Electro-Impulse De-Icing (EIDI)

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Intended or Actual Application: Innovative Dynamics Inc. (Innovative Dynamics Inc. 2007) has developed Electro-Impulsive De-Icing (EIDI) systems in collaboration with the NASA Glenn Research Center and Lockheed Martin for use on aircraft and ships. A version of the system is currently in use on the horizontal stabilizer of the Raytheon Premier I business jet, and another version has been demonstrated for deicing ship hatches. The EIDI system uses electromagnetic coils underneath a rigid or semi-rigid icing-prone surface to produce an impulsive force sufficiently large to debond and expel the ice. A variation of the EIDI system has been commercialized by IDI with Cox & Company.

Operating Environment: The primary application is for in-flight aircraft icing, but a version is developed for ships at sea. The technology was originally designed for FAA FAR25 Appendix C conditions, which all aircraft deicing and anti-icing systems must meet for certification (FAA 1991). The EIDI system is capable of expelling thin ice, which is more difficult than expelling thicker ice. Although due to the salinity of sea spray superstructure ice, which is naturally softer, the shock-effect of an expulsive system may be partially absorbed, lessening its effectiveness.

An EIDI system was designed for ship icing conditions with air temperatures as cold as -40°C, a saltwater content of 65 g m^{-3}, an average drop diameter of 300 µm, and a wind speed of 25 m sec^{-1} ((Innovative Dynamics Inc. n.d.).

Engineering Concept: The system operates by using electromagnetic coils located behind the surface by inducing strong and sudden magnetic forces from a high-current DC pulse through the coil. This results in the rapid acceleration and flexure of the icing surface, causing the debonding and expulsion of the ice (Figures 37 and 38).

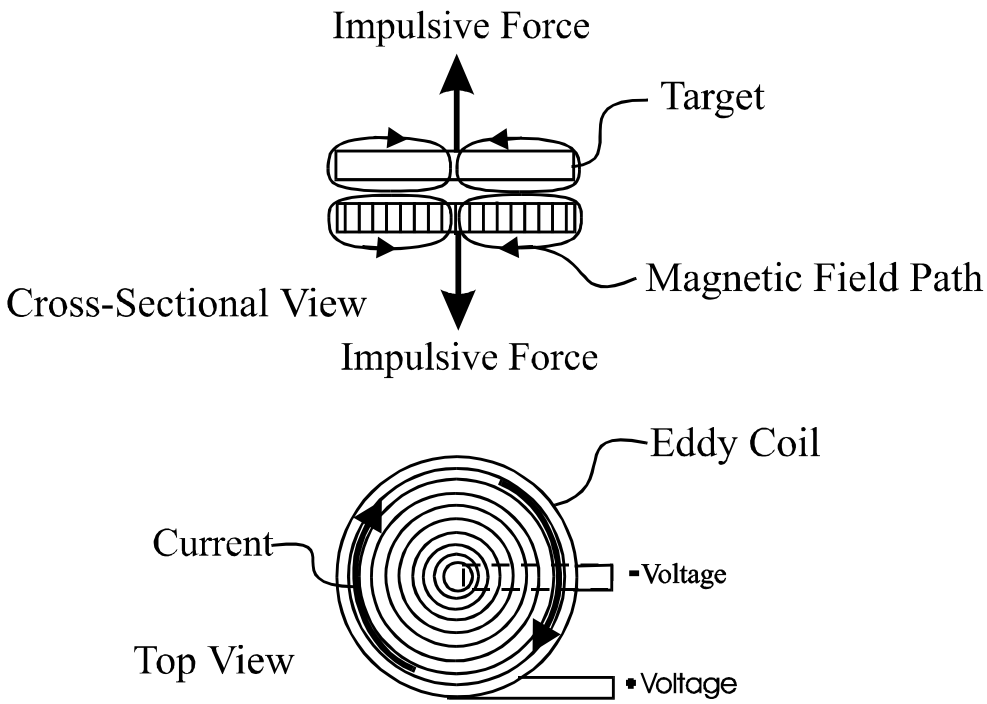

Figure 37. Diagram of EIDI coil. Coil is positioned in close proximity to target surface and discharged with high current impulse source. Magnetic field lines induce currents in target surface to cause rapid shock to pulverize surface ice accumulation.

Figure 38a. Single actuator under 3.2-mm metal plate with 25-mm ice sheet (Innovative Dynamics Inc., n.d.,).

Figure 38b. Single actuator under 3.2-mm metal plate breaking a 25-mm ice sheet (Innovative Dynamics Inc., n.d.,).

