Color Changing Refractory Coatings As Quality Control Tool For Various Foundry Sand Systems & Its Economics

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ABSTRACT

The paper deals with the latest development in India, in Color Changing Refractory Coatings technology which acts as a Quality control tool for the today’s modern foundries which are switching over to the latest resin sand systems. The change over from traditional solvent based coatings to latest water based coatings in most of the foundries, these color changing coatings not only enables visual confirmation of complete dehydration of coatings, but also optimize on energy consumption in drying these coatings and increases productivity of the foundry. These water based refractory coatings change color from either Pink to Yellow on drying or Yellow to Pink on drying depending upon the resin sand system. These coating are reversible in nature and indicate moisture pick-up by core or mould by changing the color reversibly. At the same time it eliminates all moisture related defects such as metal penetration, scabbing and blow holes. The present paper explains in detail these color changing refractory coatings for various Foundry Sand systems.
1. **INTRODUCTION**

It is a well know fact that the Foundry Coatings are widely used to improve the surface casting finish and to achieve the best cosmetic look of the castings. But at the same time we all know that the best of the Foundry coating can never achieve this on a bad core or moulds. A conventional foundry using Sodium silicate – CO2 gassed binder system uses mostly solvent based refractory coatings. In view of improving productivity, castings quality, to reduce rejection %, to have cleaner environment in the foundry, all modern foundries are shifting to modern resin systems such as phenolic ester cured, cold box resins, shell sand (Hot-Box), Furan Resin, Alpha set etc. Most of these sand resin systems whether for moulds or cores utilizes water based coatings to avoid casting defects such as metal penetration, sand erosion, veining etc.

1.1 **Two Types of Coatings :**

1. Solvent Based Coatings  
2. Water Based Coatings

Modern Foundry switching to New Resin Binder Systems  
Water based coatings more popular

- Cost - Environment Friendly  
- Safety - Storage Regulations  
- Better Shelf Life - Hassle free Transportation

1.2 **Challenges before a Foundryman :**

- Complete de-hydration of coating  
- Drying Oven parameters working efficiently

Above process is critical as wet coatings results into serious casting defects

- Scabbing  
- Metal penetration  
- Blow holes  
- Surface Porosity

Solutions to these Casting Defects -  
Latest Technological based Color Changing Refractory Coatings

1.3 **For Water Based Coatings :**

*Pink to Yellow*

*Purple to Yellow*

*Yellow to Red*
2. **FOUNDRYMAN NEEDS VISUAL CONFIRMATION OF COMPLETE DRYING OF COATING**

- To eliminate all moisture related defects
- To identify poor sand compaction in a core or mould (as these areas will absorb more moisture from coating and will take longer time to dry)
- To optimize on cost of drying – Avoid over heating by oven / torch
- Avoid over dilution of coating as color of coating will fade
- Coating will take more time to change color due to higher moisture content
- Easy to apply multiple coats as Pink color coating will be applied on dried yellow coating
- Applicator knows areas where multiple coats are applied
- Reduces production cycle time

Normally Foundries use various types of sand systems such as Three Part Alkyd Resin, Two Part Alpha set (Alkaline Cure), Shell core (Hot Box) & (Cold Box), Furan Resin, Phenolic Two Part (Acid Cured), Cement Molasses, Cement Dextrose, where water based coatings finds application. Similarly, for Sodium Silicate, Alpha Set & Olivine Sand (Manganese Steel) solvent based coatings are popular.

Different water based Refractory coatings (non-graphite) based were developed for various sand systems and the results obtained are as per Table No.1.

