THE PAVEMENT THERMOGRAPHIC MEASUREMENT AS SUPPORT FOR AIRPORT WINTER MAINTENANCE

Abstract

The main aim of the paper is to describe procedures which might be employed during an installation of the anti-icing system into the airport pavement in order to enhance the efficiency of airport winter maintenance. The paper illustrates the surface measurements with the use of a thermographic camera which leads to depicting optimal suitable location for the pavement sensors. The idea is supported by experimental measurements performed at the chosen airport in various conditions.

Keywords: airport, runway, temperature, sensor, ice accretion, installation, system, runway surface, winter airport maintenance.

Introduction

In order to deal with winter maintenance resources such as manpower, machinery, chemicals – pavement de/anti-icing materials effectively, the manager of an airport should possess appropriate information on the current and future condition of the movement area. Ideally, the airport should be equipped with a kind of a surface condition detection system with sensors providing essential information. Not only do the quality of the system consisting of a variety of surface sensors and processing hardware and software provide the final resolution but also the location of sensors plays an important role.

Pavement Surface Temperature Measurement

The current measurement of a surface temperature for the use of winter maintenance is not conducted in the Czech Air Force environment. Instead, the surface air temperature 5 cm above ground is applied and obtained from a meteorological duty service each 24 hours on call. The mentioned temperature is measured from the airport meteorological site which is close to the ATC tower. The airport winter maintenance operational unit usually requests information at about 7 a.m. just after taking over the duty. The lack of knowledge on such an important value as it is pavement surface temperature is rather disadvantageous in a decision making process over the application of pavement de/anti-icing materials, its type and amount. The difference between pavement surface temperature and surface air temperature might be significant as it might cause the use of employment of pavement de/anti-icing materials (over-dosage), or on the other hand, a lack of employment when necessary. In this rate, such a particular condition definitely requires the application of pavement de/anti-icing...
materials and if possible prior to an increase of surface air temperature. Considering that, it is obvious that a reliable measurement of the pavement surface measurement is rather essential. For such a measurement, it is possible to employ special temperature indicators built in reference points on the movement area. In some cases, especially emergency ones, a pavement surface temperature might be obtained by mobile means. The measured surface should be cleaned free of snow and ice prior to the measurement and it should be conducted regularly as often as possible to provide a sufficient image over temperature development [1, 2, 3].

**Weather detection and pavement condition detection systems**

The pavement de/anti-icing materials application with the support of a surface condition detection system is the most effective and economical way. For a proper application pavement de/anti-icing materials as anti-icing, it is necessary to add weather forecast into a winter maintenance system besides instant monitoring and forecast of a surface condition. In a ultimate condition, it might be fulfilled by inducing a pavement condition detection system. Such a system contains three elements: an input head, a signal processor unit and data display unit. The system can be formatted to any end-user, pilots, ATC or airport maintenance [2].

The system measures and displays information on:
- runway pavement surface temperature (variety of location);
- dry pavement condition (no moisture);
- wet pavement condition (visible moisture on the surface);
- ice prediction (alert of ice formation);
- pavement ice formation;
- air temperature, wind speed and direction;
- precipitations;
- relative humidity/dew point;
- indication of relative concentration of anti-icing chemicals [1, 2, 3].

**Determination of sensor locations**

**Theoretical determination of sensor locations**

After performing a detailed survey of the systems successfully applied throughout Europe, there are employed at least three sensors, one always in each third on a single RWY, two roughly three hundred meters from both RWY ends whereas the third in the middle in the length retrospect. Then, all of the sensors are located about fifteen meters distant on both sides from the RWY center line often two in the assembly including back up ones. Nevertheless, such a distance fluctuates presumably according to aircraft undercarriage characteristics which should ensure to avoid a possible contact of tires with the sensors to the lowest level in order to guarantee the best resolution of the measurement.

**Location determination with the use of thermal mapping**

Thermal mapping is a procedure which might be applied in determining the optimal sensor locations. This method is just a refined technique and the companies specializing in assembling pavement condition detection systems do not apply it in general. The technique is aimed at finding the coldest and warmest spots on the RWY
surface where the sensors could be placed. This has, however, a major drawback as such spots despite being diverse might be very close to each other leaving a vast surface of the RWY unmonitored. This may also happen if the spots were found on both the RWY ends leaving the middle of the RWY without measurement.

