Summary of the deliverable D1.4: Material fatigue and removal predictions

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The objective of this research is to develop a methodology for predicting solid material behaviour in response to impacting pressure loads from collapsing cavitation bubbles. The overall interest is the physical process of cavitation erosion where surface damage of solid surface takes place due to the collapse of local cavitating structures. The applications are in the field of aerospace, hydrodynamics, diesel injectors where severe degradation in mechanical structure and operating performance is reported due to the high pressure impact loads from violent collapse of the cavitation structures. An accurate, efficient numerical methodology has been developed to model the fast, unsteady flow characteristics for the collapse of cavitation bubble in the CFD code YALES2. An Arbitrary Lagrangian-Eulerian (ALE) formulation has also been implemented in the fluid domain for fluid mesh deformation to model coupled fluid structure interaction(FSI) as demonstrated in deliverable D1.3. In the present work, a one-way solid surface deformation prediction model is presented using the finite element based solver Cast3M. The proposed methodology uses the pressure loads predicted on a rigid wall from collapsing 2D cavitation bubble in compressible fluid. The resulting pressure loads are used as boundary condition for the solid FEM simulation to predict the resulting local stress, plastic deformation and plasticity accumulation in an aluminium alloy. The underlying physical model assumptions and results on cavitation pit formation to demonstrate the methodology are presented. The solution predicts the elastic and plastic deformation depending on the loading condition imposed by a 2D collapsing bubble. The effective stress peaks correspond well with the hydrostatic pressure peak on the solid boundary. The aluminium alloy undergoes permanent plastic deformation after the liquid micro-jet and shock interaction which generates a deformation pit of depth 51 μm on the solid surface at the end of the solution.