SURFACE COATINGS FOR SMALL AIRCRAFT BRAKES APPLICATION

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INTRODUCTION

The rapid development of additive manufacturing technologies has improved the choice of materials in various industrial sectors, specifically relating to friction materials for brakes application in the aeronautical sector.

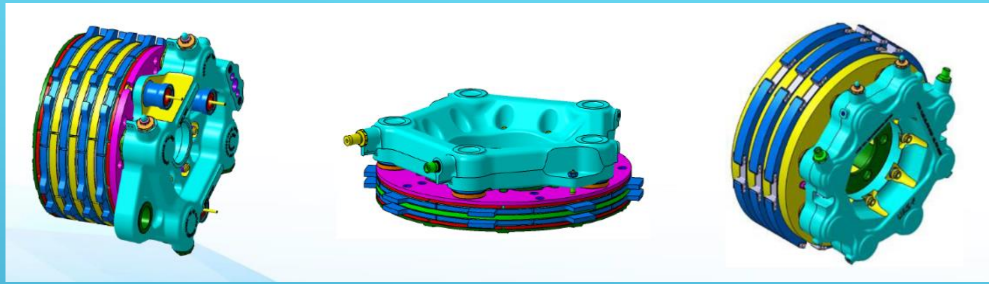
Currently, materials for small aircraft brakes range from the low-cost sintered friction pad/liner material vs sintered rotor disc material to the high cost carbon fiber material vs carbon fiber material. The subject of this work was developed in the framework of a European project (E-BRAKE).

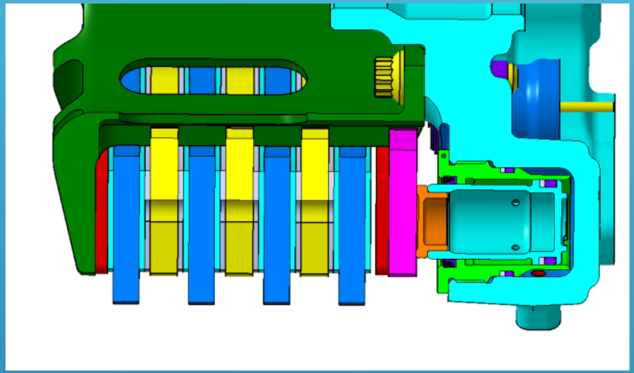
The friction material selection is based on the following main criteria:

- System performance requirements. Friction material should exhibit adequate Dynamic braking performance (maximum temperature, dynamic friction coefficient, dynamic braking pressure, friction material wear rate) and Parking condition performance (static friction coefficient, parking pressure)
- Weight requirements. Wheel brake assembly total weight is one of the key points and guideline on friction material selection.
- Cost aspects. The selection of friction material has a direct implication on cost aspects. Both non recurrent and recurrent costs, including scheduled maintenance costs, drive the selection.
- Maintenance aspects.

In this work friction composite surface coatings were deposited with two different thermal spray additive manufacturing technologies for the purpose of creating high friction and wear resistance composite surface coatings onto low-carbon steel surface.

The innovative solution proposed is to use rotor and stator discs made in steel, both equipped with a thin coating (e.g. 0.5 mm) of a suitable friction material. In this way the main brake material is steel covered with a noble coating.





METHODS AND MATERIALS

Additive Manufacturing Technique

- High Velocity Oxygen Fuel (HVOF)
- Atmospheric Plasma Spraying (APS)

Friction Materials deposited with HVOF technology

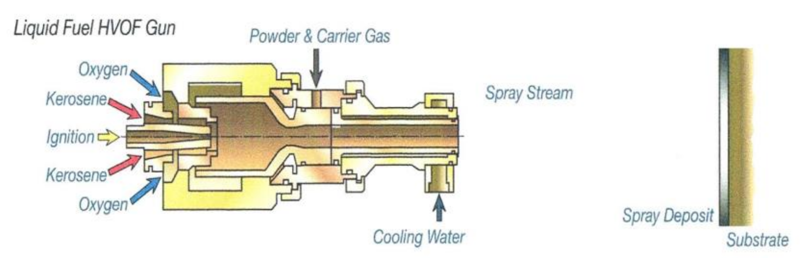
- Stellite grade 1. It’s a range of cobalt-based alloys composed of chromium and tungsten with a small percent of carbon. Chromium content gives resistance to oxidation and hardens by solid solution and by precipitation of carbides. Tungsten, mainly, gives hardening for solid solution.
- Colmonoy 6. It is a nickel-based alloy and provides sufficient adhesive and abrasive wear resistance, owing to the presence of high chromium and boron content. Colmonoy 6 alloys have also high hardness due to the presence of chromium carbides and chromium borides content in the substance.
- Tungsten Carbide. Carbide compound that exhibit a high hardness, tribological properties, wear resistance, thermal properties.

