RESEARCH ENGINEER – Post-doctorat

« Toward automatic identification of transformation products in Steels on EBSD maps»

1 year contract-Full time
Based at LEM3 – Université de Lorraine – CNRS - METZ - France

We are recruiting a Post-Doc R&D Engineer on a fixed-term contract, as part of a collaborative study between the Industeel research center (ArcelorMittal) and LEM3, coordinated by the IRT M2P.

***Industeel**, a branch of ArcelorMittal, employing about 2200 people, is a producer of carbon and stainless steels, specialized in the manufacture of products and semi-products of large dimensions for a wide variety of markets: abrasion, corrosion, cryogenics, moulds and tools, energy, petrochemicals, shipyards, land/sea protection, etc... Its Materials Research Center in Le Creusot (the CRMC) employs around fifty engineers and technicians who work to improve Industeel's offer for special steel solutions and provide technical support to the group's customers and plants.*

***The LEM3 laboratory** is a Mixed Research Unit n° 7239 CNRS - University of Lorraine - Arts et Métiers ParisTech of about 250 people including 110 teacher-researchers and 100 doctoral and post-doctoral students. The fields of activity of LEM3 concern Materials, Mechanics, Study of Microstructures and Processes. LEM3 benefits from a worldwide recognized expertise on many topics, including advanced methodological developments for microstructure analysis by orientation microscopy.*

***The IRT M2P** is a mutualized research center created in June 2013, bringing together industry and research institutions. Their field of interest are advanced technologies for the elaboration, transformation and characterization of materials. Organized in 3 poles of activities (Elaboration, Surface treatment and coating, Composite & Assembly), it has today more than 90 employees spread over 4 sites (Metz, Porcelette, Uckange et Duppigheim).*

Context :

Steels of the new generation have complex and multi-phase microstructures. They can include martensite, MA islands (martensite + austenite), lower, upper or granular bainite, ferrite and/or perlite. Their mechanical properties are controlled mainly by the volume fractions of these constituents and their distribution. Therefore, it is essential to better control the inherited microstructures according to the elaboration process and to ensure a quality follow-up of their production.

Unfortunately, the identification and precise quantification of all these constituents is still complicated today: Current etching agents are not efficient on all steel grades and the same reagent will never reveal all the particular phases. Moreover, the distinction between lower and upper bainites requires additional observations at high magnification. Thus, all these approaches are not consistent with automated techniques for identifying features on a micrograph.

In this context, the EBSD technique has not yet revealed its full potential. Of course, it does not allow today to directly distinguish ferrite, bainites and martensite, all indexed in Ferrite α with a body centered cubic structure. However, EBSD maps intrinsically include information that discriminates these phases: the presence of crystal defects, the existence and type of orientation relationship with the neighborhood, the spatial distribution of micro-constituents. In this framework, several codes have been developed at LEM3 to extract descriptors capable of distinguishing these transformation products from EBSD maps.

The SERAPHIA project aims at applying « Machine Learning » and/or « Convolutional Neuronal Network» algorithm to improve automatic identification of the phases in EBSD maps and contribute to quality control of these steels.

Objectives :

In collaboration with Industeel-ArcelorMittal, the aim is to develop a database of EBSD microstructures as reference metallurgical states and to use it to train an algorithm for recognition of transformation products in Steels.

The postdoctoral work has several tasks:

- Acquisition of EBSD maps of metallurgical states provided by ArcelorMittal
- Applying codes developed at LEM3 to identify the different phases (Labeling)
- Literature review on Machine Learning and Convolutional Neuronal Networks to determine the most appropriate approaches to the problem.
- Implementing an algorithm for phase recognition in Steels based on EBSD maps, using existing libraries and developing partnerships with specialized teams in the field if necessary.

Candidate profile :

The candidate should have a thesis in Materials Sciences or more generally in Engineering Sciences with skills in programming and statistical data analysis. The candidate should be motivated to discover and deepen artificial intelligence approaches for data and image analysis. An experience with EBSD analysis would be appreciated.
The position is open from November 2020 (to be filled preferably before March 2021).
Proposed remuneration: > 37k€.

Apply with Curriculum Vitae and cover letter at:

- LEM3 : Lionel GERMAIN – lionel.germain@univ-lorraine.fr
  Nathalie GEY – nathalie.gey@univ-lorraine.fr
- IRT M2P : Pierre-Emmanuel ABA-PEREA - pierre-emmanuel.aba-perea@irt-m2p.fr

(We reserve the right to respond only to candidates within a relevant profile)

Litterature review related with the research topic :

[1] K. Tsutsui, H. Terasaki, T. Maemura, K. Hayashi, K. Moriguchi, et S. Morito, « Microstructural diagram for steel based on crystallography with machine learning », Comput. Mater. Sci., vol. 159, p. 403‑411, mars 2019, doi: 10.1016/j.commatsci.2018.12.003.

[2] D. L. Naik, H. U. Sajid, et R. Kiran, « Texture-Based Metallurgical Phase Identification in Structural Steels: A Supervised Machine Learning Approach », Metals, vol. 9, nº 5, Art. nº 5, mai 2019, doi: 10.3390/met9050546.

[3] S. M. Azimi, D. Britz, M. Engstler, M. Fritz, et F. Mücklich, « Advanced Steel Microstructural Classification by Deep Learning Methods », Sci. Rep., vol. 8, nº 1, p. 2128, déc. 2018, doi: 10.1038/s41598-018-20037-5.

[4] J. Goulden, K. Mehnert, K. Thomsen, et H. Jiang, « A Method for Separating Crystallograpically Similar Phases in Steels using EBSD and Machine Learning », Microsc. Microanal., vol. 23, nº S1, p. 110‑111, juill. 2017, doi: 10.1017/S1431927617001234.

[5] D. S. Bulgarevich, S. Tsukamoto, T. Kasuya, M. Demura, et M. Watanabe, « Automatic steel labeling on certain microstructural constituents with image processing and machine learning tools », Sci. Technol. Adv. Mater., vol. 20, nº 1, p. 532‑542, déc. 2019, doi: 10.1080/14686996.2019.1610668.

[6] M. Ben Haj Slama, N. Gey, L. Germain, K. Zhu, et S. Allain, « Key Parameters to Promote Granularization of Lath-Like Bainite/Martensite in FeNiC Alloys during Isothermal Holding », *Materials*, vol. 11, nº 10, p. 1808, sept. 2018, doi: 10.3390/ma11101808.