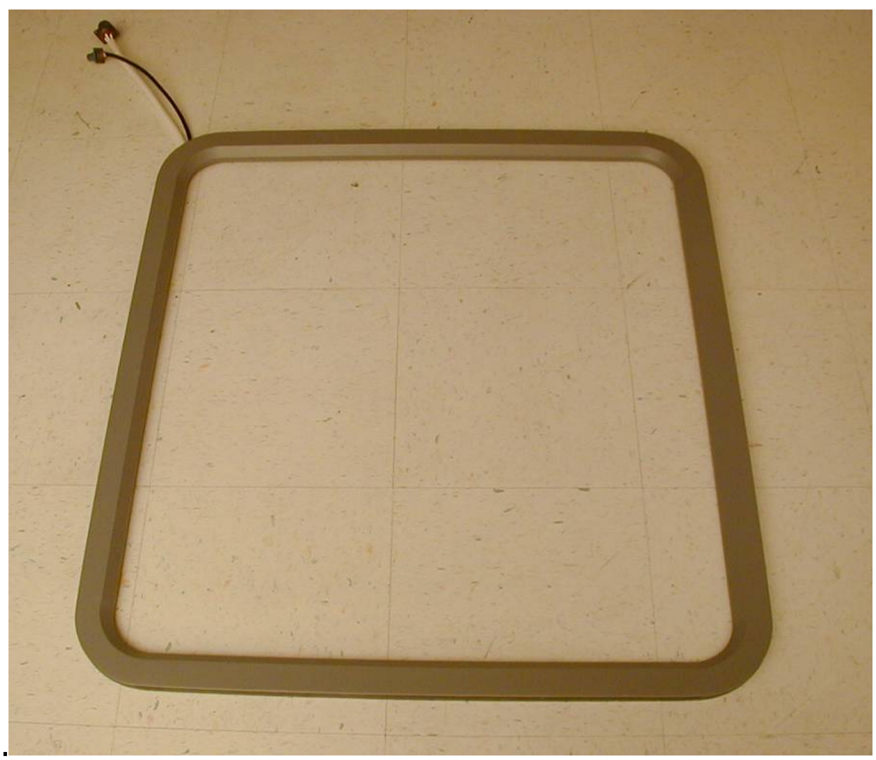

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Figure 18c. One-piece EIDI ship hatch de-icer used to break ice accretion and allow hatch to be easily opened.

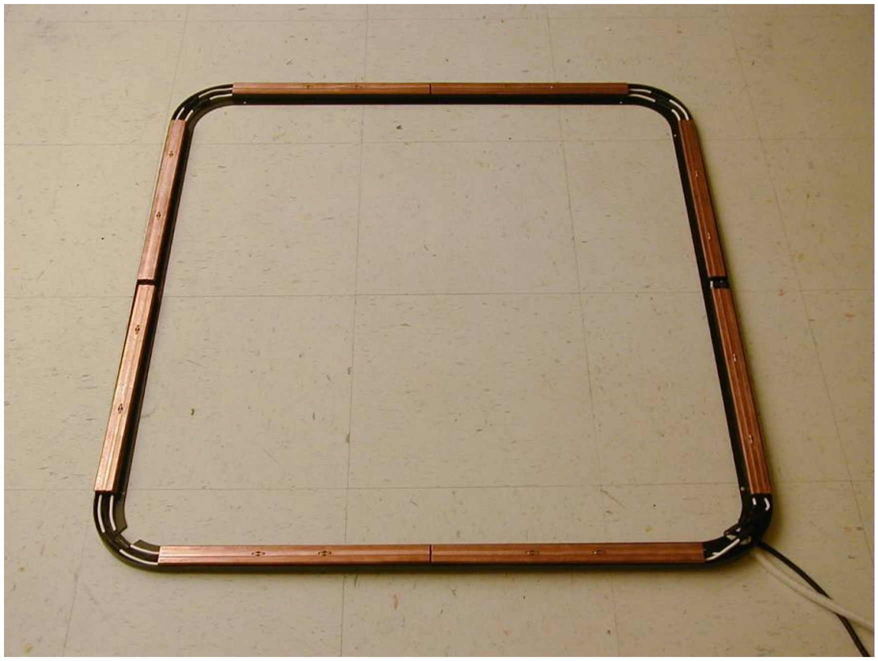

Figure 38e. Multiple actuators integrated into a one-piece ship hatch de-icer seal

TRL: 8. System is currently available for aircraft.

Deicing or Anti-icing: Deicing.

Current Advantages and Disadvantages: Ice can be shed in a variety of thicknesses. The system has been evaluated successfully in saline ice and for application to ship hatches, but certain details are proprietary. Although fundamental design work has been accomplished, specific applications require some redesign. The system utilizes high voltage – a potential safety concern- but requires less power compared to electro-thermal systems and features a low IR signature.

Current Acquisition Cost: Unknown. Some redesign is necessary for each specific application.

Operational Cost: Unknown.

Maintenance Requirements: System may be cycle limited due to high voltage charging capacitors, though it has been certified on aircraft for hundreds of thousands of actuation cycles.

Potential Marine Application and Safety Enhancement: The EIDI system would allow energy efficient, automated deicing.

Marine TRL: 6.

Marine Advantages and Disadvantages: The system can only perform with a flexible icing substrate – not directly with the very thick plate or structures typical of marine applications. A special flexible icing substrate “skin“ may be needed which is on the order of a few mm thick; the actuators are located between this and the original structure. The surface may need reinforcement for use in the heavy industrial environment. The system will generate ice debris, which for example, will deposit at the base of vertically oriented surfaces such as bulkheads.

Marine Technology Transfer Requirements: Tests have been performed in a simulated marine environment with sea ice mixtures at a range of temperatures, but additional testing would be appropriate. Additional research would be required to achieve a robust and electrically safe system for operation in a marine and heavy industrial environment. Application to surfaces of various shapes and orientations would also require investigation.