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An investigation of the performance of a positive displacement reciprocating pump at low pressure NPSH incorporating a three phase cavitation model

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The full cavitation (Singhal et al. 2002) multiphase CFD model of a positive displacement reciprocating pump is presented to investigate performance during the pumping cycle through 360° of the crank shaft rotation. This paper discusses the cavitation appearance and dynamics inside the pump chamber at 100kPa, 50kPa, 25kPa and 0kPa inlet gauge pressure and evaluates the Singhal et al. (Singhal et al. 2002) cavitation model in conditions of incipient cavitation, partial cavitation and full cavitation (Opitz & Schlücker 2010; Opitz et al. 2011). The paper also investigates the role of pump inlet valve inertia on cavitation dynamics. The transient CFD model takes into account a three phase flow composed of water, water vapour and 15 parts per million (ppm) of non-condensable ideal gas mass fraction, and utilizes the moving mesh technique to deal with the inlet and outlet valve dynamics. A User Defined Function (UDF) is utilized to couple the pressure field and the valve force and displacement-time histories so that the valves are "self-actuated". A second UDF handles the compressibility model of water which is essential for high outlet pressure and to stabilize the simulation in the situation when the valves are both closed. The paper shows the feasibility of such a complete CFD model of a PD pump, equipped with the Singhal et Al. cavitation model and the capability to assess the rate of phase change, the efficiency loss and to predict the valve lift history.

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