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High velocity oxygen fuel (HVOF) cermet coatings for metallurgical roll components — Guidance with requirements

Revêtements de cermet par pulvérisation oxycombustible à grande vitesse (HVOF) pour les composants de rouleaux métallurgiques — Recommandations et exigences

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by ISO/TC 107, *Metallic and other inorganic coatings*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Metallurgical rollers are the key components used in the steel industry. However, rollers considered to be consumables with premature failure often occurring on the roller surface. The surface quality of rollers determines the quality of products and also affects production efficiency. High velocity oxygen fuel (HVOF), as an environmentally friendly technology, has become a promising technology for improving the surface quality of rollers, thus extending the service life. Up until now, HVOF cermet coatings (e.g. tungsten carbide based, chromium carbide based) have been widely used in various rollers (e.g. hot dip galvanized line, continuous annealing furnace) in the metallurgical industry around the world. In the process of metallurgical production, the specific coating is determined by the working conditions of the rollers used.

This document aims to promote the technical progress of the industry.

High velocity oxygen fuel (HVOF) cermet coatings for metallurgical roll components — Guidance with requirements

1 Scope

This document specifies recommendations and requirements for the selection of coating materials, the pre-treatment of rollers, the preparation and post-treatment of the coatings, as well as the quality and performance evaluation of high velocity oxygen fuel (HVOF) cermet coatings used on metallurgical roll components.

This document is applicable to four metallurgical rollers: pot inner roller (sink/stabilizing roller) of continuous galvanized line (CGL), cold rolling process roller, hot-rolled straightening roller and furnace roller.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14921, *Thermal spraying — Procedures for the application of thermally sprayed coatings for engineering components*

ISO 14916, *Thermal spraying — Determination of tensile adhesive strength*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
pot inner roller (sink/stabilizing roller) of continuous galvanized line
pot inner roller (sink/stabilizing roller) of CGL
roller that ensures the stable flow of the steel strip into the zinc pot

3.2
cold rolling process roller
main working part of the sheet mill, which determines the quality of the rolled material and the production efficiency of the mill

3.3
hot-rolled straightening roller
core part of the hot rolling strip mill, which is composed of six rollers

3.4
furnace roller
key part of a continuous annealing furnace in the continuous strip production line

Note 1 to entry: The quality of the furnace roller directly affects the surface quality of strip steel.

4 Recommended HVOF cermet coating materials for various metallurgical rollers

The appropriate coatings for the pot inner roller (sink/stabilizing roller) of CGL, cold rolling process roller, hot-rolled straightening roller, and furnace rollers should be as given in Table 1. Generally, the damages to rollers include corrosion, wear, high-temperature oxidation, etc. The recommendation of coatings is determined by the failure of the rollers, as shown in Table 1.

Table 1 — Failures and recommended coating materials for various metallurgical rollers

Rollers	Failures				Example of recommended coatings	Powder manufacturing methods	Particle size
	Corrosion	Wear	Oxidation	Accumulation of tumours			
Pot inner roller (sink/stabilizing roller) of CGL	√	√	/	√	WC-*x*Co	Agglomerated and sintered	−45 µm +15 µm
Cold rolling process roller	√	√	/	/	WC-*x*M(NiCr, Co)		
Hot-rolled straightening roller	/	√	/	/	WC-*x*Co		
Furnace rollers (500 °C to 700 °C)	/	√	√	√	Cr_3C_2-*x*NiCr		
Furnace rollers (≥800 °C)	/	√	√	√	MCrAlY(M = Ni/Co/NiCo) + oxides, carbides or borides		

Key
√ : possessing this failure form
/ : there is no such failure form
x : mass fraction of the metallic phase, which should be controlled within a mass fraction of 10 % to 50 %

5 Preparation of HVOF cermet coatings for various metallurgical rollers

5.1 Pre-treatment of various metallurgical components

The surface of the rollers should be inspected and reviewed to ensure their suitability before spraying. These procedures should be followed for the pre-treatment and surface preparation of the metallurgical components:

a) It is necessary to remove the impurities generated during the production process to obtain a clean surface. For the pot inner roller (sink/stabilizing roller) of CGL, the residuary zinc on the surface should be removed by dilute acid solution, using the following steps:

   1) Preparation of dilute acid solution: The concentration of sulphuric acid mass percentage should be controlled within 3 % to 7 %.

   2) Immersion: The dipping time of zinc removal treatment should be controlled within 6 h to 72 h.

3) Cleaning: The sinking/stabilizing rollers together with the special lifting frame should be cleaned by soaking and rinsing.

