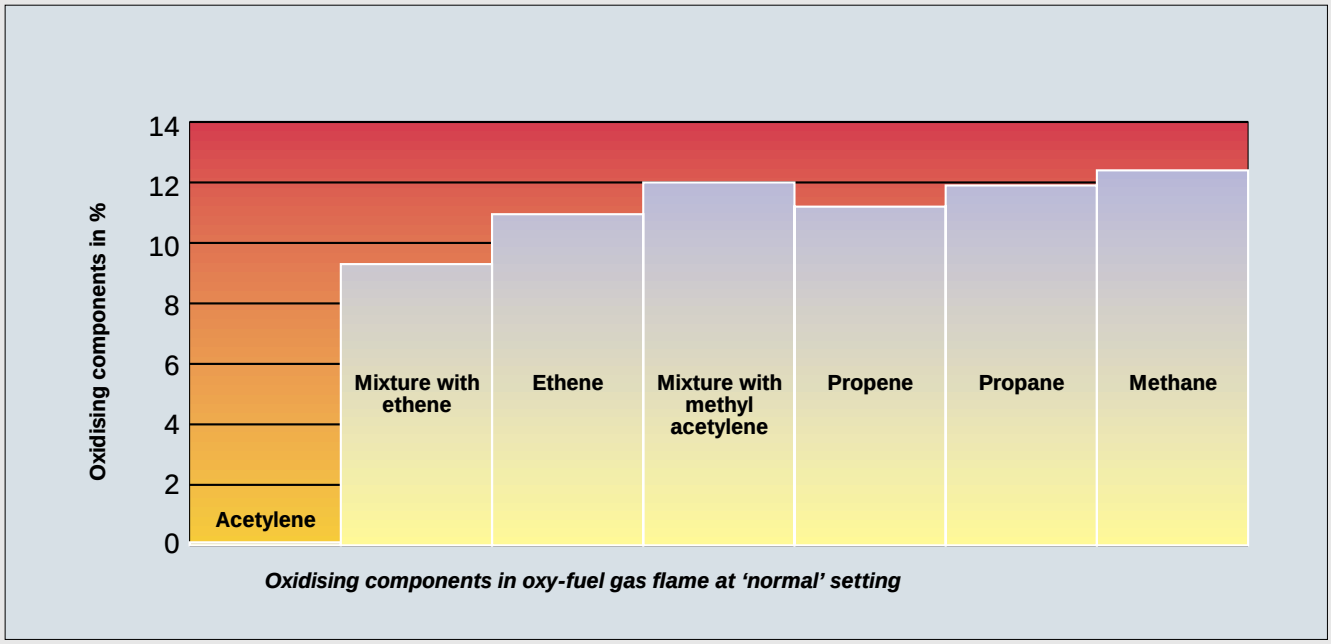
Hard-facing

For preventive reduction of wear on tools and machinery components surfacing with high-strength metal alloys by welding is a tried and proven method. The process is known as hard-facing (hard-surfacing) and can be applied for facing with ferrous, low-iron and non-ferrous materials.

① ***Rightward welding***
② ***Gas welding work on heat exchanger***
③ ***Valves for automobile engines hard-faced by the oxy-acetylene process***
④ ***Gas welding work in large Diesel engine construction***

Correct flame adjustment



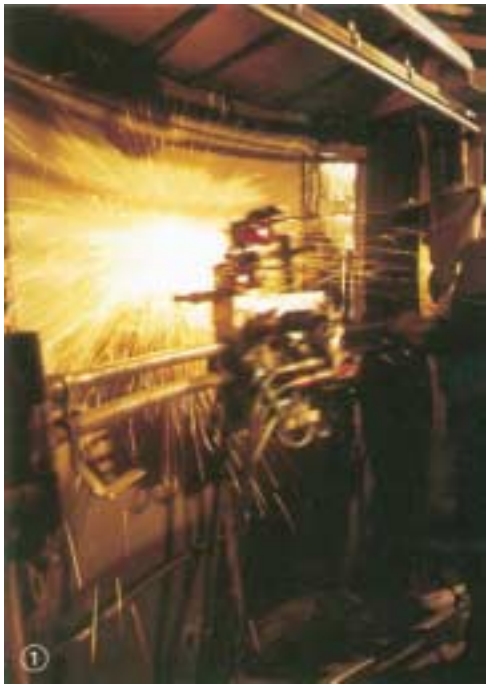


Oxidising components in oxy-fuel gas flame at 'normal' setting

Another advantage is the flame adjustability as such. Thanks to the sharply defined primary cone it is easy to adjust the oxy-acetylene flame by observing its appearance. The appropriate optimum mixture ratio can easily and exactly be set by eye judgement. Complex and expensive measuring instruments can be dispensed with. The operator will appreciate this advantage because the quality of his work depends largely on the correct mixture. And a constantly correct setting will also save gas.

