SIX DECADES OF PORCELAIN ENAMELING

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Abstract
Robert Long provided an overview of six decades of enameling art and science reflecting in his broad experiences and active involvement in the industry. Early in his career he attended Muskegon Community College in Muskegon, Michigan. In 1995 Robert Long chaired the 17th International Enamellers Congress in Nashville, Tennessee.

Introduction

Robert Long started in the enameling industry at the age of 14 when he visited some customers with his father, the founder of American Porcelain Enamel in Muskegon, Michigan. His first job was spraying stipple on various cooker parts. His active career after military service started in the late 1940's. At this time, significant changes in the industry were occurring as the US and other countries were converting from war materiel production to consumer products again.

Changes in the Enameling Industry

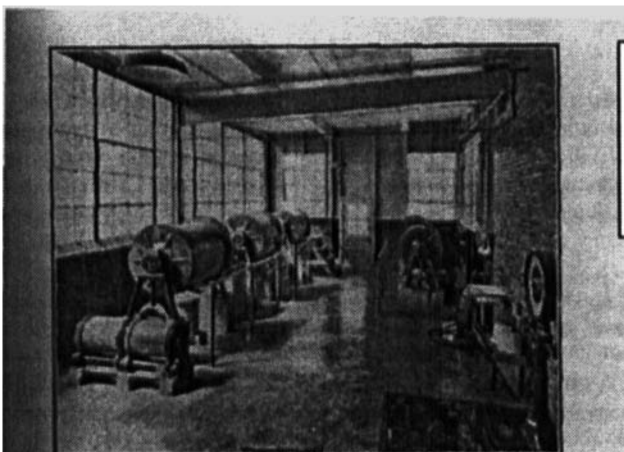
One of the aspects of enameling at this time was the use of open hearth furnaces for manufacturing ingot cast steels. The cause of fishscaling was not known and steel companies felt it was an enamel fault. The ground coats were generally high fire, about 1600°F with the steels having a very strong alkaline cleaning and acid etch followed by a borax-soda ash neutralizer. The acid of choices for etching the steels were either sulfuric or muriatic.

Application of the enamels was by dipping, usually manual but gradually supplanted by various automated systems moving parts through the dipping tanks. The effects of the borax-soda ash neutralized on enamel dipping properties such as pick-up and drain time were part of the "art" of enameling controlled by the individuals skilled in the process. One interesting aspect of art was the "beading" of the edges of cookware. The beading was done by skilled individuals using their hands to put a very precise and narrow band of a soft glass of the edges of the steel. This banding helped to terminate the thick enamel edge with a high expansion glass to minimize edge stresses. The bands were usually bright red, black or blue.

Various shapes of kitchen utensils coated with enamel by slushing or dipping process.

Cookware with edge "beading" applied by hand.

Enamels were nearly always milled by the end user in a variety of ball mills. The "mill room" was a key part of the enameling plant and the individuals managing the work were highly skilled in manipulating the mill formulations to achieve optimum application.



A modern mill room, showing enamel grinding mills, scales, enamel containers, and two small color-matching mills in the foreground.

Typical mill room of the first half of the 20th century for preparation of wet enamels.

Cast iron enameling was more widespread than it is today. Casting were coated with "white" ground coats which were then dried and fired if a wet process was used or directly if a dry process was used. Subsequently, either clear or opacified enamel was applied as a finish coat. The opacifier of choice was antimony oxide smelted into a glass and required 10 or more mils of application for satisfactory coverage. This was said to be *the most difficult type of product to run in an enameling plant.* In the 1930's through the late 1970's, many of the dry process cast iron product producers were "self-smelters". Self-smelters produce their own frit products in-house and are integrated through the finished product. Self-smelters still represent significant tonnage of frit produced in the US.

The types of cover coats available before 1940 were either antimony or zircon opacified. These coatings had good alkali resistance but poor acid resistance. Acid resistance was achieved by a clear overcoat. These coatings had an interesting degree of apparent depth but also were very thick with a total thickness approaching 20 mils. Brushing of the edges of various parts was normally done to minimize edge spalling or chipping. Appliances of this era are easily identified by the black edges seen on component parts. In the 1950's, with the advent of better sources of titanium dioxide and an understanding of what caused yellowing of the titanium oxide in glasses, high reflectivity acid resistant enamels were now possible. Today nearly all of the bright white porcelain enamels are titanium dioxide opacified.

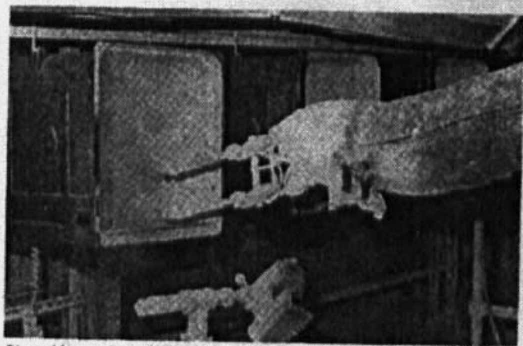
The advent of nickel pickle, nickel sulfate baths for replacement deposition of nickel metal on the steel surfaces after acid etching, allowed the development of "high speed ground coats". The high speed ground coats are similar to the standard ground coats that are used today, but in the early 1950's, this allowed the development of ground coat enamels firing about 1450°F. At the same time, high opacity titanium cover coats firing about 1500°F provided the enameller with greatly improved products. The titanium opacified cover coats were two-thirds the weight of the older zircon and antimony enamels. Additional development of the pickling systems resulted in the development of high etch and high nickel deposition allowing "direct-on" enameling with only the cover coat. This improved the mechanical properties of the finish coats with less chipping tendency and the elimination of any brushing.

Batch pickling operation moving baskets of parts from various tanks with cleaner, acid, nickel and neutralizer solutions to prepare the metal surface for application of enamel.

Low temperature enameling of about 1200°F to 1350°F seemed feasible. However, due to the cost of lower temperature enamels with more costly raw materials and the loss of radiation heat transfer below 1350°F, temperatures of enameling settled to about 1500°F. About this time, it was determined that the cause of fishscaling was due to the lack of micro voids in the steels.

This spurred on the steel suppliers to produce fishscale resistant steel typically termed low carbon steels. Micro voids in the steel were created by the development of iron carbides, which are crushed during cold rolling and then eliminated by open coil annealing (OCA). In the early 1970's, various continuously cast steels were developed and adapted to the enameling processes. At the same time, enamel products began the development of no-nickel, no-pickle ground coats, which eliminated the previously necessary pickling process of acid etching and nickel deposition. This greatly reduced the solid waste associated with the pickling processes.

The application of wet spraying techniques and equipment processed from the early 1930's to highly automated systems in the 1960's with equipment suppliers providing better spraying equipment. The traditional dipping operations were used primarily of complex and bulky shapes such as refrigerator liners and dishwasher interiors. This was also automated with wet spray and robotic application in the early 1970's.



Pictured here is the number one robot in the second station of KitchenAid's dishwasher porcelain enamelling booth spraying the top and sides of a unit's tank. Two 12-in long, 90° angle AGB guns are employed.

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Robotic application of cover coat enamel, direct-on to dishwasher cavities.

Summary

Continuing developments such as electrostatic powder has helped the industry compete with organic coatings. The mentality of our industry is and has been, "we can do more." We have kept abreast of the ever-changing process and regulatory environments and kept enameling a premier coating technology recognized for its leading attributes.