

6. Working Procedures

Workpiece thickness			Nozzle size for flame straightening	Gas consumption	
Mild steel	Stainless steel	Aluminium and its alloys		Acetylene	Oxygen
mm	mm	mm		l/min	l/min
1-2	2-3	1-2	1-2	2.5	2.8
2-4	3-4	2-3	2-4	5.0	5.5
2-5	5-8	2-4	4-6	8.3	9.2
4-6	7-12	3-5	6-9	12.5	13.8
5-7	10-18	4-8	9-14	19.2	21.1
6-12	15-30	5-10	14-20	28.3	31.2
10-16	25-50	8-15	20-30	41.7	45.8
15-25	> 50	10-20	30-50	66.7	73.3
20-40	> 50	15-30	50-100	125.0	137.5
			Multi-nozzle torch (3 nozzles)		
5-15	8-20	5-10	2-4	15.0	16.5
10-30	15-40	8-25	4-6	25.0	27.5
15-40	20-50	12-35	6-9	37.5	41.3
1-300	1-300	1-300	Specialised torch	2-333	2.2-366.3

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. The selection of the 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 stainless steel

By maintaining the correct heating temperature for a "dark red glow", the structural composition of these steels (apart from a possible slight surface oxidation) will not be changed by flame straightening. By selecting a neutral flame or, even better, an oxidising flame, carburisation 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 the material and on the corrosion resistance.

Flame straightening of hot-galvanised parts

Hot-galvanised structures can be straightened without adversely affecting corrosion resistance. The most effective flame temperature is obtained when the "dark red glow" has been reached. However, as it is not possible to observe this colour on hot-galvanised 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 aluminium 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 as large as that of steel. In many cases, expansion during the heating process is therefore 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.

Tips for the Practitioner Flame Straightening

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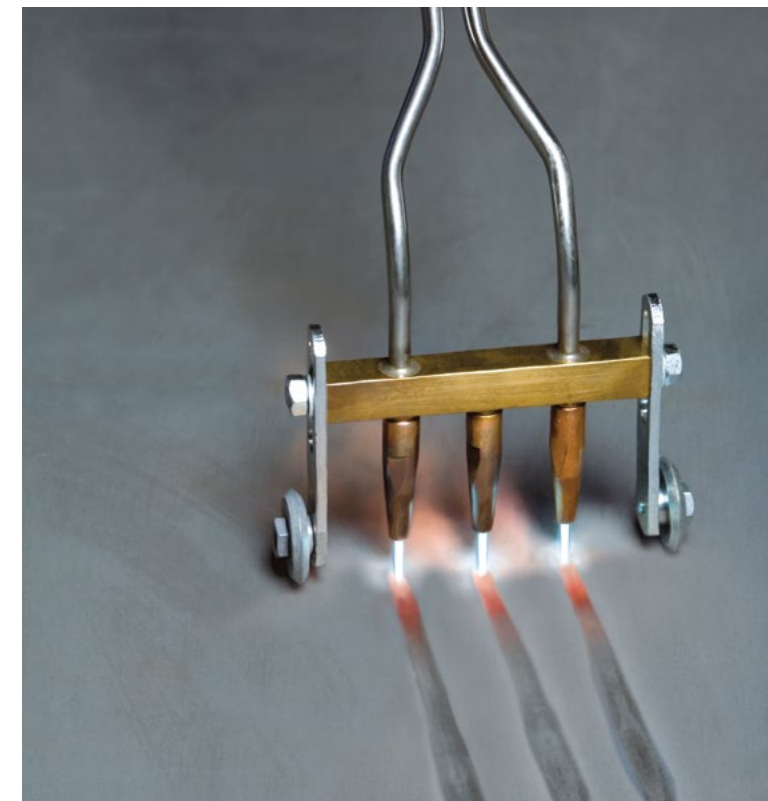
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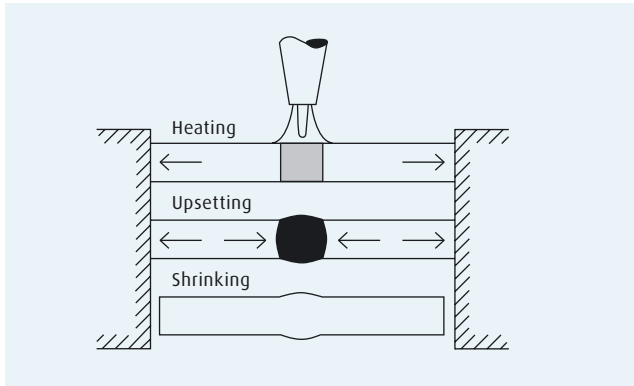
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1. Application Principle

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. As the workpiece (section) cools down, the length of the workpiece is reduced, which in turn leads to the intended corrective deformation.

