COATING WATER HEATERS
BY POWDERING, SPRAYING OR FLOODING
ON OVERHEAD CONVEYOR CHAIN

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Coating water heaters

by powdering, spraying or flooding on overhead conveyor chain?

Ladies and Gentlemen,

For some time now, we have been regularly contacted by companies wanting to manufacture hot water tanks made of mild steel. Capacities vary from 15 – 75 liters or from 150 to 500 litres and more. The large ones are mostly for the solar energy.

Some of our customers want to improve their existing equipment, but others are “newcomers” in the enamel sector and need our full consultation. This led us to compare various coating processes. But one thing is certain:

“The design of the product gives you the technique”.

Today we will be talking about processes for HWT inside coating:

By Conventional Spraying, Flooding and Electrostatic Powdering

We will take you through the following points:

I. Choice of enameling process with the required pre-treatment

II. Resulting surface coating according to the enamel distribution inside the water heater

III. Quantity of enamel applied
    With the possible recovery and re-use of the slip or powder

IV. Maintenance of each system
    With the wear and tear of line components
    Constraints such as cleaning during and after production

V. Economic aspects
    Working cycle per HWT
    Manpower needed for running the production

VI. Ecological aspects
    Enamel recovery and air filtration
Generally speaking we can say that there are 2 different types of HWT in the world:

a) tanks made of one part with and without pipes inside, common in a wide range of countries (see picture)

and

b) tanks made of 2 parts:

- the tank shell with welded top
- the bottom with and without flue pipe
I. The choice of enameling process

This is the biggest issue for a customer, especially when the customer decides to start manufacturing enameled HWT.

This choice depends essentially on the design of the tank to be enameled, the production capacity, and in which country the customer is located.

We can divide our customers into 2 categories belonging to:

- highly industrialized countries
- rich emerging countries

We can divide HWT into two ranges:

- Electric heaters: up to 200 litres
- **Solar heaters**: from 100 up to 3,000 litres and more

Solar heater with inside coils

3,000 litres solar heater
Generally speaking, electric heaters can be powdered, sprayed or flooded thanks to their simple design.

Solar heaters are mostly flooded. They can be powdered when the geometry of the boiler allows it, that is to say:

the size of diameter should not exceed 450 mm and the pipes should preferably not be built inside.

The spraying process is not very common, except in USA.

In principle and according to our experience, we recommend our customers located in emerging countries, where labour costs are rather low, to use also the wet process by flooding, because of the simple and efficient process.

For our customers from highly industrialized countries, where the labour costs are high and where the manpower is used to work with automatic processes, we offer two options:

- Powdering when the design and size of the tanks allow it, for example when the tank is a simple cylinder.

- Most of the time we recommend flooding because this process is possible for any design and size of tanks, with coils or without coils, for any capacity.
The pre-treatment

The choice of the pre-treatment depends on the manufacturing process of each customer and in which country the customer is located.

There are two possibilities:

**Shot blasting** is mainly used for electric heaters, because of their simple geometry.

Nevertheless alkaline is necessary to remove grease on bottoms

**Chemical pre-treatment** is used for both electric and solar heaters, because this process is able to pre-treat all inside areas of the tank even when coils are built in.
II. The resulting surface coating according to the enamel distribution inside the water heater

By powdering 200 litres tanks
Our experience made at customers’ during the production confirms that with powder application the enamel distribution is not so regular as expected from top to bottom for the closed tank, and difficult to control as well as to repeat:

The desired thickness by using customized powder and customized guns:
average measurement on 200 liter tank with a flange opening of 70 - 110 mm:

- top: 200µ - 250µ
- body: 150µ – 200µ
- bottom: 300µ – 400µ

Usual thickness by using standard powder and standard guns:
- top: 200µ - 250µ
- body: 250µ – 300µ
- bottom: 500µ – 600µ

Enameling electric heater by powdering
By Flooding 200 litres tanks on overhead conveyor chain

Our experience made at customers during the production confirms that by flooding, the enamel distribution shows a more homogeneous thickness between top, side walls and bottom inside the closed tank.

**Thickness:**
The average measurements on a closed tank with a flange opening of 70 - 110 mm
- top: 180 - 300 µ
- body: 180 - 300 µ
- bottom: 350 - 400 µ, sometimes 600 µ

Enameling solar water tanks by flooding

The thickness reached on the bottom depends on the geometry of the tank. Some flat bottoms can accumulate enamel around the flange opening, but this can be improved by adjusting the angle during timing of coating cycles and tilting the tank, which is impossible by powdering or spraying.
By Conventional Spraying
It seems that by spraying, the enamel distribution is more regular from top to bottom for the open and even for the closed tank.