**Table No. 1 : For Water Based Foundry Coatings for various Sand Systems**

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Type of Sand System</th>
<th>Color of Wet Coating</th>
<th>Color of Dried Coating</th>
<th>Air Dried / Oven Dried</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Three Part Alkyd Resin System</td>
<td>Pink</td>
<td>Yellow</td>
<td>Air Dried / Oven Dried</td>
</tr>
<tr>
<td>2.</td>
<td>Two Part Alpha Set (Alkaline Cure) System</td>
<td>Pink</td>
<td>Yellow</td>
<td>Air Dried / Oven Dried</td>
</tr>
<tr>
<td>3.</td>
<td>Shell Core [Hot Box]</td>
<td>Pink</td>
<td>Yellow</td>
<td>Air Dried / Oven Dried</td>
</tr>
<tr>
<td>4.</td>
<td>Shell Core [Cold Box]</td>
<td>Pink</td>
<td>Yellow</td>
<td>Air Dried / Oven Dried</td>
</tr>
<tr>
<td>5.</td>
<td>Furan Resin</td>
<td>Pink</td>
<td>Yellow</td>
<td>Air Dried / Oven Dried</td>
</tr>
<tr>
<td>6.</td>
<td>Two Part [Acid Cure] System</td>
<td>Yellow</td>
<td>Pink</td>
<td>Air Dried / Oven Dried</td>
</tr>
<tr>
<td>7.</td>
<td>Cement Molasses System</td>
<td>Pink</td>
<td>Yellow</td>
<td>Air Dried / Oven Dried</td>
</tr>
<tr>
<td>8.</td>
<td>Cement Dextrose System</td>
<td>Pink</td>
<td>Yellow</td>
<td>Air Dried / Oven Dried</td>
</tr>
</tbody>
</table>
The lab trials were conducted for various sand systems, Two Part Alpha Set (Table no. 2), Three Part Alky Cores (Table no. 3) & Cold Box Cores (Table no. 4).

The weight of the naked core was noted (W) and the cores were dipped in the coatings and weight of the core was noted as (W0) and the cores were dried at 150 deg.cent. Readings were noted at different time intervals of 3, 6, 9, 12, 15 & 18 mins. It was found that the weight of the core decreases due to moisture evaporation which was indicated by the change of color of the coating.

3. LABORATORY EXPERIMENT RESULTS

3.1 Calculations:

Weight of the coating = \((W0 - W)\) gm
Weight of Moisture in Coating = \((Wc - W0)\) \(Wc -\) Constant weight of the core

% of Moisture at Wt = \((W0-W) - (Wc - W0)\)

Table No. 2: Cores were prepared of Two Part Alpha set Core @ 150° C

<table>
<thead>
<tr>
<th>Time [Min]</th>
<th>Weight of Dried Core</th>
<th>Weight of Dipped Core</th>
<th>Weight of Coating</th>
<th>Moisture %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>213.50 gm (W)</td>
<td>227.50 gm</td>
<td>14.00 gm</td>
<td>100.00%</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>225.50 gm</td>
<td>12.00 gm</td>
<td>82.60%</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>223.00 gm</td>
<td>9.50 gm</td>
<td>60.87%</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>220.50 gm</td>
<td>7.00 gm</td>
<td>39.13%</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>218.50 gm</td>
<td>5.00 gm</td>
<td>21.74%</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>216.00 gm</td>
<td>2.50 gm</td>
<td>0.00%</td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>216.00 gm</td>
<td>2.50 gm</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

Table No. 3: Three Part No Bake Core @ 150° C

<table>
<thead>
<tr>
<th>Time [Min]</th>
<th>Weight of Dried Core</th>
<th>Weight of Dipped Core</th>
<th>Weight of Coating</th>
<th>Moisture %</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100.00 gm</td>
<td>109.00 gm</td>
<td>9.00 gm</td>
<td>100.00%</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>108.50 gm</td>
<td>8.50 gm</td>
<td>83.33%</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>108.00 gm</td>
<td>8.00 gm</td>
<td>66.67%</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>107.50 gm</td>
<td>7.50 gm</td>
<td>50.00%</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>107.00 gm</td>
<td>7.00 gm</td>
<td>33.33%</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>106.00 gm</td>
<td>6.00 gm</td>
<td>0.00%</td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>106.00 gm</td>
<td>6.00 gm</td>
<td>0.00%</td>
</tr>
</tbody>
</table>
Table 4: Cold Box Core @ 150° C

