Computational Acoustic Analysis on Trailing Edge of Serration Wing for Reducing Instability Noise

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***Abstract* -This paper presents an experimental study of the effect of trailing edge flat wing, wavy serrations and sawtooth serrations on airfoil instability noise. Detailed aero acoustic measurements are presented of the noise radiated by an NACA-0018 airfoil with trailing edge serrations in a low to moderate speed flow under acoustical free field conditions. The wavy serrations are found to be effective in reducing noise, compared to flat wing and sawtooth serration wing. The serration flap angle and airfoil incidence are varied in order to study the effect of secondary flow establishing between the suction and pressure sides of the serrations. The flow topology around the serrations is inferred from the analysis of time-averaged streamlines close to the airfoil surface and from the wall-normal flow velocity in between serrations.**

Broadband noise reduction by the serrated sawtooth trailing edge can be realistically achieved in the flat plate configuration, but wavy serration overcomes the sawtooth serration noise reduction around 1db.The variations of wall pressure power spectral density and the spanwise coherence (which relates to the spanwise correlation length) in a wavy serration trailing edge play a minor role in the mechanisms underpinning the reduction of self noise radiation.

Keywords – Sound absorption, Acoustic power level (db), Velocity (m/s), Wing without serration, Wingwith serration, Wavy serration.

I. INTRODUCTION

Broadband airfoil noise emissions that originate due to the interaction of the airfoil turbulent boundary layer with the sharp trailing edge (Brooks et al. 1989) have been shown to be effectively reduced using trailing edge serrations. Evidence of this has been observed in acoustic measurements performed both in wind tunnel experiments (Gruber et al. 2013; Moreau and Doolan 2013; Dassen et al. 1996) and on full-scale wind turbines (Schepers et al. 2007; Oerlemans et al. 2009). For the latter, airfoil self-noise reduction is relevant in relation to the observance of noise limits established by local regulations. Furthermore, experimental studies related to the flow around serrations and surface pressure characterization have also been previously performed (Chong and Vathylakis 2015; Finez et al. 2011; Arce et al. 2015).An analytical model for the prediction of the noise emitted from a sawtooth serrated trailing edge has been proposed by Howe (1991a,b).It yields the nondimensional acoustic power spectrum, Ψ , of the serrated trailing edge with respect to the reference spectrum of the straight trailing edge Ψ0, , as a function of serration wavelength, and amplitude, 2*h* (see Fig. 1 for the geometric definition of wavelength and 2*h*)

$$\Psi(\omega)=\Psi 0 / (1+(4h/ /l)$$

Where ω is the angular frequency of the acoustic pressure fluctuations.

The above relation has been derived under the assumption of frozen turbulence convected across the trailing edge. In particular, the time-average streamlines are assumed to remain aligned with the freestream direction. For an airfoil at incidence, the transverse fluid motion induced by the pressure unbalance between suction and pressure side limits applicability of the theory as commented by Howe(1991b).result for flat wing.

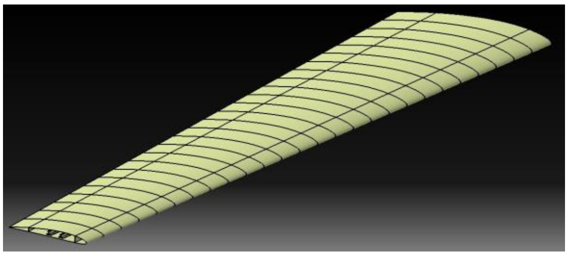

Fig.1 Flat wing.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 07, July-2018

Fig. 2 Airfoil cross section and serrated trailing edge flap. Angle of attack, α, and the serration flap angle, φ, are shown

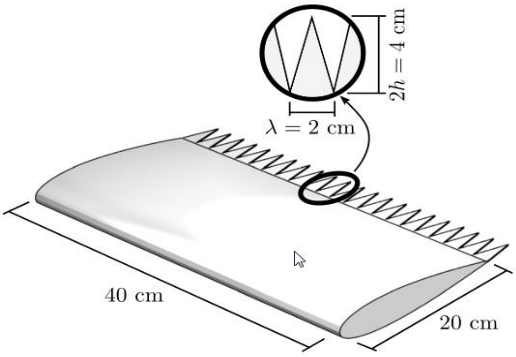

Fig.3 Sawtooth serration on wing.