Friction materials deposited with APS Technology

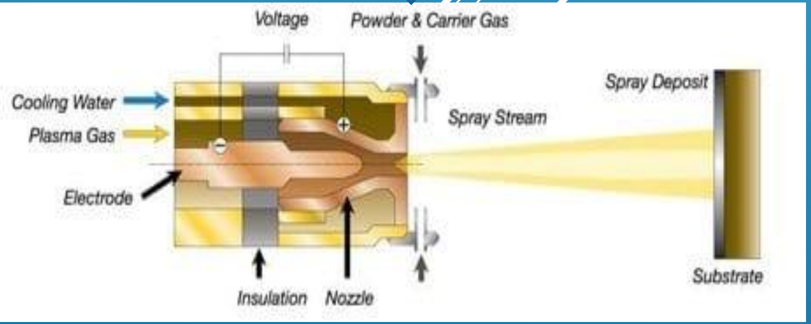
- CoNiCrAlY alloy bond coat. It is a metal alloy belonged to the MCrAlY category. Cobalt and Nickel enhance resistance to corrosion and oxidation. Chromium and Aluminum oxidize forming Chromia and Alumina that provide oxidation and hot-corrosion resistance. Yttrium enhances the oxide adherence to the substrate and limits the growth of grain boundaries.
- Chromium Aluminate top coat

Properties Investigated

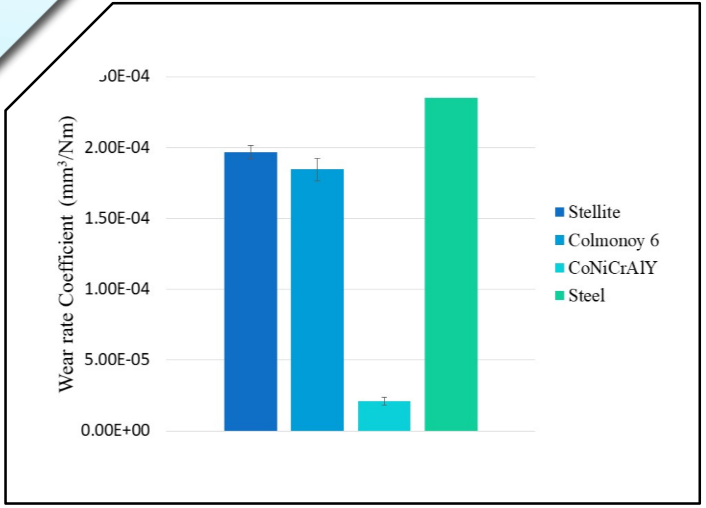
- Metallographic Structures
- Tribological Properties (Friction Coefficien and Wear Rate)
- Thermal Properties (Thermal Conductivity and Diffusion Coefficient)
- Adhesion on the low-carbon steel substrate surface

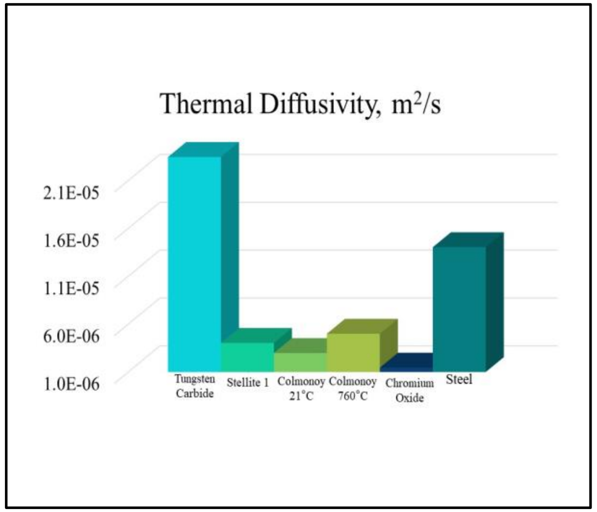


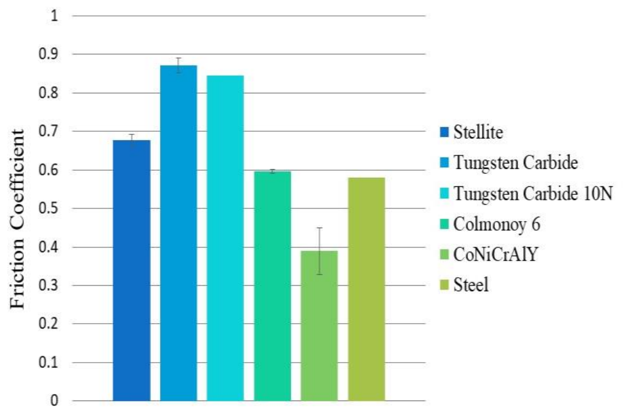
The HVOF (High Velocity Oxy Fuel) Spray Process

