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# Direction dependent wind speed measuring probes for low speeds


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## Introduction

The determination of the flow velocity vector (amount and direction) becomes more and more important in the modern flow measuring technology, particularly in aviation, in automotive industry, but also, e.g., in meteorology.

→ Use of direction dependent wind speed probes:

- **Pressure measuring probes (5-hole probe)**
- Hot-wire probes (CTA)
- Laser-Doppler-Anemometry (LDA)

The determination of the flow velocity vector with the 5-hole probe used here is possible only with a previous calibration of the probe. Because this must occur 3-dimensional, this is connected with a considerable adjustment- and analysis-work.

During calibration and data acquisition with the PC, communication of different control devices and measuring instruments has to be performed. So that the acquired measuring data can be assigned for the adjusted positions, it is an advantage if all data are written in **one** measuring file.

## Focus of Investigation

- Calibration of the 5-hole-probe available at the lab wind tunnel/flow measurements

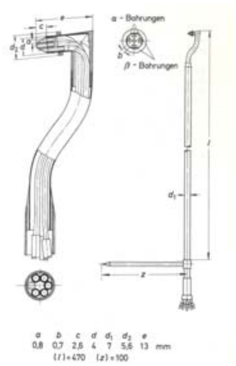

Fig. 1: Plan of a 5-hole probe (direction probe according to Conrad)

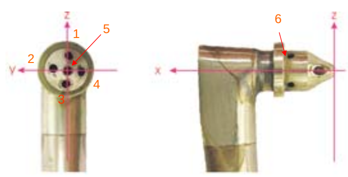

Fig. 2: Def. of the probes coordinates system; numbering of the probe drillings of a 5-hole probe

- Automation of the calibration to avoid human mistakes by the measurement acquisition and subsequent processing
- Development of a measuring program to
  - Control the angle-positioning device
  - Acquire the adjusted angles
  - Measure various physical values with different measuring instruments

## Realization

- Calibration of the 5-hole probe with the introduced procedure of K. Wörrlein (TU Darmstadt), which makes a up to now required zero comparison at every single measurement unnecessary
- Setting of the required angles $\alpha_T$ and $\beta_T$ with the help of the angle-positioning device, designed by G. Schmitz

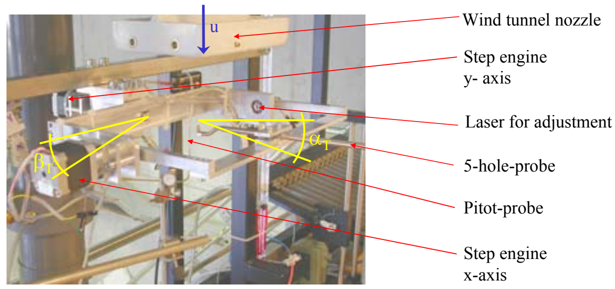


Fig. 3: Angle-positioning device with clamped 5-hole probe

- Use of the programming platform "LabView" for development of the measuring program "KaliQuick" for automization of the calibration


Fig. 4: Part of the measuring program "KaliQuick"

## Conclusions

- Determination of the coefficient matrix K (20 x 4 - matrix) with the help of the
  - flow dimensions: · blade angle $\alpha_T$ · rotation angle $\beta_T$ · total pressure $p_t = p_{ges}$ · static pressure $p_{stat}$ · pressure in the probe drillings $p_1$ to $p_5$
  - influencing variables: $C_{\alpha_T} = \frac{p_1 - p_3}{p_5 - \bar{p}}$, $C_{\beta_T} = \frac{p_2 - p_4}{p_5 - \bar{p}}$ and $C_M = \frac{p_5 - \bar{p}}{p_5}$ with $\bar{p} = \frac{p_1 + p_2 + p_3 + p_4}{4}$

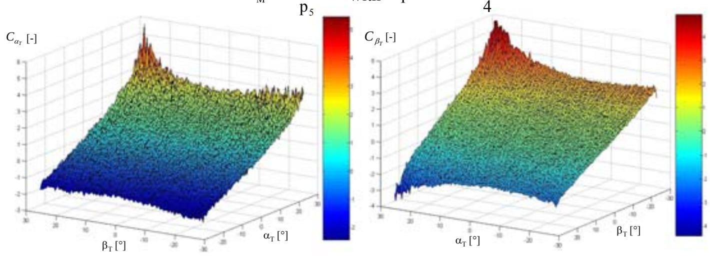

Fig. 5: $C_{\alpha_T}(\alpha_T, \beta_T)$ (left) and $C_{\beta_T}(\alpha_T, \beta_T)$ (right) for u = 20 m/s

$-27° \le \alpha_T \le 27.075°$, $-27° \le \beta_T \le 27.075°$, $\Delta\varphi = 0.525°$ ⇒ number of measuring points = 10609

- Examination of the calibration with a post measurement, determination of the empiric standard divergences s and the measuring accuracy of the 5-hole probe:

$$s_{\alpha_T} = 1.1° \qquad \alpha_T = \alpha_{T,i} \pm 1.1°$$
$$s_{\beta_T} = 0.60° \quad \Rightarrow \quad \beta_T = \beta_{T,i} \pm 0.60°$$
$$s_u = 0.18\frac{m}{s} \qquad u = u_i \pm 0.18\frac{m}{s}$$


## References:

- Wörrlein, K.: *Kalibrierung von Fünflochsonden*, Bericht Technische Universität Darmstadt, Fachgebiet Gasturbinen und Flugantriebe, 1990
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