# DESIGN AND CALCULATION OF THE DEICING SYSTEM FOR SMALL PASSENGER AIRCRAFT TO TAKE-OFF WEIGHT 2000 kg

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The role and aim of the thesis was to design and calculate the deicing system small transport aircraft to take-off mass of 2000 kg. In the introduction it is dismantled icing problems, its effect on the airplane and flight characteristics, eliminating the possibility of frost in flight and analysis of the current state of de-icing systems described in specific types of aircraft. The core of the work consists of three separate sections. The second chapter consists of the actual design of the mechanical de-icing system leading edges of wings and tail surfaces. The third chapter discusses the design of the electrical system defrost windscreens cockpit, propeller leading edges, the entry of air into the powerplant and defrost flaps in the air duct nacelle. Last of the chapters deals with the design of detection and alarm icing. The work includes calculations of specific components of the whole system and also by pictures and diagrams of the proposed system.

Keywords: mechanical de-icing systems, electrical de-icing system design, calculation

## 1 INTRODUCTION

One of the main problems that the pilots while flying in adverse weather conditions to contend is the formation of ice on airframe and engine portion of the flight. Icing on these parts adversely affects the aerodynamics, weight, airplane performance and increases the probability of a hazardous situation. For these reasons, almost from the beginning of aviation aerospace engineers engaged in the development of the necessary de-icing systems.

The primary task of de-icing systems is to increase the safety of flight which is associated with the protection of passengers and aircraft. A negative use of ice protection systems is to increase the total weight of the airplane and energy burden, which would further increase the operating and acquisition costs.

The aim of this thesis is to provide a comprehensive picture of the problem and create the overall design de-icing system for small transport aircraft to take-off mass of 2000 kg. The proposal is accompanied by the necessary calculations and schematic representation of the proposed de-icing systems.

## 2 ANALYZES THE CURRENT IN THE SCOPE

Icing on the aircraft arising from the perspective of aerodynamics, weight and steerability undesirable phenomenon, which should be prevented.

The resulting gel airplane adversely affects mainly:

- aerodynamics,
- the functionality of the control surfaces,
- airplane weight and center of gravity change,
- operation of instruments and sensors on the surface of the airplane,
- opening doors and door operating on the fuselage,
- move and safe operation of power units,
- reduces the view from the cockpit through the frozen windscreens.

Frost resistance also causes an increase in airplane (increasing drag coefficient) and its deposition on the wing leading edge causes negative changes in aerodynamic wings (impairment lift coefficient) (Fig. 1).

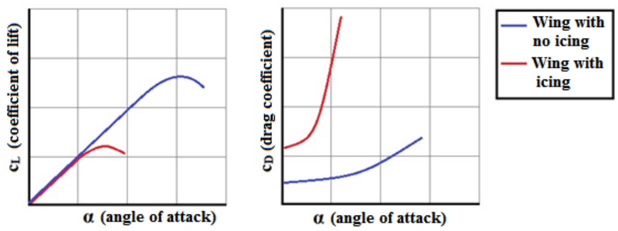


**Fig. 1 Changes drag and lift coefficients caused by frost**

Ice can be divided into several types according to its characteristics and different conditions of:

- white granular ice,
- small crystalline deposition,
- frost,
- transparent ice,
- matt ice. [1]

To assess the danger of frost has important concept icing intensity. The rate of the intensity of icing accretion of ice layer on the front of the aircraft per unit of time (mm.min-1). [1]

The intensity of icing know:

- weak to 0,6 mm for 1 minute,
- mild from 0.7 to 1 mm in 1 min,
- thick from 1.1 to 2 mm for 1 minute,
- very strong over 2 mm for 1 min. [1]

The chapter also describes the various de-icing systems and their use for specific types of aircraft:

- electrical de-icing systems (Boeing 787 Dreamliner and the Super King Air 200),
- hot air systems for de-icing (McDonnell-Douglas DC-9),
- mechanical systems for de-icing (Cessna 550),
- chemical de-icing systems (Cirrus SR22).

