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# Detection the Ice Formation Processes Using Multiple High Order Ultrasonic Guided Wave Modes

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**Abstract :** Icing brings significant damage to aviation and renewable energy installations. Air-conditioning, refrigeration, wind turbine blades, airplane and helicopter blades often suffer from icing phenomena, which cause severe energy losses and impair aerodynamic performance. The icing process is a complex phenomenon with many different causes and types. Icing mechanisms, distributions, and patterns are still relevant to research topics. The adhesion strength between ice and surfaces differs in different icing environments. This makes the task of anti-icing very challenging. The techniques for various icing environments must satisfy different demands and requirements (e.g., efficient, lightweight, low power consumption, low maintenance and manufacturing costs, reliable operation). It is noticeable that most methods are oriented toward a particular sector and adapting them to or suggesting them for other areas is quite problematic. These methods often use various technologies and have different specifications, sometimes with no clear indication of their efficiency. There are two major groups of anti-icing methods: passive and active. Active techniques have high efficiency but, at the same time, quite high energy consumption and require intervention in the structure's design. It's noticeable that vast majority of these methods require specific knowledge and personnel skills. The main effect of passive methods (ice-phobic, superhydrophobic surfaces) is to delay ice formation and growth or reduce the adhesion strength between the ice and the surface. These methods are time-consuming and depend on forecasting. They can be applied on small surfaces only for specific targets, and most are non-biodegradable (except for anti-freezing proteins). There is some quite promising information on ultrasonic ice mitigation methods that employ UGW (Ultrasonic Guided Wave). These methods are have the characteristics of low energy consumption, low cost, lightweight, and easy replacement and maintenance. However, fundamental knowledge of ultrasonic de-icing methodology is still limited. The objective of this work was to identify the ice formation processes and its progress by employing ultrasonic guided wave technique. Throughout this research, the universal set-up for acoustic measurement of ice formation in a real condition (temperature range from +240 C to -230 C) was developed. Ultrasonic measurements were performed by using high frequency 5 MHz transducers in a pitch-catch configuration. The selection of wave modes suitable for detection of ice formation phenomenon on copper metal surface was performed. Interaction between the selected wave modes and ice formation processes was investigated. It was found that selected wave modes are sensitive to temperature changes. It was demonstrated that proposed ultrasonic technique could be successfully used for the detection of ice layer formation on a metal surface.

**Keywords :** ice formation processes, ultrasonic GW, detection of ice formation, ultrasonic testing
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