Metallic materials for aerospace applications: state-of-the-art and perspectives

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Abstract: Materials have always been one of the key factors in the development of aircraft and aircraft equipment. They have largely contributed to the considerable progress made in the field of reliability and performance of these structures, in terms of strength as well as mass reduction and durability. The issues of increasing light and performance involve research on new lighter materials, supporting higher temperatures or higher strengths. For metallic materials, whether referring to breakthrough alloy systems or incremental optimization of existing materials, the development of new, more efficient aerospace alloys requires understanding of the microstructures at different scales and the phase transformation mechanisms they involve. Structurally hardened aluminum alloys are a typical example of aeronautical alloys for aircraft cells. Discovered as early as 1906, the principle of structural hardening in these alloys, caused by the formation of nano-precipitates during specific transformations, has been used over the centuries to offer even more resistant materials to flight solicitations. In this field, the understanding of the kinetic precipitation path and the mechanisms of structural hardening are at the basis of the latest developments of alloys that compete today with composite materials. In contrast, titanium aluminide based intermetallic alloys have just been introduced as low pressure turbine blades in the latest generation of aerospace turbines. Their main interest lies in their excellent high temperature specific resistance, based on a density half that of conventional nickel-based alloys. As a counterpart, these materials suffer from low ductility at low temperature. Their introduction is based on a real technological breakthrough, which required a change in the thinking of the design offices and an adaptation of the sizing rules. This march forward is not yet over, even if the way now seems narrower, especially when we integrate the economic component to purely technical considerations. The materials used in the Aerospace industry are constantly improving in terms of performance (mechanical strength, temperature capacity, low density), process control and cost reduction. New simulation tools for the design of innovative materials are now more and more available, which suggests that there is still significant progress towards achieving objective specifications that would not have been imagined 20 years ago: metallic materials have not finished surprising us...