Exam Physical Measurement Methods (4P580)

Friday October 3, 2008 9:00-12:00

Problem 1 Various topics. Provide to-the-point answers including brief argumentation.

(a) Can a Pitot-tube be employed under unsteady flow conditions?

(b) What is an important advantage of a hot-wire anemometer over LDV?

(c) What effects may cause visualisation with tracer particles to become unreliable?

(d) What information can be obtained with PIV that is impossible to obtain with LDV? Conversely, what information can LDV yield that is beyond the reach of PIV?

(e) Can the indicator method be employed for a laminar pipe flow?

Problem 2 Flow-rate measurements using orifice meters (e.g. measurement flange).

(a) Describe the general working principle of orifice meters.

(b) Describe the characteristics of the three orifice meters discussed during the lectures.

Orifice meters employ relation

$$\Phi = \alpha A \sqrt{\frac{2\Delta p}{(1-m^2)\rho}} \ ,$$

for evaluation of the flow rate.

(c) Derive the above relation.

(d) What is the meaning of parameter α? How is its value determined?

(e) Why is it not advisable to use an orifice meter directly behind a bend in a pipe?

Problem 3 Temperature measurements with thermocouples and LIF.

(a) Explain the physical principle behind thermocouples.

(b) Derive a relation for the typical response time of thermocouples to temperature fluctuations. Assume that the tip of the thermocouple is at uniform temperature and that heat exchange with the environment occurs by convection only.

(c) Describe potential error sources for temperature measurements with thermocouples.

(d) Describe the principle of ratiometric intensity that underlies measurements with LIF.

(e) What is the principal advantage of the ratiometric approach compared to an approach in which the temperature is evaluated *directly* from the fluorescence intensity?

Problem 4 Velocity measurements using Particle-Tracking Velocimetry (PTV).

(a) Sketch the general laboratory set-up for velocity measurements using PTV. Specify its basic components and briefly describe their function.

(b) Describe the basic steps and the working principle of the PTV data-processing.

The standard nearest-neighbour algorithm is the simplest possible matching algorithm. However, an important limitation is that it can handle only relatively low seeding densities.

(c) Explain how the standard nearest-neighbour algorithm works. Support your explanation with mathematical expressions.

(d) Explain the cause of the limitation mentioned above.

(e) How can the algorithm be improved such that it can handle higher seeding densities?