① ***Most suitable flame setting for welding***

Flame spraying



Flame spraying is used for surface coating of metallic and non-metallic materials. The spray material, wire or powder, is melted by the oxy-acetylene flame and sprayed onto the pre-treated workpiece by compressed air or another gas. The high flame temperature of the oxy-acetylene flame permits to spray also high-melting point materials, like molybdenum. Flame-sprayed coatings have demonstrated their excellent properties in all fields of engineering. For instance, as a wear-resistant coating, or for up-grading machinery components, or

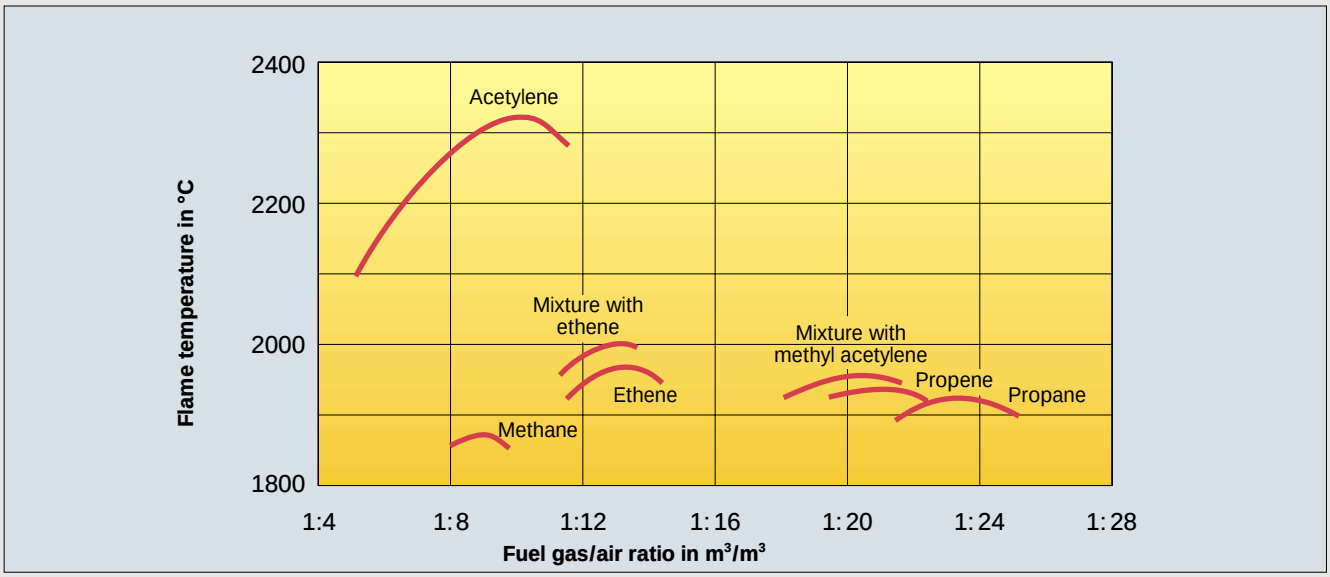
for applying anticorrosion coatings of zinc, aluminium, copper or CrNi steel.

