Job offer: postdoctoral Fellow

Project Title: Physics and mechanics of β TiMo alloys – Application to forming

Research Fields: TiMo alloys; material elaboration; microstructure; thermo-mechanical behavior

Work Place: Lorient and Rennes (Brittany, France)

Research Laboratories: IRDL (Lorient) and ISCR (Rennes)

http://irdl.fr/

https://iscr.univ-rennes1.fr/cm/

UBL Research Department: Industry

Head(s) of the Scientific Project: Pr Sandrine THUILLIER (IRDL) – Dr Philippe CASTANY (ISCR)

Offer type: postdoctoral researcher (short term contract, 12 months)

Hiring institution: IRDL, Université Bretagne Sud

Application deadline: 30 June 2017

Job Starting Date: November 2017

Environment

This project is a collaborative academic project between two French partners. The scientific coordinator (Pr Sandrine Thuillier, Université Bretagne Sud, FRE CNRS 3744, IRDL, F-56100 Lorient) has scientific skills in physical metallurgy and in mechanical engineering and a broad experience in the characterization of the mechanical behavior of metallic alloys, modeling and material parameter identification. Dr. Philippe Castany (INSA Rennes, Institut des Sciences Chimiques de Rennes, UMR CNRS 6226 – Chimie Métallurgie (ISCR/CM)) has a strong expertise in elaboration and characterization of β titanium alloys. Thermo-mechanical processes are mastered from melting to final cold rolling and annealing steps. The whole characterization of microstructure can be done in the laboratory (X-ray diffraction, texture, optical micrography) or using facilities of University of Rennes 1 (SEM-EBSD, TEM).

Mission (scientific project)

Context

Over the last few decades, the interest in titanium alloys has continuously increased due to their properties of high strength, excellent hardenability, low density and good corrosion resistance, making these alloys very interesting for many industrial applications from aeronautics to biomedical devices. In this study, metastable β TiMo alloys are considered, with a microstructure consisting only of body-centered cubic β phase. A precipitation of nano-scaled particles of ω phase, observable only by TEM, can be obtained from aging in a specific range of temperature for some alloy compositions, which results in a significant improvement of the mechanical properties. Precipitation of ω phase after aging is observed in specific β titanium-based alloys, named metastable-β, containing appropriate β-stabilizer elements such as Fe, Mo, Ta, Nb, Cr and/or V.

The aim of this project is to investigate and model the thermo-mechanical behavior of β-stabilized titanium alloys from room temperature up to 500°C, as a function of the chemical composition and up to rupture. Indeed, Portevin-Le Châtelier (PLC)-like instabilities are recorded for a chemical composition of Ti-15w%Mo [1] and the proposed, but still under discussion, mechanism is related to competing processes of development of soft ω-free channels and dynamic precipitation of ω [1] or α [2] phase, depending on temperature range and alloy composition. This phenomenon is associated to a serrated flow and macroscopic bands of localized deformation visible on the surface of specimens during tensile tests. As for aluminium alloys and C-Mn steels, this phenomenon occurs in specific ranges of temperatures and strain rates: between 300°C and 500°C and 6.510^{-5} and 6.510^{-3} s^{-1} for Ti-15w%Mo, respectively. Within a virtual mechanical design approach, such instabilities must be considered, since they alter significantly the final part appearance and influence strongly the deformation at rupture.

Aims of the project

Previous studies in literature mainly deal with the physical origin and its influence on the flow curve in a tensile test. The aim of this project is to go several steps further: from several metastable β TiMo alloys elaborated on purpose, with different chemical compositions, the thermo-mechanical behavior is investigated under different strain paths, e.g. tension and simple shear, and for different temperatures and strain rates. The macroscopic effect of PLC-like instabilities is of interest, as well as the microscopic mechanisms investigated with Transmission Electron Microscopy (TEM) observations, that could be different depending on the alloy composition. A model, based on the physical mechanisms, and including the temperature dependence, is then proposed. Such a model is implemented in a finite element software, to predict these instabilities at the macroscopic scale and perform simulations of forming operations.

The strength of this project is two-fold: firstly, to improve and enlarge the modeling of PLC type effect. Indeed, this modeling is currently dedicated to diffusion-based phenomenon of atoms in solid solution. Moreover, current approaches are limited to considering the temperature dependence via material parameters that are functions of the temperature. Additionally, the dependence of the phenomenon on the chemical composition of the alloy has not been investigated. This project brings an enlargement to dissolution and precipitation as key mechanisms, and temperature dependence is introduced directly in the constitutive equations. Secondly, the project covers different scientific fields from the material elaboration to the numerical prediction of the mechanical behavior and involves physical metallurgy and experimental, theoretical and computational mechanics.

