Enamel Coating*

*** Glass lining, glass lined steel,**

Glass fused to steel (amorphous glassy ceramic layer formation)

Porcelain enamel (also known as vitreous enamel)

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Process stages of enamel coating

- Frit preparation
- Substrate preparation (surface cleaning)
- Application
- Firing

* Most modern applications involve two layers of enamel:

- A ground coat to bond to the substrate.
- A cover coat to provide desired external properties.

Frit: The unfired enamel mixture

Frit is normally prepared by mixing the ingredients and then milling the mixture into a powder.

The ingredients of frit are most often metal oxides and minerals such as quartz (or silica sand), soda ash, borax, cobalt oxide and scrap glass.

Frit preparation:

- Powder mixing.
- Smelting. (at 1150-1300 °C)
- Grinding into powder. (most often by ball milling grinding is used)

*Frit compositions are depend on type of substrate or alloy of steel.

Substrate

- Most commonly used are steels of various compositions and cast irons.
- Aluminium and copper are also used.

Substrate preparation (surface cleaning):

- Degreasing.
- Pickling.
- Alkaline neutralization.
- Rinsing.

Application

Method:

- Dry: applied as a dry powder.
- Wet: liquid slurry suspension.

Dry application:

- The simplest method of dry application especially for cast iron substrates, is to heat the substrate and roll it in powdered frit.
- The most common method of dry application in industry is electrostatic deposition.

Electrostatic deposition:

- Before application, the dry frit must be encapsulated in an organic silane; this allows the frit to hold an electrical charge during application.

- An electrostatic gun fires the dry frit powder onto the electrically earthed metal substrate; electrical forces bind the charged powder to the substrate and it adheres.

Wet application:

- Dipping: Complete immersion coats all available surfaces of the substrate. Dipping is not often used in industry however because many prelining trial dippings are required.

- Flow coating: Rather than dip the product in an bath of slurry, slurry is flowed over the surface of the product to be coated. This method allows for much more use of slurry and time.

- Spraying: Liquid slurry is fed into the nozzle of a spray gun and compressed air atomized to the slurry and ejects it from nozzle.

Firing process

Converts the adhering particles of frit into a continuous glass layer.

The effectiveness of the process is highly depends on time, temperature and the quality or thickness of the coating on the substrate.

Process time:

- Most frits for industrial applications ~ 20 min.
- Heavy duty industrial applications ~ 40 min.

Process temperature:

- For steels > 800 °C
- For Al ~ 530 °C

Chemical fusion process

- Oxidization of metal.
- Enamel becomes liquid and dissolves ferrous oxide.
- Ferrous oxide saturates enamel and reacts with other oxides.
- Steel surface develops rough features.
- Enamel penetrates features whilst still in liquid form.
- Enamel hardens during subsequent cooling process.

Applications of enamel coatings

- Parts under regular chemical attack or high heat.

Cookware, burners, laboratory equipments, kitchen or bathroom area: pots, pans, cooktops, appliances, sinks, toilets, bathtubs,

- Weather and corrosion resistance:

Escalator side panels, tunnel walls, counters (turnike), agricultural silos, outdoor mild steel products, signages (tabela).

* For architectural applications a ground coat is combined with two cover coats to achieve an overall enamel thickness of 300 – 400 µm.

Properties of vitreous enamel

- Versatile.
- Variety of colours and finishes.
- Colour fastness (solmazlık).
- Resistance to corrosion (The steel is encapsulated in glass).
- Hygienic: Due to the absence of pores. (Enamel does not absorb or transmit odours or flavours.)
- Resistance to abrasion (Mohs hardness ~ 5-7).
- Resistance to chemicals. (Enamel is resistant to most alkali, all acids at room temperatures except HF.)

- Heat and fire resistance:

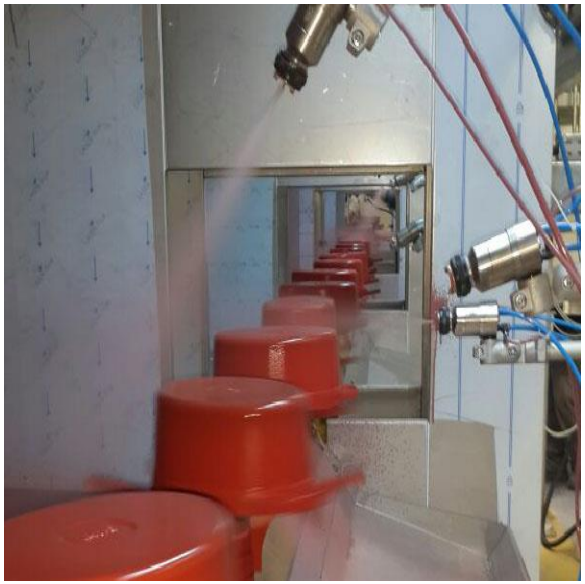
  Resistance to heat, naked flames or fire up to 650 °C and continuous temperatures up to 400 °C. Vitreous enamel is incombustible and does not give off any toxic gas.
- Resistance to thermal shock.
- Vermin (haşerat) proof.
- Acoustic and thermal insulation.
- Dielectric properties:

  Enamel has a high degree of electrical resistance and acts as an excellent insulator. Especially at room temperature.