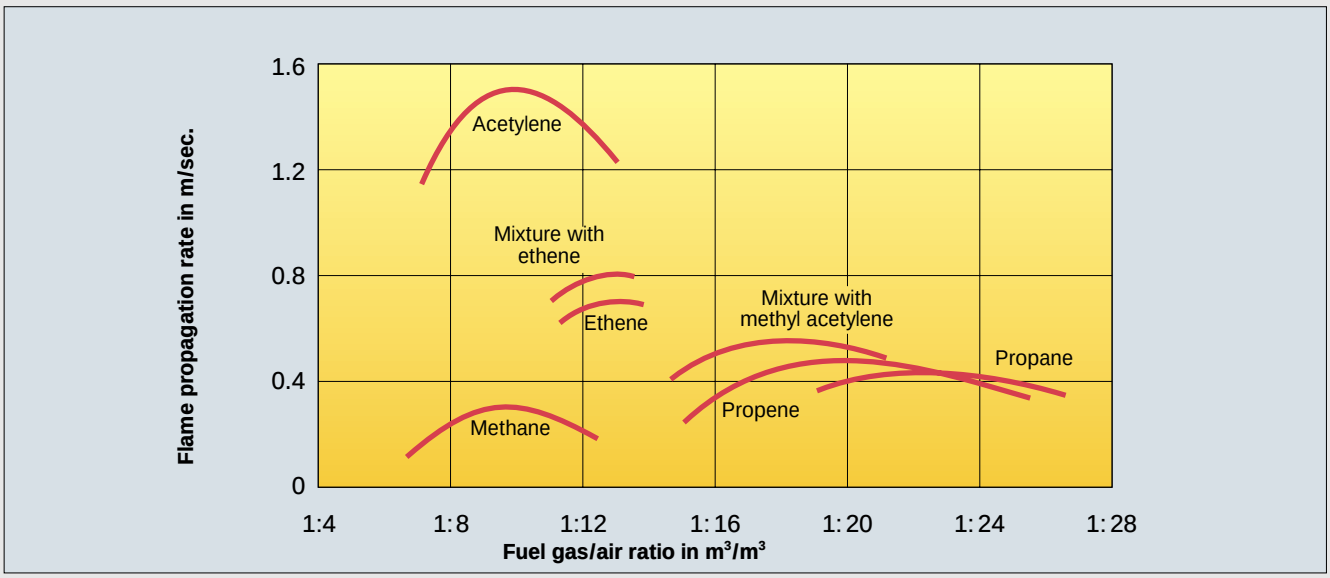
Flame-brazing

Flame-brazing, like gas welding, belongs to the group of thermal joining processes. By brazing, however, it is possible to join materials of quite different types, which would cause problems in welding. Also in the case of thin and heat-sensitive workpieces brazing has proved to be an excellent method for producing high-strength, reliable and leak-proof joints. In general, both, the oxy-acetylene flame as well as the air-acetylene flame are used for brazing.

① ***Flame-spraying of a shaft***
② ***Flame-brazing in automobile construction using the flux method***
③ ***Automatic fusing of CrNi BoSi alloy sprayed on rope pulley by means of the powder flame-spraying process***
④ ***Flame-brazing of copper piping***

The soft air-acetylene flame

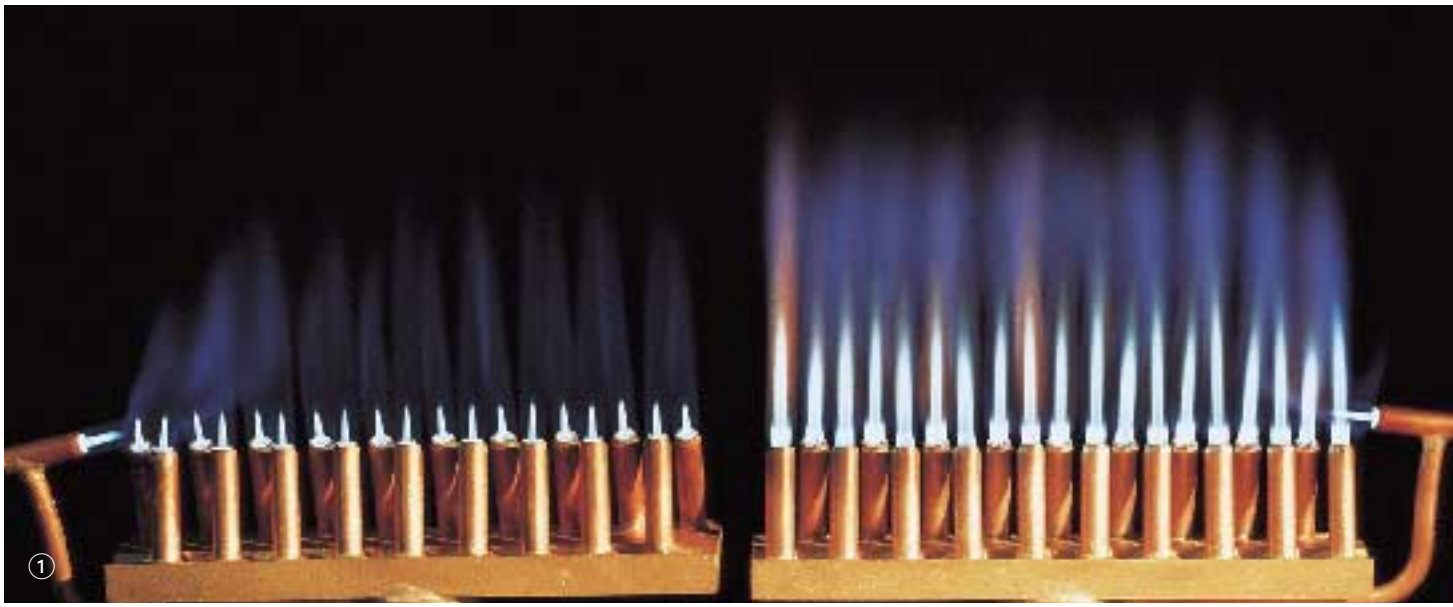




The soft air-acetylene flame features a more gentle action compared with the oxy-acetylene flame. This is important when a flame using pure oxygen is too hot for the workpiece or for the solder. Here again, acetylene is superior to other oxy-fuel gas mixtures as its flame intensity is still 2,325 °C and its flame propagation rate 150 cm/sec. With the air-acetylene mixture a favourable ratio of 1:9.6 is obtained.

For air infeed mainly two torch systems are being used: the air-suction torch (working according to the Bunsen principle) and the compressed-air-acetylene torch in which the acetylene is aspirated by the compressed air.