Methodology

The aim of this project is to further investigate plastic instabilities in several Ti-xMo alloys (x in weight %). The first step deals with the elaboration of metastable β titanium Ti-xMo alloys by cold crucible levitation melting and performing subsequent thermal treatment to control the microstructure and the texture [3,4]. The ingots are then cold rolled down to thin sheets of around 0.5 mm thickness. Several alloys, with chemical composition in-between 10-15wt% of molybdenum, are designed on purpose. This leads to a controlled microstructure, which is thoroughly characterized. The challenge is to obtain large enough ingots to prepare macroscopic samples with the desired size. The second step concerns the investigation of the thermo-mechanical behavior of Ti-xMo alloys as a function of the chemical composition, temperature and strain rate. Such an investigation is novel compared to previously published results. Microstructures after deformation are characterized by TEM to determine the density and size of ω particles, activated slip systems and deformation bands features. In situ Scanning Electron Microscopy (SEM) and TEM tensile tests give also information about the initiation and propagation of slip bands and individual dislocations, to highlight the mechanisms at the origin of the instabilities. The third step is the modeling of this phenomenon based on McCormick's model, e.g. [5], modified to consider temperature and alloy composition [6]. An important point is the influence of plastic instabilities on the hardening and rupture of the material and the numerical simulation of a simple forming process, e.g. cup drawing, of such an alloy at warm temperature is considered to investigate the formability.

Required Profile

Doctor (PhD) in mechanical engineering, mechanics of materials, maximum 3 years of experience after thesis defense[1]. An international experience in research is required (during or after Doctorate). Candidates must not have supported their thesis in the hiring institution and not previously worked in the host research unit.

Usefull References

[1] S. Banerjee, U. M. Naik, Plastic instability in an omega forming Ti-15%Mo alloy, Acta Metall. 44 (1996) 3661-3671

[2] D. Choudhuri, S.A. Mantri, T. Alam, S. Banerjee, R. Banerjee, Precipitate-dislocation interaction mediated Portevin-Le Chatelier-like effect in a beta-stabilized Ti-Mo-Nb-Al alloy, Scripta Met. 124 (2016) 15-20

[3] F. Sun, J.Y. Zhang, M. Marteleur, T. Gloriant, P. Vermaut, D. Laillé, P. Castany, C. Curfs, P.J. Jacques, F. Prima, Investigation of early stage deformation mechanisms in a metastable β titanium alloy showing combined twinning-induced plasticity and transformation-induced plasticity effects, Acta Mater. 61 (2013) 6406-6417

[4] P. Castany, M. Besse, T. Gloriant, In-situ TEM study of dislocation slip in a metastable beta titanium alloy, Scripta Mater. 66 (2012) 371-373

[5] P.Y. Manach, S. Thuillier, Y.W. Yoon, J. Coër, H. Laurent, Kinematics of Portevin-Le Chatelier bands in simple shear, Int. J. Plasticity 58 (2014) 66-83

[6] L.Z. Mansouri, S. Thuillier, P.Y. Manach Thermo-mechanical modeling of Portevin- Le Châtelier instabilities under various loading paths, Int. J. Mech. Sci.115-116 (2016) 676-688

How to apply ?

Please send the following documents by email to : sandrine.thuillier@univ-ubs.fr

- Short Curriculum Vitae and a covering letter showing your interest and especially addressing your professionnal project
- A list of your major works (2 pages max.) : scientific publications, patents and others scientific productions
- Letters of recommendation (not required)
- A copy of your PhD diploma[2]

[1] The thesis defense must have taken place after 31/08/2014, except in rare exceptions. Periods of sickness, maternity or parental leave shall not be counted in this 3-year period.

[2] For doctors graduated from a French establishment, a link to the thesis notice in the SUDOC Catalogue or the French official portal Theses.fr is sufficient.

The general selection process is described here:

https://u-bretagneloire.fr/dossiers/postdoc/candidatures

Further information

Annual gross salary: 42 k€

This Fellowship is cofounded (50%) by Université Bretagne Loire. The remaining part can come from the applicant or from Campus France Prestige program (http://www.campusfrance.org/en/prestige). **A dedicated application to Prestige call is required.**

The Université Bretagne Loire federates 7 universities, 15 “grandes écoles” and 5 research organiations in the West of France (Bretagne and Pays de la Loire). This community of universities and institutions aims to develop the scientific and academic potential of this territory at national and international level.