II. ACOUSTIC MEASUREMENT

The acoustic measurement has been done by using FEA software. The design of the wing section having dimension of wing chord length of 200mm and wing span of 400mm and the maim thickness of the wing is 35mm. A flat wing consist of the above dimension and the serrated wings such as sawtooth serration and wavy serration trailing edge has been extended 40mm. The length of the serrated edges having 20mm then the height of the serration is 2h is 40mm.The sawtooth serration having sharp edges and the wavy serration having curved edges. Then the outer section has been designed with the dimension of 4L from the leading edge, 4.5L from the trailing edge. The total height of the outer section becomes 4L (2L from the center of the airfoil). Then the airfoil is considered as a soil then the outer section is considered as a part body. The acoustic measurement calculate in supersonic speed velocity of 400m/s.

Then it has been meshed, size of 1.5e-002. Then the acoustic power level has been measured. The flat trailing edge produces the more noise,but in the serrated trailing edge produces less noise level compared to flat. The serration has been studied in several forms: M-shaped [3,4], wavy[5] and sawtoot. This paper focuses specifically on the sawtooth shape and wavy serration.In this paper explained,the wavy serration reduces the more noise compared to sawtooth serration.

III. AIRFOIL WITH SERRATED TRAILING EDGE

The effect of adding the serrated trailing edge on the flowfield will be examined in this section. As it will be shown, the flow field in this case is characterized by a three dimensional, secondary flow. Attention is focused first on the characterisation of the spanwise inhomogeneity of the time-average flow. The streamwise flow fields at two planes (through the peak and the trough)are shown in Figure17. The flow patterns in these two planes resemble the patterns around a straight and blunt trailing edge, respectively.

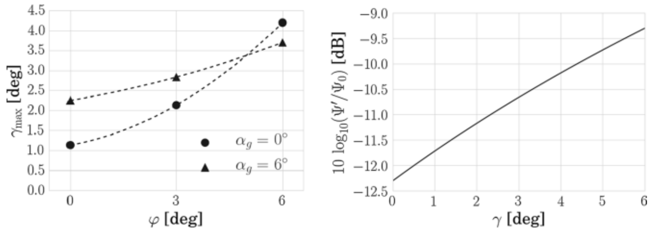

Fig. 4 Values of γ for different cases measured over the serration trailing edge (*left*). Expected influence of γ on Eq. (4) (*right*) max

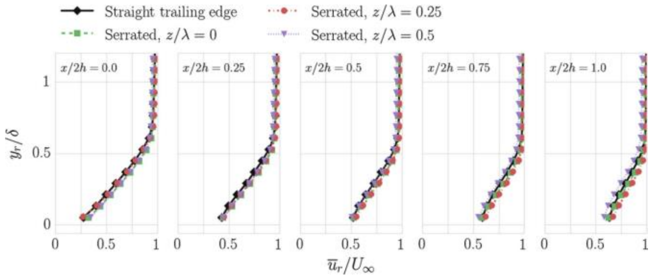

Fig. 5 Profiles over the wallnormal coordinate direction of *ur* for the straight trailing edge and three spanwise locations ofthe serrated edge for a ag= 0◦ and ϕ = 0◦

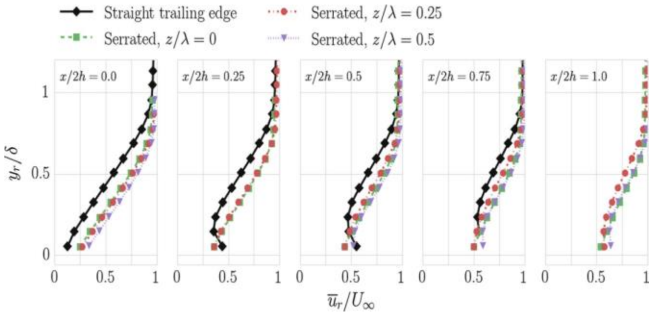

Fig. 6 Profiles over the wallnormal coordinate direction of *u r* for straight and serrated trailing edge for a *g*= 12◦ and ϕ = 0◦. Suction side.

IV. RESULT

In this paper presented the wavy serration reduces the 1db noise compared to acoustic level of flat wing and sawtooth serration.this result has been shown by using FEA software.