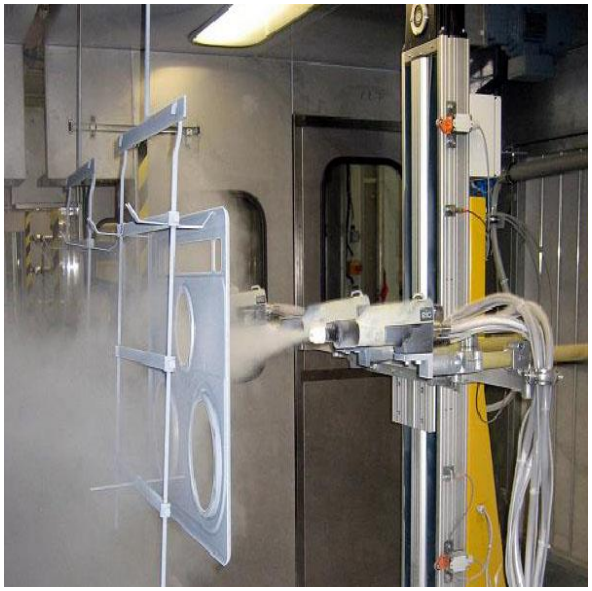
- Low maintenance
- Environmental friendly:

  Both the elements that are used to produce enamel and the steel base are recyclable as they contain no polluting substances.

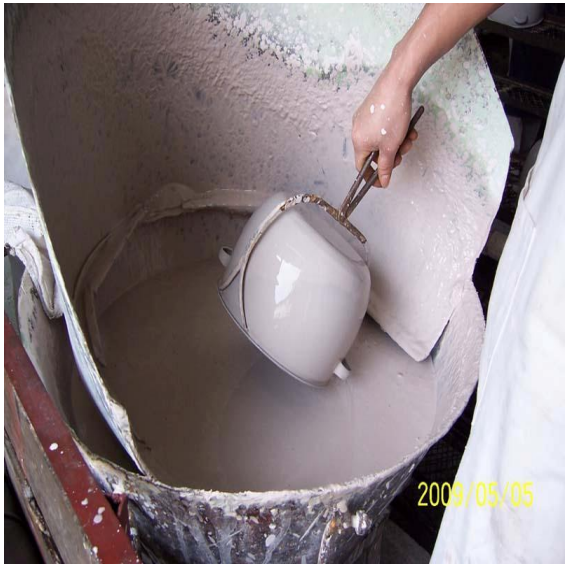
- Brittleness and relatively low impact resistance.



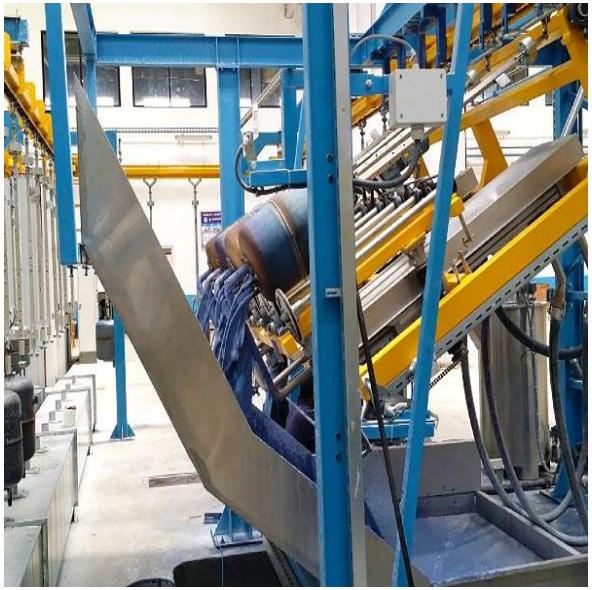
Conventional wet enamaling (spraying)



