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Experimental Investigation of Wing Tip Vortex

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Particle image velocimetery was used in a low-speed wind tunnel to investigate and characterize wing tip vortex structures. A rectangular wing of a SWIM model was used as a vortex generator in two different configurations, (i) plain wing and (ii) flapped wing with trailing edge flap extended at 20 degrees. Vortex flow quantities and their dependence on angle of attack at a chord base Reynolds Number of 32.8x103 and 43.8x103 were evaluated. Assessment of measured data reveals that the peak values of tangential velocities, vortex strength and vorticities are directly proportional to the angle of attack. The vortex core radius value grows slowly as the angle of attack is increased. Both plain and flapped configurations showed similar trends. The peak tangential velocities and circulation distribution doubled when the flapped configuration was used instead of the plain wing.

Nomenclature

c	=	chord length
k	=	number of points
r	=	radius
r_c	=	core radius
Re_c	=	Reynolds number based on chord
SG	=	specific gravity
V_∞	=	free stream velocity
v_θ	=	tangential velocity
x	=	streamwise coordinate
y	=	spanwise coordinate
z	=	transverse coordinate
α	=	angle of attack
δ	=	flap deflection angle
Γ	=	circulation

I. Introduction

Trailing vortices behind aircraft are inevitable consequences of the creation of lift. It generates downwash on the aircraft wing, which reduces lift and increases drag. Since trailing vortices tends to persist for many miles behind the aircraft, they pose a potential hazard for the follower aircraft. Wake vortex encounter is most likely near airport runways both because planes are likely to fly in close proximity when they are near the runway, and because the tip vortex circulation is maximal when a plane is taking off or landing[1]. Chow et al[3] examined the roll-up process of wing tip vortices in terms of mean flow field and Reynolds stresses tensor at x/c=0.678 downstream (x is the downstream distance from trailing edge and c is the chord length) using a seven-hole pressure probe. They found that the axial velocity in the vortex core reached 1.77 times the free stream velocity just upstream of the trailing edge and turbulence levels in and around the vortex were initially very large but decayed rapidly. Significant tip vortex

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