WORKING WITH PROTECTIVE GAS

When steel is heated, unwanted scale is produced, which causes costs. It contaminates equipment and cooling lubricants, reduces the service life of tools and, depending on the work piece, makes additional machining steps necessary. **This can be avoided by heating under inert gas.**

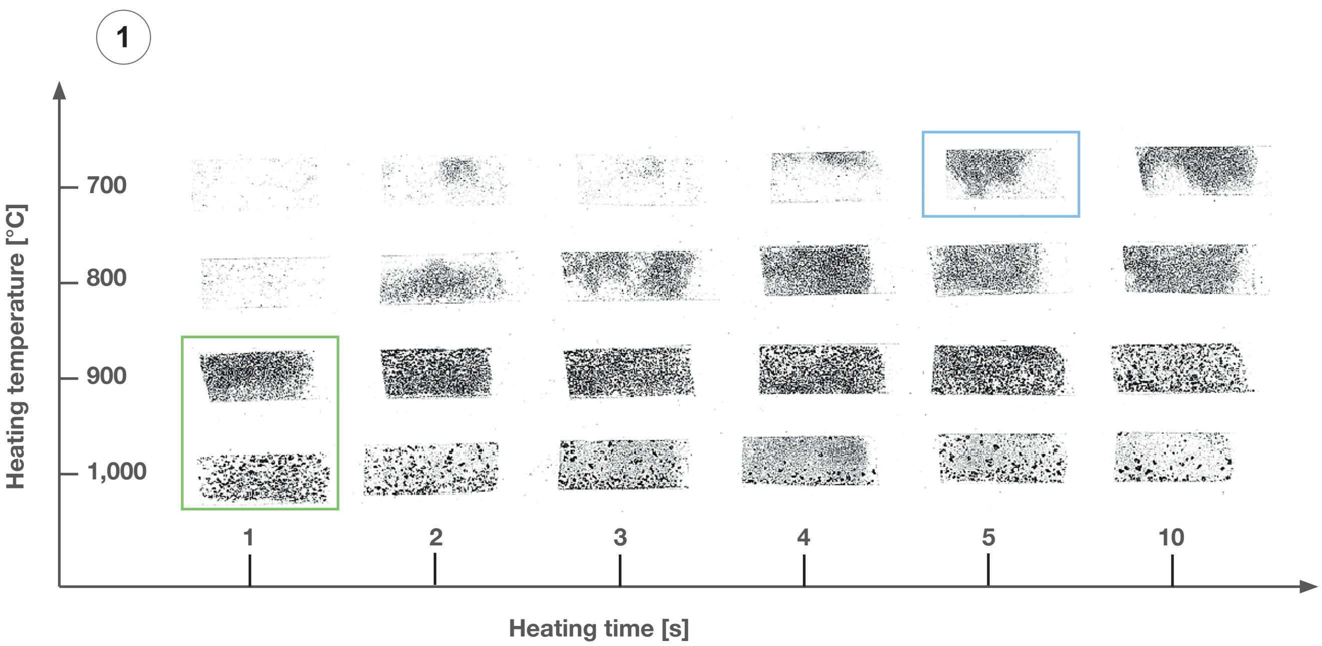
A **steel surface** starts to oxidize at a room temperature of just 20 °C. However, only an oxide layer invisible to the naked eye is formed. This haematite layer (Fe_2O_3) has a depth of just 25 * 10^{-6} mm, so that the surface appears blank. The thickness of the layer continues to grow with increasing temperature and the surface initially takes on a dim appearance.

As of approximately 200 °C, the surface starts to turn yellow; the layer thickness is now around 45 * 10^{-6} mm. With a further increase in temperature, the layer becomes even thicker and the discoloration moves into shades of brown and blue. At about 300 to 560 °C, the magnetite layer (Fe_3O_4) with a higher iron content forms beneath the haematite layer (Fe_2O_3).

At higher temperatures and depending on the composition of the material, the wuestite layer (FeO) forms below the two aforementioned layers. This is now what is commonly known as scale, which loosely adheres to the steel surface. This is detrimental to the production process and has to be removed regularly. Scale generally consists of the three layers named above.