## 3 DESIGN OF THE DEICING MECHANICAL SYSTEM FOR SMALL PASSENGER AIRCRAFT TO TAKE-OFF WEIGHT 2000 kg

The main criterion in the design of the de-icing system is the mass of the system, which affects the total weight of the proposed aircraft.

How to defrost system leading edges of wings and tail surfaces for reasons of efficiency and low energy consumption is proposed to use a mechanical de-icing system.

Mechanical de-icing systems requires a certain amount of compressed air which is taken from the power unit, or air conditioning system of the aircraft. For this aircraft as mentioned counts using two powerplants TP 100 It is a small turboprop engines which is calculated by taking the air from the compressor. For this reason, it will be taken compressed air system from another aircraft. Since this aircraft will not appear pneumatic control system of mechanical parts wings, tail surfaces or chassis must be taken compressed air from the air conditioning system. It is assumed that the air pressure in the air conditioning system shall be obtained from the heat exchanger placed on the motor unit. From there will be piped to the air conditioning system.

The proposed mechanical system icing leading edges of wings and tail surfaces of the aircraft consists of (Fig. 2):

- deicing boots (1,2,3,4,5),
- control panel (6),
- solenoid valve (7),
- pressure regulator (8),
- simple solenoid valve (9,10),
- line pressure sensor (11),
- control unit with timer (12),
- expansion joints (13),
- connections outside source (14).

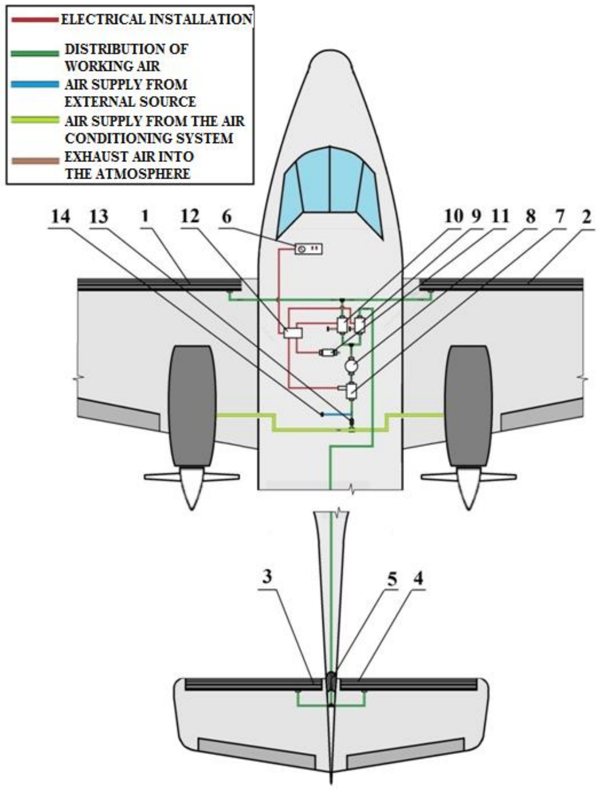


**Fig. 2 Schematic representation of the proposed mechanical de-icing system**

Chapter also calculate the mass of the mechanical de-icing system (Table 1).

**Tab. 1 Calculate the total weight of the deicing system**

| Part name | Weight(g) | Number (ks) | Total weight (g) |
|---|---|---|---|
| Solenoid valve | 500 | 1 | 500 |
| Line pressure sensor | 90 | 1 | 90 |
| Pressure regulator | 190 | 1 | 190 |
| Simmple solenoid valve | 1000 | 2 | 2000 |
| Deicing boots | 3000 * | 2 | 6000 |
| Deicing boots | 800 * | 3 | 2400 |
| Control panel | 300 | 1 | 300 |
| Control unit with timer | 400 | 1 | 400 |
| Pipe I | 719 | 1** | 719 |
| Pipe II | 457 | 12** | 5484 |
| **Total mass of the system** | | | 18083 |

* mass calculated by averaging the weight of aircraft de-icing bags similar category.

