Summary of Deliverable 4.5 - Investigation on the removal of the cavitation erosion risk in a prototype control orifice inside a diesel injector

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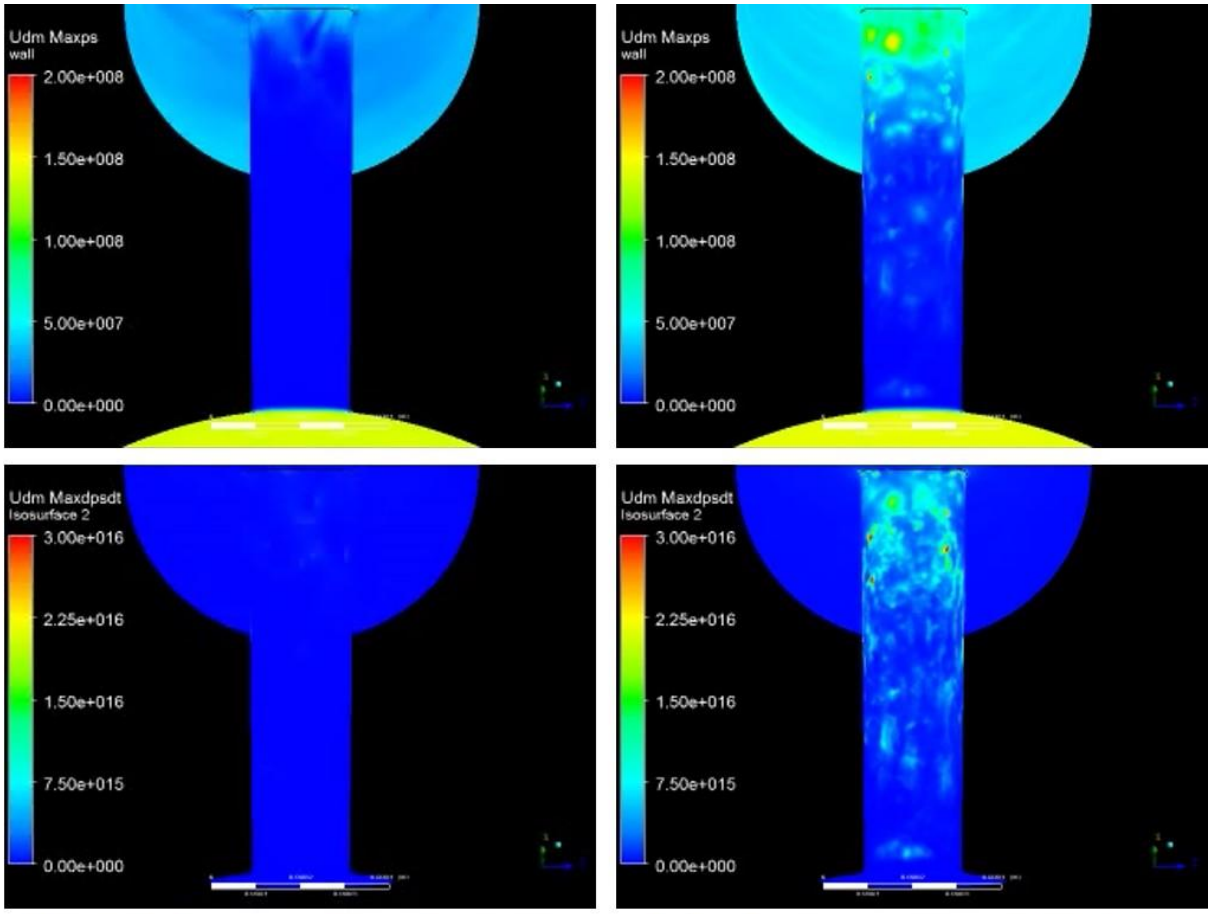
In some cases, the collapse of cavitation can lead to erosion of high strength metals and thereby damage system components. Being able to predict if and where such erosion is likely to occur would be beneficial to many fields, like automotive and naval. The diesel injector is a common subject in cavitation based research as cavitation in the flow cannot be avoided, particularly so in modern systems, and so it must be understood and managed. As the injector is of great importance to the performance of engines it is an area for continued development to meet future environmental and performance standards. Hence, an understanding of the fundamental behaviour of hydraulic control orifices is needed to optimize the performance and production while avoiding any potential complications due to cavitation or cavitation erosion.

A CFD investigation is in progress to study the cavitation characteristics and potential erosion risks of a control orifice in a prototype injector. An early design of the orifice resulted in cavitation erosion after endurance testing. A design modification eliminated the erosion and subsequent prototypes were free from damage. Initial results for the two designs using different simulation methods are discussed, along with the effects of different rates of evaporating and condensing mass transfer.

The CFD study includes initial simulations using Reynolds-Averaged Navier-Stokes (RANS) turbulence modelling and the standard Zwart-Gerber-Belarmi (ZGB) cavitation model. For increased accuracy and detail, this work was then expanded upon with a hybrid LES-RANS turbulence model: Detached Eddy Simulation (DES). The DES simulations were first run using the standard ZGB model. Then a modified ZGB method was used, by means of a user-defined function (UDF) which enabled significant changes to be specified for the rates of mass transfer.

The report provides preliminary results of this on-going project. The methodology is described in section 2. Then the results are presented and analysed with regards to the effects of the different simulation methods and the influence of the two different designs in section 3. The simulation results are backed up with photographic evidence of damage

on an early prototype component. The initial findings on indicators for cavitation erosion risk are then summarised and discussed in section 4. Next steps are then outlined in section 5 and finally how the work relates to state-of-the-art is covered in section 6.



CFD results from a cavitating flow inside a control orifice in a prototype diesel injector. Accumulation of maximum pressure (top, 0 to 2e8 Pa) and rate of pressure change (bottom, 0 to 3e16 Pa/s) over 10µs (left is at time 0). Maxima correlates well with the location of damage on hardware.