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Nitriding and nitrocarburising

Both nitriding and nitrocarburising are low temperature treatments that produce thin, hard layers on the surface of steel to improve its wear resistance.

Why nitride or nitrocarburise?

It's mainly to do with wear. In general terms the harder a piece of steel is the less it wears. So if we are producing a component like a gear we want it to be as hard as possible so that it does not wear out. Unfortunately, in steels, high hardness has other consequences – one of those is loss of ductility. Hard steel tends to be brittle. So, if we made our gear out of hard, wear resistant steel, then as soon as it was shocked – by changing gear for instance – the gear teeth would fracture and fall off. The solution to the problem is to produce a hard wear resisting outside and a tough shock resisting core.

Carburising is the commonest way of doing this; however, both nitriding and nitrocarburising offer some advantages. Because of the low treatment temperature and the elimination of the need to quench the parts, there is less distortion. The layer produced by nitriding is harder that that from carburising, but a typical treatment is sixty hours for nitriding as against four for carburising. In addition to wear resistance, nitrocarburising provides corrosion resistance and can be treated to give an aesthetically pleasing matt black finish (Figure 1).

Figure 1. Black finished nitrocarburised parts

How is it done?

Both treatments diffuse nitrogen into the surface of the steel to form the layer. Unfortunately under most circumstances ordinary nitrogen is inert at the treatment temperature of between 500 and 600°C. Ammonia acts as a source of nascent nitrogen as it cracks on the steel surface and the nascent nitrogen diffuses into the steel.

Without the careful control of nitriding possible using the most modern nitriding equipment, a brittle layer of alpha-iron nitride is formed on the surface above the diffusion layer. This layer must be removed before the component can be put into service. The formation of this layer can also be avoided by using plasma nitriding. In this process ordinary nitrogen is ionised by an electric current making it possible for the nitrogen to diffuse into the steel. The ionised gas around the part is clearly visible in Figure 2.

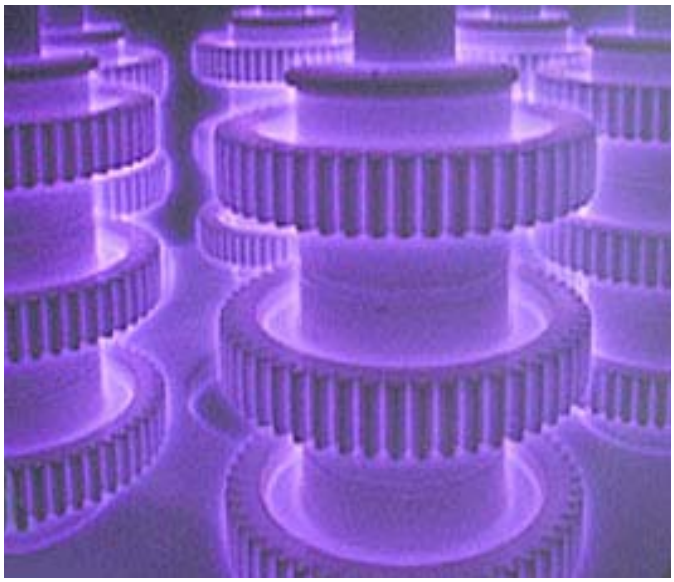

Figure 2. Plasma nitriding

In nitrocarburising on the other hand, an oxidant is added and an epsilon-iron nitride layer forms above the diffusion layer. Unlike alpha-iron nitride this layer is ductile so does not need to be removed. In addition it has a low coefficient of friction and is very corrosion resistant. Using Linde's NITROFLEX® atmosphere system for nitrocarburising means that you can accurately determine the thickness and porosity of the different layers due to its ability to create an infinite range of different atmospheres.

How do the layers compare?

A comparative wear study of many types of wear resistant diffusion layers under lubricated conditions – those normally found in industry – it was found that the various nitrocarburising treatments gave the lowest wear (Figure 3). Next came nitriding, then carburising and finally carbonitriding.

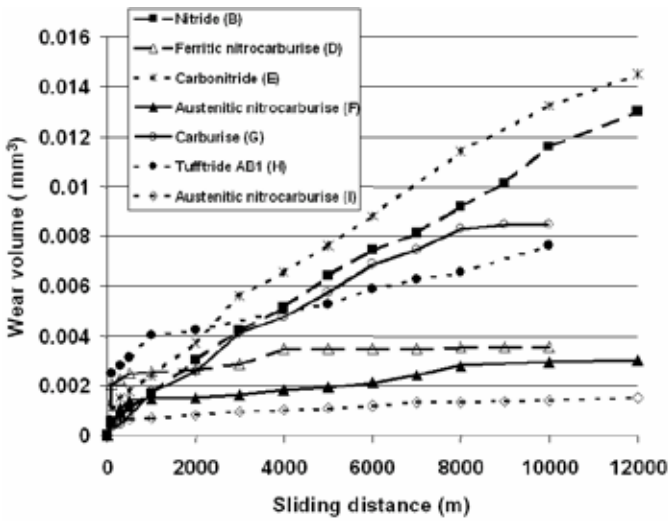

Figure 3. Comparative wear for various types of layer

What types of furnaces are used?

Most nitriding and nitrocarburising is carried out in pit furnaces. Pit furnaces are so called because they are usually installed with most of the furnace below ground level as they are loaded from the top although Figure 4 shows one installed above ground so that the whole thing can be seen. The ones used for these processes have a metal muffle that contains the atmosphere and are sealed by a lid.

Some of the nitrocarburising processes can be performed in a sealed or integral quench furnace, but care must be taken as they are operating with a flammable atmosphere below its self ignition temperature. Plasma nitriding is carried out in specially designed vacuum furnaces. It is also possible to carry out nitrocarburising in a vacuum furnace.

Figure 4. A pit furnace for nitriding and nitrocarburising

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