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Multiphase Flow Regime Detection Algorithm for Gas-Liquid Interface Using Ultrasonic Pulse-Echo Technique

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Abstract : Efficiency of the cooling process for cryogenic propellant boiling in engine cooling channels on space applications is relentlessly affected by the phase change occurs during the boiling. The effectiveness of the cooling process strongly pertains to the type of the boiling regime such as nucleate and film. Geometric constraints like a non-transparent cooling channel unable to use any of visualization methods. The ultrasonic (US) technique as a non-destructive method (NDT) has therefore been applied almost in every engineering field for different purposes. Basically, the discontinuities emerge between mediums like boundaries among different phases. The sound wave emitted by the US transducer is both transmitted and reflected through a gas-liquid interface which makes able to detect different phases. Due to the thermal and structural concerns, it is impractical to sustain a direct contact between the US transducer and working fluid. Hence the transducer should be located outside of the cooling channel which results in additional interfaces and creates ambiguities on the applicability of the present method. In this work, an exploratory research is prompted so as to determine detection ability and applicability of the US technique on the cryogenic boiling process for a cooling cycle where the US transducer is taken place outside of the channel. Boiling of the cryogenics is a complex phenomenon which mainly brings several hindrances for experimental protocol because of thermal properties. Thus substitute materials are purposefully selected based on such parameters to simplify experiments. Aside from that, nucleate and film boiling regimes emerging during the boiling process are simply simulated using non-deformable stainless steel balls, air-bubble injection apparatuses and air clearances instead of conducting a real-time boiling process. A versatile detection algorithm is perennially developed concerning exploratory studies afterward. According to the algorithm developed, the phases can be distinguished 99% as no-phase, air-bubble, and air-film presences. The results show the detection ability and applicability of the US technique for an exploratory purpose.

Keywords : Ultrasound, ultrasonic, multiphase flow, boiling, cryogenics, detection algorithm
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