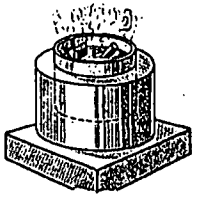


INSPECTING machined hard-facing deposit on large gate-valve disk for defects. Disk takes high pressure and temperature

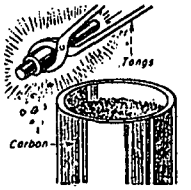
SOME WAYS OF CASEHARDENING STEEL



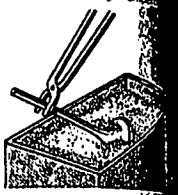
CYANIDE salt is melted to make bath where parts "bake"



INDUCTION hardening low voltages, high amper



CARBON-containing powder is also used for casehardening



CARBURIZE by packing in charcoal, other mat

One Way to Fight Wear Is to Make Steel Hard and Tough

There are quite a few things that can be done to steel to make it harder or tougher. Changing the carbon content makes a lot of difference. For example, carbon content accounts for the difference between pure iron, steel and cast iron. Let's see why:

Carbon Content. Pure iron, known as *ferrite*, is soft, but tough, ductile and malleable. Of commercial metals, *wrought iron* comes closest to pure iron. It's essentially ferrite with fibrous slag inclusions. Adding carbon to pure iron makes a big difference. Relatively small quantities (less than about 1.7%) form what we know as *steel*. *Cast iron* has even more carbon.

So it's carbon that makes our modern steels. How does it get into iron? Mostly from the coke used as fuel in blast furnaces. From the time iron gets spongy it continues to absorb carbon. It usually takes all it can hold—3 to 5%. Later carbon is burned out in converting pig iron to steel. For exact control, small quantities are added in the finishing operations.

Heat Treating. In addition to adjusting carbon content, we can change the character of steel by *heat treating*. As steel is heated, molecular changes occur at temperature levels called critical points. Changes in structure also occur as the steel cools, but the critical points come at slightly different temperatures. If the cooling is slow (*annealing* or *normalizing*), the final structure is similar to the original one. This will usually change the grain size and the mechanical properties.

Rapid cooling, by quenching in water for example, arrests the structure changes at some intermediate point, giving a harder structure. This is *hardening*. In general, the higher the carbon content, the harder the steel can be made.

Some structures formed by heating and quenching are unstable. If we heat hardened steel to temperature below the critical points, structures begin to change. Quenching at the right point gives a steel that is less brittle. This carefully controlled reheating and quenching is called *tempering*.

Alloying. Hardness and other characteristics of steel can also be altered by adding small amounts of other elements to form *alloys*. By juggling carbon and alloy content and by using the many kinds of heat treatment, we can tailor steels to meet a wide variety of service needs.

Plating. Where surface protection is major need, electroplating or ... coatings are used, particularly to ... tect against corrosion. Chrome-plat... as on the liners of internal-combustio... engines, increases wear resistance. Co... ings such as aluminum or chromium ... also sprayed on surfaces to prevent ... terioration.

Surface Hardening. For some ser... it's best to have a material that is ... and fairly soft, with an extremely ... outer surface. The general term for ... is *casehardening*. There are two ... ways of casehardening: (1) heating ... entire object and fixing things ... picks up additional carbon or ... hardening agents at the surface, ... having a uniform carbon content but ... ranging to heat only the surface of ... object. Big advantage of either se... is that part may be machined first, ... hardened.

Carburizing involves packing a ... low-carbon-steel part in carbonac... material. Surface absorbs carbon ... hardens when quenched. In the ... days, carbon was absorbed from ... leather or similar materials. Today's ... carbonaceous materials are mixtures ... charcoal, barium, calcium and so... carbonates. Carbon may be abs... from a gas instead of solid mat...

In usual setup, part to be hardened ... packed in a box with carbon-giving ... Box is sealed and heated to ... 1700 F. Resulting hard "case" may ... 1/32 to 3/32 in. deep.

Cyaniding, another long-familiar ... doesn't penetrate so far. Cya... salt is melted to form a bath. Parts ... hardened are dumped in and al... to "bake," depending on hardness ... desired. Or part may be heated ... dipped into dry cyanide salt. While ... case is only a few thousandths ... process is quick. Caution: Cya... fumes are deadly poison.

