EQUINOX

A novel process for manufacturing complex shaped Fe-Al intermetallic parts resistant to extreme environments

Volume 1

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Project background

After World War II some east European countries were facing severe problems in the purchase of Chromium (Cr) and a shortage Nickel (Ni) on the free market to cover their needs for stainless steel production and materials for high temperature using.

To overcome this shortage countries of Eastern Block initiated a research in national research institutions, universities and local industry in the 50s – 60s to develop low cost alternatives for heat resistant cast iron and stainless steel alloys based on intermetallics casted from accessible and cheap Iron, Aluminium and Carbon.

These efforts result in the past in the materials such as Thermagal© Tchugal© and Pyroferal©. Pyroferal© offered quite impressive results on high temperature corrosion resistance. It was tested against various severe conditions, such as air atmosphere, vanadium pentoxide, molten glass, carburization, nitration and the atmosphere of the natural gas cracking generators.

Though Pyroferal© was manufactured only by casting, welding was the important procedure not only to produce complicated shapes, but also to repair the faults in casts. Unfortunately, the practical use of these materials was limited due to various problems.

These problems related to instability and welding could not be overcome by state of the art in material science at that time.

In the 60s, access to Cr was no problem any longer and the dust of history covered the knowhow on (pre-) industrial use of FeAl. But things may change again. Cr and Ni are listed in the table of CRMs with a current projected lifetime of 25 - 100 years.

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Project overview

EQUINOX tries to blow away the dust of history from this early work on FeAl, aiming to combine latest state of the art in intermetallic metallurgy to overcome the problems that our ancestors were facing when they failed to translate unique corrosion and wear properties of FeAl into a low cost Cr/Ni-free alternative for stainless steel products.

There is a need to find solutions to replace Critical Raw Materials (CRMs) such as Cr, Ni, Molybdenium (Mo) and Vanadium (V) in high volume end consumer products. Steels and superalloys with considerable amounts of these CRMs are widely used in many industrial applications, particularly under extreme conditions where corrosion and wear resistance are needed.

It is generally accepted, that intermetallics in particular low cost FeAl offer outstanding material properties. Unfortunately it is difficult to translate their properties to real products, as intermetallics suffer from low ductility at ambient temperature and poor machinability.
The impact of FeAl intermetallics as a low cost Cr-free alternative for stainless steel would therefore be much higher if a cost effective industrial process would be available, that allows to manufacture complex 3-D geometries of almost unlimited shapes from small grain size (0.1-5.0 µm) high ductility material.

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Objectives

The main objective of EQUINOX is to develop a novel process that allows to substitute Cr/Ni based (stainless) steel parts used in high volume end consumer products such as in the lock industry, electronics, process industry and automotive industry with a novel near net shape production technology for a new class of highly advanced ductile Fe-Al based intermetallics..

To produce extremely fine grained FeAl material with high ductility via reactive infiltration of porous iron preforms with liquid Al.
To understand how ultrafine particle based porous iron structures of complex 3D-shape may be tailored to be used as optimized preforms for reactive infiltration of liquid Al-alloys.
To develop a reactive infiltration process by using two different techniques: suction and centrifugal casting.
To simulate reactive infiltration process by physically based multi-scale models based on StarCast and MICRESS.
To optimize mechanical properties of **EQUINOX** material with respect to microstructure based on process conditions and consecutive heat treatment.
To scale up the process from lab to small pilot plant with respect to the industrial needs.
To transfer the concept to at least one real demonstrator which will be tested for high corrosion and wear resistance.
To evaluate the industrial impact of **EQUINOX-concept** with respect to economic as well as technical aspects.

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Concept and approach

The **EQUINOX** process well fits into "Growing a Low Carbon, Resource Efficient Economy (1) with a Sustainable Supply of Raw Materials (2) - for materials under severe conditions (3)" by many aspects

No CO2 is produced as side product as oxygen from raw material iron-oxide is fixed as H2O.
No waste of material: 100 % of the material that enters into the process chain ends up as final product of complex 3D-shape.
No energy is used for "material tourism" All steps of the process run at one single location – Fe3O4 and Al entering through the front door and final 3D-shaped Intermetallic parts leaving through the back door.
Solar heat may be used to cover most part of energy input as temperature level is just slightly above the melting point of Al in all steps involved.
The process may be completely based on H2 (which could be made from renewable energy). Materials with properties close to stainless steel are manufactured from abundant Fe and Al - without (or at least drastically reduced) CRM-materials Cr/Ni/Mo.

EQUINOX materials exhibit properties that withstand corrosion, cavitation and wear offering good results on LCA (life cycle analysis).

