

The application of plasma-sprayed ceramic coatings on lift roller in float glass

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Abstract: Oxide ceramic was sprayed via high-energy plasma spray using MCrAlY manufactured with special technique as bond coating and oxide ceramic as top coating in this article. Investigation showed that the dense and highly adhesive coating could be obtained with optimized technique. After grinding and polishing, coating roughness was lower than $0.2\mu\text{m}$, which could meet the requirements of lift roller. After one year service, molten Tin could not adhere to the ceramic coating, well it greatly alleviated its corrosion to the roller, kept the surface of oxide ceramic coating smooth and the improve the quality of glass due to the strengthened lift roll.

Key words: float glass; lift roller; plasma spray; oxide ceramic

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1 Introduction

The flattened glass is transported from molten Tin to annealing klin using lift roller in float glass line. Glass temperature is far below the softening point of glass, the hardness of glass, however, is low, thus glass is easily scared by foreign substances during transportation and this will lead to scrapped product. Therefore, the roughness of roller surface has magnificent influence on the quality of glass. Steel is commonly selected as using material and can be attacked by molten Tin when contacting with molten Tin. What's more, Tin will solidify and crystallize on the surface of roller at lower temperature after long time service. Buildup, which will scratch glass, will appear on the surface and lead to lower quality of glass during contact^[1]. Otherwise, when lift roller is used in thermal shock environment from room temperature to 230°C , it will deform eventually^[2].

Molten Tin can not adhered to the oxide ceramic coatings owing to its high contact angle with coating. Oxide ceramic coating has excellent corrosion-resistance to molten Tin. With its thermal barrier properties, oxide ceramic coatings can reduce the thermal influence on the lift roller and inhibit its deformation. As a result, oxide ceramic coating can extend the service life of lift rollers and lower production cost. Generally, traditional plasma spray produces higher porosity (around 10%), and easily leads to corrosion attacked by molten Tin from the pores and finally lower service life of rollers. With high power spray system, dense oxide ceramic coating is firstly sprayed onto the lift rollers in China. After grinding and polishing, the coat-

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ing can completely meet the requirements of float glass line and has been used more than a year in a float glass line.

2 Experimental

2.1 Powder

MCrAlY is chosen as bond coating due to the big difference between substrate and top coating. Commercially available oxide ceramic is sprayed as top coating. The particle size of both powders is $-45+10\ \mu\text{m}$ and the purity is higher than 99.9%.

2.2 Experimental devices and plasma spraying conditions

Traditional plasma spray leads to higher porosity due to the low speed impact on the substrate surface. The dense coating was prepared by F4 plasma gun in this paper. The thickness of bond coating is 0.1 mm, and top coating 0.3 mm. The spraying process parameters used in this paper are listed at Table 1.

Table 1 Spray parameters for MCrAlY and oxide ceramic coating

	Flow rate of primary gas /(L · min ⁻¹)	Flow rate of secondary gas /(L · min ⁻¹)	Current/A	Power/kW
MCrAlY	40	10	600	42
Oxide ceramic	40	10	700	50

2.3 Coating characterization

Coating microstructure was studied by Lecia DMIRM optical microstructure and SM5940 SEM. Hardness testing was performed using a Rockwell hardness tester. The bonding strength was tested according to ASTM C633-79. Roughness was measured by Tokyo-Seimitsu E-30A.

2.4 Finishing and application of oxide ceramic coating to lift roller

The dimensions of lift rollers sprayed are $D305\ \text{mm}$, $L5000\ \text{mm}$. Bond coating and top coating were sprayed using powders and parameters mentioned above. After grinding and polishing, the roughness reached to $0.2\ \mu\text{m}$, which met the requirements of roller. After one year normal service in float glass production line, the roller was checked.

3 Results and discussion

3.1 Oxide ceramic properties

Oxide ceramic properties are listed in Table 2. The table shows that the bonding strength reaches 40-42MPa and it ensures no spalling or delaminations during service of rollers. The hardness is higher than that of steel (commonly $HR_{15N}\ 40-50$). This means that the roller can not be easily abraded. Optical microscopy revealed dense coating with porosity about 3%-5% which enhanced the corrosion-resistance performance in molten Tin.

Table 2 Parameter index of oxide ceramic coating

Bonding strength/MPa	Porosity	HR _{15N}	Roughness/ μm
40—42	3%—5%	88—90	2—3

3.2 Coating microscopy

Cross-section microscopy of oxide ceramic coating is showed in Fig. 1. The lower part is the substrate, and the middle is MCrAlY bond coating and the top is oxide ceramic. The dense coating is observed due to finer powder and optimized parameters adopted. High melting point and low thermal conductivity that characterize the ceramic powder, therefore, finer particles can be melted well by the spray jet and achieve lower porosity. Correspondingly, corrosion can be weakened^[3]. The oxide ceramic coating sprayed on the lift roller can strengthen the corrosion-resistance to molten Tin and increase the surface quality of glass.

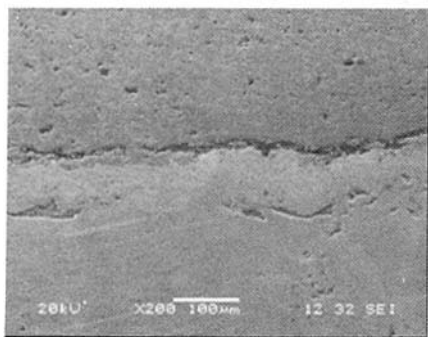


Fig. 1 SEM Cross-section of coatings

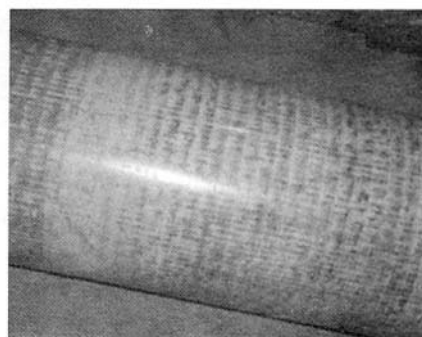


Fig. 2 Roller appearance after one year service

After grinding and polishing, coating roughness was lower than $0.2\mu\text{m}$, which could meet the requirements of float glass line. The quality of glass was enhanced using the oxide ceramic coated lift roller. The appearance of lift roller was showed in Fig. 2. From it, there is no cracking, spalling and apparent corrosion can be observed. The roller was put back into the float glass line after polishing and is still working well now.

4 Conclusions

Dense, adhesive, and corrosion-resistance coating was deposited by high power plasma spray with MCrAlY as bond coating and oxide ceramic as top coating. After grinding and polishing, the coating surface roughness can meet the requirements in float glass production.

Molten Tin hardly adhered to the oxide ceramic coating after one year service. This showed oxide ceramic coating could greatly inhibit and reduce the molten tin corrosion.

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