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Thermal spraying — Pre-treatment and finishing of thermally sprayed coatings

Projection thermique — Traitements préliminaires et postérieurs des couches projetées thermiquement

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ICS

English version

Thermal spraying - Post-treatment and finishing of thermally sprayed coatings (ISO/DIS 14924:2002)

This draft European Standard is submitted to CEN members for parallel enquiry. It has been drawn up by the Technical Committee CEN/TC 240.

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Foreword

This document (prEN ISO 14924:2002) has been prepared by Technical Committee CEN/TC 240 "Thermal spraying and thermally sprayed coatings", the secretariat of which is held by DIN, in collaboration with Technical Committee ISO/TC 107 "Metallic and inorganic coatings".

This document is currently submitted to the parallel Enquiry.

1 Scope

The successful service of a thermally sprayed component depends decisively on the right choice of procedure for post treatment and/or finishing after spraying. In order to work and/or to treat a thermally sprayed coating especially the property of the lamellae structure shall be taken into account. The structure is quite different from those of the same materials in the cast or wrought state and finishing techniques which may be suitable in these latter cases would be likely to damage thermally sprayed coatings.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

EN 22063, *Metallic and other inorganic coatings – Thermal spraying – Zinc, aluminium and their alloys (ISO 22063:1991, modified)*.

EN ISO 14920, *Thermal spraying – Spraying and fusing of self-fluxing alloys (ISO 14920:1999)*.

ISO 504, *Turning tools with carbide tip – Designation and marking*.

3 Mechanical post treatment

3.1 Chip cutting

3.1.1 General

For the reasons stated above, the common basis of chip cutting techniques cannot be applied to thermally sprayed coatings because of their different properties. There are many different hard phases in sprayed coatings such as oxides, carbides, borides, silicides and others. These require specific attention to the geometry of the cutting edge to prevent high wear of the flank.

3.1.2 Turning

The possibility of turning a thermally sprayed metal coating depends upon the specific property of a thermal spray coating e.g. structure and hardness as well as any previously applied thermal spray process.

a) Tool selection

Due to hard phases in metallic thermal spray coatings and the partly extremely hardening spray particle the turning tool is more heavily loaded compared to cast or forged material consisting out of the same or similar material.

Because of this reason hard metals and ceramic cutting materials are required. The ones commonly used for turning grey cast iron, chilled cast iron and short cutting chip malleable cast iron. In contrast thermally sprayed aluminium or copper coatings can be turned economically using high speed steel cutting tools. Good operation times are achieved by using hard metal quality K01 and K10 according to ISO 504.

Thermally sprayed coatings with hardnesses $x > 700$ HV (60 HRC) may be turned satisfactorily using boron nitride tools, consisting of poly-crystalline, cubic boron nitride (CBN), which are sintered to a hard metal body.

Thermally sprayed copper and aluminium coatings can be turned economically using high-speed steel.

b) Cutting speed

The optimum cutting speeds for thermal spray coatings are different. They are lower because of imbedded hard phases compared to homogeneous materials and require sharp cutting tools with cutting radius R 0,8 mm - 1,2 mm.

Tables A.1 to A.4 show approximate values which may be adjusted from case to case. A test cut is recommended in order to avoid unfavourable results.

NOTE Applying too high cutting velocities the thermal spray coating acts like lapping tool because of imbedded oxides and no economic life time of the tool is achieved. The blunt cutting tool generates a high surface load and can lead to coating damage.

c) Traverse feed

Traverse feed per revolution shall be of the order of particle diameter of thermal spray coating. Tables A.1 to A.4 show approximate values for turning of thermally sprayed metal coatings which may be adjusted from case to case.

3.1.3 Milling

In some cases thermal spray coatings may be machined also by milling. Concerning selection of tool and choice of feed and speed the same considerations as turning shall be taken into account.

3.1.4 Cooling during chip cutting operations

When coatings of self fluxing alloys, which are fused to provide a dense structure, are machined, a coolant may be used in order to prevent overheating. (This does not apply when CBN cutting tools are used).

Otherwise a coolant shall not be used when as sprayed coatings (which are not fused) are being machined. The micro porosity of the coating permits penetration of the coolant causing discolouration and other problems.

If coolant is used areas of high hydraulic pressure can wholly or partially remove particle giving a poor surface finish.

3.1.5 Grinding

3.1.5.1 General

Wet grinding shall be preferred to dry grinding in order to avoid over heating of the thermally sprayed coating as well as of the work piece.

3.1.5.2 Preparation

It is advantageous to seal the coating before grinding. This will prevent penetration of the coolant to the interface with the substrate material causing possible corrosion problems (see 4.1) It will also minimise the generation of grinding debris which may contaminate the returned coolant.

Additionally, sealing of ceramic coatings is also preferred before grinding to prevent unsightly staining of the coating due to penetration of the coolant.

3.1.5.3 Selection of grinding process

All thermally sprayed coatings may be ground. The loading of the thermally sprayed coating is lower compared with that of turning. Tables B.1 and B.2 show details for grinding.

3.1.5.4 Selection of grinding wheel

The shape of the grinding wheel will vary depending on the geometry of the component to be ground. e.g. cup wheels may be used where appropriate. Dry grinding may be carried out although the use of a coolant, where possible, is preferred

Tables B.1 to B.3 show the kind of wheels to be used, which will depend on the thermal spray material used.

3.1.5.5 Belt grinding

Where a smooth finish is required and dimensional accuracy is not important, belt grinding may be used. Typically silicon carbide or diamond belts are used for this purpose.

