Flame Hardening

Flame hardening are methods for hardening the surfaces of components, usually in selected areas, by the short-time application of high-intensity heating followed by quenching. The heating and hardening effects are localised and the depth of hardening is controllable. Unlike thermochemical case-hardening treatments (carburising / carbonitriding) applied to low-carbon steels, induction and flame hardening do not promote chemical enrichment of the surface with carbon, but rely on the presence of an adequate carbon content already in the material to achieve the hardness level required. The properties of the core remain unaffected and depend upon material composition and prior heat treatment. Induction and flame hardening are typically used to treat components such a gears, shafts, rolls, slideways, cams, crankshafts and camshafts.

Flame hardening involves the direct impingement of oxy-gas flames from suitably designed and positioned burners onto the surface area to be hardened, followed by quenching. Depth of hardening is controlled by the design of the flame head, time of heating and the hardenability of the material. Again, hardening can be single-shot or progressive.

What are the benefits?

- flame hardening imparts a hard, wear-resistant surface to the component whilst improving its fatigue strength through the development of residual surface compressive stresses in suitably deep cases. Because only the surface is heated and quenched, heat treatment distortion can be minimised.

- Faster localised cooling rates permit higher surface hardness values than might be achieved by through hardening.

- Deeper hardening can be obtained than with thermo-chemical treatments. Depending upon process parameters, hardened depths can be in the range 0.5-10mm.

- Localised hardening can be used to strengthen components at critical points while leaving other areas soft, without the need for the stopping-off procedures required in thermochemical case-hardening.

- Induction and flame hardening offer options for the treatment of exceptionally large components, where conventional furnace heating and cooling would be impractical and where only localised surface hardening is necessary.

- Both techniques can be automated for reproducible results once the processing parameters have been set.

What sort of materials can be treated?

- Induction and flame hardening can be applied to a wide range of steels and cast irons. Normally, medium-carbon steels (0.35-0.5% carbon), with or without alloying additions, are used to ensure a satisfactory hardening response, final choice depending on required surface hardness and core properties. With higher carbon contents there is an increased risk of cracking and careful control is necessary for successful treatment.

- The processes are used in certain circumstances for hardening previously-carburised surfaces on low-carbon steels. Consult your heat treater when selecting materials for induction or flame hardening.

What are the limitations?

• Applications such as gears and shafts, which have readily-accessible and geometrically-uniform surfaces, are easily treated. Components with irregular shapes and surfaces requiring treatment can be difficult to induction harden in view of the restrictions imposed by coil design or limited accessibility. Flame hardening offers a somewhat greater degree of versatility.

• The treatments can be applied to materials in the hardened and tempered, normalised or annealed condition. Because of its metallurgical structure, material in the hardened and tempered condition promotes optimum response to these short-time processes.

• The size and shape of a component that can be induction or flame hardened depends on the type of equipment operated by the heat treater. For large components, check the availability of suitably-sized facilities at an early stage.

What problems could arise?

• Decarburised surfaces will not respond properly to induction or flame hardening and must be avoided (e.g. parts made from cold-drawn bright bar which has not been machined on the diameter).

• There is a danger of overheating thin sections and edges (e.g. keyways, oil holes, section changes, etc). Where possible, account should be taken of this factor at the design stage (by use of chamfers on edges, for example).

How do I specify?

All of the following information should be included if possible. If uncertain, ask your heat treater before producing a specification:

• Instruction: flame harden.

• Material: identify the material used as accurately as possible using a BS number and grade or maker's code.

• Condition: indicate the existing heat treated condition (e.g. hardened and tempered).

• Specify the hardened depth required, indicating a realistic acceptable range. State clearly whether this is an effective depth (to a specified hardness level) or a total depth (to core hardness level).

• Specify the surface hardness required, indicating an acceptable range.

• Provide drawings indicating selective hardening patterns.

• Quote any relevant customer specification/ standard.

• Where destructive testing is not admissible, representative test pieces (or scrap components) should be supplied for setting up and hardened-depth measurement.