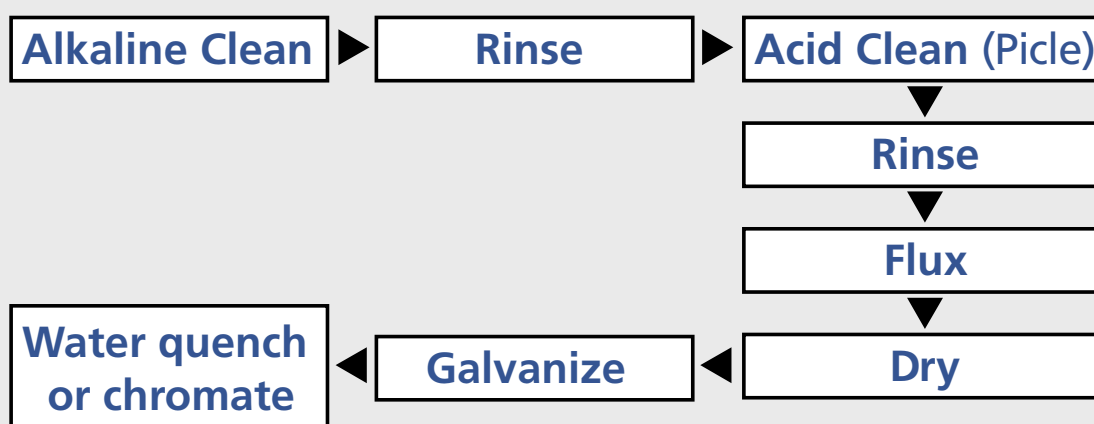


HOT DIP GALVANIZING OF HARDOX and WELDOX

Hot dip galvanizing is the process of applying a zinc coating to fabricated iron or steel material by immersion in a bath consisting primarily of molten zinc.

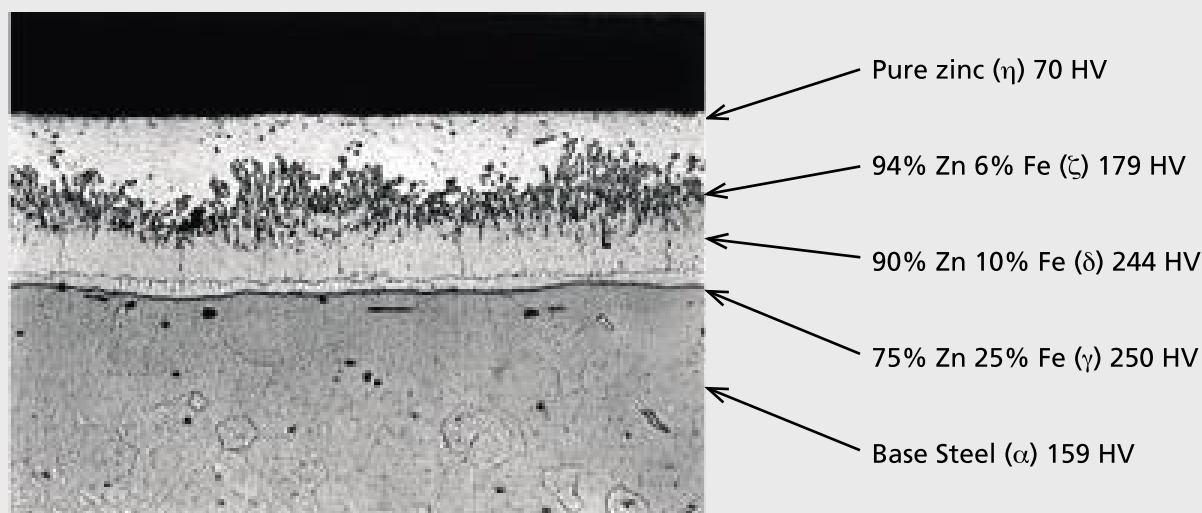
Galvanizing forms a metallurgical bond between the zinc and the underlying steel creating a barrier that is part of the metal itself.

The galvanizing process consists of three basic steps: surface preparation, galvanizing and inspection.



Surface preparation for galvanizing typically consists of three steps: caustic cleaning, (to remove organic matter such as dirt, paint, oil and grease.) acid pickling (to remove scale and rust) and fluxing (to prevent oxides from forming prior to galvanizing).

