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M3Or1A-05: Cryogenic material testing with gaseous hydrogen for hydrogen-electric aircraft propulsion

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The development of hydrogen-electric aircraft propulsion offers a perspective for emission-free aviation. Liquid hydrogen, which is stored in cryogenic tanks at 20-30 K, is used as energy source and to cool the electric engine. This increases power density and efficiency of the electric engine. In this application, the components are exposed to low temperatures and direct contact to hydrogen, which can highly affect the mechanical properties of the material.

In this work, various additive manufactured metallic alloys were investigated for the effect of hydrogen on mechanical properties in tensile and fatigue tests. Tests were conducted at room temperature and at 77 K in liquid nitrogen. To study the effect of hydrogen, the tubular specimen method was used, in which a deep hole is drilled through the longitudinal axis of the specimen and filled with hydrogen during testing. This allows to simultaneously expose the specimen to pressurized gaseous hydrogen from the inside and to cool it with liquid nitrogen from the outside during testing. By examining the fracture surfaces under a scanning electron microscope, a deeper insight into the damage behavior could be gained.

These investigations on additive manufactured materials show several effects on the mechanical properties caused by anisotropy due to build-up direction, low temperature and hydrogen.

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