Thickness:
The average measurements on open tank  average measurements on closed tank
  o  top:  200µ - 350µ             top:  200µ - 300µ
  o  body: 200µ - 350µ            body-bottom: 200µ – 400µ
For a number of years, we thought that open tanks (US version) could only be sprayed, but then we ran flooding trials on an EIC equipment and achieved astonishing, excellent coating results!

**Average measurements on open tank**

- top: 250 – 300 µ
- body: 250 - 350 µ

The enamel distribution by open tank (US version) is homogeneous. Thanks to the lack of a bottom there is no accumulation of the enamel inside the tank.

**The surface results are extremely promising!**
Coating HWT by powdering, spraying or flooding on overhead conveyor chain?

Coating results inside the open tank by flooding

<table>
<thead>
<tr>
<th>Area</th>
<th>Area A</th>
<th>Area B</th>
<th>Area C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Sample Value</td>
<td>324.55</td>
<td>467.75</td>
<td>446.15</td>
</tr>
<tr>
<td>Lower Sample Value</td>
<td>203.13</td>
<td>250.70</td>
<td>277.07</td>
</tr>
<tr>
<td>Mean</td>
<td>243.28</td>
<td>336.50</td>
<td>336.54</td>
</tr>
<tr>
<td>Mean Upper DESVPAD</td>
<td>181.53</td>
<td>135.03</td>
<td>115.58</td>
</tr>
<tr>
<td>Mean Lower DESVPAD</td>
<td>80.62</td>
<td>36.52</td>
<td>96.55</td>
</tr>
</tbody>
</table>
Example of thickness measurement inside of EU and USA tanks

Two tanks of roughly comparable thickness though different diameters. Both selected as good examples of well coated tanks.

Some thickness data from European flooded Tank (shell only)

100 measurements over 15 sq. ft. (1.39 sq. meter) of surface.

Tank is 18.5” diameter, and shell cylinder is 36.6” coated

<table>
<thead>
<tr>
<th></th>
<th>mils</th>
<th>microns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>12.55</td>
<td>318.8</td>
</tr>
<tr>
<td>Average</td>
<td>12.73</td>
<td>323.3</td>
</tr>
<tr>
<td>Std Dev</td>
<td>1.75</td>
<td>44.3</td>
</tr>
<tr>
<td>Max</td>
<td>18.8</td>
<td>477.5</td>
</tr>
<tr>
<td>Min</td>
<td>9.6</td>
<td>243.8</td>
</tr>
</tbody>
</table>

Thickness data from wet sprayed USA tank (shell only)

70 measurements over 3.9 sq. ft. of surface (0.37 sq. meters)

Tank is 14 in diameter, and shell cylinder is 40.25 in (coated)

<table>
<thead>
<tr>
<th></th>
<th>mils</th>
<th>microns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median</td>
<td>13.55</td>
<td>344.2</td>
</tr>
<tr>
<td>Average</td>
<td>13.48</td>
<td>342.3</td>
</tr>
<tr>
<td>Std Dev</td>
<td>2.66</td>
<td>67.6</td>
</tr>
<tr>
<td>Max</td>
<td>19.9</td>
<td>505.5</td>
</tr>
<tr>
<td>Min</td>
<td>6.7</td>
<td>170.2</td>
</tr>
</tbody>
</table>

The flooded tank has better thickness control than the wet sprayed in this simple comparison. The deviation of the flooded tank is less than the wet sprayed one.
III. The resulting enamel quantity after firing

We noticed that the enamel quantity per enameled m² is roughly the same for each application process.

**Spraying**
In the closed tank the average quantity of enamel sprayed is around 650-700 gr/m²
Performance 95-96%, Repair 4-5%

In the open tank (US version) the average enamel sprayed is around 720 gr/m²
Performance: 94% good results with 6% repair

**Flooding**
In the closed and the open tank the quantity of used enamel is around 700 gr/m²
Performance: 97% good results with 3% repair

**Powdering**
In the closed tank the quantity of enamel is around 700 gr/m²
Performance: 98% good results with 2% repair

Re-use of recovered slip:

**By Spraying**

The possible recovery of the overspray is estimated to 99% for closed tanks and for open tanks (US version)

Nevertheless, you need to bring the overspray back to the mill room. The transfer between the spray booth and the mill room needs time and manpower.
By Flooding

The transfer of the slip is done automatically from the recovery tray via a vibration sieve back to the working tank, so that it is possible to re-use minimum 99 % of recovered enamel.

Powder

The recovery of powder via a filtration system is almost 99% with low handling
IV. Maintenance, spares and running costs

By spraying

The maintenance of equipment and spare parts is, of course, more intensive by spraying than by flooding, because the system itself is more sophisticated.

