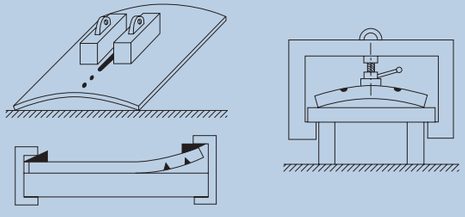
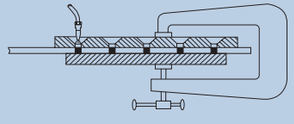
Material thickness			Torch size		Acetylene consumption
Mild steel Boiler steel (mm)	Austenitic CrNi steel (mm)	Aluminum and its alloys (mm)	(DIN EN)	(mm)	(liters/hour)
			Single-flame torch		
1–2	2–3	1–2	size 2	1–2	150
2–4	3–4	2–3	size 3	2–4	300
2–5	5–8	2–4	size 4	4–6	500
4–6	7–12	3–5	size 5	6–9	750
5–7	10–18	4–8	size 6	9–14	1,150
6–12	15–30	5–10	size 7	14–20	1,700
10–16	25–50	8–15	size 8	20–30	2,500
15–25	> 50	10–20	size 9	30–50	4,000
20–40	> 50	15–30	size 10	50–100	7,500
			Switch-tip torch		
5–15	8–20	5–10	size 3 3/2 5/3	2–4	900/600 1,500/900
10–30	15–40	8–25	size 4 3/2 5/3	4–6	1,500/1,000 2,500/1,500
			Three-flame torch		
15–40	20–50	12–35	size 5	6–9	2,250
			Specialized torch		
1–300	1–300	1–300			100–20,000

5. Mechanical appliances

If restricting the thermal expansion by the surrounding cold metal is not sufficient, mechanical expansion restrictions are useful. They can support the upsetting process, and increase the flame straightening effect.



Auxiliary equipment is not supposed to clamp but should merely keep parts in place!



Perforated plate for straightening sheet metal sections.

6. Working procedures

For better heat transfer and, consequently, satisfactory generation of heat buildup, the flame adjustment should be hard/neutral or, even better, contain excess oxygen (up to 50%). The distance between the flame cone and the workpiece surface should be kept as short as possible. Selection of torch size is determined by the type of material and the material thickness (see table).

Flame straightening of mild steel, fine grain structural steel, and thermomechanically treated steel

Flame straightening will be possible without substantial structural change provided that the heating temperature is maintained to produce a “dark red glow” on the work area. Cooling is usually obtained by calm air. Rapid cooling may result in shorter straightening times on sheet metal and insensitive material.

Flame straightening of high alloy austenitic steel

By use of correct heating temperature for “dark red glow”, the structural composition of these steels will not be changed by flame straightening, apart from a possible slight surface oxidation. By selecting a neutral flame or, even better, an oxidizing flame, carburization can be avoided entirely. Due to lower thermal conductivity and higher thermal expansion, heat buildup and efficient straightening results are easily obtained. Therefore, heating attachments are used that are smaller in size than those used for mild steel straightening. Rapid cooling has a positive effect on material and corrosion resistance.

Flame straightening of hot galvanized parts

Hot galvanized structures can be straightened without adversely affecting corrosion resistance. The most effective flame temperature is obtained when the “red hot glow” has been reached. However, it is not to observe this color on hot galvanized steel, use of a brazing flux is recommended, e.g. type F-SH1. Because of its fusion temperature, this flux is a good temperature indicator and, at the same time, protects the surface from oxidation.

Flame straightening of aluminum and its alloys

The selected flame type is commonly neutral or contains a small quantity of excess acetylene. Because of the high thermal conductivity, the heating tips used are larger than those used for steel. Thermal expansion is twice that of steel. Therefore, in many cases expansion during the heating process is restricted by the use of mechanical appliances. Depending on the alloy, the guide value for heating is in the temperature range of 150 to 450 °C (462 to 802 °F), which can be quickly and easily checked with a wooden chip.

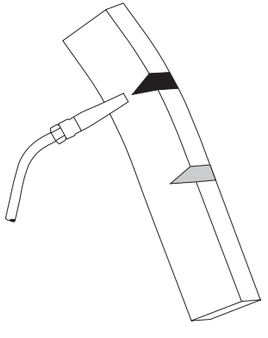
Linde AG
Linde Gas Division
Seitnerstrasse 70
82049 Höllriegelskreuth, Germany
Phone +49.89.74 46-0
Fax +49.89.74 46-12 30
www.linde-gas.com

43491308 0605 – 1.2 Au Subject to alteration.

Tips for the practitioner.
Flame straightening.

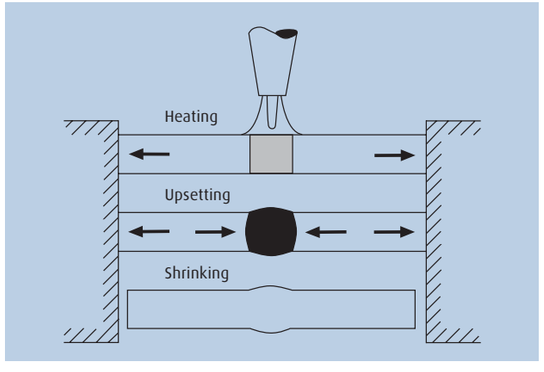
Linde Gas

Contents



1. Application principle

In flame straightening applications the construction element is heated locally to the ductile state. At that stage, permanent upsetting occurs due to restricted thermal expansion.
A reduction in length of the workpiece results as the workpiece (section) cools down, with the intended deformation being the consequence.

