1 General Introduction

Most processes in the production of fiber composite components are based on the application of additional pressure during the curing cycle. For this purpose, after inserting the fiber materials in an open mold, vacuum setups are used for the evacuation of the layup. An often observed problem with vacuum setups is the vacuum tightness, which can lead to manufacturing deviations (Fig. 1) or even the loss of the part (scrap). Especially infusion processes, where leakages cause pores and air inclusions, depend on a good vacuum quality. For this reason, the process reliability plays an important role in composite parts production. This is particularly relevant in case of large components such as wing covers or fuselage shells, because of the high cost for time consuming repairs.

To increase the process reliability quality control techniques are required to allow the doubtless proof of the vacuum tightness and – in case of leakage – a precise localization of the sources before further processing. For this purpose an infrared thermography application has been developed, which locates possible failures in the vacuum setup in a fast, reliable and automated manner so that corrective measures can be derived.

2 State of the Art

There are different devices suitable for the detection of leaks available on the market, but some of them require a certain effort of manual and time-intensive search due the fact that leakages are invisible for the user. Typically vacuum setups are checked for their vacuum integrity by using a vacuum drop test with a vacuum gauge. A common used technology is the detection by using ultra sound sensors which generates a hearable signal for the user [1], but the manual effort is very high, depending on part dimensions, and the detection is influenced by surrounding noise. An additional technology is provided by using gas sensitive detectors (typically Helium or Nitrogen), which detect minimal gas molecules in the vacuum flow [2]. The only known detection principle that provides a visibility of vacuum leakages is an oxygen sensitive leak detection film, that has a high potential for automation [3]. The disadvantage of this method is that the films are not reusable after part curing.

Up to now, there was no method available to detect leaks accurately and automatically combined with low additional costs for each process. The issues of todays available technologies can be overcome by the application of a new infrared thermography technology for leakage detection.

3 IR-Thermography for Leakage Detection

Infrared thermography uses the effect of thermal radiation, hence the temperature distribution of the surface is measured. Differences in the temperature distribution are visualized in a so called thermal image where the discontinuities are shown in a false color representation [4].
3.1 Detection Principle and Objectives

The use of this sensor technology allows the detection of leaks in vacuum setups (Fig. 2), since the surface is cooled by the air flow through the leak and the refrigerant expansion. Visualized in a temperature plot, the temperature shows a significant gradient.

![Fig. 2 Surface leakage and leakage at the sealing tape (left) and Vacuum leakage below a fold of the bagging film (right)](image)

To reduce manual effort, the infrared detection system can be integrated in the head of a robot unit. The position of the leakage on the vacuum setup is determined in relation to the position of the robot tool center point (TCP). This allows an automatic scan of the vacuum setup using the high positioning accuracy of the robot together with the IR-camera data. Hence leakages in surface areas as well as leakages under folds of the bagging film and in the region of the sealing tape can be detected and localized.

3.2 Industrial Application Concept

For the integration into an industrial environment, the system is integrated into a robot cell. Using the automated image processing and TCP coordinates leaks are detected accurately and shown in an quality message log display (Fig. 3). Using a laser projector in addition, the leakage positions are shown directly on the vacuum setup and necessary repairs can be executed.

![Fig. 3 Concept for automated leakage detection and visualization](image)

References