3.1.6 Other cutting processes

3.1.6.1 Chip cutting with geometrically defined tool edges (drilling)

Certain thermal spray coatings can be drilled using sharp spiral drills.

3.1.6.2 Planing, sawing, reaming, broaching

These cutting processes are commonly not recommended because the probability of damaging the coatings.

3.1.6.3 Chip cutting with geometrically undefined but hard tool edges

- a) Abrasive cutting, honing

For these cutting processes the same recommendations as for grinding shall be taken into account.

- b) Applying loose grains

– Polishing, lapping: Polishing of ground or turned metallic thermally sprayed coatings may be carried out by using polishing machines and applying polishing filler materials. A heat build up shall be avoided to prevent coating damage.

– Super finishing: Thermal Spray coatings especially ceramic coatings (e.g. Cr_2O_3 , $\text{Al}_2\text{O}_3/\text{TiO}_2$, blends of these respectively alloys with other ceramics as well as hard materials) can be super finished in order to achieve very low coating roughness (R_a down to 0,05). These results can be achieved only using wet operating procedures.

3.2 Other mechanical processes

3.2.1 Shot peening

In special case metallic thermal sprayed coatings can be post-treated by shot peening. The shot peening process densifies the coating and can generate a compressive stress. This post-treatment can increase the corrosion resistance of especially arc and flame sprayed coatings. Care has to be taken that the thermally sprayed coating is not too highly loaded locally during shot peening to avoid spalling.

3.2.2 Brushing

Thermal sprayed coatings can be brushed in order e.g. to smooth the surface, to remove spray dust to achieve clean surfaces or decorative effects.

4 Chemical treatment

4.1 Sealing

4.1.1 General

Untreated thermally sprayed coatings contain micro porosity. In many cases it is desirable to close the pores using specially formulated sealing materials which will penetrate the pores and not simply lie on the surface. Control of the viscosity of the sealant is vitally important in this respect. It is also important that the coating does not take up moisture or become otherwise contaminated between spraying and sealing.

4.1.2 Sealing for hydraulic and pneumatic applications

In order to avoid a loss of static or dynamic pressure loads by the coating of a component pores shall be closed by applying a suitable sealant.

4.1.3 Sealing for increasing the corrosion resistance

Avoiding interfacial corrosion of thermally sprayed coated components is important.

If base materials have to be coated with electrochemical more precious spray materials, penetration of the coating by liquids or gases which lead to an interfacial corrosion shall be avoided. The galvanic series is significant and has to be considered. Several sealants are available on the market like liquid phenol resin, hard wax, anaerobic materials etc.

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4.1.4 Sealing for influencing friction and sliding properties

The friction and sliding coefficient of thermally sprayed coatings can be decreased by applying Poly Tetra Fluor-Ethylene (PTFE) containing sealers and thus the friction and sliding properties are improved.

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4.1.5 Sealing for achieving special surface properties

Beside the application fields named above several suitable sealers exists in order to achieve special surface properties.

Examples are as following:

EXAMPLE 1 Sealing of thermally sprayed coatings for electrical insulation in order to avoid penetration of humidity, for instance into an alumina coating which will reduce the insulation.

EXAMPLE 2 Sealing in order to achieve anti sticking properties, e.g. glue applying rolls.

EXAMPLE 3 Sealing in order to achieve wetting or non-wetting (hydrophilic / hydrophobic). The printing industry is a typical example for this application.

EXAMPLE 4 Sealing in order to achieve visual properties as is required for artistic pieces or architectural effects.

4.2 Pickling

For visual purposes metallic thermally sprayed coatings can be chemically post treated. Using suitable pickling solutions colouring of the metal spray coating can be achieved.

4.3 Painting

Thermally sprayed coatings may be painted in order to improve the aesthetic appearance. Normally paints are applied to zinc or aluminium coatings after they have been sealed (see EN 22063).

5 Thermal treatment

5.1 Fusing

Flame sprayed self fluxing alloys (NiCrBSi and others) are usually post-treated by fusing (see EN ISO 14920).

5.2 Diffusion annealing

In special cases thermally sprayed coatings can be treated by a diffusion annealing procedure which provides diffusion of the coating into the substrate, thus increasing the bond strength. This process shall be carried out in a vacuum chamber, or in a controlled inert atmosphere in order to avoid an undesired oxide formation within and on the coating.

5.3 Hot isostatic pressing

The density and adhesion sprayed coatings may be enhanced by subjecting the coated component to a hot isostatic treatment in a controlled manner.

6 Health and safety

In carrying out these treatments all protective labour and environment guide lines for the processes and procedures shall be followed.

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Annex A (informative)

Some estimated values for chip cutting of thermally sprayed coatings

Table A.1 — Chip cutting applying hard metal tools on thermally sprayed coatings (non fused)

coating hardness x	Hard metal quality	cutting angle	clearance angle	cutting velocity (m/min)	feed (mm/revolution)		cutting depth (mm)		cooling
					rough machined	finish-machined	rough machined	finish-machined	
x < 200 HV (95 HRB)	K10	+8° to 10°	5°	up to 70	0,2	0,05 to 0,08	0,5	0,05	no
200 HV (95HRB) < x < 300 HV (30HRC)	K10	+5°	5°	up to 50	0,1 to 0,2	0,05 to 0,08	0,5	0,05	no
300 HV (30HRC < x < 700 HV (60HRC))	K01	5°	5°	up to 30	0,1 to 0,2	0,05 to 0,08	0,5	0,05	no