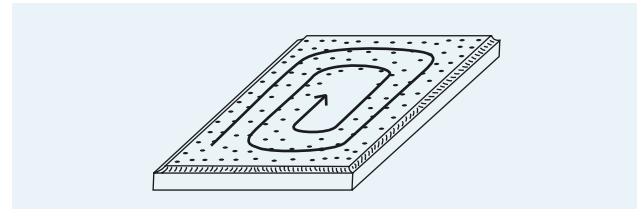


2. Correct Process Steps

- Determine the section to be shortened and upset by using the flame.
- Select suitable straightening torch.
- 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 neighbouring areas. Maximum heat buildup will be achieved by using an excess oxygen (lean/oxygen-enriched) flame.
- Shrinking will continue until ambient temperature has been reached.
- Check straightening effect.

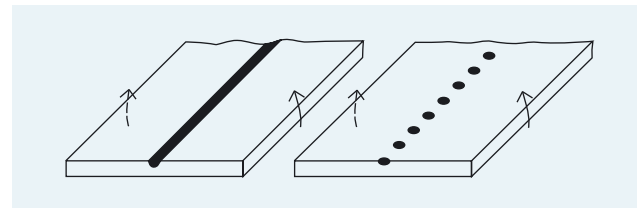
3. Heating Techniques

Heat spot



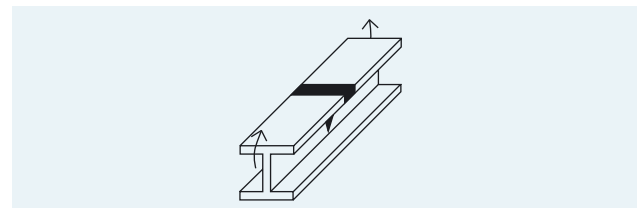
Applications: Plate sections, pipes/tubes, shafts. The heat spot applied must be kept as small as possible. To be applied from the support (frame) towards the plate centre.

Heat line



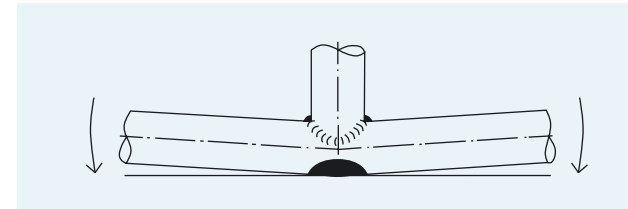
Applications: To reduce angular warp, e.g. the heating of fillet welds from the back side. For maximum effect, the straightening temperature should be applied to only one third of the plate thickness. Aligned heat spots produce less distortion than a heat line.

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

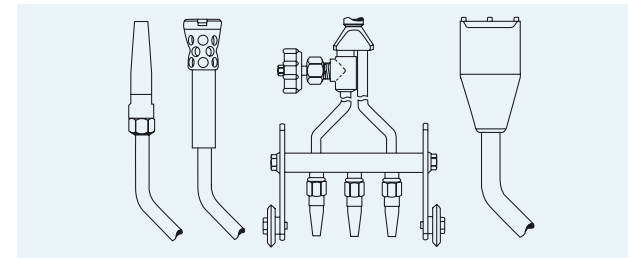


Applications: On pipes, e.g. after welding of T-joints. The heat oval is thoroughly heated and arranged lengthways with the pipe axis.

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 application and the thickness of the workpiece material:



Single-flame torch

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

Multi-flame torch

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

Multi-nozzle 2-flame, 3-flame, and 5-flame torch

These torches are used to eliminate angular warp, and to flame-straighten shells in shipbuilding and on sheet metal sections.

LINDOFLAMM® specialised torch

This torch 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 of up to 3 mm thickness, e.g. construction steel, the same torch size is selected as for welding.

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.

