

Greenhouse gas emissions are one of the biggest issues that need to be addressed today. Jet engines (JE) and stationary gas turbines are one of the sources of greenhouse gas emissions. The energy and air transport sectors are thought to account for two-thirds of global greenhouse gas (mainly CO₂) emissions. Therefore, there is a strong need to reduce greenhouse gas emissions in these sectors. One solution may be to increase the efficiency of the turbine. According to the Carnot cycle, the simplest way to increase turbine efficiency is to increase the inlet temperature. However, it should be remembered that the currently used materials, i.e. nickel-based alloys, work close to their temperature limits. Another way to reduce greenhouse gas emissions is to use an alternative and environmentally friendly fuel. Hydrogen is considered as a potential candidate for such an alternative fuel. The product of the hydrogen combustion reaction is water vapor. However, the combustion of a mixture of hydrogen and air (oxygen) is difficult to control. From a CO₂ reduction point of view, hydrogen works in two ways: it significantly raises the operating temperature and produces H₂O instead of the CO₂ that comes from burning traditional fuel (i.e. hydrocarbons). The use of hydrogen-enriched fuel simultaneously causes two effects: a significant increase in operating temperature and an increase in the water vapor content in the exhaust. Therefore, it is necessary to develop a new type of material that will be characterized by reliable resistance to oxidation under the conditions of combustion of hydrogen-enriched fuel, i.e. at a much higher temperature and in an atmosphere containing a significant amount of water vapor. Therefore, the aim of this project is to develop a new material that could be used for parts in the hottest part of hydrogen-rich burning gas turbines. Since the combustion of pure hydrogen is difficult to control, a first stage using mixtures of green hydrogen and methane CH₄ (H₂ content between 0 and 50% by volume) is proposed. Several steps have been planned in the proposed project to provide this solution. First, new high-entropy alloys will be developed for use in gas turbines burning H₂-rich fuel and a proper heat-treatment procedure will be applied. In the first step HEA alloys with the highest resistance to high-temperature corrosion in dry air will be selected during preliminary oxidation tests in dry air. Then, selected alloys will be tested in wet atmospheres (air + H₂O, Ar-H₂-H₂O) in laboratory conditions to determine their durability in wet atmospheres. In the last step, the HEA alloys tested in step 2 will be exposed to real exhaust gases of fuels that are mixtures of green hydrogen and CH₄ (H₂ = 0, 10, 20, 30, 40 and 50 % by volume) on a hydrogen bench to verify the project objectives, i.e. numerical models, comparison of the results obtained in simulation conditions and verification of the oxidation resistance of the developed HEA's in real conditions. In all three steps, currently used nickel superalloys will also be tested for comparison. The next step will be the modeling of microstructural changes during exposure to high temperatures in laboratory tests and on a hydrogen stand. In the last stage, the mechanisms of the oxidation process depending on the oxidizing atmosphere will be developed. In parallel diffusion coefficients of hydrogen for studied materials will be determined. All the obtained results will significantly expand the knowledge of materials working in hydrogen fuel gas turbines and will certainly lead to the development of new reliable HEAs capable of operating in gas turbines and/or hydrogen-powered jet engines through a basic understanding of the oxidation mechanisms of alloys in "real" conditions of combustion of high hydrogen fuels.