Co-free wear-resistant alloys for nuclear applications: design and characterization

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Among wear-resistant alloys, Stellites (Co-Cr-C alloys) occupy an exceptional place. Yet, their main disadvantage comes from the presence of cobalt; a strategic element, to be avoided in nuclear applications due to the ^{60}Co activation. Several alloys, like Norem [1], have been developed to replace Stellites, without a true success. The purpose of this work is to design a Fe-rich alloy with properties similar to the Stellites' ones.

First, machine learning tools (Gaussian process and pair-wise comparison algorithm) have been used to create mathematical models for hardness and wear resistance. CALPHAD method (Calculation of Phase Diagrams) allowed to predict phases stability and some physical properties. These models were integrated in a genetic algorithm to optimize compositions with different sets of objectives and constraints.

Then, among the so-designed chemical compositions, two alloys have been elaborated and tested (microstructure, hardness, wear and mechanical properties …). Finally, further improvement of models led to a 2nd step of design and elaboration of a third alloy. The experimental characteristics of all so-designed alloys (especially, their wear resistance) are very promising.

Keywords: alloy design, wear resistance, machine learning, Stellites, nuclear industry

References:

[1] EPRI patent, July 1989