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Flow visualization and force measurements on a hovering flapping-wing MAV 'DelFly II'

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Particle image velocimetry measurements and simultaneous force measurements have been performed on the DelFly II flapping-wing MAV, to investigate the flow-field behavior and the aerodynamic forces generated. For flapping wing motion it is expected that both the clap and peel mechanism and the occurrence of a leading edge vortex during the translational phase play an important role in unsteady lift generation. Furthermore, the flexibility of the wing foil is also considered of primary relevance. The PIV analysis shows a strong influx between the wings during the peel but no downward expelling jet during the clap. The force measurements reveal that the peel, oppositely to the clap, contributes significantly to the lift. The PIV visualization suggests the occurrence of a leading edge vortex during the first half of the in- and outstroke, which is supported by a simultaneous augmentation in lift. The early generation of a leading edge vortex during the flex cannot be assessed from the PIV images due to optical obstruction, but is likely to appear since the wing flexing is accompanied with a large increase in lift.

Nomenclature

R	=	wing semispan
ζ	=	deviation angle
θ	=	camera view angle
τ	=	non-dimensional time
φ	=	stroke angle
ψ	=	dihedral angle

I. Introduction

THE development of micro aerial vehicles (MAV) is motivated by the need for autonomous unmanned aerial vehicles to observe barely accessible areas, such as disaster or war areas, wildlife reserves, high constructions etc. Such missions require a small and highly manoeuvrable airplane as a stable camera platform, operating at low flight speed and with the possibility of short landing and take-off[1]. In contrast to the usual fixed wings, rotary wings generate both lift and thrust resulting in a high manoeuvrability and low flight velocity. However the complexity of the construction, the marginal stability and the low efficiency limit the utilization of helicopters for the applications considered above. A solution to this problem is believed to be found in nature. Flapping wings, as used by birds and insects, generate lift and thrust and subsequently introduce a favourable manoeuvrability and wide flight envelope. A stable and fully controllable vehicle can be achieved with a relatively simple drive mechanism that offers the potential of miniaturization.

Figure 1. DelFly II *in hovering flight*

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