Wear and tear concern:
- Reciprocator
- Spray guns: air cup, nozzles, needles
- Pumps
- Hoses
- Dust filter

By powdering

The maintenance of equipment and spare parts is very intensive by powder coating than by spraying or flooding because the powder material is deteriorating the injectors and spraying nozzles. Besides, this system needs more electrical energy and compressed air than the other ones.

Wear and tear concern:
- Reciprocator
- Powder Spray guns: nozzles
- Powder Injectors
- Vibration sieve
- Air conditioning
- Dust filter

By flooding

Maintenance of equipment and spare parts is the less intensive one, because the mechanical design is very simple. Small volume of compressed air and electricity is required.

Wear and tear is mainly in
- Pumps
- Vibration sieve
V. Constraints of each system

<table>
<thead>
<tr>
<th></th>
<th>BY SPRAYING</th>
<th>BY FLOODING</th>
<th>BY POWDERING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fluid hoses and guns</strong></td>
<td>needed at production start</td>
<td>not needed</td>
<td>needed by production start</td>
</tr>
<tr>
<td>control &amp; adjustment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Enamel control</strong></td>
<td>viscosity, set up, density before each re-filling of the working tank</td>
<td>viscosity, set up, density before each re-filling of the working tank</td>
<td>not needed. Enamel suppliers’ responsibility It works or it does not !</td>
</tr>
<tr>
<td><strong>Cleaning the equipment</strong></td>
<td>hoses, guns, pumps, spray booth</td>
<td>hoses and pumps 1x/week</td>
<td>depending on the customer</td>
</tr>
<tr>
<td><strong>Air conditioning</strong></td>
<td>not required</td>
<td>not required</td>
<td>need to be controlled</td>
</tr>
<tr>
<td><strong>Humidity control</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

VI. The economic aspects of each system based on 200 L tanks with 2 tanks per system

**Cycle by spraying closed tank**

Cycle time estimated up to 70 sec.

**Cycle by flooding**

Cycle time by closed electrical tank estimated up to 55 sec.

Cycle time by closed solar tanks estimated up to 2 min with coils inside

**Cycle by powdering of course without coils inside**

Cycle time by closed tank estimated up to 80 sec.
**Manpower**

The manpower depends on the degree of automation used in a factory.

In Europe, most of the enameling shops are highly automated in order to save a maximum of manpower costs.

In emerging countries, although the manpower is very cheap, the trend is definitely to automate too. This has also another reason: the repetition of tasks in order to get a consistent and identical quality. Nevertheless we speak here of a semi-automation.

The necessary manpower also depends on the manufacturing concept of the tank.

Spraying a tank with open end will require more handling, which means more manpower than to spray a closed tank. As a matter of fact, an open tank is made of 2 parts which are handled and applied separately:

- On the tanks shell line
- On the bottom line

<table>
<thead>
<tr>
<th></th>
<th>BY SPRAYING</th>
<th>BY SPRAYING</th>
<th>BY FLOODING</th>
<th>BY POWDERING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>closed tank</td>
<td>open tank</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loading HWT</td>
<td>3 workers</td>
<td>6 workers</td>
<td>3 workers</td>
<td>3 workers</td>
</tr>
<tr>
<td>Threads cleaning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unloading HWT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(This chart does not include the transfer on the furnace line)
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VII. Ecological aspects

Spraying causes more costs to coat cleanly:
- Spray guns have to be cleaned after each spraying cycle to avoid rejects
- Resulting waste water has to be treated
- Compressed air is needed

Flooding requires less costs to coat cleanly:
You need:
- A recovery tray for the excess enamel which has to be cleaned once a week
- Less waste water which has to be treated

Powdering is environment friendly, but uses more energy

No waste water treatment needed
- Compressed air needed
- Air conditioning needed
Conclusion

By looking at the 3 different application processes, we can say that the running costs of the installation and the repetition of the surface coating are essential indications for the right investment.

It is evident that the cheapest process is the flooding process and remains a reliable process:

- flooding can be used for all kinds of tanks with and without coils
- flooding does not need any special tank and coil design
- the investment of a flooding equipment is cheaper than other systems, because
- flooding does not need filtration with air conditioning
- flooding does not need numerous reciprocators
- flooding requires a far lower number of spare parts than by the other processes
- flooding has a simple design
- flooding needs reduced factory space

Last but not least, the direct material costs affect the manufacturing costs:

- the cheapest material is the milled frit
- more expensive is the RTU, the Premix or the RTM
- the most expensive is the powder material (at least double than milled frit)

On the comparison of the closed tanks the thickness on the bottom head is slightly higher with wet spray and higher yet with flooding but very high with powder. Thus the extra coating which is essentially waste occurs to the greatest amount with the system that uses the most expensive coating, powder. That higher cost of waste coating by over thickness should be a major factor in the customer’s decision for the right investment.