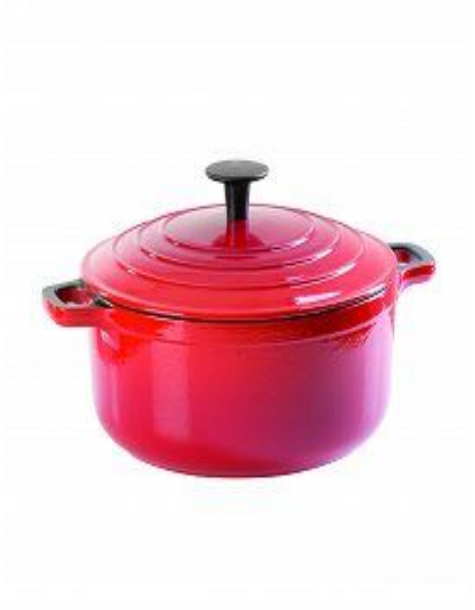
Electrostatic powder enamaling

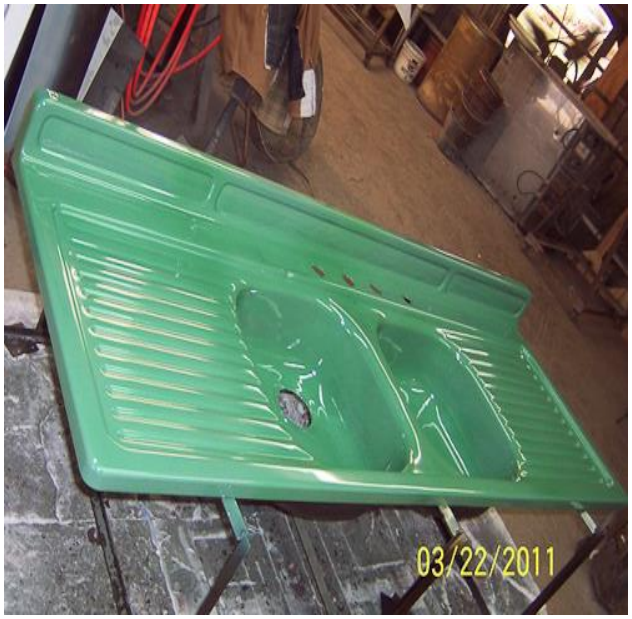


Dip enamel coating



Flow enamel coating

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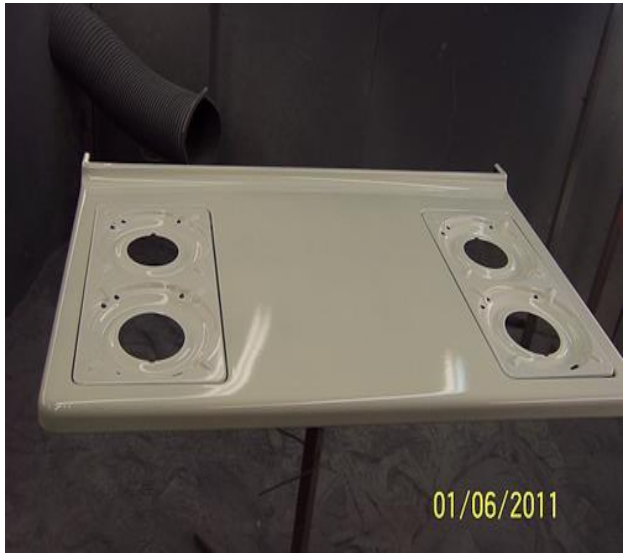
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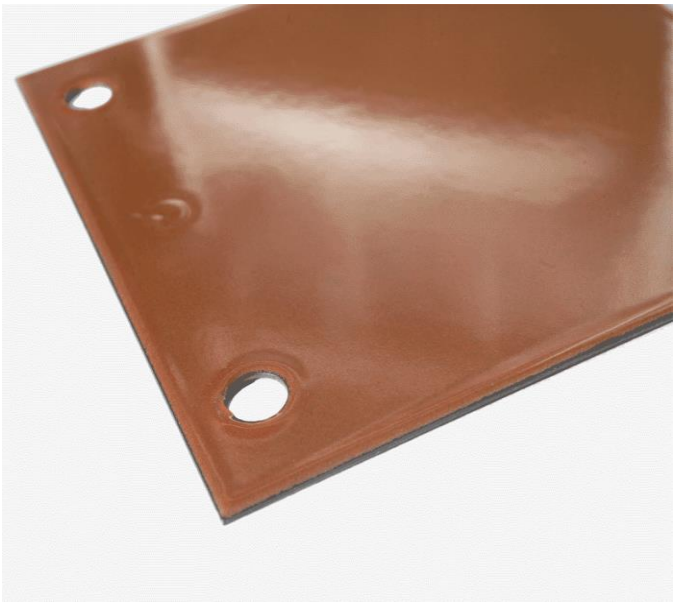

Video links

- https://www.youtube.com/watch?v=Q-tkxAa9o7w
- https://www.youtube.com/watch?v=gK7uyGg3FK8
- https://www.youtube.com/watch?v=vXBx7V2oNhg
- https://www.youtube.com/watch?v=PoXq7vTTJD4
- https://www.youtube.com/watch?v=Ga7KQlvU814