



TO WHOM IT MAY CONCERN

Hard chrome characteristics

The hard chrome plating process is characterized as follows:

1. The current efficiency of the process is low. Depending on various process parameters the current efficiency will be no more than 15 – 30 pct. of the current input. The rest of the current consumption is mainly used for dissociation of water leading to formation of hydrogen and oxygen in the form of free radicals and as gases in the end.

The chromium is plated as chromium hydride molecules. These are layered at the component surface and arranged in a hexagonal lattice structure. This means that it is not possible to avoid build in of hydrogen in the coating. This is a serious challenge because the hydrogen might lead to hydrogen embrittlement destroying the coating. Thus the plater must ensure that as much hydrogen as possible is released during the process to avoid hydrogen embrittlement.

The bath additives and the choice of process parameters allow the plater to get rid of the hydrogen during the process. Using these tools correctly leads to a recrystallization of the surface crystals; i.e. the hexagonal chromium hydride crystals are transformed into hydrogen gases and metallic chromium arranged in body-centred cubic crystals. The metallic chromium crystals are however smaller than the chromium hydride crystals. The recrystallization will generate an internal stress in the coating. The bath catalyst ensures that this tensile stress is released regularly during plating forming micro-cracks in the coating. The micro-cracks will be perpendicular on the surface of the component being coated. The crack-depth will typically be in the range of 1 – 5 μm and it will not normally penetrate from the topcoat to the base material. The crack-depth however depends on the chosen process parameters and might evolve into macro-cracks going through the coating to the base material.

The surface of the chromium crystals surrounding these cracks are however subject for oxidation leading to formation of chromium oxide (Cr_2O_3) in the grain boundaries. The electric conductivity of chromium oxide is less than that of the metallic chromium leading to formation of a hard chrome coating ending up in a pillar structure. This structure is responsible for the hardness of the coating. In general – the more cracks, the harder chrome coating. The cracks are unfortunately also weak points where corrosion might start. In general – the more cracks, the shorter lifetime of the hard chrome coating due to corrosion attack.

2. The throwing power of the hard chrome electrolyte is poor meaning that the electric current always chooses the shortest distance on its way from the anode to the cathode (the component to be plated). This is challenging because part of the electricity is used to reduce hexavalent chromium (Cr^{6+}) to metallic chromium (Cr^0) as described before.

The challenge relates to the fact that the current density varies over the component to be plated. The anode-cathode distance is not the same at all locations of the surface. As a consequence the amount of chromium plated at the component surface varies from location to location. Most chromium is plated at high current density areas leading to variations in the layer-thickness of the hard chrome coating.

The main key to successful hard chrome plating is creation and preparation of the anodes ensuring that the anode-cathode distance is as uniform as possible. Indeed the distance is crucial; i.e. bad hard chrome plating can deliver chrome coated components with excess chrome at high current density areas such as edges and pipe-ends and at the same time leave low current density areas (f. x. recesses) without chrome at all.

The poor throwing power of the hard chrome electrolyte also explains why the surface roughness will be no better after plating. The electrolyte does not possess the ability to level out a surface. On the contrary the roughness of the surface will increase during plating; a fact that the electroplater must be aware of when creating the anodes and choosing the process parameters after careful examination of the component to be plated. Doing this the plater might ensure that the roughness of the component will be no worse than it was before plating.

Hard chrome plating of inner pipe surfaces

Hard chrome plating of inner pipe surfaces do require focus on the following:

1. The condition of the pipe to be plated must be examined carefully.

The circularity of the pipe to be plated shall be as concentric as possible. Any ovality will change the anode-cathode distance leading to an uneven distribution of plated hard chromium; i.e. variations in the thickness of the hard chrome coating.

Any repair introduces the risk for defects in the hard chrome coating. Any repair welding shall be performed in such a way that the material of the welding wire is as close as possible to the material of the pipe material. Furthermore the welding quality shall be as high as possible reducing the welding slag to a minimum. Different material and welding slags changes the electric conductivity of the pipe and might lead to spots where no chromium can be plated.

2. The pipe to be plated internally has to be arranged in the plating electrolyte in such a way that the produced gases (hydrogen and oxygen) can escape. The electroplater has to minimize the risk for gas pockets and has to ensure that gas bubbles do not stick to the surface. No chromium will be plated if gases shield the component surface.

The pipe to be plated shall be arranged in such a way that the electrolyte freely can circulate through the pipe allowing gases to escape and fresh electrolyte to be available for hard chrome plating during the whole process.

Both pipe ends are high current density areas and the electroplater has to take this into account when preparing the pipe for hard chrome plating.

It is to be expected in general that the thickness of the hard chromium coating will be greatest in the pipe ends and least in the middle of the pipe. Furthermore it is to be expected that any pipe ovality lead to different layer thicknesses across the inner pipe surface.