Impinging Spray Technique for Ground Deicing

13 OCT 2016 BY SALEH YAKHYA ET FRANÇOIS MORENCY

Abstract

This article describes current practises, regulations and costs related to ground deicing. Some considerations have been made about the environmental impact of using glycol and natural gas, the future of deicing techniques and how these new techniques could change the current system and its procedures.

The installation of a new deicing system is complex particularly with the expansion of new technologies and environmental regulations.

Key words: impinging sprays, ground deicing, propylene glycol, aeronautics

Aircraft Icing Conditions

In aeronautics, icing conditions appear on the ground through a precipitation – either ice, frost or snow. Depending on their form, these icing conditions could cause aerial accidents. Indeed, when accumulating on the aircraft's critical parts such as the wings, fuselage and stabilizers, the frozen precipitation disrupts airflow and, consequently, impedes the aircraft's flight.

In order to avoid accidents, steps are taken to ensure the aircraft's airworthiness. Deicing and anti-icing are among the decontamination processes. Deicing is a procedure by which the frozen contaminant is removed from an aircraft using deicing fluid. This liquid, ethylene glycol, is heated to assist in surface cleanup. Anti-icing is a procedure that involves applying aircraft anti-icing fluid on a surface, free of frozen contaminants, in order to protect it from the accretion of such contaminants for a limited period of time (Transport Canada, Guidelines for Aircraft Ground – Icing Operations. Second edition, 2005, 148 p.).