** values in m [meter].

## 4 DESIGN OF THE DEICING ELECTRICAL SYSTEM FOR SMALL PASSENGER AIRCRAFT TO TAKE-OFF WEIGHT 2000 kg

Electric defrost system-pink these parts:

- windscreens of cockpit,
- leading edge propeller,
- entry of air into the power train,
- sensors static and dynamic pressure.

### 4.1 Design of the deicing system windscreens cockpit

Cockpit windscreens come into direct contact with the air flow bypassing the airplane. The formation of a layer of ice on the windscreens of cockpit would have the effect of reducing the transparency of glass. For this reason it is necessary to effectively protect windshields against icing and misting.

The proposed electrical de-icing system is divided into two sections:

- defrosting windscreens cockpit (PCB),
- emergency defrosting windscreens cockpit (resistance wire).

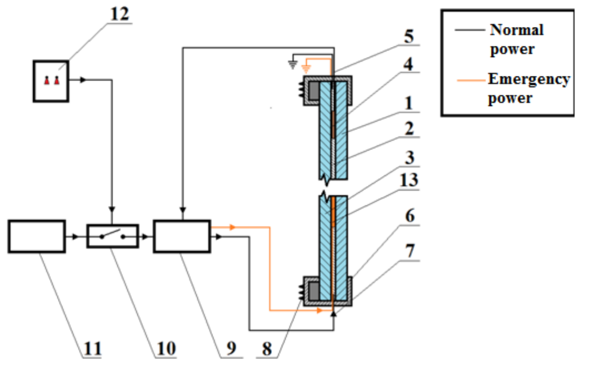


**Fig. 3 Schematic illustration of an electrically heated windscreen cockpit**

Key to figure:

1 - exterior glass, 2 - fired element (PCB), 3 - interior glass, 4 - temperature sensor, 5 - output signal of the temperature sensor, 6 - Frame, 7 - input electrical power, 8-seal, 9 - Control Unit, 10 - switch 11 - bus, 12 - control box, 13 - fired grill.

### 4.2 Design of the deicing system for leading edges of propellers

Leading Edge propellers are designed by deicing electric heating system. It is a reliable and effective method for removing ice.

- rotating parts: radiators propellers and transmission rings,
- non-rotating parts: the timer transmission brushes, control panel and wiring.

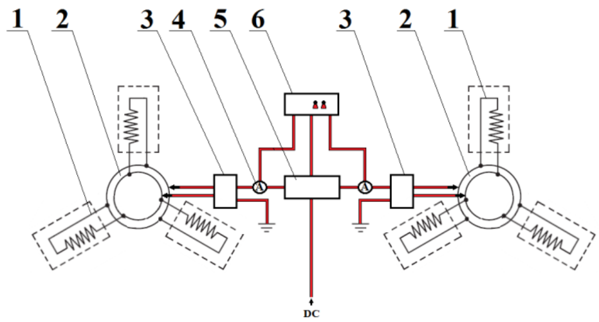

**Fig. 4 Schematic representation of electrical deicing system for leading edges of propellers**

Key to figure:

1 - heater, 2 - Transport Ring, 3 - Transfer brush, 4 - ammeter, 5 - timer, 6 - Control Panel,

### 4.3 Design of the deicing system for air aintake

The air intake is exposed to direct contact with the air flow. If you would create icing on these inputs and in its subsequent release would be sucked powertrain, which could cause damage to the system input and engine compressor blades. Therefore, these inputs are needed to protect against icing.

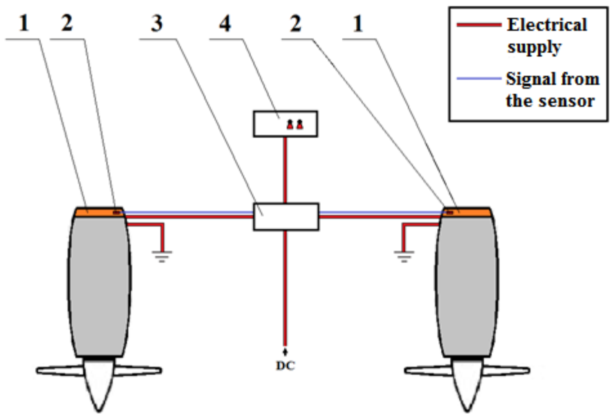


**Fig. 5 Schematic representation of the electrical deicing system leading edges of propellers**

Key to figure:

1 - heating elements 2 - temperature and 3 - control block 4 - control panel.

