Material Advancements of Thermal Spray Coatings for Oil and Gas Industry

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Content

Key Characteristic of WC based powders on HVOF and HVAF application

- Production Methods
- Effect of powder on coating properties
- Influence of carbide size on HVOF coatings

Review current specified HVOF WC materials for Oil & Gas Segment

- 86WC-10Co-4Cr (TA10C)
- 88WC-12Co (TA12)
- 90WC-10Ni (TA10N)

Next generation of Wear & corrosion resistant coating materials and potential chrome plate replacement alternatives.

- 83WC-20Cr3C2-7Ni (TA07N)
- 82WC-18NiMoCrFeCo (TA18NM)
- 37WC-45Cr3C2-18NiCoCr (TA18NR)
- 63Cr3C2-7WC-24Ni-6Cr (TA37NT)
- 70WC-30WB-10CoNiCr (TA520S)
Manufacturing Process

- **Cast & Crushed**
  - Poor flowability of fine powders < 25 µm
  - High Apparent Density
  - Lower degree of melting in the spray process
  - Higher coating porosity

- **Dense Sintered**

- **Agglomerated Sintered**
  - Better flowability
  - Lower Apparent Density
  - Higher degree of melting in the spray process
  - Dense coatings

Decreasing amount of W_2C and η-phases
Development of Carbide Size (WC-Co)

Plasma

Average: 8 µm
Range: < 20 µm

HVOF (Gas Fuel)

2.5 µm
< 6 µm

HVOF (Liquid Fuel)

1 µm
< 3 µm
Future Requirements for HVOF Carbide Coatings

- **Lower surface roughness as-sprayed**
  - Finer powder grain size
  - Dense coatings - powder grain size must be adjusted to spray system

- **Improved wear resistance**
  - Finer carbides

- **Improved corrosion resistance**
  - Modified matrix alloys
  - Co – Ni – CoCr – NiCr – NiMoCrFeCo
Review current specified HVOF WC materials for Oil & Gas Segment
86WC-10Co-4Ni (TA10C)

PSD: -45/+15µm
Hardness (HV0.3): 1250
ASTM G65 Procedure A: 0.081 g. (Adj. mass loss)
Porosity: 0.39%
Cracks: None
Delamination: None
Un-melted particles: None
Salt Spray Test Cycle: 240h

Properties:
- Agglomerated and Sintered, HVOF & HVAF
- Densified structure with fine carbide dispersion
- CoCr matrix higher corrosion and abrasion resistance than Co matrix.
- Useable in water based solution and wet corrosive environments
- Smooth coating with fine microstructure and high bond strength
- Hard Chrome replacement
- Most specified HVOF/HVAF carbide coating material for Oil & Gas Market Segment
- Useful up to 500°C
WC-12Co (TA12)

PSD: -45/+15µm
Hardness (HV0.3): 1200
ASTM G65 Procedure A: 0.096 g. (Adj. mass loss)
Porosity: 0.12%
Cracks: None
Delamination: None
Un-melted particles: None
Salt Spray Test Cycle: 240h

Properties:
- Agglomerated and Sintered
- Max. operation temperature 500°C
- Hard, dense coatings with good abrasion, erosion and sliding wear resistance
- Smooth coatings with fine microstructure and high bond strengths.
**WC-10Ni**

*(TA10N)*

PSD: -45/+15µm  
Hardness (HV0.3): 1162.31  
ASTM G65 Procedure A: 0.094 g. (Adj. mass loss)  
Porosity: 0.51%  
Cracks: None  
Delamination: None  
Un-melted particles: None  
Salt Spray Test Cycle: 240h

Properties:

- Agglomerated and Sintered  
- Max. operation temperature 500°C  
- Smooth coatings with fine microstructure and high bond strengths.  
- Higher erosion resistance than WC-Co and better ductility.
CrC-25NiCr (TA25NC)

PSD: -45/+15µm
Hardness (HV0.3): 983.26
ASTM G65 Procedure A: 0.120 g. (Adj. mass loss)
Porosity: 0.52%
Cracks: None
Delamination: None
Un-melted particles: None
Salt Spray Test Cycle: 240h

Properties:
• Agglomerated and Sintered
• Max. operating temperature 870 C
• For Dense oxidation and erosion resistant coatings
• Good cavitation resistance
• Hot gas corrosion resistant
Next Generation of Thermal Spray Powder for Oil and Gas
**WC-20CrC-7Ni**
**(TA07N)**

