Process Intensification Quick Scan of the Galvano Hengelo plant

Management Report

Date Final Report: June 2nd 2008 Expert 1: H.N. Akse Expert 2: A.A.H. Drinkenburg
Revision 2.0

Background information

Galvano Hengelo started its operations in 1997. Galvano is a medium sized and specialized galvanizing company. Among its applications are galvanizing with silver, zinc, tin, nickel, tin/nickel, gold and copper. Furthermore, Galvano can attach surfaces of gold and nickel by a chemical process. Finally, chromatizing, passivating stainless steel and attaching ceramic surfaces on metal by the Keronite process can also be accommodated by Galvano.

Overall impression

Galvano operates flexible and smartly automated production lines. This flexibility gives Galvano a competitive edge in the business. The PI team mentions this since this commercial advantage has a clear impact on the way in which the processes are operated today. It is also noteworthy to mention the innovation-mindedness of the company's management. This can be derived from the fact that Galvano is currently investigating pulsed galvanization technology, contrary to the competition who allegedly favors conventional processes.

Approach

With the representatives of Galvano Hengelo, mr. R. Smit, General Manager, mr. D. Ekkel, Pre-work Organizer, we analyzed the process on unit operation level and discussed present operation, issues and bottlenecks.

We have looked into Galvano's process in two ways:

a) **Short term:** What can be done to intensify operation without major investment?
b) **Medium/long term:** how can Intensification bring value for Galvano?

PI- Quick Scan:
Procedure:
The information received from the customer is further analyzed. Information consists of:

- Information given by email prior to the Analysis Meeting on December 8th 2008
- Information given orally during the Analysis Meeting
- Information exchanged during the Management Report Meeting on May 5th 2009

On the basis of the received information the process is assessed on potency for PI-improvements on the short and long term.

Score:
The overall potency of the Galvano Hengelo process has been judged as:

medium for the short/medium term and *high* for the long term.

Justification:

Process challenges are:

1. Combine high flexibility and high throughput
2. Reduce energy consumption by ventilation to a safe minimum
3. Minimize manual operation
4. Reduce emissions to soil, water and air to zero
5. Reduce process energy consumption to stoechiometric minimum
6. Optimize operational safety

A. Process description

In view of the process challenges, the PI team focuses on the following process characteristics:

1. Multi-bath countercurrent cascade or one bath per step concept
2. Type and magnitude of current applied
3. Ventilation
4. Drying

Table 1. List of processing steps

1	Degreasing with caustic
	Accumulation bath / Rinsing bath
2	Electrolytic degreasing
	Accumulation bath / Rinsing bath
3	Staining
	Accumulation bath / Rinsing bath
4	Activating
	Accumulation bath / Rinsing bath
5	Galvanizing (processing)
	Accumulation bath (2x) / Rinsing bath
6	Passivating
	Accumulation bath / Rinsing bath
7	Warm rinsing with demi water
8	Drying

Typically, Galvano uses about 7 different steps. Each step comprises of three baths. Finally, there is a drying step to complete the galvanizing process.

A1. Multi bath or one bath per step?

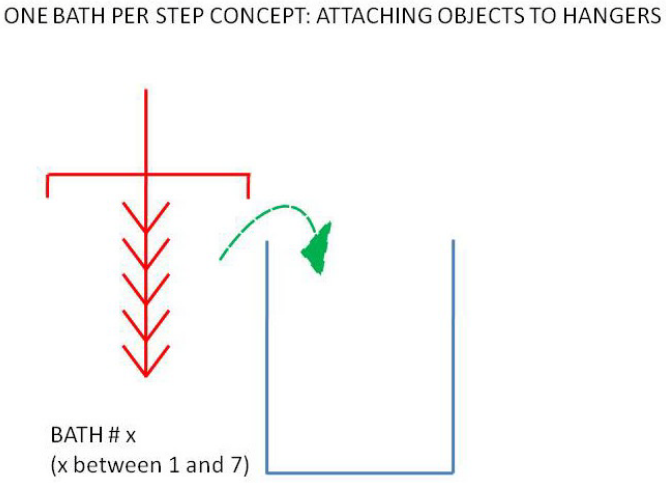
From the discussion with Galvano on December 8th it becomes clear, that each step is a sensitive one and that Galvano wants to prevent contamination of a following bath by a preceding one at any cost since this is detrimental to product quality.