The use of Lindoflamm® special torches

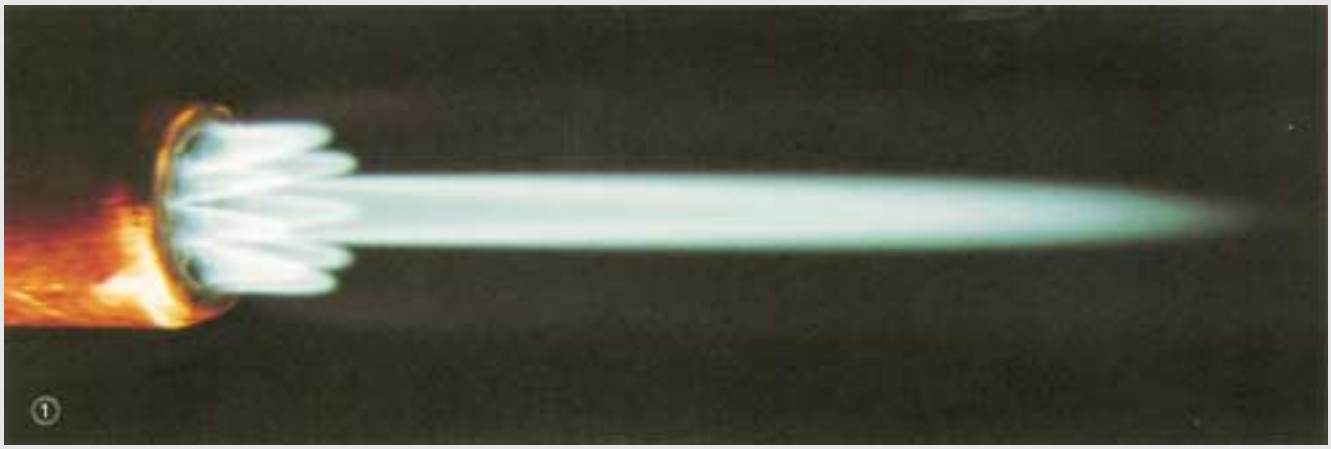


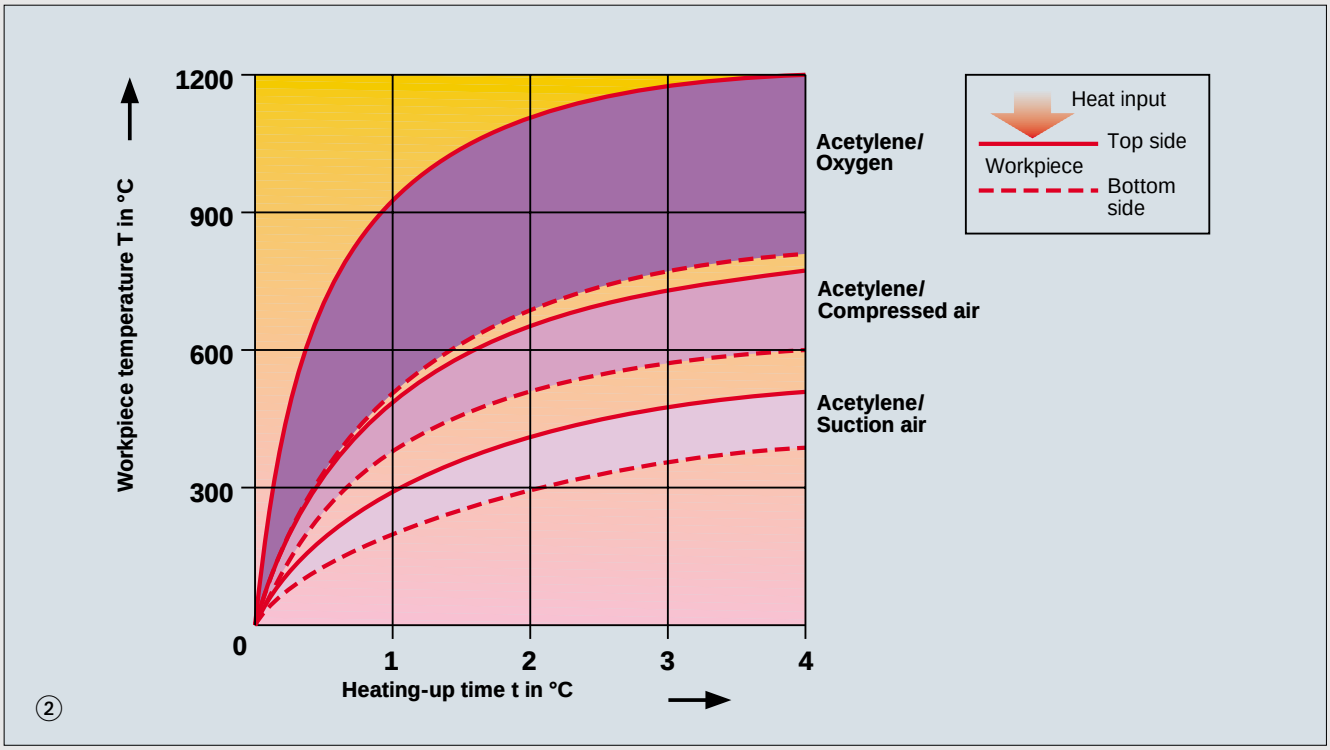
The use of purpose-designed Lindoflamm® acetylene torches offers many advantages:

- optimum heat input into workpiece because the torch is adapted to the job
- economical gas consumption by adjusting the torch to the job
- possibility of mechanisation

① ***Compressed-air-acetylene torch with pilot flames, flame output adjustable on both sides***
② ***Compressed-air-acetylene torch for flame-brazing a heat exchanger***
③ ***Flame-brazing on rotating brazing device***

Temperature of workpiece



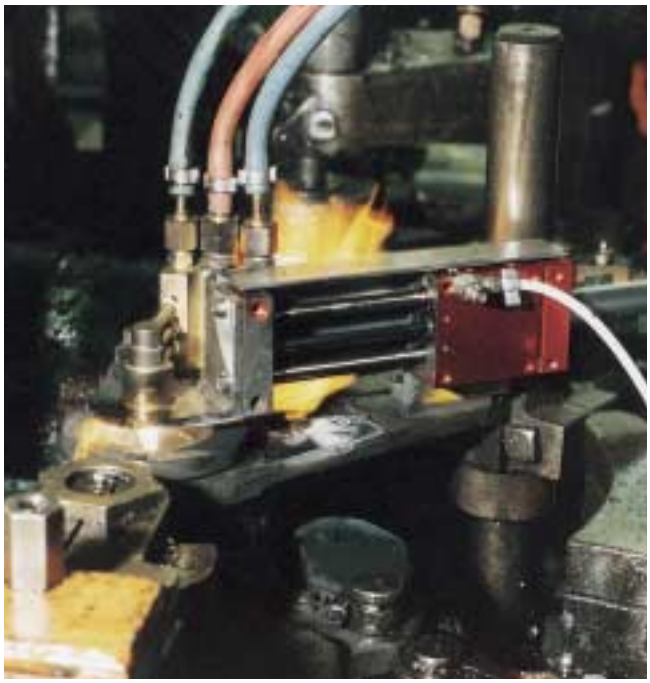


The air-acetylene flame works gently, but nevertheless is intensive and economical. Of course, it is no alternative to the oxy-acetylene flame, but a very useful addition to the great variety of processes available in production plants and workshops.

