**HM132 Vertical visualisation of flow fields**

Fine gas bubbles are perfectly suited to visualising flow fields. Due to analogies, many flow processes that occur in air can also be demonstrated by experiments in water.

The trainer consists of a vertical experimental section in which an interchangeable model is inserted. Water flows from bottom to top through the experimental section. Electrolytically generated hydrogen bubbles rise with the flow, flow around the model and visualise the flow.

**Movement detection**

Flows can be visualized by floating particles or gas bubbles. These particles or gas bubbles must be so small that they follow the flow without distortion.

For good visualisation of the flow fields it is important to have a good contrast between the fluid and the particles or gas bubbles. As gas bubbles reflect the light well owing to their spherical shape this allows for an excellent contrast.

**Learning objectives / experiments**

- streamline course in flow around and through models
- flow separation
- vortex formation, demonstration of Karman vortices
- qualitative observation of the velocity distribution in laminar flow
- analogy to air flow
- in conjunction with a special camera (i.e. PCO Pixelfy) and suitable software (i.e. ImageJ):
  - image processing evaluation of the experiments (particle image velocimetry, particle tracking velocimetry)

Optional accessory: high-sensitivity camera

Electrolytically produced hydrogen bubbles as contrast medium.
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**Working with exposure times** $t_E$

There are various possibilities for detecting a movement process. Exposure time controls the duration of a recording. The intensity and duration of the exposure determines how the movement processes in the photograph are displayed.

- **Short** $t_E$: Standing image
- **Long** $t_E$: Motion blur occurs

Exposure time $t_E$ variable. Lighting constant.

**Snapshot with single bubbles** $v = 7\text{cm/s}$

Clarity of vortex structures

Visualization of the affected area

With a camera with adjustable exposure time $t_E$, the flow state can be kept as an image in a simple manner. Individual bubbles can smear to lines. If the lines are still clearly separated, the velocity of the bubbles can be calculated by reproduction scale, length/width of lines, and exposure time.

- $t_E = 1/200\text{s}$
- $t_E = 1/5\text{s}$
- $t_E = 1/1\text{s}$

Exposure time $t_E$ short, double. Lighting short, intense.

**Particle Tracking Velocimetry – PTV**

Motion blur gets directional information by decreasing illumination intensity.

Exposure time $t_E$ variable. Lighting dimming.

By dimming the illumination within the exposure time, the bubbles produce lines in the image. The fading of the lines shows the flow direction. The length of the lines is proportional to the velocity.

**Particle Image Velocimetry – PIV**

Double image. Usually applied in two image files.

Software compares two images taken one after the other quickly. The direction of motion and magnitude of the bubble patterns are calculated. With the reproduction scale and the time offset between the images, the speed can be determined.