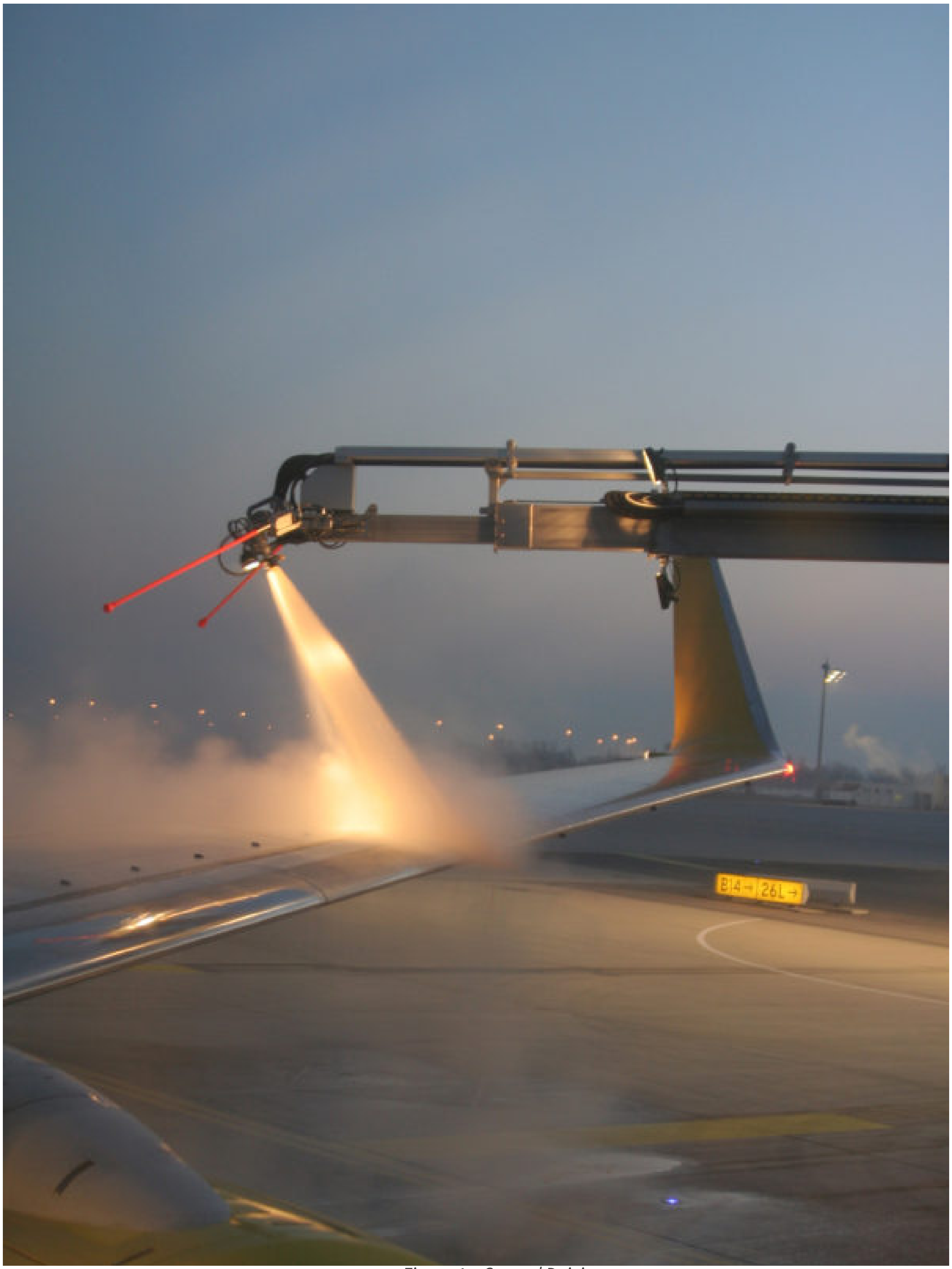

Figure 1 – Ground Deicing

The purpose of this report is to examine current ground deicing practices, as well as their regulation and operating costs.

Case Study on Impinging Sprays

Impinging spray flows have various objectives depending on the field of study. The impinging jets are also used to decontaminate surfaces. Regarding their efficiency and scope of application, two methods are recognized to date: wet cleaning and dry cleaning. There are two principal approaches in developing models for impinging sprays: experimental systems such as testbeds, and digital simulations using calculation software to model the fluid mechanics. However, the required time and resources are limited in both approaches. CFD (Computational Fluid Dynamics) can generate a lot of data on the nature of flows, at a lower cost than experimentation (Pratt & Whitney Canada, CFD Industry Applications, 2016). But depending on the complexity of flow type or impinging spray (tridimensional spray), using CFD to simulate the entire system could require unfeasible or unavailable resources.

This spray modeling impinging on a flat surface, is part of a research program to design a testbed for aircraft deicing. Testing will simulate various scenarios of ethylene glycol spraying on the cold surface mock-up of an aircraft wing. The spray characteristics, such as the projection angle, pressure, temperature, distance between the spray exit and the impact point, will be controlled during simulation. These parameters will allow the measurement of ground deicing quality levels. In the long term, after ruling on the formula with the best performance, this study will be used to improve ground deicing personnel training.

Alternatives to the use of glycol-based products

On one hand, the efficiency of a heated liquid spray impinging on a surface can be improved. On the other hand, replacing a liquid spray with infrared radiation can also be effective. A report written by Carroll McCormick in 2008, on infrared deicing, presents the patented InfraTek^{TM} technology. This solution is design to avoid damage to the environment caused by chemical deicing methods. However, this technology still uses energy from infrared wavelengths generated by Energy Processing Units (EPUs) (figure 2).

