A NEW TEST FACILITY FOR ADVANCED TESTING OF VARIABLE INLET GUIDE VANES

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ABSTRACT

Integrally geared compressors with a multi-shaft centrifugal design are commonly used in energy intensive (petro-)chemical industry, steel processing, and air separation units. In order to reduce operating costs, a power supply oriented operation of these compressors becomes particularly interesting on volatile electricity markets. The power supply oriented operation will, however, only be profitable if the exploitation of energy price fluctuations outperforms the expenses due to a decreased efficiency of the compressor service off the design point.

Variable inlet guides vanes (VIGV) are an essential control unit of integrally geared compressors and their operating point adjustment. Correspondingly, the limits of the efficient operation range of a VIGV will always limit the flexibility of the entire compressor. Therefore, improvements on the VIGV are essential to enable a flexible and efficient compressor operation. In order to extent the operation limits of the VIGV, common blade designs were reconsidered. Stark & Böhle [1] and Moheseni et al. [2] tested a variety of aerofoil concepts in regard to an increase of the efficient deflection range. Their most promising approach, the split vane, was further developed and evaluated by Händel et al. [3]. Secondary flow phenomena, however, were not considered within the previously mentioned measurements nor within further known experimental investigations on VIGVs. Due to the superimposition of secondary losses and profile losses, it has to be expected that the predicted improvements of the efficient VIGV deflection range will not fully apply to the VIGV application in service. For this reason, a new wind tunnel facility was commissioned at the Bundeswehr University Munich which enables the extensive, more application-oriented tests on annular VIGV cascades.

The measurement section as depicted in Figure 1 features the core of the newly setup VIGV wind tunnel. It provides both probe and optical access to the inflow and the outflow of the VIGV. In total, six discrete cross sections can be accessed by six probe supply bores, whereof two are located upstream and four downstream of the VIGV. The circumferential and radial probe position of the available cross sections a_1 to b_4 can be accessed by a fully automated traverse unit. A space-saving design of the bearings enables an axial probe position as close to the VIGV blades as possible. The radial positioning of the probe, in contrast, is enabled by a linear guide rail. Due to anticipated high gradients of the circumferential flow deflection, a third stepper motor was implemented in order to pivot the probe along the shaft axis. This permits an automated alignment of the probe into the circumferential flow direction. Measurements off the calibration range can thus be avoided.

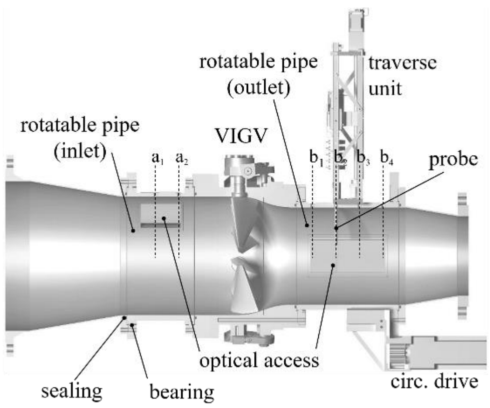

Figure 1. Layout of the measurement section

Furthermore, optical access to the flow is available via bent glass panes at the in- and outflow region of the guide vane. Accordingly, probe measurement techniques, like five-hole probes or hot wire anemometry, can be complemented in future by optical methods without the spatial restrictions of the probe procedures. Particle image velocimetry (PIV), for instance, can supplement the probe measurements in the wake and the secondary flow regions, whereas pressure sensitive paints (PSP) provide the option to gain the pressure distribution on the entire blade surface.

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