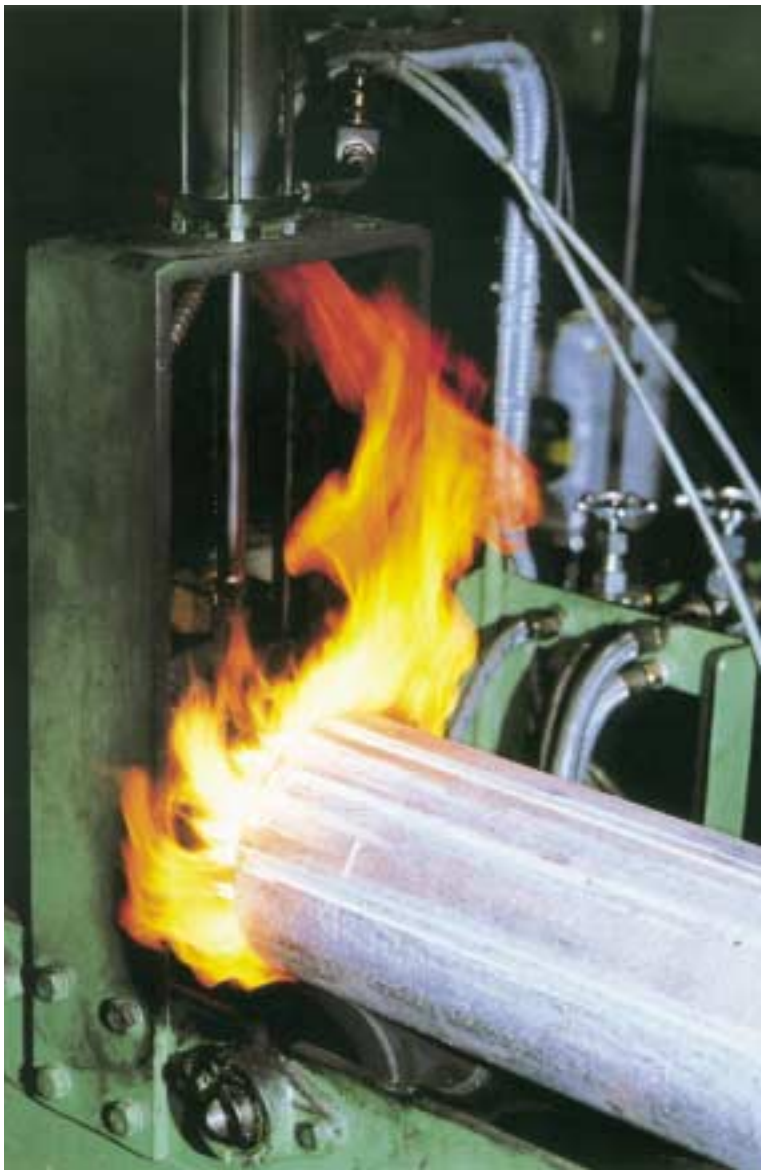
① ***Acetylene air flame***

② ***Temperature of workpiece depending on heating-up time and type of flame***

Linde Carboflam® process

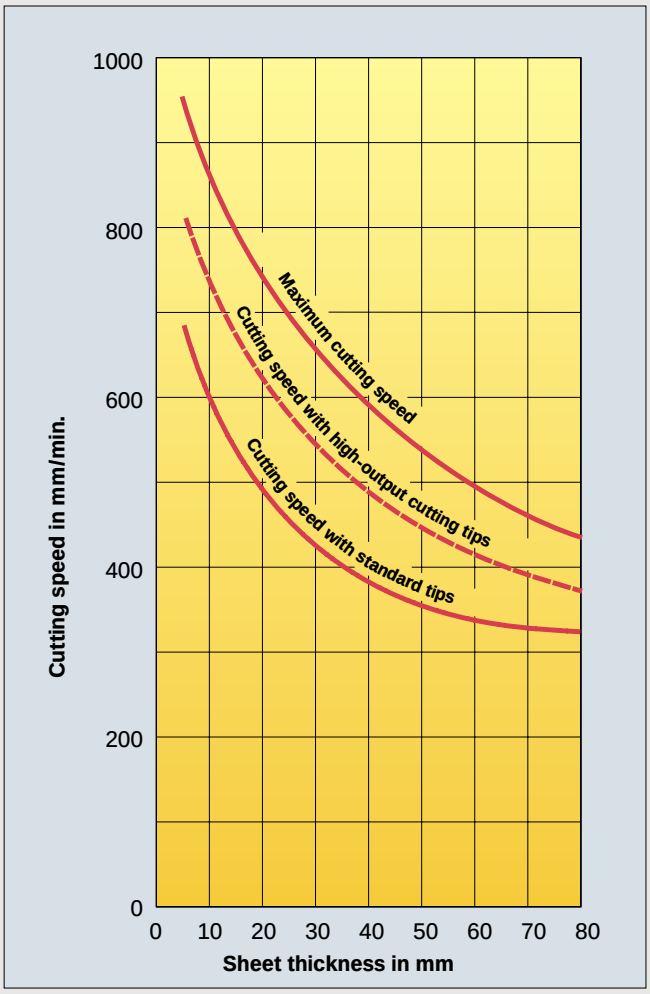


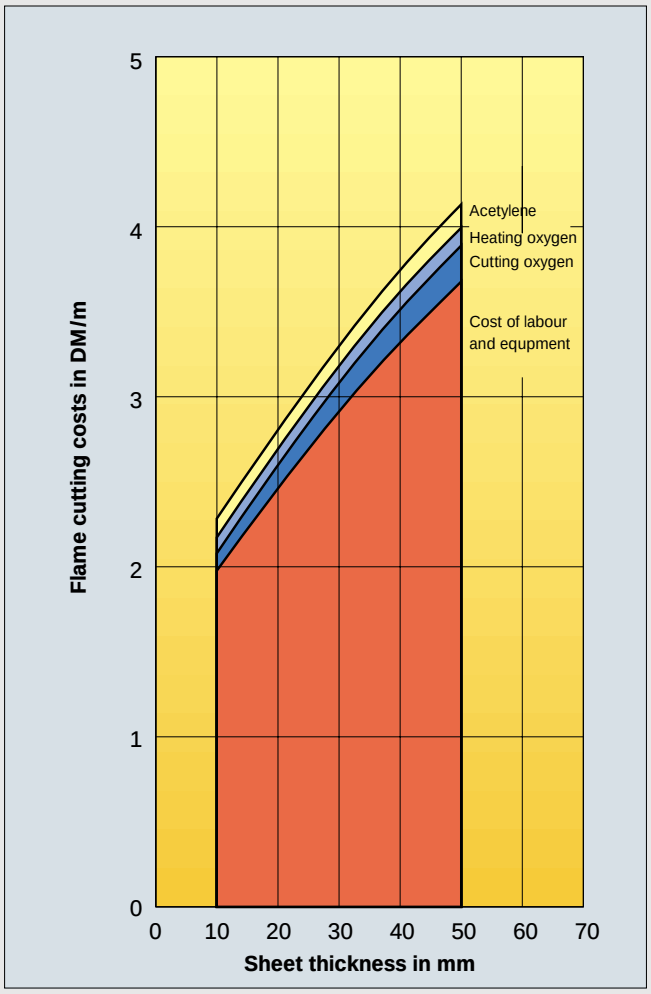
Use of Carboflam® to apply a reproducible carbon coating to a glass mould for manufacturing glass containers. ▲



