2.16 GALVANISING: MODIFIED DEGREASING PROCESS TO REDUCE FUME EXPOSURE

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Issue

A new production process was put in place to reduce hazardous conditions in a galvanising plant for steel constructions.

Problem

Hot dip galvanising involves the immersion of iron or steel objects in molten zinc to apply a protective coating. This galvanising reaction will only occur on a chemically clean surface, therefore this needs to be free from grease, dirt and scaling. One of the common ways of degreasing is to dip the component into an alkaline or acidic solution. It is then rinsed and pickled in hydrochloric acid to remove rust and mill scale. After further rinsing, the components then normally undergo a fluxing procedure. This is normally applied by dipping in a flux solution – usually 50% zinc ammonium chloride – at around 65–80 °C. After drying, the clean iron or steel component is galvanised by dipping into the molten zinc, which is normally used at around 450 °C.

Exposure to fumes and vapours in the galvanising plant were causing concern for the employees' health and safety, and resulting in high levels of absence.

A risk assessment identified several hazards arising from this process.

- Acid degreasing: exposure to phosphoric acid vapours; high risk of injury from splashes.
- High hydrochloric acid – low iron chloride pickling solution: hydrochloric acid corrosive vapours, high risk of splashing.

- Fluxing in 50% zinc ammonium chloride at 60–85°C: ammonium chloride fumes.
- Galvanising: ammonium chloride fumes, risk of splashing.

The biological degreasing system

Solution

Previous attempts at solving the problem inside the galvanising plant had included installing roof fans to extract the fumes and vapours. However, these methods were never completely effective and the company realised that it needed to revise and improve its safety and health measures, including work organisation as well as working environment. At the same time it wanted to improve its environmental performance. It was clear that the alternative to collecting and treating waste process chemicals – producing huge amounts of sludge and hazardous fumes and vapours – is to avoid making them in the first place.

The activated pickling system

In close cooperation with external experts, the company set in motion a new galvanising process with two main goals:

- A clean working environment,
- No release of hazardous waste.

The new process involved a series of changes to the various process phases.

Hot-dip galvanising

Biological degreasing

The acid degreasing was substituted by a biological degreasing system. The new system operates in three steps: First, the grease and oil are removed from the parts and emulsified in the degreasing liquid. Second, the chemicals in the degreasing systems form an ideal environment for microbiological activities. Bacteria (*Pseudomonas alcaligenes*) are incorporated into the system with the aim of consuming the oil and grease through a biological process that produces only carbon dioxide and water. This also removes the need to dispose of the used degreasing bath. Third, there is an inhibitor effect from

the degreaser. Together with the fact that it operates at pH 9, there is no need for rinsing between the degreasing bath and the pickling bath.

Only small amounts of sludge (containing inorganic materials) are produced. The degreaser operates at a temperature of 38-40 °C and a pH level of 9, which mean a very low risk of injury from splashes, and there are no phosphoric acid vapours.

The activated pickling system

A low acid-high iron chloride system (HCl 4–6%, Fe 140-190 g/l) was introduced to replace the high hydrochloric acid-low iron chloride pickling solution. The system works in a closed loop that only needs fresh acid and water.

From the environmental point of view, the system can be used continuously without producing any waste. It operates with a lower acid concentration (4–6% compared to 15% for conventional systems), which implies a reduced risk of injury from splashes and less hazardous fumes.

The continuousness flux regeneration system

This also works in a closed loop and is virtually a flux chemical production unit.

Zinc chloride ($ZnCl_2$) from the zinc-stripping process is recovered and re-used as flux salt. The flux is no longer a double zinc-ammonium chloride solution. The ammonium chloride (NH_4Cl) is replaced by non-fuming sodium or potassium chloride and the flux bath operates at 30–40°C compared to conventional 65–85°C. Again, the risk of injury from splashes and exposure to fumes is reduced.

Galvanising

The main problem with ammonium chloride (NH_4Cl) in the old flux process was that this salt decomposes at very low temperature, much lower than the temperature of the molten zinc in the galvanising bath. Ammonia (NH_3) and hydrochloric acid (HCl) recombine as micro or nanocrystals just over the bath.

Using non-fuming fluxing chemicals avoids the generation of fumes over the galvanising bath. This also means that no waste is produced, although there is still a risk of injury from molten zinc splash.

Results

Several aspects showed clear improvements as a result of the changes in the galvanising process.

- The levels of exposure to hazardous vapours and fumes were reduced to levels well below legal exposure levels.
- Risks of injury from splash were minimised.
- There is no waste released to the water stream.

- The general appearance of the galvanising plant is now very good. Cleanliness has become the rule and not the exception.
- There was a 50% reduction in the rate of absence during the first year of operation of the new process.

Other positive outcomes included higher staff motivation, better working climate, and better understanding of working procedures by management.

Comments

Improvements in health and safety are also often associated with better environmental care. It is important to consult and inform staff about any proposed changes, and to monitor the effectiveness of novel solutions to ensure that they do not cause any new risks over time.