Implementation of Pressure Sensitive Paint technique in Applied Aerodynamics Laboratory

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Introduction

The Applied Aerodynamics Laboratory (AAL) of the Institute of Aviation in Warsaw recently started implementing the use of PSP as an alternative method of calculating a pressure gradient on objects. This contribution presents development of data reduction software, testing of the system components and results of experimental validation of the system performance.

In recent years, Pressure Sensitive Paints (PSP) have been developed as an efficient method of pressure measurement in wind tunnel tests [2]. The PSP technique allows measurement of a surface pressure distribution on a model without the use of pressure taps [1]. The measurement is based on acquiring images of a paint which luminescence is a function of pressure under proper illumination conditions. The PSP system typically consists of a scientific grade camera, light source and pressure sensitive paint. Since optical measurements do not require interference and modifications of the model, implementation of PSP technique can bring considerable reduction of wind tunnel tests preparation time and costs. Additionally, application of pressure sensitive coatings provide surface pressure distribution, substantially exceeding the capabilities of classical pressure taps in terms of data quantity acquired in a single experiment.

Materials and methods

Implementation of PSP technique in a research facility requires considerable expenditures of resources, either for development of an in house PSP system or buying a commercial system, as well as training. One can buy a full commercial PSP system consisting of: cameras and filters, light source, data reduction software, calibration chamber and various types of paint. This approach is more and more used in institutions performing commercial tests for the industry. This paper presents development of an in house PSP system. The following objectives was taken into account:

- maximum use of measurement equipment available in the AAL
- development of in house data reduction software
- use of UV light source recommended by PSP community
- buying well performing commercial pressure sensitive paint
- testing of individual parts of the system before painting

The AAL PSP imagining system consisted of PCO2000 camera, adapted from PIV system and a dedicated high pass optical filter used to suppress UV light. A binary-FIB™ paint form ISSI company was used. The paint was excited with UV light emitted by HardSoft IL-106X pulsed LED illuminator [5]. The pressures for calibration of the system was measured with use of ESP scanners of the DTC Initium system.

In the presented studies, image processing and a PSP calibration algorithm were developed and tested. Two approaches to the image resection [3,4] were proposed. The first used a manual marker selection tool. The second used an algorithm to detect the similarities in the images to automatically find the markers. The performance of the developed algorithms were tested with use of images and pressure data acquired with use of camera and pressure scanners intended as elements of the IoA PSP system.

Testing

To test the robustness of the software, experiments were conducted before any paint was used. For that reason a dedicated test stand was build. Two aspects were tested: first for the image resection procedures and second for the synchronization of the image acquisition system and traditional pressure scanners. After successful testing of the software and individual system components the pressure gradient on two surfaces was determined: i) flat plate exposed to impinging jet of air, ii) suction surface of an airfoil for Mach numbers in range 0.1-0.45.

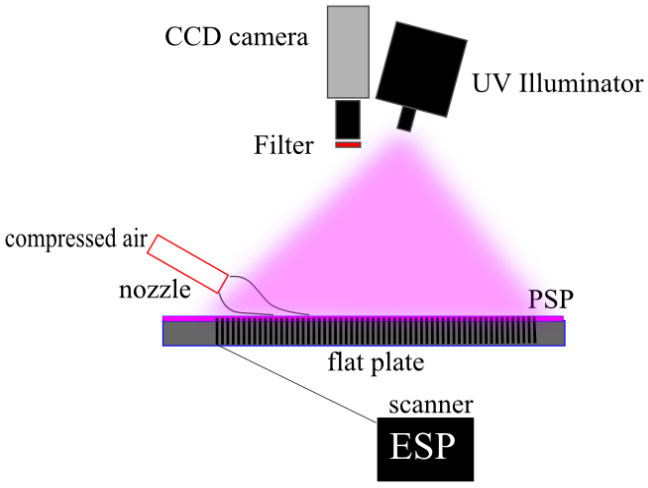

Figure 1: Impinging jet experimental setup

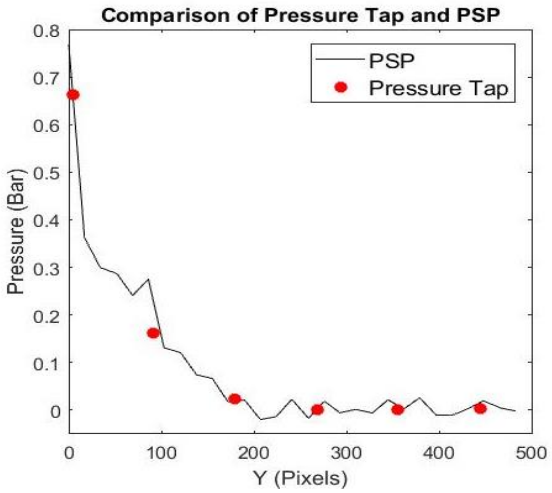

Figure 1: Pressure distribution on flat plate exposed to air jet, measured with PSP.

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