
# AUTOMATED INTELLIGENT COATING CONCEPT FOR FERROUS FOUNDRIES

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Today, automation of coating control and preparation is an established process in many foundries. Since the introduction of density measurement and automatic online-monitoring by Foseco in 2008 substantial developments have taken place leading to significant improvements of the measurement method and equipment functionality. The following article will demonstrate how, by intelligent control, a great number of new automation applications become possible.

## AUTOMATED COATING CONTROL

There are two widely adopted techniques for measuring coating density; by a pressure differential or by volume/mass determination. The current methods of achieving this have some disadvantages, e.g. the use of measuring sensors with moving parts that require thorough and regular cleaning to ensure consistency of operation or to accept delays and inaccuracies in density measurement due to external influences such as machine vibration.

**TO OVERCOME THESE ISSUES A NEW DESIGN PHILOSOPHY HAS BEEN ADOPTED:**

- There should be as few moving parts installed as possible
- The unit's components should be designed as maintenance-free wherever possible
- The achieved measuring accuracy and speed should surpass current technology
- It should be possible to integrate the measuring 'intelligence' directly into other applications, e.g. dip tanks, flooding or spraying units without having to invest in a centralised preparation unit.

Furthermore, the unit should be compact and sturdy in order to withstand the rough foundry environment.

## IMPLEMENTATION

When considering the equation for the pressure in a liquid:

$$p = \rho g h$$

Where:
$p$ = pressure in a liquid
$g$ = gravity at surface of liquid
$\rho$ = density of the liquid
$h$ = column height of liquid

It follows that if you measure the pressure at two different heights, the formula can be rearranged for density, so that:

$$\rho = \frac{\Delta p}{g * \Delta h}$$

One can recognise that the density is related in a linear way to the measured pressure difference [5].

Example: The pressures in a tank of coating are measured at two fixed depths, and a difference between the two pressures is recorded at 0.50 bar. After adding 100 litres of water to the tank the pressure difference decreases to 0.25 bar. It follows that since all other factors have remained constant, a halving of the pressure difference is due to the overall density of the liquid in the tank reducing by 50%. Note that the coating and water will need to be mixed to achieve a homogenous density.

## THE INTELLIGENT COATING UNIT (ICU)

The ICU consists of a coating homogenisation tank, in which the pressure probes are incorporated into the surface of the tank and do not limit the effectiveness of the mixing unit. The PLC control continuously monitors the density of the coating, automatically adding water or undiluted coating to maintain the required density at all times. The control unit also controls the mixer timing and speed to ensure homogeneity of the coating. From this tank coating is supplied to one or more coating application stations for use, excess coating is returned to the tank via a filter configuration for re-checking and homogenisation.

**THE PRESSURE PROBES ARE EXTREMELY ROBUST WITH A GUARANTEED LIFE TIME/ WARRANTY OF UP TO 10 YEARS.**

They also allow the ICU to monitor each measurement automatically and provide the possibility to determine any sedimentation tendency of the coating. Until today this has not been possible with other units and provides significant benefit. When considering a possible contamination by bacteria in a water coating it is important to understand that this will not result in any change of the density. The coating will change, however, regarding its properties like matt time, flow length and sedimentation tendency which will affect indirectly the structure of the layer - a parameter which must be kept constant unconditionally (1). By measuring sedimentation rate it is possible to monitor rheological changes in the coating and affect appropriate action.

It is also advisable and possible to integrate within a pressure sensor a coating temperature monitoring programme for registering at least critical product temperatures and fluctuations that may cause concern [3].

**The advantages are:**

1. Optimised processing of diluted coating.
2. Continuous monitoring and recording of coating density
3. Automatic dosage of coating or dilutant to maintain density
4. Coating application (applied layer thickness) is more consistent and predictable.
5. Reduction of maintenance down-time


Figure 1. ICU - Intelligent Coating Unit

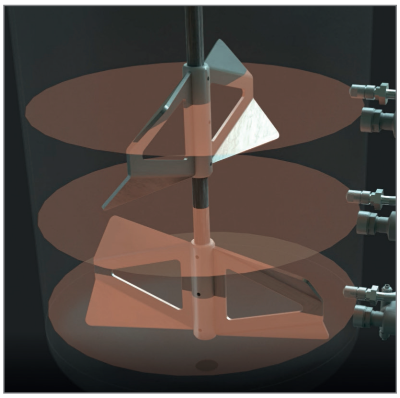

Figure 2. Pressure Sensors

Figure 3. Optional UV treatment

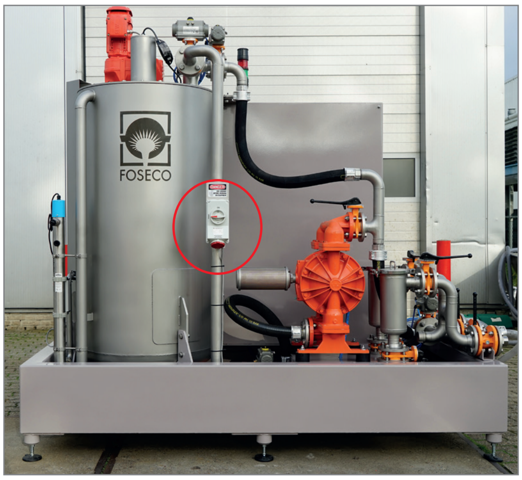


Figure 4. Integrated timer control

## MEASUREMENT ACCURACY

The self-control and calibration is affected by means of a third sensor (Figure 2) enabling comparison of three separate differential pressures (top-bottom; top-middle; middle-bottom) and which thereby not only monitors the homogeneity in the vessel but also displays simultaneously a possible increased sedimentation tendency.