Nitriding uses ammonia as source of nitrogen, the hardening agent. Only 900 to 1100 F is needed so chance for warping is lessened. Treatment can be used on alloy steels or steels of high carbon content. Nitrided case is extremely hard and corrosion resistant.

Surface-heating methods are widely used today. Steel of right carbon content is heated by a flame or by induction so only the surface is affected. Quenching then gives a hard surface with a tough core.

To induction-harden a crankshaft journal, for example, inductor blocks are snapped around surface to be treated. Then a high-frequency (1000 cycles or so), low-voltage, high-amperage current is turned on for a few seconds. Sprayed water does the quenching. This method is well suited to production-line operations.

So we see there are many ways to make steel more wear resistant. But most of the schemes we've just talked about apply to new parts. What can we do about boosting the wear resistance of parts already in service, perhaps already worn? For the answer to this big maintenance question we turn to . . .

Another Way—Hard Facing—Applies Alloys to the Surface

We generally use the term, *hard facing* (hard facing for short) in... applying an alloy coating to a ... part. The facing alloy is usually ... for wear resistance, but other ... such as corrosion may enter the ... Hard facing is widely used in ... production. But one of its great advan... lies in its suitability for mainte... work—protecting parts exposed ... tough wear conditions and building ... parts already worn.

Hard facing alloys are most often ap... by electric arc or gas torch, but ... are several other methods particu... suited to some types of alloys and ... applications. Later pages of this man... give practical pointers on ways to ... hard facing. Right here, let's take ... look at the many metals that can be ... faced and the many alloys available for ... job.

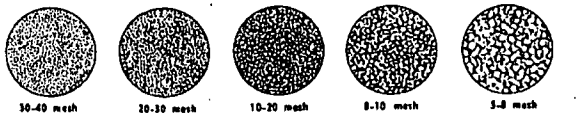
Which Metals? While most common ... metals can be hard-faced, ... are some exceptions and in many ... you have to know just how to do ... job. Here's a rundown on familiar ... what you can and can't do:

Low- and medium-carbon steels (less ... 0.5% carbon) can be hard-faced ... electric arc or oxyacetylene.

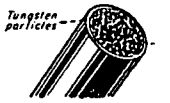
High-carbon steels (more than 0.5% ... can also be faced by arc or ... but you may have to heat-treat ... jobs before and after facing to ... hardness and brittleness, prevent ... cracking.

Low-alloy steels are in about same ... as ... carbon steels. Depending on ... composition, you may need to heat-treat.

Manganese steels (11-14% manga... are built up by the electric arc. ... base metal to avoid overheating. ... applying welding heat uniformly, ... deposit with machinist's hammer ... relieve cooling stresses.



CRUSHED CARBIDES come in bulk, in screen sizes shown. They are diamond substitutes and extremely hard. Use for unfinished surfaces needing high abrasion resistance



CARBIDES also come in tubular for welding rods like this



INSERTS or blanks of tungsten carbide come in a variety of shapes. Braze or weld to the base metal

The high-chromium and chrome-nickel steels, worn in service, may be restored by electric arc and torch. Be sure to know the properties of each type you work on. Heat evenly and cool slowly to prevent warping or cracking, because most steels of this class have a high coefficient of expansion. Doing the job right and knowing the metal's composition helps avoid brittleness and loss of the facing's corrosion resistance.

Cray and alloy cast iron: When facing with arc or torch, watch thin edges. Cast iron's lower melting point makes thin edges likely to melt off.

Malleable iron can be hard-faced, but welding heat hardens iron directly under facing. You may have to remove hardness by reheating finished job to above 1500 F.

Monel metal hard-faces easily and gives no trouble with ordinary care.

Brasses and bronzes, along with some other nonferrous alloys, are very easily surfaced with similar copper-base metals. Heavy sections preheated to a red glow can be faced by electric arc.

Copper and copper alloys conduct heat rapidly and have low melting points. Method used with brass may work.

Aluminum and aluminum alloys cannot be hard-faced.

Comparative Ratings. With so many alloys on the market to help solve almost every problem, the American Welding Society prepared the table on p 112, Comparative Ratings of Surfacing Alloys. Ratings are given on a scale of 10 to 100: 100 means you can expect the best possible wear, while 10 usually gives the poorest for service shown.

How to Select Alloy: While all the many wear problems cannot be shown, table does include most general cases, with nearest general solution. Most