The Golden Rules of Flame Straightening

Welding and other manufacturing processes where heat is introduced leave stresses in the metal during the subsequent cooling, causing distortion or warping. Flame straightening is an efficient and long established method of correcting the distorted parts. It is based on the principle that metals expand when heated and contract when cooled. If expansion is restricted, compressive stresses build up and result in plastic deformations if the temperatures are high enough. Upon cooling, the plastic deformations remain.

In practice, an oxy-acetylene flame is used to rapidly heat a well-defined section of the workpiece. Upon cooling, the metal contracts more than it could expand when heated and any resulting distortions can therefore be straightened out.

The technique works on the basic principle of differential heating of surface areas of a reasonably thick plate along a straight or a curved line.

An oxy-acetylene burner is used for the purpose of heating. As the burner raises the surface temperature of the plate locally, the stress caused by heating exceeds the yield point of the material. During cooling, shrinkage forces are generated in the upset zone, which lead to the desired change of shape.

Welded, bent, twisted and dented workpieces are straightened with the flame rapidly, and without impairing the material.

The material has to be heated locally to obtain a certain thermal expansion with a considerable decrease in yield strength. For instance, in the case of steel, it must be heated to over 550°C. To enable visual determination, the practical specialist heats to ‘cherry red’, which is usually between approximately 600°C to 650°C, but below 750°C.

Heating Techniques

There are four commonly-used heating techniques in flame straightening:
- **Heat Spot**: is used for straightening plates.
- **Heat Oval**: is used to straighten pipes and shafts.
- **Heat Line**: is used in straightening of angular warp and heavy plates.
- **Heat Wedge**: is used for straightening of severe distortions and sections.

These various types of heating are used in combination with each other. The extent of upsetting determines the contraction and hence the straightening effect. A precondition for upsetting is a good heat build-up.

In order to ensure an adequate heat build-up, appropriate torches have to be used. If too much heat is conducted into neighbouring zones, the heated area becomes too large and will not be upset, but deformed. The surrounding cold metal confines thermal expansion. If the thermal expansion stresses in the heated area exceed the strength of the material, upsetting occurs.

By contraction matching the extent of the upsetting effect, the work piece is drawn into the desired shape during cooling. The straightening effect is measurable only when the work piece has cooled to ambient temperature, because the forces of contraction continue to act up to that point. To the extent that the material permits it, the cooling time can be shortened by cooling with compressed air or water.

Flame straightening can be used to restore components whose geometry has been changed, by the action of heat during welding, to their desired shape.

Sources:
Flame Straightening by Professor Volkmar Schuler
The Golden Rules of Flame Straightening

When it comes to flame straightening, there are two golden rules:
- The heat must be applied quickly.
- A local heat build-up must be achieved.

Tips for Effective Flame Straightening

1. Check the admissible deviations in the specification.
2. Put the structure in a ‘neutral’ position (to avoid incorrect measurements due to the structure’s own weight deformations).
4. Measure the member to establish the degree of distortion in mm. The ‘long side’ (the one that has been shortened) must be identified.
5. Provide restraint for the thermal expansion (clamping devices).
6. Apply the heat as quickly as possible to localise thermal expansion.
7. Cool down the structure as quickly as possible (material dependent).
8. Measure the effect of straightening only after complete cooling to ambient temperature.
9. Assess the effect of what has been achieved and think carefully about the next step.
10. Follow the heating patterns on the structure.
11. Continue straightening if needed, heating intermediate points.