Although inductive hardening does offer a certain advantage over conventional hardening methods due to the typically very short process times, scaling cannot be completely avoided.

Graphic (1) shows the results of our experiments on scale formation as a function of the heating temperature and time. Our **experiments (1)** showed that even with very short heating times, a considerable amount of removable scale formed on the work piece surfaces upwards of approximately 700 °C (blue rectangle). At the usual inductive hardening temperatures of 900 to 1,000 °C (green rectangle), oxide formation is already clearly visible after one second. Upwards of heating to 900 °C with a holding time of a few seconds, the typical plate-like structure of the scale is evident. The same applies to a temperature of 1,000 °C after just one second. The scale platelets adhere only loosely to the work piece surface, which is confirmed by the fact that the relatively 'large' scale particles can be washed off at these high temperatures and increasing process times during quenching.



Protective Gases

Inert gases protect the metal surfaces from unwanted changes or specifically influence the surface properties. It should certainly be noted that even small amounts of residual oxygen or oxygen compounds such as H_2O or CO_2 can still have a detrimental effect on quality at high temperatures. As such, only gases are considered which are highly inert, only participate in few chemical reactions and are affordable. Inert gases form few or no chemical bonds. They include nitrogen and, at low temperatures, carbon dioxide as well as all noble gases (argon, helium, neon, krypton, xenon and the radioactive radon).
Economical and safety-related noble gases are argon, helium and maybe even neon.
Experience has shown that nitrogen is usually the most suitable protective gas. Nitrogen is a colorless, tasteless, odorless and non-flammable gas. It is lighter than air and much cheaper than e.g. argon or helium and does not react chemically with most metal surfaces up to about 1,000 °C.

Protective Gas Enclosures

EMA Indutec has developed many solutions for hardening processes under protective gas and, as such, possesses many years' experience in protective gas hardening.
We generally distinguish between three main solution approaches for avoiding scaling during the heating process. As shown in **figure 2**, the work piece is enclosed by a small housing filled with protective gas and is therefore heated without oxygen. This can also take place with very large work pieces, however in this case, only the zone to be heated is protected by a protective gas enclosure (see also EMA Indutec's patent no. EP 2 264 192 A1). Depending on the process, it is sometimes necessary for several work pieces to be protected from oxygen at the same time or for a longer component to be continuously conveyed through a protective gas enclosure. In this case, an enclosure like the one shown in **figure 3** is used. It is filled with protective gas but is separated from the atmosphere at one or more openings by means of an airlock that uses quenching medium.
If the heating and quenching of the work pieces takes place in several or different stations, the entire machine housing is filled with protective gas, as shown in **figure 4**. Loading and unloading take place in this case via an airlock specially developed for this purpose by EMA Indutec.
Several examples of this are given on pages 54 to 57 for the ***Vela*** and ***Centaurus*** machines.

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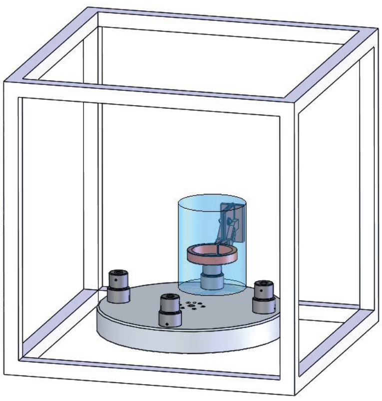

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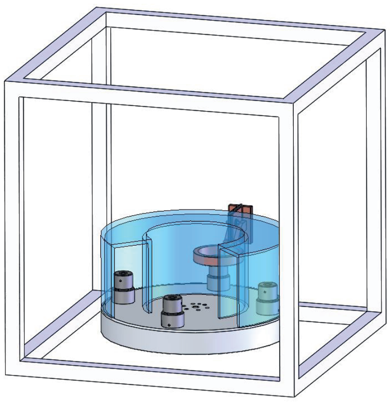

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