### 4.3 Design of the defrost damper in the air duct nacelle

Icing on the air intake and the subsequent tearing can cause serious damage to the system input power unit. How to prevent this negative impact of the proposal to use de-icing system dampers in air duct nacelle. It is a system to protect engine parts from the penetration of ice cubes into the input system power unit. The system consists of two movable flaps of servo controlled and of servo itself.

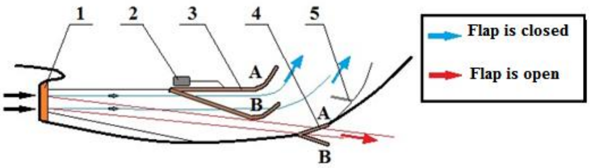


**Fig. 6 Schematic ilustration of deicing flaps**

Key to figure:

1 - visual signaling icing, 2 - visual indicator light frost detection area, 3 - mechanical detector icing, 4 - Information tableau, 5 - switches heat plants and lighting visual detection area of the ice.

## 4 MOTION DETECTION AND SIGNALS OF ICING

Due to early indications of frost should be placed on a particular aircraft type detector or detection area of the ice. For this type of aircraft suggest using a mechanical detector placed icing on the fuselage. We also propose to use visual annunciator illuminated ice control lamp placed in front of the cockpit, due to its simplicity and effectiveness.

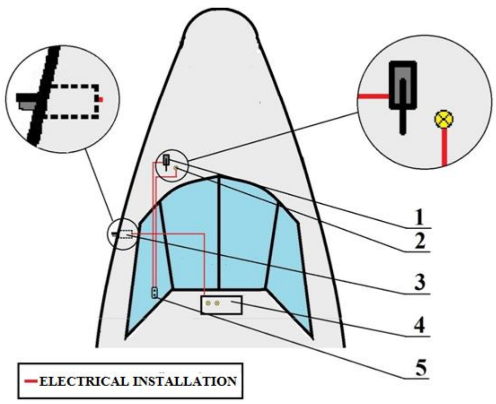


**Fig. 7 Schematic ilustration of design detection and alarm icing**

Key to figure:

1 - heating elements, air intake, 2 - servo, 3 - protinámrazová valve, 4 - valve, 5-sieve, A - position damper when the system is off, B - position damper when system.

## 5 CONCLUSION

The main task of this thesis is to provide a complete proposal for de-icing system, a small transport aircraft to take-off mass of 2000 kg. In making the proposal we used two different ways of de-icing systems. It is a mechanical de-icing system used on wing leading edge de-icing and tail surfaces and electrical system designed for defrosting windscreens cockpit, leading edges of the propeller blades, the air intake sensors and static and dynamic pressure. Both methods are often used for de-icing and tested for transport aircraft, which demonstrated its outstanding capability and quality.

Development of de-icing systems nowadays is progressing, which is mainly due to the significant developments in the field of electrical engineering, which is progressing by leaps and bounds forward. This is mainly to increase the reliability and performance and on the other hand, reducing the weight and dimensions of electronic components, which has a very positive impact on aviation technology.

Currently, researchers introduced an entirely new concept de-icing system. It is a de-icing system using nanotubes, which is driven by an electric current. This concept has countless benefits. It is mainly its low weight, the possibility of nanotubes simple painting application technologies (spray) which results in different icing curved airframe parts without significant problems. The great advantage of this system is its low energy consumption compared to today used electric defrost system. This concept is in development, beginning with its testing in wind tunnels.

## BIBLIOGRAPHY

[1] TŮMA, Jiří: Letadla pro učební a studijní odbory na SOU. Praha : Nakladatelství technické literatúry, 1981, 177 s

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