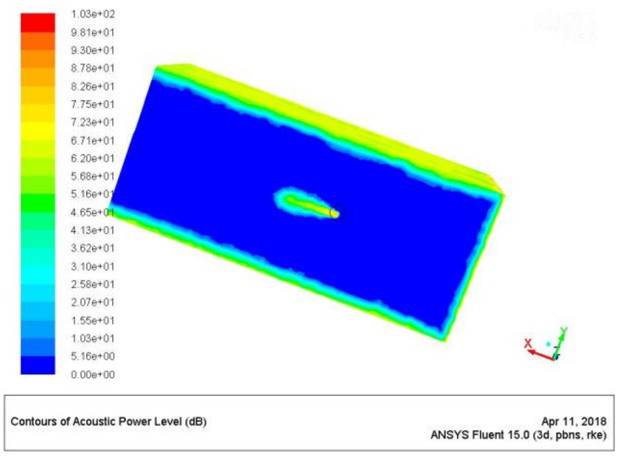

Fig. 7 Acoustic level measurement for flat wing

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 07, July-2018

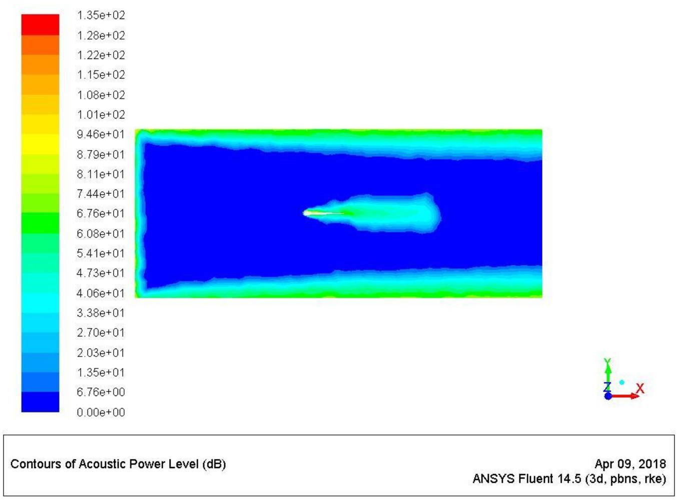

Fig. 8 Acoustic result for sawtooth serration wing.

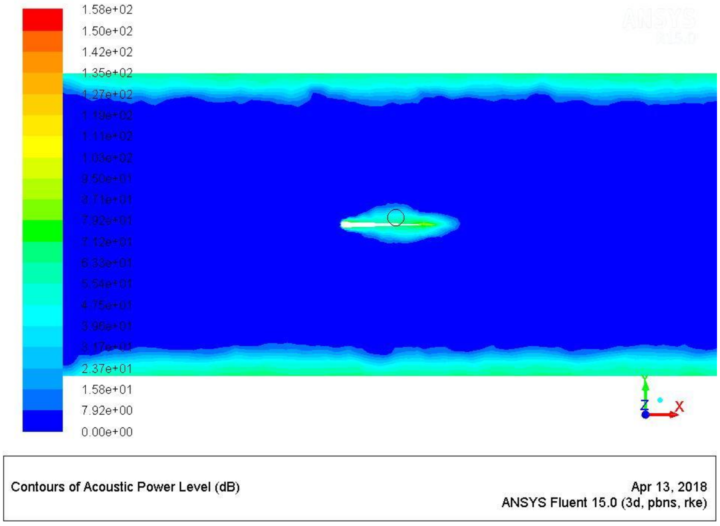

Fig. 9 Acoustic measurement of wavy serration.

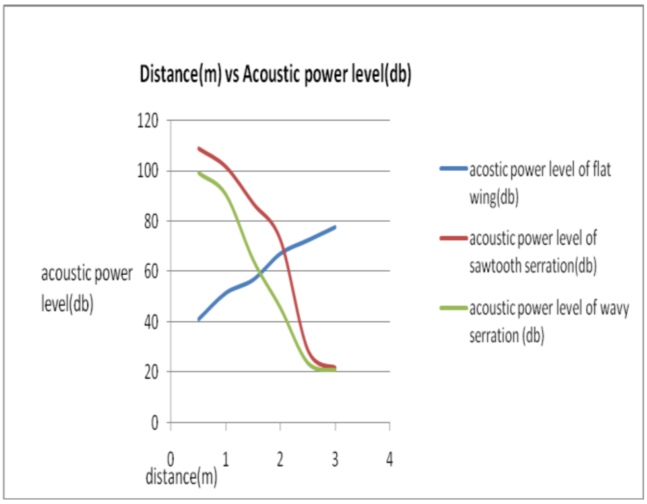

Fig. 10 Comparison graph for flat wing, sawtooth serration and wavy serration

V. CONCLUSION

The mean topology and the turbulence statistics of the flow near trailing edge serrations have been studied using FEA(finite element analysis) software.thus the acostic level(db) of the flat wing,sawtooth serration and wavy serration at trailing edge has been anlysed. The results of the mean flow measurements input to a simplified version of the model in Howe (1991b)that estimates relative noise reduction on the basis of the local angle between the flow and the trailing edge.

The study is complimented with acoustic measurements,by which it is shown that the serrated trailing edge effectively reduces the turbulent boundary layer trailing edge noise of the airfoil, although to a lesser extent than that which the prediction suggests. This is consistent with experimental findings reported in the literature.

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