In aluminium bar extrusion the surface is coated with carbon by means of an oxy-acetylene or air-acetylene flame providing a separating and insulating layer. ▶

Economics and quality when using acetylene in oxy-fuel gas processes





In respect of actual work performance the use of acetylene means high cutting speed, fast start-up and preheating, concentrated heat input and, therefore, significant time saving.

And, regarding quality: smooth clean cut edges and surfaces, no need for preparing weld seams, good gap bridging capability, and, therefore, an excellent overall quality standard.

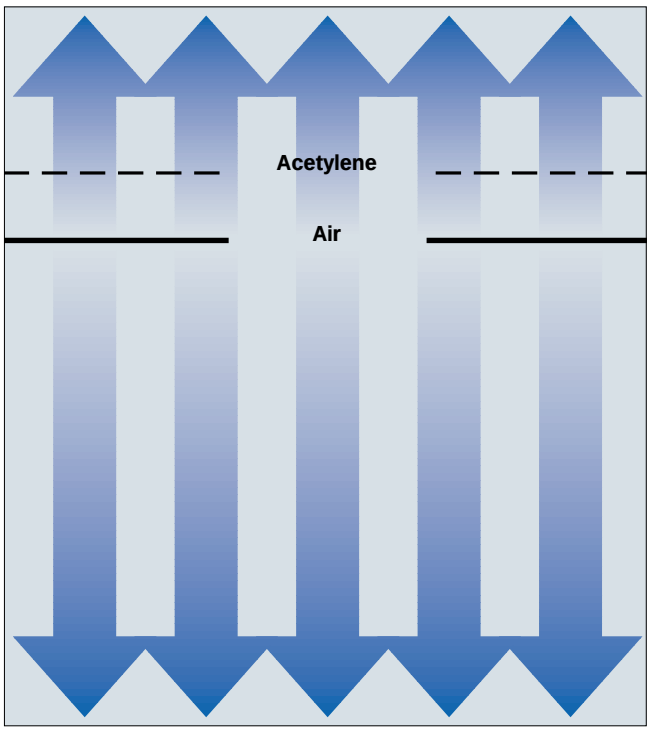
When considering the economics of a process it is not sufficient to merely look at the cost of fuel gas and oxygen.

The decisive factor, rather, is the cost of labour and equipment, which may add-up to 90% of total cost. Therefore, the use of acetylene as a fuel gas provides the key to profit by optimum utilisation of its high inherent energy.

Safety

Acetylene features a particular physical property of high value: its density of 1.095 kg/m^3 (at 15 °C/1 bar). This means that acetylene is about 10 % lighter than air. If it should escape inadvertently, it will go up and disappear in the atmosphere. Gases heavier than air sink down and there is always the risk that they will form explosive mixtures. The only fuel gas which is lighter is methane. Therefore, these are the only fuel gases which may be used for work below ground level or in confined spaces with little ventilation above, for instance in shipbuilding or mining.

Anything required in respect of special safety for acetylene applications is already “built into” the steel cylinder: the porous mass which stops any possible decomposition of the acetylene. The acetone or dimethyl formamide (DMF) contained in the porous mass acts as a solvent. It multiplies the storage capacity many times. On the other hand, what is prescribed for safe withdrawal applies to acetylene just as to other fuel gases: the discharge points in distribution piping must be equipped with flashback arrestors.

