**Failure analysis and damage mechanisms of newly developed, gamma-prime strengthened Ni - based superalloy**

**7th Framework Programme of the European Union**

Clean Sky Joint Undertaking

## Executive summary

Reduction of the fuel consumption and emission of NOX and CO2 by jet engines is a priority of the EU ACARE SRA 2020 objectives. The development of an environmentally friendly aircraft engine (like open rotor SAGE1) considers using lightweight and efficient turbine components. It will have great impact on reduction of pollution and fuel consumption. Within the objectives of open rotor development in SAGE1, activities are underway to develop new technologies for rotating structures.

The rotating structure transmits the torque generated by the engine to the propellers and is subjected to the high temperature exhaust gas from the core engine. It is likely that the rotating frames will be made as a weld assembly consisting of some cast parts in a newly developed nickel based precipitation hardening superalloy. However, it is a great challenge to cast this alloy in the investment casting process because it was primarily developed in wrought form. In addition, its composition and properties are not optimized for casting processes, post cast operations and heat treatment. Currently, cast versions of this low content gamma-prime strengthened Ni-based superalloy are widely investigated, however failure analysis and damage mechanisms are not fully explored.

Thus the aim of the project was to perform complex failure analysis and damage mechanisms investigations of a newly developed, gamma-prime strengthened Ni - based superalloy, which is an enabler material for manufacture turbine engines components exposed at high temperature. In the scope of the research activities implemented the optimized the casting process parameters and post casting heat treatment were settled for a range of microstructures (grain sizes); experimental studies of mechanical behaviour of the newly developed, gamma-prime strengthened Ni - based superalloy with different grain size under different loading and temperature regimes during monotonous and fatigue tests were carried out and damage mechanisms/failure modes were described by advanced microstructural characterisation techniques.

Ductility and ultimate tensile strength of the alloy, as well as Young's moduli have been assessed in tensile tests. In creep and fatigue tests, performed in application relevant range of service temperatures, useful stress and temperature applicability ranges for the engine components made of the alloy in question were established. The fatigue tests enabled also to evaluate the endurance limit of the material as well as the number of cycles till failure for given stress / temperature conditions. The fracture mechanics properties of the alloy were evaluated in crack threshold, crack propagation, fracture toughness and crack growth under constant load and/or constant load with periodic unloading test. It was also shown that fracture mode of the analysed alloy can be clearly related with the dislocations arrangements observed. Moreover, three stress-temperature regimes of the service parameters of the new developed nickel superalloy were specified where prevailing deformation mechanism of the material have been identified.