KW21 BWL32DT: Influence of droplet size on erosion processes

(Tropfengrößeneinfluss auf Erosionsvorgänge)

Beginning of the project: 01.07.2010

End of the project: 31.12.2012

Objectives

Erosion of steam turbine blades, especially the last low pressure ones, in power plants has been a significant problem throughout the history in terms of turbine performance, efficiency, safety and durability. Turbine blades (Figure 1) and components can be affected by erosion damage due to water droplet impingement in a wet steam environment.

The aim of this research project was to develop a model based on the FEM method in order to investigate the influence of droplet size on the erosion process.

Figure 1: Leading edges of steam turbine blades where damage due to drop impingement erosion is most significant

Methods

To simulate the erosion process by means of continuum mechanics on the macroscopic level, the finite element method (FEM) provides two promising possibilities:

The first possibility is based on the application of the Arbitrary Lagrangian-Eulerian (ALE) adaptive meshing technique (Figure 2, middle) and the ABAQUS user subroutine UMESHMOTION. ALE adaptive meshing algorithm relocates the mesh by an amount equal to a computed value – this feature can be used for simulating erosion where the mesh would be relocated in accordance to the computed erosion depth. The erosion depth would be calculated at each node based on the erosion rate obtained in the UMESHMOTION subroutine. Once calculated, the erosion depths of all surface nodes would be applied to modify the mesh using the adaptive meshing algorithm. The displacement of the nodes contains the material deformations as well as the displacements due to mesh motion. The partial model variable VOLC measures the volume loss due to adaptive mesh constraints. This variable can be used to quantify the simulated erosion process and to compare numerical and experimental results.

The second possibility is based on the element removal technique (Figure 2, right). It is assumed that damage is characterized by the progressive degradation of the material stiffness, leading to material failure. For each simulation increment and each finite element, information about specified output variable values is requested and compared to a damage criterion. If the retrieved values reach or overtake the damage criterion, the element is removed from the mesh - by that the erosion process can be simulated.

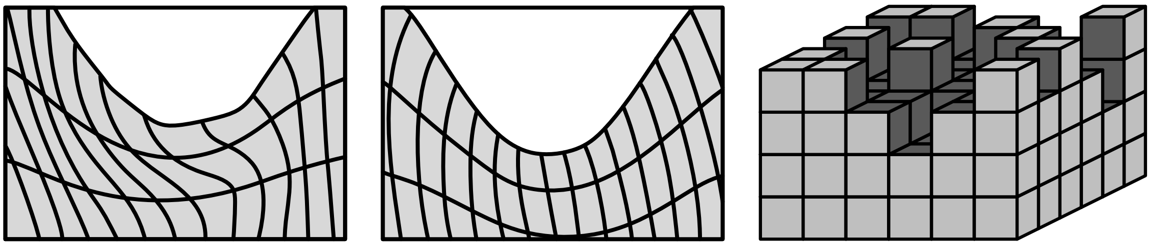

Figure 2: Left: Mesh without application of the ALE adaptive meshing technique, Centre: Mesh with application of the ALE adaptive meshing, Right: Mesh after removal of elements

Partners

The project was carried out in the cooperation with industry (*Siemens AG, Energy Sector*) and research (*Deutsche Zentrum für Luft- und Raumfahrt (DLR)*, *Ministerium für Wissenschaft, Forschung und Kunst Baden-Württemberg* and *Institut für Thermische Strömungsmaschinen und Maschinenlaboratorium (ITSM), Universität Stuttgart*) partners.

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