Hydrogen is a very promising CO_2-free alternative to fossil fuels so it becomes an important solution allowing to achieve the European Green Deal for a sustainable economy and climate-neutral. Hydrogen has huge advantages such as no greenhouse gas emission, high-efficiency and plentiful resources. The main problems with the hydrogen application is that in composition with oxygen it creates a mixture that burns explosively. The flame has a very high temperature (ca. 2100°C) and is invisible in the air. Such phenomenon can occurs even for a small cracks in the installation and can be dangerous for the working people and the infrastructure. The goal of the project is to determine methods for describing degradation processes for mechanically loaded elements in hydrogen environment, validated in the laboratory condition. It will be realised by experimental analyses and numerical modelling of phenomena related to the degradation processes of such elements and development prediction models of their degradation processes. Analyses will be performed on elements manufactured from single material (polymer, metal, carbon fibre reinforced polymer (CFRP)) and complex elements (polymer/ CFRP and metal/CFRP). Damage such as cracks or delamination in such components is inevitable due to a number of factors such as aging, impact, fatigue and chemical corrosion during their service. This usually causes serious fluid leakage problems, leading to catastrophes and economic losses. The better understanding of the degradation processes related to advanced modern phenomenological modelling methods (fluid solid interaction, FSI) with a combination of optical sensors offers new possibilities. It allows determination of prediction models and development structural health monitoring (SHM) systems solutions. Due to the strong dangerous influence of any spark due to electric current occurrence in any diagnosis/ monitoring system, only those based on fibre optics can be implemented for elements in hydrogen environment. The important advantages of fibre optics sensors methods are no electric current occurrence in the system, high corrosion resistance as well as their small dimensions and low level of the optical signal attenuation. Due to this fibre Bragg grating (FBG) and distributed optical sensors are planned to be used in the proposed SHM system. The FSI models and the optical based SHM systems will be combined together to possess a complex image of the degradation process and develop an appropriate damage development prediction model. It will increase the safety of the use of the hydrogen installations.