

Development of Fuel Filler Tube with Enhanced Adhesion Coating System on Ferrite Stainless Steel for LEV III

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ABSTRACT

A pre-treatment technique for improving coating adhesion on stainless steel has been developed. This method dramatically enhances the adhesion between the stainless steel and the coating by pre-treating the stainless steel with a known nickel strike plating for a short period of time.

Furthermore, when this process was applied to stainless fuel filler pipes to improve corrosion resistance, layout restrictions and chipping covers became unnecessary, costs were reduced, and vehicle weight was lowered.

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INTRODUCTION

In order to respond swiftly to California LEV II standards (15 years/150,000-mile warranty), Honda began taking further corrosion resistance improvements in automobile components for the North American market, beginning with the 03M Accord. Honda's North American region is considered a salt damaging region because large quantities of snow-melting agents (salts) are used. This leads to higher corrosion rates in the area, so the conventional carbon steel fuel filler pipe was changed to stainless steel to further improve corrosion resistance.

Two general types of stainless steel can be selected for the fuel filler pipe: austenite and ferrite stainless steels. Ferrite stainless steel was selected to respond to the LEV II standards because austenite stainless steel is associated with problems such as high cost and stress corrosion cracking, where ferrite stainless steel which is superior against stress corrosion cracking and relatively less expensive. Without a coating, however, ferrite stainless steel led to crevice corrosion between the main fuel pipe and bracket, resulting in earlier hole development.

To prevent this corrosion cracking, cathodic electrodeposition coating was applied to the stainless steel part. However, in the fuel pipe and where severe chipping inside the wheel houses of the undercarriage occurred, the coating tended to peel, causing early corrosion.

In addition, when fastening the main pipe of the stainless steel filler pipe and the breather pipe, the stay component (stainless steel) was mechanically fastened, instead of using a welding method in order to

handle collisions. If the fastener is made of the same stainless steel as the filler pipe, adhesion loss can be minimized without any differences in electric potential occurring between the pipe and the fastener. However, looseness occurs if a stainless steel fastener is used, therefore a carbon steel fastener is required. Because a local battery is formed between the stainless steel pipe and the carbon steel fastener, however, the area of the stainless steel sheet where coating defects exist (on the cathode side) become OH⁻ rich, causing markedly greater adhesion loss than when the stainless steel fastener combination is used.

As a result, it is necessary to use a fuel filler pipe coating containing a unique corrosion-resistant pigment or resin, a layout in which chipping does not occur, or the addition of a chipping cover, but these increase costs further.

MATERIAL DEVELOPMENT DESIGN

1. Conventional Process

Degreasing, surface roughening, and chemical conversion treatment are examples of widely known coating pre-treatment methods for stainless steel that are intended to improve coating adhesion[1,2].

For degreasing, the oil content of the raw material surface can be removed by using an organic solvent or an aqueous concentrated alkaline solution, but the passivation film of the stainless steel surface cannot be removed.

Surface etching by acid washing is believed to be the most effective type of surface roughening, but it causes sheet reduction and affects component strength. Also, residual acid-wash solution can remain behind in components with complex shapes, such as the fuel filler pipe. Since this residual acid wash can cause pitting corrosion, the surface must be washed with plenty of water.

Before the cathodic electrodeposition coating process, zinc phosphate treatment must be performed to provide adhesion. The zinc phosphate film formed in that process functions as an anchor. In addition, the underfilm is also treated by methods other than zinc phosphate treatment, such as chromate treatment or zirconium treatment. If the substrate is steel or aluminum, the addition of hydrofluoric acid and the hydrogen bonding of the chemical conversion film produced by reacting the base material with the substrate treatment solution act as an anchor to ensure coating adhesion. However, when coating the stainless steel, a stable oxidation film and passivation film have already been formed on the stainless steel surface. Therefore, a zinc phosphate or other surface treatment film for increasing coating adhesion cannot be formed, and sufficient coating adhesion cannot be obtained.