4) Airing: After soaking and rinsing, the workpieces should be together with the special lifting frame on the fixed pit position to dry.

b) The roller surface should be inspected to ensure that there are no defects or cracks on the surface. If shrinkage cavities, pores and sand holes are present, their size should be smaller than 0,5 mm. If there are cracks or defects with a size larger than 0,5 mm, partial substrate from the roller surface should be carried out by a carbide tool head. Pits larger than 3 mm in diameter shall not be present on the roller surface after processing. The surface roughness should be lower than 3,2 µm.

c) Prior to spraying, grinding and polishing should be carried out to obtain a surface of which the roughness is lower than 0,8 µm. To enhance the adhesion of coatings to rollers, sandblasting is employed to roughen the working surface.

5.2 HVOF spraying

HVOF spraying shall be operated in accordance with ISO 14921.

5.3 Post-process of HVOF sprayed coatings

There should be a post-process inspection and operation of HVOF sprayed coatings, including sealing pores, heat treatment and dynamic/static balance.

The inspection of the coatings should be carried out after spraying via measurement of thickness, roughness, microhardness and bonding strength.

Thermal spraying sink/stabilizing rollers and furnace rollers should be sealed. Once spraying is finished, seal the pores as soon as possible. For sealing, a range of different sealants and procedures are available and the supplier's instructions should be followed.

6 Coating quality and performance evaluation

6.1 General

The performance of the coating, such as thickness, roughness, porosity, hardness, etc., can influence wear resistance, corrosion resistance and stability, thereby affecting its service life. Therefore, it is necessary to provide the coating quality (see 6.2) and an evaluation of its performance (see 6.3).

6.2 Coating quality

Recommended performance indicators for various metallurgical roller components is given in Table 2.

Table 2 — Recommended performance indicators for various metallurgical roller components

	Performance indicators					
	Thickness µm	**Bonding strength** MPa	**Surface roughness** R_{pk}	**Porosity**	**Micro-hardness** $H_{V0,3}$	**Friction coefficient**
Pot inner roller (sink/stabilizing roller) of CGL	≈ 150 to 200	≥70	≤30 % (decreasing rate after 360 h operation)	≤1 % for as-sprayed; ≤ 0,3 % after sealing	1 050 to 1 150	/
Key / : no performance requirement						

Table 2 *(continued)*

	Performance indicators					
	Thickness µm	**Bonding strength** MPa	**Surface roughness** R_{pk}	**Porosity**	**Micro-hardness** $H_{V0,3}$	**Friction coefficient**
Cold rolling process roller	≈ 180 to 200	>65	3,6 µm ± 0,1 µm	/	750 to 1 100	0,23 ± 0,02
Hot-rolled straightening roller	≥180	>70	<0,8 µm	<1 %	1 000 to 1 300	/
Furnace rollers (500 °C to 700 °C)	100 to 200	>65	Not constant value, determined by the specific work position	<1 %	775 to 950	/
Furnace rollers (≥800 °C)	100 to 200	>50	Not constant value, determined by the specific work position	<5 %	600 to 850	/
Key / : no performance requirement						

6.3 Performance evaluation of coatings

6.3.1 Thickness

Although there are many methods for measuring the thickness of the coating, for the HVOF cermet coatings of rollers, two common and accurate measurement methods are given, as follows:

a) Destructive test method: In order to test the thickness of the coating accurately, the specimens should be cut, cleaned, mounted and polished. A scanning electron microscope (SEM) is used to measure the coating thickness following the steps in ISO 9220.

b) Non-destructive test method: The in situ coating thickness can be measured in the production line through non-destructive methods. A magnetic sample is fixed next to the roller being sprayed and the coating thickness is determined by measuring the thickness of the magnetic sample with an eddy current thickness gauge when the coating process is finished.

The steps for in-line testing of the coating thickness are as follows:

— The specimens used for thickness test should be magnetic and the distance to the spray gun should be consistent with the roller.

— Prepare three samples cooled to room temperature.

— Measure the thickness by the non-destructive method. The number of points measured for each specimen depends on its size. The detailed requirements are as follows:

  — For samples with a main surface less than 1 cm^2, 1 to 3 distributed measurements shall be made.

  — For samples with a main surface greater than 1 cm^2 and less than 1 m^2, 3 to 5 distributed measurements shall be made.

  — For samples with a main surface greater than 1 m^2, 9 points and 10 distributed measurements shall be made. The first and tenth measurement points shall coincide.

The distribution of measurement points is shown in Figure 1.