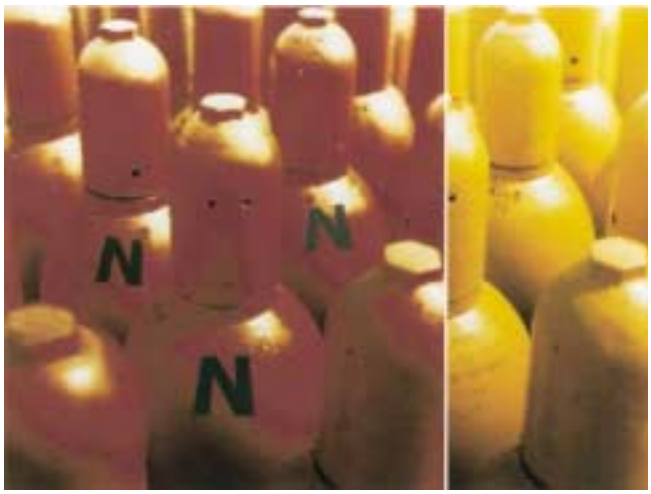


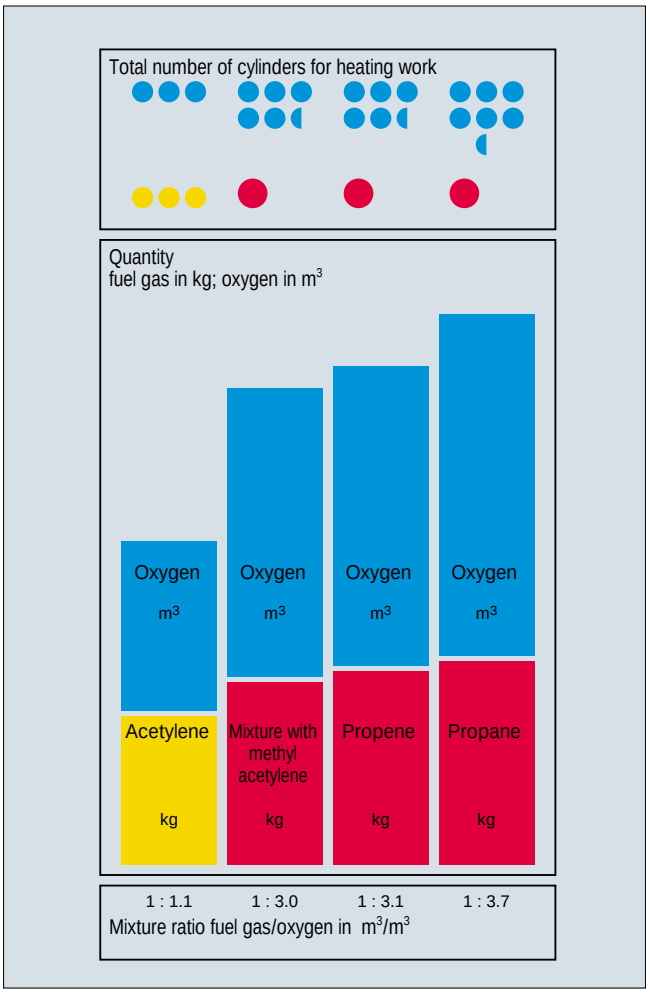
Acetylene is approx. 10 % lighter than air

10.000 x magnification of the high-porosity Linde M1 mass (photographed by scanning electron microscope)

Flame cutting
Gouging
Flame spraying
Flame heating
Flame straightening
Flame-cleaning
Gas welding
Hard-facing
Gas powder welding
Gas pressure welding
Flame-brazing
Flame hardening

Oxygen requirements





Examples for the oxygen/fuel gas ratios in a comparative heating test

Versatility

This is another convincing point regarding cost-effectiveness.

When using acetylene only one type of fuel gas is needed for all the oxy-fuel gas processes, whether inside a plant or on the building site. This is a high-performance fuel gas proved in decades of practical use. With the lowest number of cylinders required. Ready for use at any time, even with varying production jobs. An insurance for economy and quality.

With any fuel gas oxygen is needed for ingnition. The proportion of oxygen influences the “flame quality” in respect of temperature, output and speed. Acetylene attains the absolutely highest flame temperature of 3,160 °C at a mixture ratio of 1:1.1 to 1:1.5. All other fuel gases need more oxygen (up to a ratio of 1:4.5) to achieve maximum performance. Of all fuel gases the oxygen requirements of acetylene are the lowest. A feature that brings multiple benefits. Because consequently the total number of cylinders needed is lower than with other fuel gases.

Acetylene cylinder supply systems

Delivery as	Type	Contents	Gas withdrawal l/h		
		kg	short term < 20 min.	normal 8 h/day	continuous > 8 h / day
Single cylinder	40/48/50	6.3/8/10	1,000	500	350
Cylinder bundle (6 cylinders)	46	43.2	6,000	3,000	2,000
Cylinder bundle (16 cylinders)	61	144	16,000	8,000	5,500
Trailer (128 cyl.) 8 bundles		1,152	128,000	64,000	44,000
Trailer (256 cyl.) 16 bundles		2,304	256,000	128,000	88,000

A single-cylinder set combined with an oxygen cylinder permits using the oxy-fuel gas process at nearly any time and anywhere. If a single cylinder is not sufficient to supply larger types of torches, several cylinders can be combined to a battery.

Depending on requirements, in this case also the small acetylene bundle with 6 combined cylinders can be used. For large-scale consumption the acetylene bundle with 16 cylinders will provide the most economical solution.

Several 16-cylinder bundles combined to a battery will cover the demand of large steel processing enterprises.

For even the largest possible users of acetylene we supply cylinder systems holding these quantities ready for consumption plus a well-sized reserve - our acetylene trailer.

① ***Cylinder bundle supply system***

② ***Trailer supply system***

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