High Temperature Materials: an Introduction to Onera's Contribution

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The third issue of Aerospace Lab is dedicated to high temperature materials. Onera has been at the forefront of research and development for this class of materials for the past five decades, especially for aerospace engine applications. Starting in the mid 1960's, many new materials and processes were invented, and cutting-edge research was carried out during this period. Similarly and concurrently, great progress has been made in mechanical modeling and lifing analysis, but a description of these aspects will require a full separate issue. The focus here is on materials in the hot sections of compressors and turbines. These materials have a wide range of applications.
The purpose of the papers that follow is to illustrate the state-of-the art, the progress made and the future outlook for such materials in propulsion systems.

General introduction

The work presented here is essentially in the form of 'overviews' that describe mainly the in-house efforts and the progress achieved up until now within the broader context of world-wide developments on propulsion materials. Because of its specific role as a research establishment in France, the work undertaken at Onera has traditionally focused on the specific needs of the French aerospace industry, extended lately to some of the requirements of European industry, mainly through collaborative European programmes.

Broadly speaking, the papers in this issue cover a wide spectrum of activities which are based on the short, medium and long-term requirements of industry.

Superalloys and thermal barrier coatings

Onera has been at the forefront of a number of new superalloys for turbine blades and for disc applications which are already being used in French military and commercial aircraft engines, including helicopter engines. In the case of superalloys, the main objective is to satisfy the short-term requirements, and the emphasis in this issue is on the most recent alloy developments addressing various aspects of relationships between the chemistry, microstructure and mechanical properties. For disc alloys, some of the on-going research on new compositions and processing parameters is presented. An attempt is made to clarify the complex interaction between processing, the microstructure and the mechanical behavior, particularly in creep.

A sustained medium and long-term effort on thermal barrier coating degradation mechanisms and new advanced thermal barriers has been actively pursued over the past twenty years with the objective of both increasing the life times and achieving higher turbine inlet temperatures. Concurrently, additional effort has accompanied this work to develop new bond coats under the thermal barrier coatings. The nature of the approach has been essentially multidisciplinary (the micro and macro 'mechanics of coatings' and the mechanical characterization are not included here).

Lightweight intermetallics, silicides, ceramic composites and ultra- high temperature materials

In terms of long-term research, and depending upon the type of material, various processing approaches are being pursued. The material which is closest to potential applications is currently Titanium aluminide. Here again, the primary effort for many years has been to acquire a basic understanding of complex structures produced through various processing routes and to relate these microstructures to the

mechanical properties. The main objectives are to establish robust processing routes which, when scaled-up, will yield reliable properties and meet the industrial requirements.

Another area of activity in the context of long-term research involving a substantial collaborative effort within Europe has been on materials such as silicides, which could potentially replace some of the rather 'heavy' superalloys with lighter-weight materials. This is a very long-term effort, but still worth pursuing.

Finally, in the same vein, there are alternative materials for certain applications which will require a sustained and patient approach such as eutectic composites, oxide-oxide composites and ultra- high temperature materials for various applications.

This issue will attempt to cover a very wide spectrum of materials with a multidisciplinary research approach and a strong interaction between basic and applied research.