Galvanizing. In this step the material is completely immersed in a bath consisting of 98% pure molten zinc. The bath temperature is maintained at about 450 Celsius. The zinc metal then reacts with the iron on the steel surface to form a zinc/iron inter-metallic alloy.



The hot-dip galvanized surface consists of four separate layers. The first three layers have a mixture of iron and zinc, and the external top layer is typically composed of 100% zinc.

Can HARDOX and WELDOX components be hot dip galvanized?

There are some facts to be noted:

- Hydrogen cracking
- Zinc penetration
- Decrease of the fatigue strength
- Decrease of the hardness/strength

Hydrogen cracking

The main problem for high strength steels is hydrogen cracking. In literature from a Swedish group for galvanizing they advice not to hot dip galvanize steels with UTS above about 650 MPa and hardness above 330 HBW. There will be an embrittlement due to hydrogen pick-up from the pickling since the solution contains acid. Local stress concentrations or residual stresses

from welding, gas cutting or cold forming will increase the risk. These problems may occur even for steels of the S355 J2 type. In order to reduce hydrogen induced cracking phenoma, the cleaning of the surface in an acid bath prior to galvanizing should be reduced to a minimum or better omitted completely. Instead shot blasting should be preferred to remove oxides.

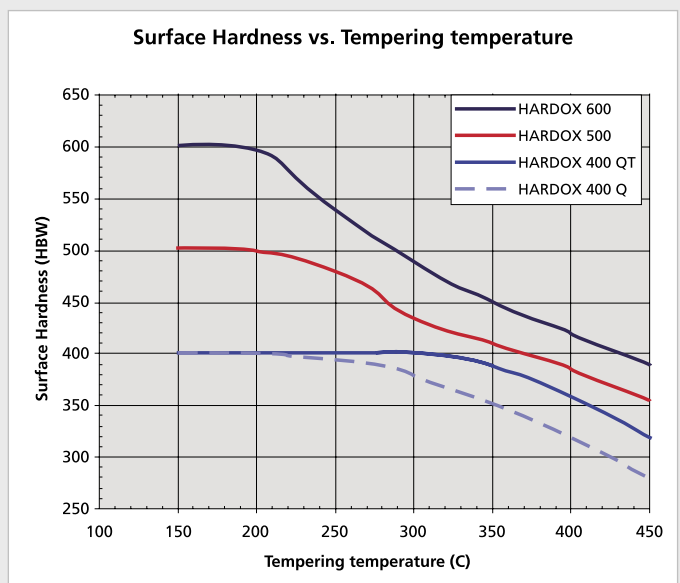
Zinc penetration

Hot dip zinc coating gives a zinc layer of 70 to 80 μm with a metallic bonding. There is a risk for zinc penetration into grain boundaries of the parent material due to the thermal stresses

created. When the Si content is above 0,3% the thickness of the Zn-layer grows more rapidly which is mainly an aesthetic problem.

Reduction of the hardness and strength

During galvanizing the material is immersed for approximately 5 minutes in a bath of molten zinc. The bath temperature is about 450 Celsius which tempers the material. For HARDOX this will reduce the hardness to the range of 320 – 360 HBW. WELDOX 1030 and 1100 can not be galvanized due excessive loss of strength.



Decrease of the fatigue strength

For steels with yield strength above 650 MPa a decrease of the fatigue strength of the base material after galvanizing has to be taken into account.

This is due to minor cracks in the zinc layer acting as cracks initiation sites. The fatigue properties of weldments are not significantly affected by hot dip galvanizing.

Conclusion

- Hot dip galvanizing of HARDOX and WELDOX 700 -1100 is a high risk project which we do not advice our customers to undertake.
- SSAB Oxelösund has very limited experience on hot dip galvanizing. Some tests on small coupons have been made without cracking, but we have also had a case where medium sized parts with drilled holes cracked from the holes after galvanizing
- SSAB Oxelösund has very limited experience on spray galvanizing. Spray galvanizing has a much smaller thermal impact on the base material properties than hot dip galvanizing. A spray layer does not adhere to the substrate as well as a hot dip galvanized layer.
- SSAB Oxelösund has very limited experience on electroplating. Electroplating is a cold process with good bonding which does not affect the base material properties. The thickness of the zinc layer is of the order 5 to 25µm

References:

1. *Nordic Galvanizers Association.*
2. *American Galvanizers Association.*

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