<table>
<thead>
<tr>
<th>Time [Min]</th>
<th>Weight of Dried Core</th>
<th>Weight of Dipped Core</th>
<th>Weight of Coating</th>
<th>Moisture %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>236.00 gm</td>
<td>246.00 gm</td>
<td>10.00 gm</td>
<td>100.00%</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>244.50 gm</td>
<td>246.00 gm</td>
<td>8.50 gm</td>
<td>80.00%</td>
</tr>
<tr>
<td>6</td>
<td>243.50 gm</td>
<td>244.50 gm</td>
<td>7.50 gm</td>
<td>60.00%</td>
</tr>
<tr>
<td>9</td>
<td>241.50 gm</td>
<td>243.50 gm</td>
<td>5.00 gm</td>
<td>33.33%</td>
</tr>
<tr>
<td>12</td>
<td>240.00 gm</td>
<td>241.50 gm</td>
<td>4.00 gm</td>
<td>20.00%</td>
</tr>
<tr>
<td>15</td>
<td>238.50 gm</td>
<td>240.00 gm</td>
<td>2.50 gm</td>
<td>0.00%</td>
</tr>
<tr>
<td>18</td>
<td>238.50 gm</td>
<td>238.50 gm</td>
<td>2.50 gm</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

Fig. 1

(Fig.1) As per the graph, it was found that the weight of the core remained constant as soon as complete dehydration of the coating was over after 15 mins. And the color of the coating also changed completely from pink to yellow. This visual confirmation of change of color of coating indicates complete drying and no further drying of cores is required, resulting in saving of energy required for drying. (Fig.2)
4. SHOP FLOOR EXPERIMENT RESULTS

The color changing coating was tested at a renowned Foundry manufacturing Automotive castings for hub cores. The Cold box cores were dipped in the purple colored coating and left for air drying. The air-drying phenomenon was visible as the coating was changing color during the drying process. (Fig.3)

Similarly, the color changing coating was tested at a renowned Windmill Casting Foundry manufacturing Windmill Castings. The Furan Sand Mould & Cores were painted by brush in Pink colored coating and dried with LPG torch after 30 minutes. The color change phenomenon was visible as the coating was changing color during the drying process. It was very easy to apply multiple coats on a dried yellow surface. (Fig.4)
5. ADVANTAGES OF COLOR CHANGING REFRACTORY BASED COATINGS

5.1 To eliminate all moisture related defects:

As is clear from the data collected for various types of resin core systems, the color of coating changes completely as soon as the total moisture is removed. This ensures that no moisture is present in the coating. In conventional white coating there is no visual confirmation to the applicator whether total moisture has been removed or not particularly from grooves. OR Any area has been left out during the drying process. This eliminates all moisture related defects.

5.2 To identify poor sand compaction in a core or mould:

As these areas will absorb more moisture from coating, more moisture penetration inside the sand surface. Will take longer time to dry. Visual confirmation is more important particularly in case of Flood & Dip coating applications.

5.3. To optimize on cost of drying:

- Most important aspect resulting color change is Energy Saving.
- Avoids over heating by oven / torch.
- In case of drying ovens it acts as an Energy saver.
- In case of drying by torch overheating of cores / molds is avoided.
- Saves Time for drying.
- Cores are ready for assembling.
- Improves Production cycle.

5.4 Visual confirmation of Over Dilution:

Avoid over dilution of coating as color of coating will fade & Coating will take more time to change color due to higher moisture content

5.5 Easy to apply multiple coats as Pink color coating will be applied on dried yellow coating:

- Applicator knows areas where multiple coats are applied
- In Conventional White coating few areas can be left out with single coating
- Thickness of coating is visible due to distinct colors
5.6 Reduces production cycle time:

- Visual identification makes operator understands cores / molds can be sent for final pouring.
- In case of air drying, no further waiting is required.
- Production cycle time is reduced.

5.7 Coatings are reversible in nature in few cases:

- Cores / Moulds on storage if absorb moisture, particularly in monsoon season change color from Yellow to Pink OR Yellow to Purple.
- Visual confirmation In case of water spillage on core / moulds due to reversal color change.
- Operator knows moisture is absorbed and moisture can be removed before closing the boxes and pouring.
- This feature eliminates Moisture related defects completely

6. CONCLUSIONS

Color changing coating acts as a Quality control tool for almost all the Foundry sand systems. Except for Graphite based coatings, Color changing coating has an edge over conventional white or Colored (non-Color changing) coating. Color changing technology not only eliminates moisture related defects but
  a. helps in increasing the productivity,
  b. helps during application of multiple coats,
  c. helps in saving the energy consumed for drying and in application process.

These Color changing coatings proved to be a techno-economical solution over conventional refractory coatings. It has cost saving on drying operations and by way of increase in production cycle and reduction in % rejection.

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