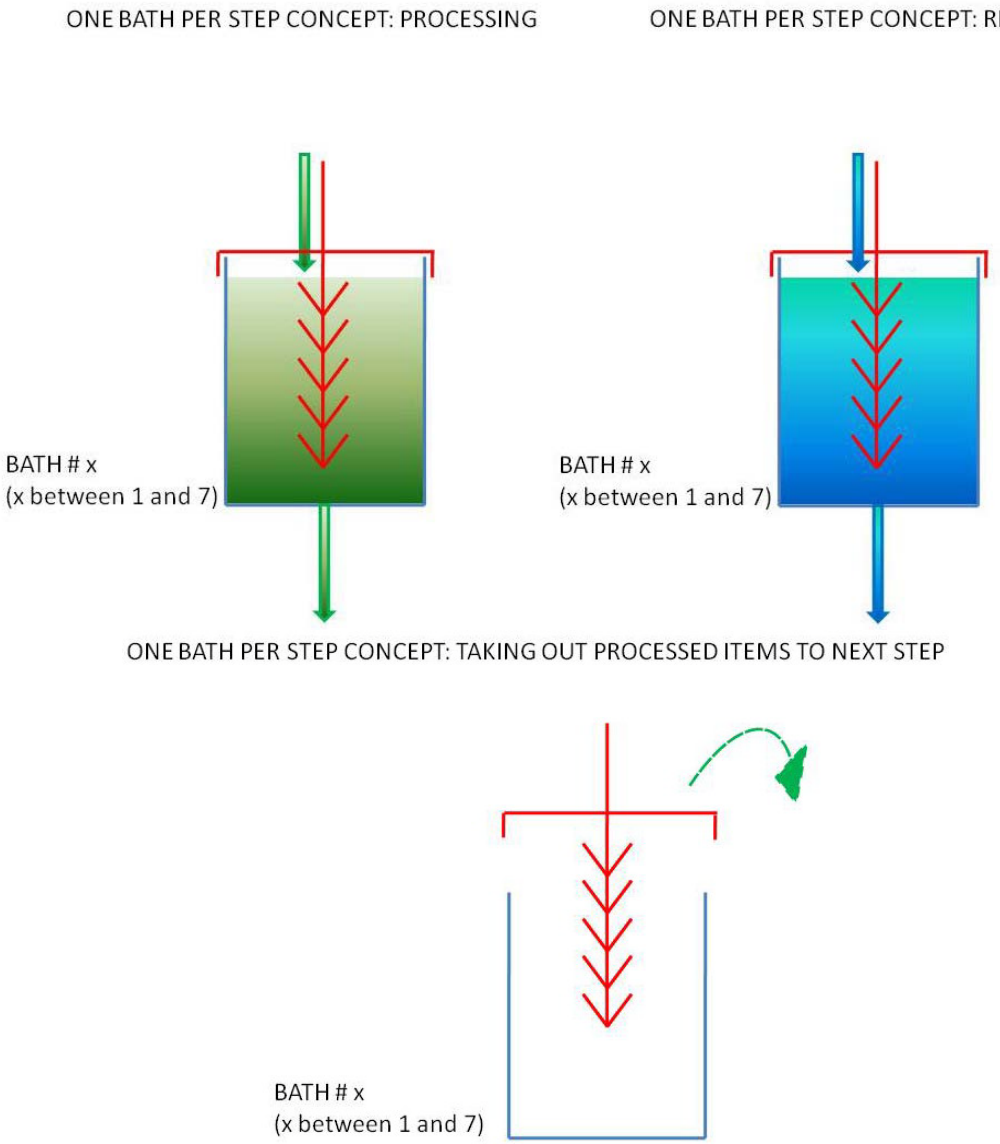
From the Management Report meeting on May 5th 2009 it becomes clear the current process uses 7 steps (apart from the drying step), each comprising of three baths. This fact changes the original proposal of the PI –team into a different one, but this proposal is based on the same Process Intensification principles.

Some galvanizing companies are focusing on achieving *countercurrent processing* as much as possible. From a chemical engineering point of view this makes sense, since in countercurrent flow the process and rinsing liquids are used as effectively as possible. However, this leads to a huge amount of individual baths, a lot of floor space and a great area of emission to take care of. Floor space means capital for building ground; emission area means ventilation energy.

We propose to consider a *one-bath per step concept*. In fact it is a turnaround in thinking: *bring the liquids to the items instead of the items to the liquids*. This reduces the current number of 21 baths down to 7. The concept could look like the one depicted below in figure 1.

