Caronitriding

Carbonitriding is a "thermochemical" treatment, usually conducted at temperatures in the range 800-940°C, in the first stage of "case-hardening". This process changes the chemical composition of the surface of a low-carbon steel component so that subsequent fast cooling, by "quenching", produces a hard "case" combined with a softer/tougher "core". Quenching is normally followed by a low-temperature tempering / stress relieving treatment. In carburising, controlled levels of carbon are introduced at the surface and allowed to diffuse to a controlled depth; in carbonitriding, nitrogen is also imparted, along with the carbon, to improve case hardenability. The heat treater employs a variety of processing media to achieve these objectives, including controlled gaseous atmospheres and molten salt ("cyaniding").

What are the benefits?

Carbonitriding case-hardening treatment offers a means of enhancing the strength and wear proper-ties of parts made from relatively-inexpensive easily-worked materials. Generally applied to near-finished components, the processes impart a high-hardness wear-resistant surface which, with sufficient depth, can also improve fatigue strength. Applications range from simple mild steel pressings to heavy-duty alloy-steel transmission components.

What sort of steels can be treated?

Steels that can be treated by these processes fall into two types:

1/ Low-carbon / non-alloy (mild) steels can be case-hardened by carburising or carbonitriding, but do not develop significant core strength. Thus they are normally treated for increased wear resistance only.

2/ Low-carbon alloy case-hardening steels, intrinsically higher-strength materials, can be carburised to yield a high surface hardness whilst developing significant strength and toughness in the core. They are not normally carbonitrided. BS970 lists some case-hardening steels and their typical mechanical properties. Consult your heat treater when selecting steels for case-hardening.

What are the limitations?

Case depth
Depending upon process temperature, duration and media, case depths can be produced within a wide range, from less than 0.1mm where some wear resistance is the only requirement (e.g. thin-section pressings), increasing where fatigue resistance is needed (e.g. carburised case depths of the order of 1mm on automotive gears) up to total depths of some 7.5mm (e.g. heavy transmission gearing).
Case depths imparted by carbonitriding, generally used for small components, are limited to no more than 0.75mm by practical considerations. It should be noted that maximum hardness of a case-hardened part is not maintained throughout the full depth of the case: part-way through the case, hardness begins to reduce progressively until it reaches the core hardness. It is therefore important not to grind a case-hardened part excessively, otherwise the resulting surface hardness and strength will be significantly diminished.

Core properties
Core properties are predominantly determined by the type of steel / section size and can only be changed marginally without adversely affecting surface hardness.

Section size
The section size of a component and the type of steel used also influence the depth of hardened case that can be achieved:

1/ With low-carbon non-alloy (mild) steels, about 12mm is the upper section-size limit for carburising where oil quenching (the norm) is employed (water quenching permits larger section sizes, but with increased risk of distortion of a carburised component). Carbonitriding can offer significant advantages here in terms of the depth of hardened case developed in larger section sizes.

2/ With alloy case-hardening steels, larger section sizes can be readily carburised and oil quenched. In some instances, with suitable section sizes, elevated-temperature quenching ("martempering" /"marquench-ing") can be an option to minimise component distortion.

The negative effect of aluminium

Plain-carbon non-alloy steels, including pressing-quality mild steels, can contain excessive amounts of aluminium which can have a harmful effect on case-hardening response (low surface hardness and low case depth).

Component size and shape

The size and shape of a component that can be carburised/carbonitrided depends on the type of equipment operated by the heat treater. Overall, items that can be handled within the contract heat treatment sector range from those of a few grams to components weighing several tonnes each. For large components, check the availability of suitably-sized facilities at an early stage.

What problems could arise?

Distortion

Changes in size or shape can arise in case-hardened components from a variety of causes, some inherent in these high-temperature / rapid-cool processes, some attributable to component design shortcomings, and others relating to earlier manufacturing steps (e.g. thermal relief of stresses introduced by prior forming). It is important to consider if preliminary normalising before finish machining will be an advantage in reducing distortion during subsequent treatment; your heat treater will advise whether this process can offer any benefit. Close-tolerance components must be ground (with care) after treatment. The case depth specification must allow for this. (Shallow-case carbonitrided components are not normally ground).

Subsequent processing

Subsequent plating (especially zinc plating) can sometimes be rendered difficult by carbonitriding.

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: case harden: carbonitride.

- The steel specification: identify the material used as accurately as possible.

- The case depth required, indicating an acceptable range. Make it clear whether this is total case depth (measured to core hardness) or effective case depth (measured to a specified hardness level, usually 550HV/50HRC). Where a test piece is supplied for case depth measurement, ensure that it is of the same batch of steel and section size as the component to be treated.

- The acceptable surface and core hardness ranges, stating type of hardness test and any special position for measurement.

- Any general standards applicable (e.g. Ford specification). Furnish drawings if possible.

- Grinding allowance - state whether the case depth includes a grinding allowance or specify the allowance to be added.

- Selective treatment requirements - a variety of procedures can be applied to leave selected areas of the surface of a component "soft". If required, specify precisely, stating what is mandatory and what is optional (e.g. area which must be hard and area which must be soft).