2. Film Composition of the Developed Coating System

In this research, various pre-treatment methods aimed at improving coating adhesion on stainless steel were studied. A Wood's nickel strike plating with superior adhesion to stainless steel was applied to a stainless steel component, allowing the strong oxidation film formed on the stainless steel to be removed and prevented from reforming. Then, cathodic electrodeposition was performed on the Wood's nickel strike plating film, and extremely good adhesion between the cathodic electrodeposition coating and the Wood's nickel strike plating was observed.

Sufficient coating adhesion and corrosion resistance were achieved on the stainless steel substrate by using a thin coating of approximately 25 μm . Fig.1 shows the composition of the coating using the developed coating system.

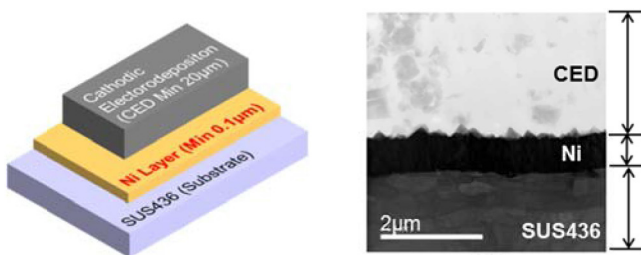


Fig.1. The diagram and cross-sectional image of enhanced adhesion coating system.

In addition, an elemental analysis of this film was conducted in the depth direction by using GDS (Glow Discharge Spectrometry). The results are shown in Fig.2.

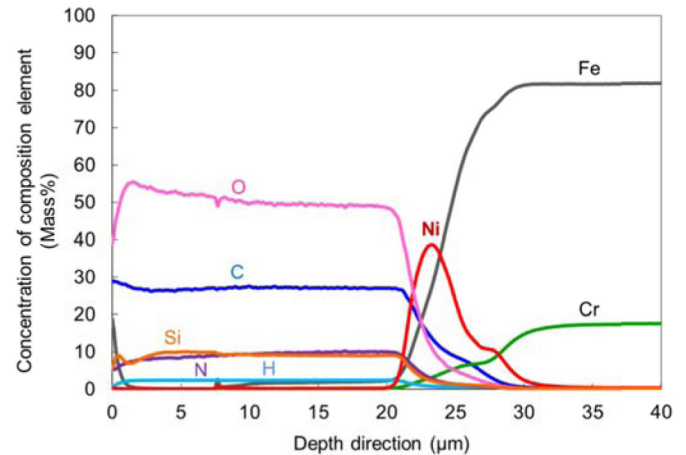


Fig.2. Depth profile of elements concentration of developed coating system.

3. Treatment Method of the Nickel Plating

Wood's nickel strike plating bath, a known plating process, was used, and it consisted of nickel chloride and hydrochloric acid. Also, cathodic electrolytic degreasing was performed on an SUS436 panel (50 mm $\times$ 100 mm $\times$ 0.3 mm thickness) for 10 minutes at 50°C with a current density of 1 A/dm² by using sodium hydroxide solution. The panel was then washed with water. Later, Wood's nickel plating was applied using a bath of the following composition with current density of 5 A/dm² for 3 minutes, under the conditions shown in the table.

1. Nickel chloride (NiCl ₂)	220 g/L
2. 35% Hydrochloric acid (HCl)	230 ml/L
3. Boric acid (H ₃ BO ₃)	30 g/L

Then, the developed material was washed, and a cathodic electrodeposition coating was applied (25 μm). After washing the developed material with water, it was cured at 200°C for 25 minutes.

QUALITY PERFORMANCE OF THE DEVELOPED COATING SYSTEM

1. Adhesion Evaluation by Hot Salt Water Test

After using a cutter to make a cross-cut in the obtained coating panel, the panel was immersed in 5% NaCl solution at 55°C for 240 hours (hot salt water test), and coating adhesion was evaluated by tape peeling. The results are shown in Fig.3.

If a carbon steel fastener is mechanically joined to the stainless steel sheet, a local battery forms between the stainless steel and the carbon steel and promotes cathodic peeling in the stainless steel sheet. Therefore, if a stainless steel sheet is used instead of nickel plating, most of the coating is peeled off of the cross-cut in the stainless steel sheet. Meanwhile, if a nickel plating is used instead of a stainless steel sheet, there is very little peeling, because the nickel plating has superior adhesion.