Metal Dusting Prevention by Two Protection Systems in One Coating, Oxide Barrier and Catalytic Inhibition

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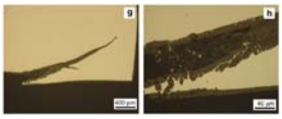
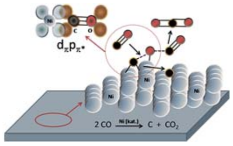
Metal Dusting

Metal Dusting destroys material´s integrity due to immense **carbon precipitation** along **grain boundaries**.
Affected materials are **iron, nickel, cobalt,** and their alloys.
MD occurs in high carbon containing atmospheres (**carbon activity >1**) such as in petro chemistry plants or steam reformers.
Critical temperature range: **450-900°C**

Coupon sample of alloy 600 after exposure in H_2-24%CO-2%H_2O at 620°C



Internal graphite deposition in nickel after 100 h at a_c=19
J. Zhang, D.J. Young (2007)

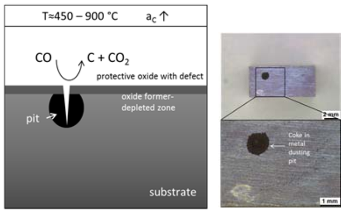


Certain metals catalyze the dissociation of carbon monoxide. The emerging carbon diffuses into the metal.

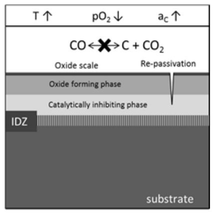
Coating concept

Conventional **metal dusting protection** by **high alloyed materials** always leads to an **oxide former-depleted zone** beneath the oxide scale. In the case of **local scale damage**, the corrosive environment gets access to the depleted material, which initiates **pit formation** and **metal dusting.**

The **combined coating concept** consists of two systems: At first **oxide forming elements** build dense oxide scales. Secondly, in the case of scale damage, an underlying **catalytically inhibiting phase** suppresses carbon precipitation until **re-passivation** of the scale.



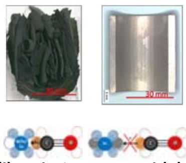
Conventional metal dusting protection by high alloyed materials (left). Metal dusting pit in alloy 602CA (right).



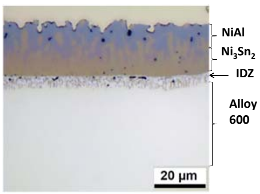
Schematic illustration of the combined coating concept.

Ni-Sn-Al system

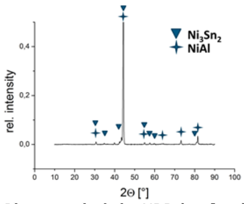
Ni_3Sn_2 coatings inhibit coking and metal dusting.
Coating process via **powder pack cementation (CVD)**
(Sn, Al, NH_4Cl, Al_2O_3, 800°C, 6 h)
→ **co-deposition** of **Sn** and **Al** into Alloy 600 (72 wt.% Ni)



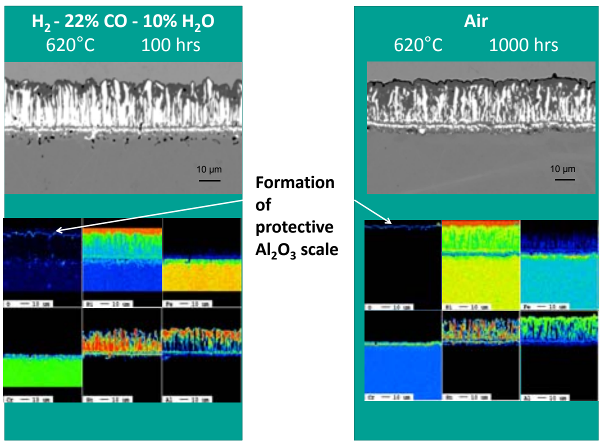
Uncoated (l) and Ni_3Sn_2-coated (r.) low alloyed steel after metal dusting exposure



Cross section image of Ni-Sn-Al-coated sample.



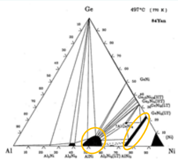
Phase analysis by XRD (surface)



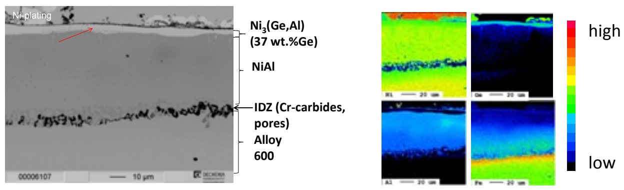
- Al_2O_3 formation on the surface in **carbonaceous** atmosphere with 10% **steam** content as well as **oxidizing** environments.
- No change in **microstructure** due to phases at **equilibrium** state
- Suitable for **Metal Dusting protection** for applications with temporarily oxidizing conditions (start-up or shut-down processes).

Ni-Ge-Al system

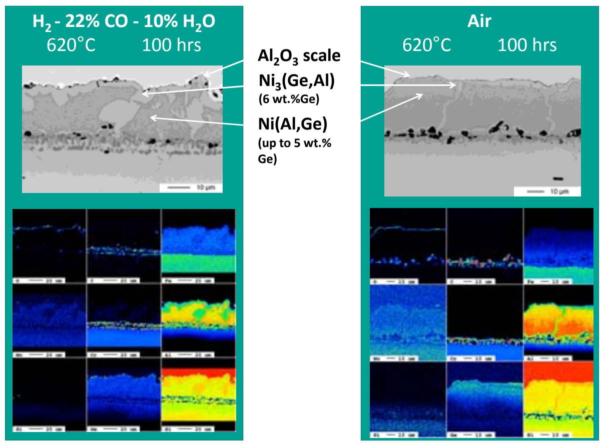
Coating process via **powder pack cementation (CVD) (Al and Ge)**
(Al, NH_4Cl, Al_2O_3, 1000°C, 4 h; Ge, NH_4Cl, Al_2O_3, 1050°C, 2 h)
→ **Subsequent deposition** of **Al** and **Ge** into Ni-plated Alloy 600



Ternary phase diagram of Al, Ge, and Ni at 497 °C *P. Villars et. al (1997)*



Cross section image (l.) and elemental distribution maps (r.) of Ni-Ge-Al-coated sample.



- Al_2O_3 formation on the surface in **carbonaceous** atmosphere and air
- **No coking or metal dusting observed**
- Initial **Ge content** at the surface: **37 wt.%.** Ge dissolves in NiAl by formation of Ni(Al,Ge)
- **Ni_3(Ge,Al)** as well as **Ni(Al,Ge)** are suitable compounds for metal dusting-protective coatings.