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Project Partnership

Eleven partners participate in the EQUINOX project, representing academic, applied research and industrial development.

NATIONAL TECHNICAL UNIVERSITY OF ATHENS, Greece

ELASTOTEC GmbH ELASTOMERTECHNIKEN, Germany

DR. KOCHANEK ENTWICKLUNGSGESELLSCHAFT, Germany

FUNDACION IMDEA MATERIALES, Spain

TECHNICKA UNIVERZITA V LIBERCI, Czech Republic

ACCESS e.V. Germany

OPEN SOURCE MANAGEMENT LIMITED, United Kingdom

CES OPERATIONS, Norway

FRENI BREMBO Spa, Italy

YUZHNOYE DESIGN OFFICE NAMED AFTER MIKHAIL YANGEL, Ukraine

IRES Innovation in Research and Engineering Solutions, Belgium

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Project progress

Following aspects are covered:

EQUINOX Meetings

EQUINOX Press release

EQUINOX Events

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EQUINOX Kick-Off meeting

The EQUINOX Kick-Off meeting was held in Athens.
Date: Tuesday, 16/2/2016.
Venue: National Technical University of Athens, Greece.

Figure 1: National Technical University of Athens, Greece.

Figure2: Equinox partners during 1st Kick-Off meeting of project.

"EU-Advanced mining countries RMD event 2016

Equinox consortium took part, after invitation from the EC, to the event **"EU-Advanced mining countries RMD event 2016 - Exchange of best practices on mining policies and technologies: challenges in the current state of the global economy"** that took place on 28 and 29 June in Brussels. Please follow the **link** to the event.
The countries which were represented to the event, besidesfrom member states of the EU, were Australia, Brazil, Canada, Chile, Mexico, Peru, South Africa and the US.

The main topics addressed were:

1. Challenges for the mining sector in the current state of the global economy and commodity prices (economic issues, investment, innovation, readjustments both from governments and industry, etc.)

2. Mining waste management (covering all its dimensions: safety, environment, technology, economic potential, zero waste concept, regulatory and legislative frameworks, initiatives driven by the industry, impact on the Social Licence to Operate)

3. Ongoing EU actions on international co-operation on raw materials.

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"EU-Advanced mining countries RMD event 2016

The Equinox consortium was represented with the presentation of a poster (Figure 1) describing the basic objectives,expected outcomes and main impacts of the project.

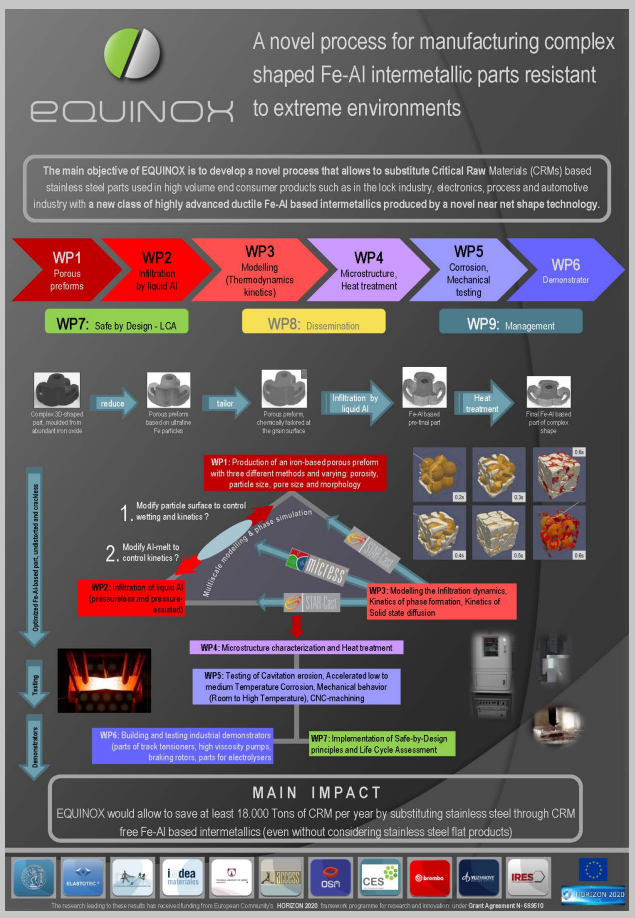

Figure 1: Equinox poster presentedat the event"EU-Advanced mining countries RMD event 2016 - Exchange of best practices on mining policies and technologies: challenges in the current state of the global economy".

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More info on Equinox-project

www.equinox-project.eu

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