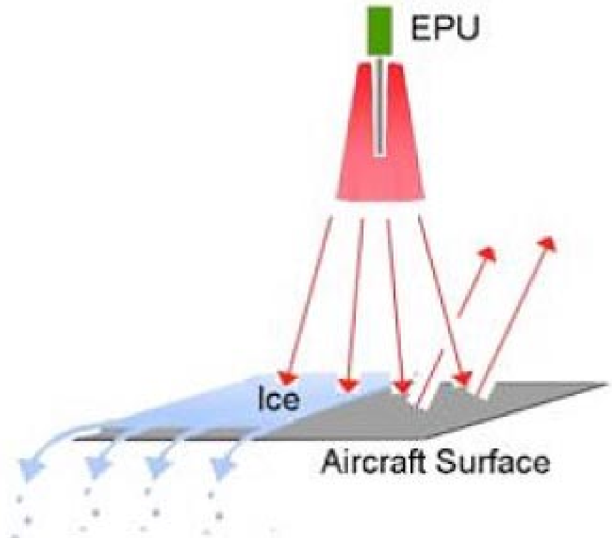

Figure 2 – Diagram of the InfraTekTM Infrared Deicing System Process

Results Analysis

The highlighted benefits of the Radiant InfraTek^{TM} system, over ethylene glycol application, are the operating cost reductons, ranging from 10% to 50% per treatment, depending on aircraft size and on icing conditions.

This system considerably minimizes glycol use, thereby leading to lower capital investments for its storage ($10 US per mm in 2008), handling and recycling (FirstPrincipals, 2009). Moreover, this system first operated in 2006-2007 and was designed to handle all aircraft sizes up to the 747-300. The documented performance was (Vasilyeva, 2009):

- A 90% reduction in glycol use per aircraft under icing conditions;
- No glycol application required for defrosting operations.

Indeed, when an aircraft arrives at the deicing facility, infrared rays are generated simultaneously from panels oriented towards all the aircraft parts to be deiced. Natural gas or propane provides the required energy for infrared production, and no energy waste is observed taking into account that the system idles at standby power level once the surface is decontaminated. There is no negative impact on the environment because the programmed remote control system does not heat the air. Rather, it penetrates the contaminant to a depth of about two microns, causing the molecules to vibrate, and thus the fusion of particles. The infrared rays, while heating the aircraft surface, do not exceed the ground level temperature under the sun nor the general temperature of impinging deicing fluids. The rays act on a dry surface without using glycol: there is less ground water contamination.

Conclusion

Numerical simulations will improve ethylene glycol application by identifying critical parameters such as liquid film thickness. Some considerations were made on the environmental impact that the use of glycol and natural gas would have on the future of deicing techniques, and how these new techniques would change the current system and its procedures.

Authors

Saleh Yakhya is an Electro-Mechanical Design Engineering graduate of the École Supérieure Polytechnique of Dakar (Senegal), now pursuing a Master's of Research with a thesis in Mechanical Engineering at the École de technologie supérieure. His research work focuses on the CFD study pertaining to the interaction between spray and surface during aircraft ground deicing. Saleh is also Co-chair of the Énergie-ÉTS Student Club which closely follows the energy sector.

François Morency is a professor at the ÉTS Mechanical Engineering Department since 2004. His research activities focus on the application of computational fluid dynamic (CFD) tools to address problems in the aviation industry. The human aspect is also considered through his research on the health and safety of workers involved in ground and in-flight aircraft de-icing. He is a member of the Thermo-fluid for transport Laboratory.

REFERENCES

Transport Canada. Lignes directrices pour les aéronefs lors du givrage au sol. Deuxième édition, 2005, 158 p.

Pratt & Whitney Canada, Applications Industrielles de la CFD, 2016.

McCormick, Carroll. 2008. « Infrared Deicing: Giving glycol a run for its money ». <http://www.wingsmagazine.com/content/view/1325/38/ >. Consulté le 29 juillet 2016.

Vasilyeva, A. (2009). Aircraft Deicing Operations. <http://ardent.mit.edu/airports/ASP_exercises/2009%20reports/Aircraft%20Deicing%20Vasilyeva.pdf >. Consulté le 29 juillet 2016.

IMAGE REFERENCES

Header picture: Source. No known use restriction.

Figure 1: bought on iStock. Copyright Thomas Hottner.

Figure 2: Hessing, H., Knoesel, E., & Sharkey, I. Infrared Aircraft Deicing Facility atJohn F.Kennedy International Airport. No known use restriction.