The pressure sensors which are used are also employed, for example, in sludge conveyance and fracking. This means that they are very robust and designed for long service life. There is no need for moving the sensors for cleaning as they are maintenance-free. It is now possible to achieve a measurement accuracy enabling a max. tolerance of 0.1 % of the desired value. For example, a range from 1.1498 to 1.522, when the desired density value is 1.1510.

## OPERATION

During filling or returning of the coating, turbulence may introduce air inclusions and, thereby, undesirable foaming. In the ICU this is prevented by a novel filling technique.

Another weak point of existing plants are the shear forces, which due to stirring or pumping act negatively on the coating by effecting the balanced rheological properties of the product. A shear force, which is too high (for example due to circulation in a measuring tank) can change the character and behaviour of the coating completely.

The newly developed propeller geometry enables the ICU, to minimise this shear load by employing extremely low revolutions (10 - 30 rpm), whilst still ensuring a homogeneous product.

By means of UV disinfection treatment (Figure 3) the water used for dilution can be disinfected without using any chemicals. This results in longer service life of the coating and, simultaneously, less waste.


At **Eisengießerei Dinklage**, the intelligence of the ICU can be integrated directly within the dip tank.

Historically, additions of undiluted coating have been left to the user and it could happen that non-homogeneous coating additions have a negative influence on the automatic preparation process.

This was taken into consideration when the ICU was designed: By means of an integrated timer control unit (Figure 4) by which the supply containers can be connected directly to the ICU, homogenised and used, thereby preventing any over-mixing. Subsequent to the container change, homogenisation of raw coating is started automatically.

## COATING CLEANLINESS

Moulding / core sand is a significant source of contamination. Sand inclusions in the coating layer can cause inclusions in the casting surface, which quite often can result in expensive re-work. To avoid this, the ICU is fitted with a double-filter system (Figure 6) which not only removes these contaminants, but which also can be exchanged without interruption to production.

## INTEGRATED APPLICATION SYSTEMS

Many users do not need a central preparation plant but are employing stationary units like dipping tanks or flow coat stations. In such a case, as per example at Eisengießerei Dinklage, the intelligence of the ICU can be integrated directly within the dip tank.

Coating monitoring by means of ICU intelligence is influencing the coating directly in the combined dipping/flooding basin. The consumed volume is filled up automatically from

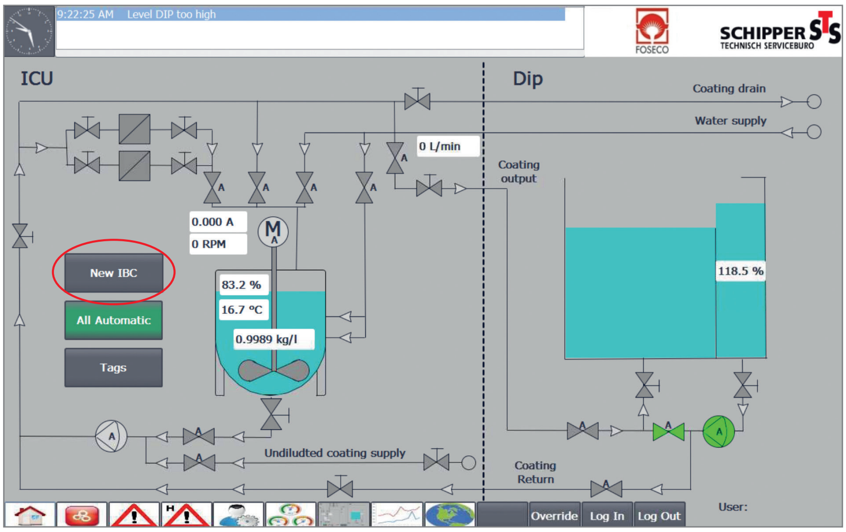

Figure 5. ICU Front Screen


Figure 6. ICU Filter system

The accurate and fast determination of the density enables the ICU to quantify the re-quired volumes of raw coating or respectively dilution medium in advance and replenishment can take place without delay.

## PROFITABILITY ANALYSIS

Profitability analysis for an exemplary foundry:

- In the core shop there are 5 dipping tanks of which 3 are by manual operation and 2 are fit-ted with robots.
- Historically a dipping tank cleaning cycle of 2 times per month is undertaken, giving rise to a coating waste amount of 86.4 t/year (24 cleaning operations per year).
- By employing the ICU, it became possible to reduce the cleaning cycle to once per quarter, resulting in a saving of 64.8 tonnes of coating.
- With waste disposal costs of 0.8 euros/kg, it is possible to save directly 51,840 euros/year.
- The diluted coating has a cost of 0.30 euros/kg. Therefore, in this case (64,800kg* 0.3) 19,440 euros/year less coating costs occur.

In addition to the direct coating costs, the foundry benefitted from improved casting quality. The foundry has a capacity of 54,000 tonnes per year and produces 16,000 t of a component having a defect rate of +- 5%. The costs for removing this defect are 0.15 euros/kg. By using the ICU, it was possible to reduce coating-related defects by 2.5 %. This equates to a quality related saving of (16mil kg * 2.5 % * 0.15) 60,000 euros per year.

**THE USE OF THE ICU WAS THUS PAID OFF IN THE FIRST YEAR WITH 131,280 EUROS.**

It is left to the reader to compare this with his own and more current values.

## SUMMARY

An Intelligent Coating Unit is the next step to streamline coating handling in the foundry industry for nearly maintenance-free automation.

In view of the increasing demands in foundries regarding process-reliability also process-reliable coating handling is needed, as this has a substantial influence on casting quality. The ICU concept is the correct route to this target.

## ACKNOWLEDGEMENT

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