

Fluid Flow in Complex Geometries – Use of PIV Systems for Flow Visualization

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Objective

- Upon harvest, strawberries need to be rapidly cooled in order to prolong their self life. This process is usually carried out by forcing cold air through the packaged fruits.
- In order to improve the rate and uniformity of cooling, a detailed characterization of the airflow pattern is required.
- The aim of this work is to use an optical technique, called Particle Image Velocimetry (PIV), to experimentally determine the airflow patterns through 3-D models of packaged strawberries. The subsequent analysis of these airflow patterns will allow the optimization of the packaging system to improve the heat transfer process.

Particle Image Velocimetry (PIV)

- PIV determines the flow fields over global domains by measuring the motion of small markers seeded in the flow. The locations of the markers at various instants are recorded optically: these particles are illuminated by a pulsed sheet of laser light, which is scattered by the markers into a photographic lens (Fig. 1).
- Based on the statistical correlation of image sub-regions, the local velocities are determined. The vector field is obtained by repeating this process on a grid of such sub-regions (Fig.2).

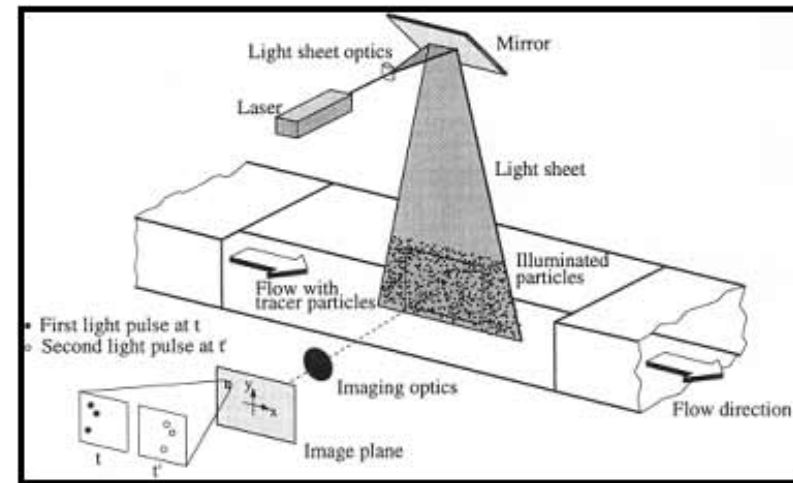


Fig.1: PIV optical system

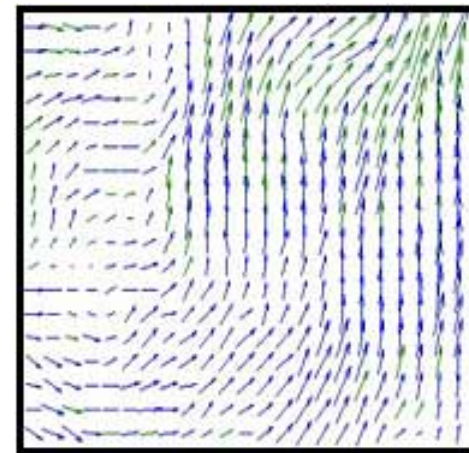


Fig.2: Velocity field sample.

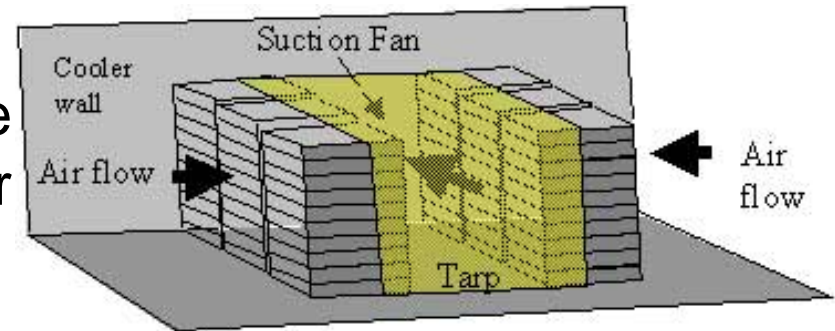
Development of PIV-Compatible Models

- Since PIV requires optical access to markers seeded in the flow, the major challenges in this study will be:
 - The accurate replication of the geometry of the system with a transparent material that does not absorb the laser light.
 - The selection of a working fluid whose refractive index matches that of the model.
- In the first step, the airflow pattern will be studied using simple geometries in acrylic for the system (cubes will be used to model the package and spheres to model strawberries).
- To further studies, the application of computer aided technologies will allow the development of accurate 3-D replications of the real package and strawberries in PIV-compatible materials (ABS, WaterClear).



Food System to be Modeled

- Strawberries are packed in clamshell containers, which are placed into trays. The trays are placed on top of each other.
- The clamshells and trays have vents through which the cold air is forced.



Ref. B.A. Anderson, 2003

Applications

- Improvements to the heat transfer process can be made based on this study. It will be possible to reduce the cooling time and improve the strawberries cooling uniformity by determining:
 - The optimum shape, size and distribution of the vents in clamshells and trays.
 - The best strawberry size distribution inside the clamshells
 - The best distribution of the clamshells in the trays