

## Investigation of off-design conditions in a radial pump by using time-resolved-PIV

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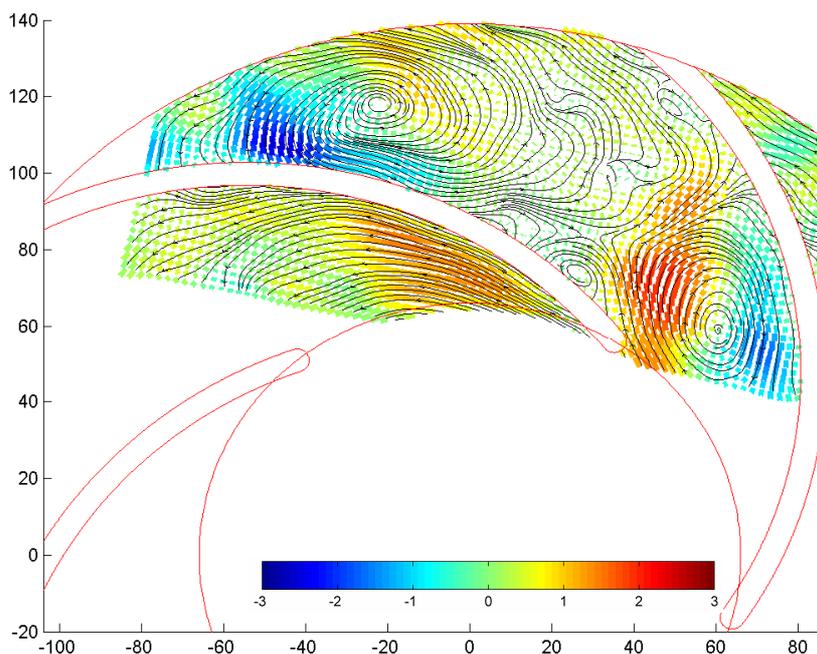
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In industrial applications turbomachineries are not only used in their design point, but also at significant lower or higher flow rates. It was indicated that in head installations over 50% of the time pumps operate at under 25% of the design flow rate. This operating range is limited on the low flow rate side by instabilities in flow leading parts of the machinery. For these operating conditions vortices are created due to the separation of the boundary layer from the walls of the flow-leading parts of the machine, e. g. in the impeller. These unique or multiple stall cells can start to propagate at a fraction of the rotor speed in the impeller when the flow is further throttled. They induce very strong pressure oscillations and as a result machine parts can even be destroyed. It is very difficult to describe these phenomena physically and especially mathematically, because they depend on many operational parameters of the considered turbomachinery.

In the present experimental set-up a radial pump is investigated for various operating conditions down to rotating stall. To investigate the flow field in every channel of the impeller Time-Resolved PIV is used, so that measurements in transient and unsteady flows of the rotating turbomachinery become possible. In this study acquisition frequencies of 50 Hz and 800 Hz are used with a

1280x1024 pixel CMOS-camera. For a frequency of 50 Hz a measuring series consists of 500 double pictures. This means that it is possible to measure the flow field over 100 rotations of the impeller. These measurements are used to calculate the frequency of the stall cell. The higher acquisition frequencies are used to investigate in more details the flow field in the impeller and characterise. The flow field is measured in each channel of the impeller at the same position. In order to determine the circumferential speed of the rotating stall in the impeller a frequency analysis is applied to the measured flow field. For this each individual velocity vector in the flow field is analyzed using FFT both for the direction and the magnitude of the vector. To obtain a characteristic frequency spectrum of the flow field the mean value of the separate frequency spectra for each vector is then obtained through averaging. The oscillation frequency of the flow field and thus the rotating stall speed can be determined in that way from the measured velocity fields. Typical flow fields in a channel during rotating stall could be characterised. The beginning is located at the inlet of the blade passage on the suction side. Over the blockage until the end of the vortex in the channel the flow fields could be observed. An example with a blocked blade passage is presented in Fig 1 with the transport velocity as coloration and the streamlines for the direction.



**Fig. 1** Blocked channel with two strong vortices in different directions (coloration shows the transport component  $w_m$  in m/s)