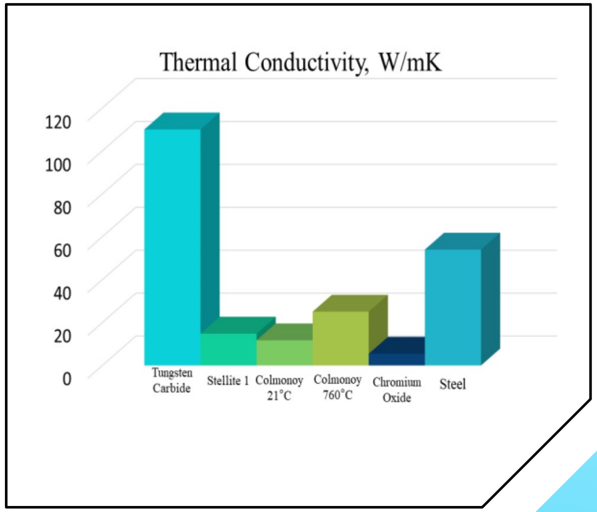


RESULTS









- All the coating analysed, except for Cr_2O_3, exhibit higher friction coefficient and wear resistance compared to the low-carbon steel substrate.
- Wear resistance results are similar. In fact, all the coatings present higher wear resistance compared to the low-carbon steel substrate.
- Scratch tests results shown a high adhesion of coatings on the low-carbon steel substrate. In fact, all the specimens exhibit high critical loads related to the crack initiation and the detachment of the coating.
- All analysed coatings exhibit lower thermal properties compared to low-carbon steel, except for the tungsten carbide. In fact, tungsten carbide coating exhibit high thermal conductivity (about 110 W/mK) and diffusivity (about 2.34·10-5). This means that coatings made in tungsten carbide has high capacity in propagate the thermal field even in non-stationary conditions without accumulating it into the braking rotor-stator interfaces avoiding the overheat of the friction surfaces with catastrophic consequences.

CONCLUSION

Carrying out a comparative analysis of the results obtained, it can be concluded that the tungsten carbide coating exhibits superior properties compared to the other investigated coatings. Therefore, a small tungsten carbide thickness (0.5 mm) can improve the braking action without greatly altering the brake weight. The application of this coating presents an additive cost, but thanks to its high properties, the braking action improves, and the brake wear is reduced, and its life in-service is improved.

In fact, among all the coating investigated, Tungsten Carbide coating presents the best properties

The higher friction coefficient (0.84)

The better adherence to low-carbon steel substrate. The results, in fact, show the higher critical loads at the beginning of cracks at about 10 N and a critical load of separation at 65 N.

It is worth to mention that the wear resistance result of the tungsten carbide coating were not reported due to the impossibility to measure the wear tracks at both the nominal loads employed (5 and 10 N). In fact, tests carried out for Tungsten Carbide coatings at both tests (5 and 10 N), the surfaces of the specimens were only flattened.

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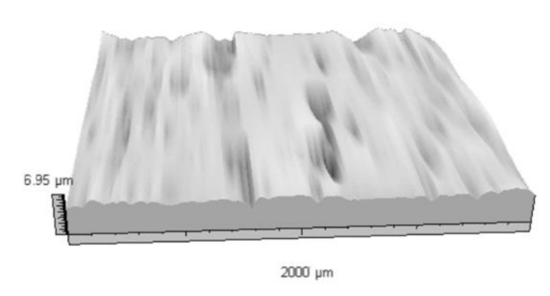

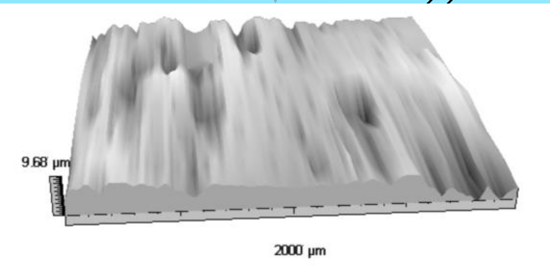

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Partner Project

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