NEWS4CSP Project

New coatings approaches to protect metallic materials from heat transfer fluids

Teresa C. Diamantino[1]; Fátima Pedrosa[1] ; T. Paiva[1]; Eduardo Silva[2]; F. Gonçalves[2]; Renato Monteiro[2]; João P. Cardoso[1]

(1) LNEG - Laboratório Nacional de Energia e Geologia, Portugal (joao.cardoso@lneg.pt); (2) TeandM - Tecnologia, Engenharia e Materiais, S.A., Portugal

MOTIVATION

Achieving higher solar-to-electricity conversion efficiencies through the use of advanced power cycles operating at temperatures ≥650°C is one of the possible pathways to lower CSP's LCOE, requiring new Molten Salt (MS) based HTF. However, both new and existing MS mixtures have been facing critical challenging issues of severe corrosion and lower specific heat capacity.

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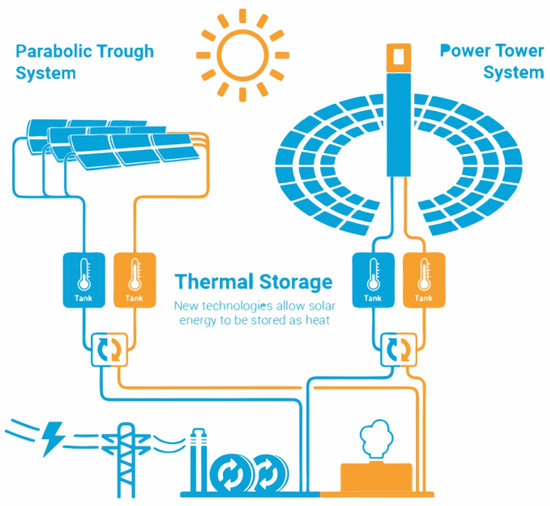
The NEWS4CSP project (*New materials approaches for concentrating solar power (CSP): Molten salts and corrosion protection*) is an ongoing project, with the following main objectives:

1. obtain new LiNaK carbonate molten salts mixtures (doped with micro/nanoparticles) with enhanced thermophysical properties and low corrosivity;
2. **obtain new coatings to increase the anticorrosive protection of structural materials;**
3. clarify the influence of cyclic thermal conditions, dynamic conditions and atmosphere in the corrosion behaviour and corrosion rate of stainless-steel materials;
4. understand the impact of these new materials (new molten salt mixtures and coatings) on the energetic and economic performance of a solar tower power plant.

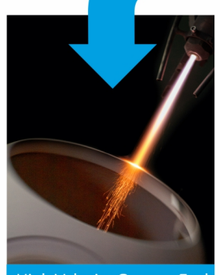
MAIN OBJECTIVE

Highlighting the main concepts being pursued and the preliminary results obtained by the NEWS4CSP project regarding the application of new coatings to AISI 430 steel by Laser Cladding (LC) and by High Velocity Oxy-Fuel (HVOF) to increase the anticorrosive protection of structural materials in contact with new MS (LiKNa carbonate salts).

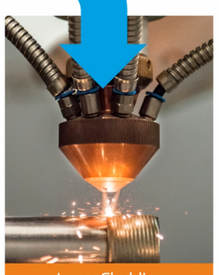


MATERIALS AND METHODS

COATING TECHNOLOGIES



High Velocity Oxygen Fuel **(HVOF)**



Laser Cladding **(LC)**

Ni-Cr-Mo base powder

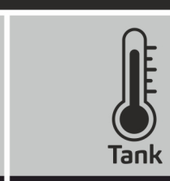
Ni	Mo	Cr	Fe	W	Co	Others	Hardness	Density
Base	15-17	14.5-16.5	4-7	3.0-4.5	2.5 (max.)	Mn, C, V, P, S, Si	240-260 HVO,1 (min.)	8.89 g/cm³

Co-Cr base powder

Co	Cr	W	C	Others	Hardness	Density
Base	27-32	3-6	0.9-1.4	Ni, Fe, Si, Mn, Mo	460-550 HVO.1	7 g/cm³

CORROSION TESTS

LiKNa carbonate salts
32.1% Li_2CO_3, 33.4% Na_2CO_3 and 34.5% K_2CO_3

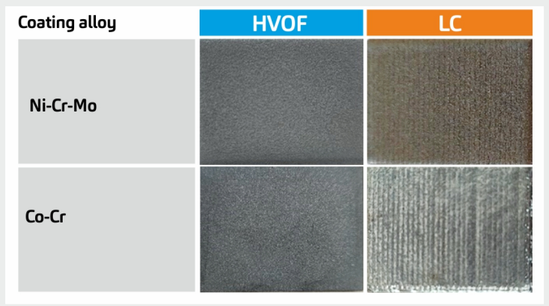


650ºC
Static conditions Air atmosphere

CARACTERIZATION

SEM/EDS

RESULTS



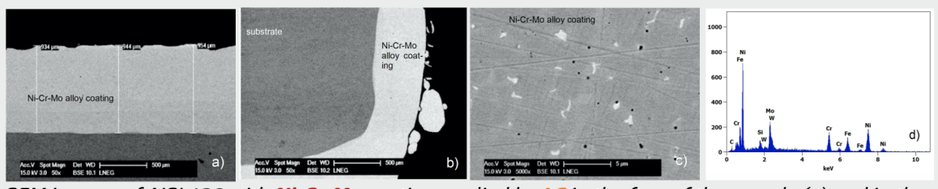
*Images of the samples after the application of the coatings by **HVOF** and **LC***

SEM/EDS evaluation of the coatings obtained by **HVOF**, both with **Co-Cr** and **Ni-Cr-Co** powders, revealed adhesion problems, namely in the areas closest to the edges. Even though the origin of such behaviour could not be precisely determined, it was considered that the level of porosity and probability of coating spallation would present significant limitations towards high temperature corrosion resistance.