PSD: -45/+15µm

Hardness (HV0.3): 1239.9

ASTM G65 Procedure A: 0.087 Adj. mass loss, g

Porosity: 0.70%

Cracks: None

Delamination: None

Un-melted particles: None

Salt Spray Test Cycle: 240h

Properties:

- Agglomerated and Sintered
- Densified structure with fine carbide dispersion
- Promotes finer microstructure, improved DE and denser, smoother coatings.
- Higher oxidation and corrosion resistance than WC-Ni based coatings
- Excellent flowability
- Useful up to 1400° F (760°C)
CrC-7WC-24Ni-6Cr
(TA37NT)

PSD: -45/+15µm
Hardness (HV0.3): 927.36
ASTM G65 Procedure A: 0.137 Adj. mass loss, g
Porosity: 0.73%
Deposit Efficiency: 47.2%
Cracks: None
Delamination: None
Un-melted particles: None
Salt Spray Test Cycle: 240h

Properties:
- Agglomerated and Sintered
- Densified structure with fine carbide dispersion
- Promotes finer microstructure, improved DE and denser, smoother coatings.
- Excellent for high temperature cavitation, abrasion and sliding wear
- Good hot gas and corrosion resistance
- Useful up to 1550° F
**45CrC-37WC-18NiCoCr (TA18NR)**

- **PSD:** -45/+15µm
- **Hardness (HV0.3):** 998.20
- **ASTM G65 Procedure A:** 0.114 g (Adj. mass loss)
- **Porosity:** 0.33%
- **Cracks:** None
- **Delamination:** None
- **Un-melted particles:** None
- **Salt Spray Test Cycle:** None
- **Properties:**
  - Agglomerated and Sintered
  - Wear & Corrosion Resistant
  - Components for use in chemical processing plants
  - Thermal spray alternative for hard chromium plating
  - Densified structure with fine carbide dispersion
  - Promotes finer microstructure, improved DE and denser, smoother coatings.
  - Excellent flowability
  - Useful up to 1290° F (700°C)
**60WC-25WC-10Co-5NiCr (TA520S)**

- **PSD:** -45/+15µm
- **Hardness (HV0.3):** 1350
- **ASTM G65 Procedure A:** 0.073 g (Adj. mass loss)
- **Porosity:** 0.11%
- **Cracks:** None
- **Delamination:** None
- **Un-melted particles:** None
- **Salt Spray Test Cycle:** 240h

**Properties:**
- Agglomerated and Sintered
- Wear & Corrosion Resistant for off shore and molten metal
- Low friction coefficient
- For very dense and ductile coating with good abrasion, erosion and sliding wear
- Promotes finer microstructure, improved DE and denser, smoother coatings.
- Excellent flowability
WC-18NiMoCrFeCo (TA18NM)

PSD: -45/+15µm
Hardness (HV0.3): 1197.63
ASTM G65 Procedure A: NA
Porosity: 0.17%
Cracks: None
Delamination: None
Un-melted particles: None
Salt Spray Test Cycle: 240h

Properties:
- Agglomerated and Sintered
- Alternative to WC-Co-Cr
- Excellent corrosion resistance in seawater, diluted mineral and organic acids
- For very dense and ductile coatings with good abrasion, erosion and sliding wear resistance
- Used for parts applied in marine, petrochemical and off-shore applications.
Corrosion Resistant – Salt Spray Test

86WC-10Co-4Cr
88WC-12Co
WC-10Ni
75CrC-25NiCr
73WC-20CrC-7Ni
CrC-7WC-24Ni-6Cr
45CrC-37WC-18NiCoCr
60WC-25WC-10Co-5NiCr
WC-18NiMoCrFeCo
Wear Test G65

Wear Test comparison
Summary

• WC based powders with carbides are available in combination with various matrix alloys and can improve coating performance over standard materials currently specified in the Oil and Gas Industry.

• Hardness and wear resistance of HVOF coatings can be improved by using powders with finer grain WC.

• Spray system and process parameters must be properly selected base not only on chemistry and particle size distribution but inclusive of apparent density and grain size of WC powder particles.

• Corrosion resistant cermet powders with complex matrix alloys are available.