Modelling of damage accumulation and fracture of structural materials under multiaxial fatigue loading, including creep pre-deformation and elevated temperature

The main goal of the project is to develop a numerical model of damage accumulation and fracture in a complex fatigue loading state, including the effect of elevated temperature and accounting for the influence of creep pre-deformation of the material. It is planned to elaborate a description of damage accumulation and fracture concerns the physical plane approach. Experimental studies for two different types of materials: aircraft aluminum alloy EN AW-2024 and high-temperature resistance boiler steel 1.4923 will become the foundation for developing the model. As a part of experimental research first it is planned to determine the monotonic, creep and fatigue characteristics of the as-received material. In the next stage, the as-received material will be subjected to creep pre-deformation at elevated temperature until certain level of strain is obtain. The effect of preliminary strain will be taken into account in the study of material behavior under uni- and multiaxial cyclically varying proportional and non-proportional loads. This applies to both room and elevated temperature tests. Analysis of the material's microstructure evolution as a result of both creep and fatigue at elevated temperature will be an important part of the studies. Such analysis will make it possible to identify the character of dynamic recrystallization occurring in the material as well as the influence on the material's behavior under the monotonic and cyclically varying loads.

The innovative character of studies is present in two essential aspects. The first concerns learning about effects linked to the influence of creep pre-deformation on the material's cyclic properties under the action of proportional and non-proportional loads at room and elevated temperature. The cyclic properties of material with pre-deformation will be compared to the properties of the as-received material. Among other things, this will make it possible to determine such parameters of the pre-deformation process that have a beneficial effect on fatigue life. The second aspect is related to the presentation of an original numerical model based on the physical plane concept, enabling prediction of the material's damage state as a result of pre-deformation and, after that, a model accounting for the influence of this damage on fatigue life, in both uni- and multiaxial loading cases. It should be emphasized that test results relating to investigations of the creep process are widely available in the literature. Similarly – the results of fatigue process of as-received material at elevated temperature. Meanwhile, the influence of creep pre-deformation on the material's cyclic behavior under various loading and temperature conditions is not fully understood. Developed model will be possible to predict the fatigue life of structural elements under service-life conditions. This may contribute to ensuring the proper maintenance periods of a structure, thereby reducing the costs of its exploitation and improving the safety of its use.