Figure 1. One bath per step concept





Advantages

1. Reduction of footprint: a 7 bath layout reduces floor space considerably
2. Reduction of handling: 7 instead of 21 baths means three times less handling of items
3. Faster process: at least 10 times faster (see below A2) than the current process
4. Reduction of emission: closed baths require much less ventilation
5. Reduction of ventilation capacity: the processing hall will have a smaller volume
6. Improvement of evenness in layer thickness

A2. Type and magnitude of current applied

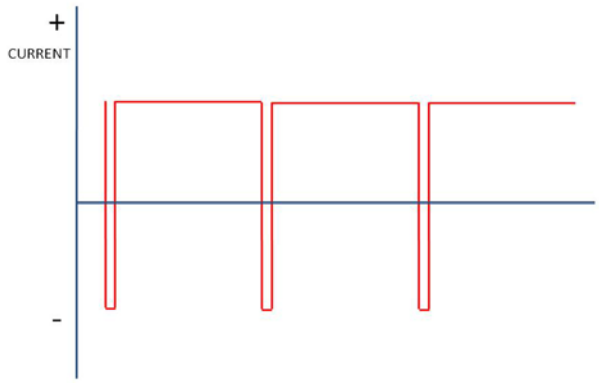
During the analysis meeting the PI team raised the question, whether an increase in current would be negative for the quality of the obtained product. Galvano states that *a significant increase in current is possible*, without sacrificing product quality.

A limiting factor in this respect is polarization. Object shape determines whether polarization will be an issue or not. Sharp edges tend to cause non-linearities in the electric field. This has an effect on metal ion diffusion speed in the liquid phase, causing differences in layer thickness.

There are two measures that can be taken to counteract polarization:

a) Increase of liquid mixing. This causes the liquid boundary layer around the objects to become thinner: more fresh liquid containing metal ions can reach the object's surface.
b) Apply an alternating current instead of a direct current.

Figure 2. Pulsed current



By applying pulsed current, the positive part of the current can be up to 10 times higher than 100% direct current. The negative spikes cause the polarization to become negligible.

The PI team proposes to take both measures: intense mixing and pulsed current. In order to prevent the objects from *damaging each other* when high mixing rates are applied through circulation of the process liquid , we propose to put the incoming process liquid in a downward position (see figure 1: "processing").

Advantages

1. Little or no variation in layer thickness, leading to less use of precious metal
2. Much faster processing (up to 10 times faster) leading to faster delivery to customers

A3. Ventilation

Galvano now ventilates the complete volume of the production hall. The PI team proposes to change this. There are two types of measures than can be taken.

a) Continue operating the present unit but apply point ventilation
b) Switch to closed bath operation and only ventilate where necessary

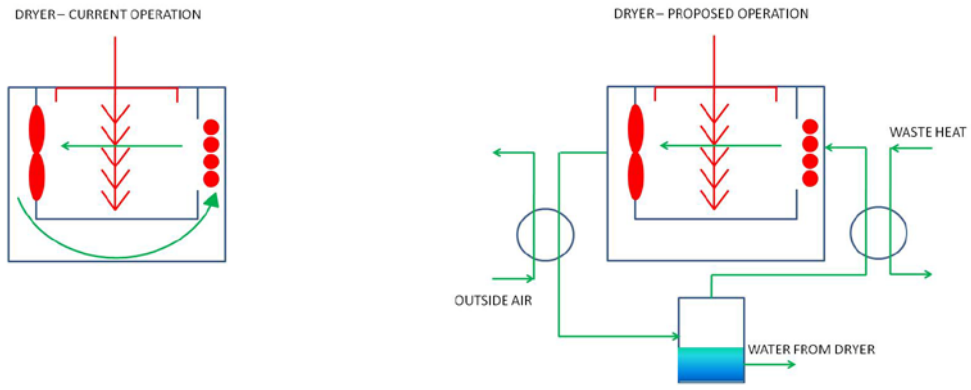
Advantages

1. Less energy required to heat up incoming air
2. Less energy required to drive the electric motors of the ventilators

A4. Drying

The present drying unit is a peculiar thing. It consumes a lot of heat (i.e. natural gas), which is what dryers normally do. But there is *no dedicated removal* of moisture/water from the outgoing air, apart from some undefined openings in the top part of the dryer.

Figure 3. Present and proposed dryer layout



There are many variations possible on this scheme; our message is merely that a *dedicated moisture removal* should be in place.

Advantages

1. Better use of waste heat requiring less natural gas for generating heat @130°C
2. Much faster drying due to dedicated moisture removal

B. Recommendations and suggestions for further phases

Short term

1. Experiment with pulsed current in existing units *to intensify the core process* whilst maintaining product quality
2. Improve *liquid mixing* in the galvanizing bath
3. Switch to *point ventilation* using the existing ventilator piping layout
4. *Redesign the dryer* unit to remove moisture

Medium/long term

1. Consider building a new line based on the *one bath per step* concept.
2. Consider applying pulsed current, intensified mixing and drying with heat recuperation / moisture removal

If Galvano agrees, the PI team can *detail the proposed concepts* – both for the short and the medium term - in a second phase with support from SenterNovem.

Woerden / Geleen,
June 2nd 2009