On the basis of the undertaken research, it can be stated that as long as sensor position is in a touch down zone, the results would be highly affected by intense traffic as well as the sensor durability. The above observations appear to be seemingly reasonable making thermal mapping rather a supplementary method (Fig. 1).

![An example of thermographic measurement](image)

**Fig. 1. An example of thermographic measurement**

**Experimental temperature survey of RWY with the support of thermal mapping**

Real thermal mapping of the RWY surface has been conducted in order to provide sufficient data which would be used while purchasing the surface detection system into service on airports. In the initial phase, the main focus was on evaluating whether the thermal mapping is a useful tool in determining measuring locations and if it resulted positively in the full scale measurement to be launched. The measurement was conducted with limited financial resources with the use of rather an unprofessional thermographic camera which, however was quite beneficial, and was very easy to handle requiring no special training and had good storage and data processing capabilities. A dozen measurements in a variety of conditions beginning with a clear sky without wind were made in total. Every single RWY measurement included 34 temperature figures, every 59 meters one after another in total covering full 2000 meters length of the RWY (Fig. 2). In order to simplify the measurement as much as possible, the RWY side lighting was applied as a reference.

The greatest differences in surface temperatures were achieved as expected in ideal conditions without wind and cloudless sky. All significant results were put into a separate airport sheet (Fig. 3) where yellow line represents the map scale 2000 meters divided by 100. For easier orientation 500, 1000 and 1500 are highlighted with a black line. The blue points located on the RWY mark logically the coldest spots as well as a blue line which depicts the coldest relatively homogeny 120 meters distance. The red marks distinguish the warmest places over the entire RWY. With respect to the Fig. 3,
it is obvious that the coldest spots are located roughly at the end of the first third of the RWY, just behind the first half and on the threshold. On the other hand, the warmest area is undoubtedly the beginning of the first third. Logically, as a consequence of this simplified thermal mapping, on top of the three sensors which follow the common procedure elsewhere, three additional sensors could be placed in two coldest places and one in the warmest. This is, however, in this particular case unnecessary as the warmest spot is located on the threshold whilst two coldest spots are right in the middle and on the other threshold. As a result of this idea with three sensors in each, the third comes with the need of thermal mapping.

Fig. 2. Variation of surface temperatures in an ideal condition without wind cloudless

Fig. 3. Locations of extremes in temperatures on RWY

Methodology draft for thermal mapping

As mentioned above, the aim of the thermographic measurement conducted was to prove whether the technique is convenient for a surface temperature survey of the RWY. Having been successful, the method is expected to be applied on other airports
after a certain refinement. Firstly, a thermographic camera, in spite of being extremely versatile and easy to handle, should be used with a better resolution particularly with the standard accuracy \(0.1\)°C. In order to create an entire picture which might be further applied in a prediction model after purchasing the system, all year seasons should be covered.

It is suggested to arrange two measuring days every month. Each measurement is not extremely time consuming requiring approximately from 30 to 45 minutes. In every mapping day, it is vital to conduct at least 2 better 3 (morning, evening and night) measurements as the RWY temperature conditions vary extensively during a night and day period. It is calculated that it is necessary to conduct 72 separate measurements within 12 months in total, each 2 mapping days and 3 measurements daily. During each measurement, it is strictly required to record an actual weather condition including predominantly air temperature. Having concluded, every measurement of the data should be transferred from the thermographic camera into the PC and arranged according to months and time. After completing a full year cycle, it is essential to find the lowest and highest temperatures. As a consequence, locations where the coldest as well as warmest places prevail should be estimated.

**Conclusion**

To sum up, in order to be able to deal with anti-icing materials effectively, it is vital to purchase a pavement detection system. If the system is, however, expected to operate according to the needs and pushed to its limits, a survey of surface temperature is highly recommended to be conducted in a variety of conditions. Apart from accuracy, it might be beneficial to get a clear image and understanding what is happening on the RWY.

**BIBLIOGRAPHY**