



## Brief description of the project

❖ **Company name:** Nuovo Pignone Tecnologie srl (a Baker Hughes' company)

❖ **Title:**

Evaluation of the effect of the microstructure of metal alloys for turbomachines on hydrogen embrittlement.

❖ **Description of the scientific and educational objective:**

As part of the ENERGY TRANSITION process, Baker Hughes has begun a phase of moving its products towards energy production through the management of non-polluting sources. In some cases this approach is involving real redesign of the turbomachines which will have to manage ever greater fractions of gaseous hydrogen, instead of hydrocarbons, up to 100% of the molar fraction of the processed gas. The redesign consists many times in a revision of the machine architecture. This review passes from an analysis of the selected materials both in terms of mechanical strength and above all compatibility with hydrogen gas which is known to reduce the toughness / ductility of the materials used.

The level of hydrogen embrittlement is strictly dependent on the type of metal alloy and its microstructure, from which the mechanical characteristics derive.

There is a vast literature dedicated to the hydrogen characterization of metal alloys, however the mechanism of interaction of each individual microstructural particularity with hydrogen has not yet been explored in a robust and detailed manner.

Achieving the objective of this research activity would allow to qualitatively define the single contribution of the microstructural elements to the mechanical behaviour of the hydrogen alloy in fracture mechanics and endurance tests. Consequently, during the selection phase of the material, one would have a clear picture of which alloy would be most suitable for a particular application. At the same time, it could be possible to intervene on all the levers of the related manufacturing process, from the realization of the ingot to the quality heat treatment, to optimize the characteristics according to a maximum possible tolerance to hydrogen embrittlement.

Furthermore, for specific applications, these results could converge towards an alloy design.

These corporate choices are in line with the provisions of the PNRR (in particular with the objectives of mission 2 Green Revolution and Ecological Transition, component C2. Renewable energy, hydrogen, grid and sustainable mobility) which aims to make "the Italian system more sustainable in the long run term, through the progressive decarbonisation of all sectors ". This objective implies the start of a gradual decarbonisation of the industry, also including the adoption of hydrogen-based solutions, in line with the European Strategy (European Commission, A hydrogen strategy for a climate-neutral Europe, July 2020), and also considering the rapid growth of the role of electrochemical accumulations.

The issues related to decarbonisation processes, as widely verified during the development of the research projects in which the company has been involved in recent years, required the use of highly qualified personnel and consultants, with qualifications linked to academic paths. or in any case connected to research and innovation activities, sometimes even with certifications the possession of which requires significant qualifications and skills. For this reason, also by enhancing what is reported in the PNRR in terms of opening doctoral courses to the involvement of subjects outside the university, the company has a great

interest in the development of research and training activities shared with university structures aimed at professional and scientific training. of highly qualified personnel.

❖ **Company Supervisor:** MEng. Angelo Donato

❖ **Methods of training and research activities:**

The company, in addition to the academic path that doctoral students will follow in the three-year period, will administer an additional training course focused on issues related to the company's products and related applications in the industrial sector.

The activity will be divided into the following modules:

- Baker Hughes product introduction module - operation of turbomachines and selection / design criteria;
- Introduction module to materials for turbomachinery - Manufacturing processes, microstructural chemical characteristics, mechanical properties
- Introduction module to H<sub>2</sub> testing methods - test planning and related parameters, analysis of results and post-processing.

❖ **Effects and expected results with particular emphasis on promoting the economic development and the production system:**

Baker Hughes' aim is to support customers in reducing their environmental impact by investing in a broad portfolio of technologies to achieve this goal. Sustainability and emission reduction are two critical elements for the future of the Oil & Gas industry and of energy generation in the decades to come and with these objectives BH will increasingly assume a leadership role in "low / no carbon" technologies in close collaboration with its customers and thanks to the enormous expertise developed in previous decades in these areas, making it a candidate as a leading interlocutor in defining energy policies for the next few years.

To create competitive products and maintain a leading position in the market, it will be necessary to introduce new alloys capable of promoting the energy transition, in the context of hydrogen production / storage / transport / use.

In addition, the company has chosen to invest in resources that can receive high quality training thanks to the academic path combined with business experiences of an application nature.

❖ **Period in the company**

The proposing company (Nuovo Pignone Tecnologie srl) will host the PhD student beneficiary of the scholarship financed on the resources of the Ministerial Decree 352/2022 for n. 12 months during the PhD program.

❖ **Period abroad:**

Period abroad for no. 6 months at the following institution:

Ecole des Mines 158 cours Fauriel - CS 62362 42023 Saint-Etienne Cedex 2.

We also declare that this program complies with the principle "not to cause significant damage" (DHS) pursuant to art. 17 of regulation (EU) 2020/852 in coherence with the technical guidelines prepared by the European Commission (Communication of the European Commission 2021 / C58 / 01) and guarantees compliance with the horizontal principles of the PNRR (contribution to the climate and digital target so-called tagging, the principle of gender equality and the obligation to protect and enhance young people).