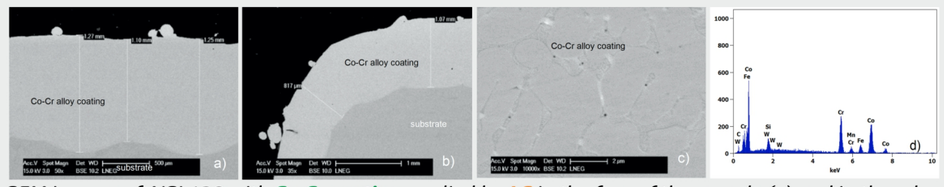
Therefore, these coatings by **HVOF** were deemed unsuitable until further optimization of coating application.

The coatings applied by **LC** have good adhesion, being promising in terms of corrosion resistance with molten salt.

Characterization of Coatings before Corrosion Tests



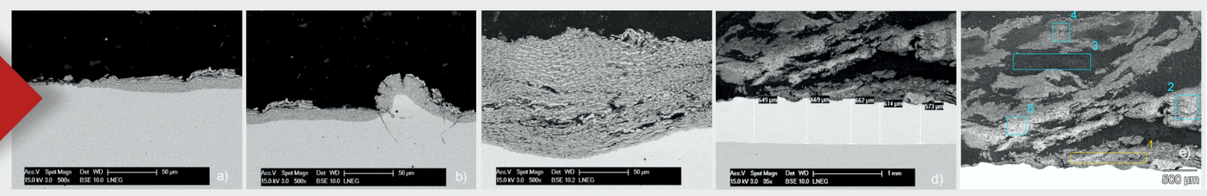
*SEM images of AISI 430 with **Ni-Cr-Mo** coating applied by **LC** in the face of the sample (a) and in the edge area (b), as well as a magnification of the coating (c) with the corresponding EDS spectrum (d)*



*SEM images of AISI 430 with **Co-Cr coating** applied by **LC** in the face of the sample (a) and in the edge area (b), as well as a magnification of the coating (c) with the corresponding EDS spectrum (d)*

Characterization of Coatings after Corrosion Tests

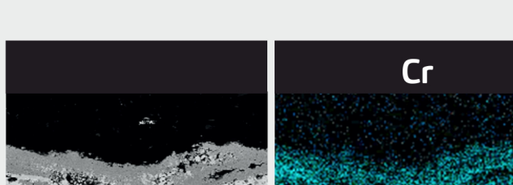
*Images of the samples with the **Ni-Cr-Mo coating** alloy, applied by **LC**, before and after contact with LiKNa carbonate salts during 1000 h*



Chemical elements	Wt (%)				
	1	2	3	4	5
C	5.6	5.8	11.6	9.0	5.8
O	26.7	27.5	82.4	41.9	28.6
Na	6.4	18.4	5.0	22.9	17.4
Si	-	0.4	-	-	-
K	0.7	-	1.0	0.6	-
Cr	8.3	4.9	-	5.8	4.7
Fe	4.3	3.8	-	1.8	5.2
Ni	43.4	39.2	-	15.9	36.2
Mo	2.2	-	-	0.5	1.0
W	2.4	-	-	1.6	1.1

f)

*SEM images of AISI 430 with **Ni-Cr-Mo alloy coating** applied by **LC** after the contact with LiKNa carbonate sats at 650ºC during 480 hours (a) to c)) and 1000 h (d) to e)) and EDS results obtained in the areas indicated (f))*



*Images of the samples with the **Co-Cr coating alloy**, applied by **LC**, before and after contact with LiKNa carbonate salts during 3000 h*

*SEM images of AISI 430 with **Co-Cr alloy coating** applied by **LC** after the contact with LiKNa carbonate salts at 650ºC after 480 hours (a)), after 1000 hours (b)) and after 3000 hours (c) and d))*

*Backscattered electrons image and corresponding EDS maps for the AISI 430 with **Co-Cr- alloy coating** applied by **LC** after the contact with LiKNa carbonate salts at 650ºC during 3000 hours*

CONCLUSIONS

AISI 430 ferritic steel is a ferritic steel with good characteristics for use with coatings for higher temperatures. Of the two coating application technologies studied (**HVOF** and **LC**), LC proved to be the most suitable technique. However, the **Ni-Cr-Mo coating alloy**, even when applied by **LC**, proved not to be appropriate for this application. The **Co-Cr coating alloy** showed good anticorrosive behaviour, even after 3000 h of testing. Before considering these coatings for use in CSP, in contact with high temperature molten salts, further studies are needed to optimise the application of these **Co-Cr alloys coatings** by **LC**, particularly in terms of thickness and chemical composition, as well as to better understand the degradation mechanisms and whether this good behaviour is maintained over longer periods.

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Partners entities

Consulting entities

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