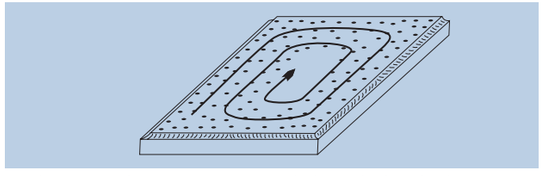


2. Correct process steps

- Determine the section to be shortened and upset by using the flame.
- Heat to the ductile state. Steel and heavy metal up to 550–700 °C (1,022–1,292 °F) (dark red glow – to be visually checked), light metals up to 150–450 °C (462–802 °F) (check with wooden chip).
- Restrict local heat buildup to produce upsetting as a result of cold neighboring areas. Maximum heat buildup will be achieved by using an excess oxygen (lean/oxygen-enriched) flame.
- Select suitable straightening torch.
- Shrinking until ambient temperature has been reached.
- Check straightening effect.

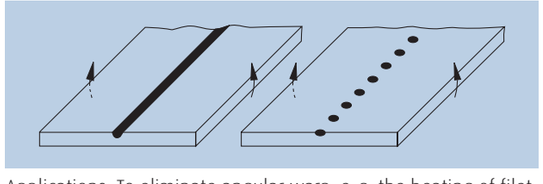
3. Heating techniques

Heat spot



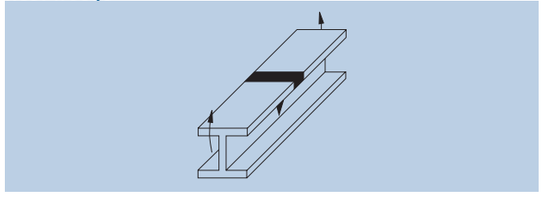
Applications: Plate sections, pipes/tubes, shafts. The heat spot applied must be kept as small as possible. To be applied from the support (frame) towards the plate center.

Heat line



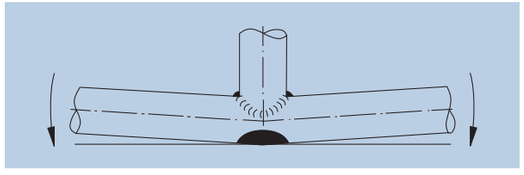
Applications: To eliminate angular warp, e.g. the heating of filet welds from the back side. For maximum effect, the straightening temperature should be applied to only one-third of the plate thickness. Aligned heat spots produce less distortion than a heat line.

Heat wedge



Applications: For severe distortion, e.g. of profiles and narrow metal plates. The heat wedge is long and thin. Heat is applied evenly starting from the tip towards the surface area up to the straightening temperature.

Heat oval

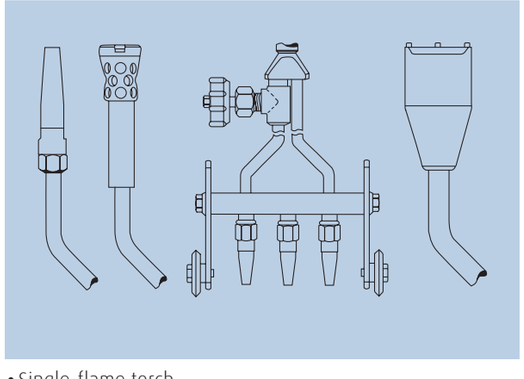


Applications: On pipes, e.g. after welding of T-joints. The heat oval is thoroughly heated and arranged lengthways with the pipe axis.

Depending on the shape of the construction/workpiece, a combination of these heating techniques may be useful.

4. Equipment

Torches for flame straightening are determined by the type of job and thickness of the workpiece material:



- Single-flame torch
- Multi-flame torch
- Switch-tip 2-flame, 3-flame, and 5-flame torch
- LINDOFLAMM® specialized torch

Single-flame torch
This is the common type for flame straightening with heat spots, lines, wedges, or ovals.

Multi-flame torch
This is employed to flame-straighten plates from approx. 20 mm thickness, using heat lines, wedges or ovals.

Switch-tip 2-flame, 3-flame, and 5-flame torch
These are used to eliminate angular warp, and to flame-straighten shells in shipbuilding and on sheet metal sections.

LINDOFLAMM® specialized torch
This is tailor-made in shape and performance for the actual flame straightening job, and is employed, for example, on large diameter pipes or thick-walled workpieces.

Gas supply
The gas supply must be designed to suit the size of the torches used and to handle the extent of the straightening job. For acetylene as well as for oxygen, it may be necessary to connect multiple gas cylinders.

Selection of torch size
The size of the flame straightening torch is determined by the type of material used and the thickness of the workpiece. For sheets up to 3 mm thick, for example construction steel, the same torch size is selected as for welding.