A NUMERICAL METHOD OF CALCULATING PROPELLER NOISE INCLUDING ACOUSTIC NONLINEAR EFFECTS*

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Using the transonic flow fields(s) generated by the NASPROP-E computer code[1] for an eight blade SR3-series propeller, a theoretical method is investigated to calculate the total noise values and frequency content in the acoustic near and far field without using the Ffowcs Williams - Hawkings equation[2]. The flow field is numerically generated using an implicit three-dimensional Euler equation solver in weak conservation law form. Numerical damping is required by the differencing method for stability in three dimensions, and the influence of the damping on the calculated acoustic values is investigated. Since the propeller flow field includes the wave systems near the propeller blade surface, the quadrupole noise source term is accounted for as are the monopole and dipole noise sources. The acoustic near field is solved by integrating with respect to time the pressure oscillations induced at a stationary observer location. The frequency spectrum at the specified observer location is calculated by representing the pressure time-history by a Fourier series and calculating the noise levels for an appropriate number of harmonics of the fundamental frequency[3,4]. Comparisons between the theoretical model and the experimental results of Dittmar, et.al[5] have been made for the SR-3 propfan, and found to be within 4% for the acoustic near field in the propeller disc plane[6]. The acoustic far field is calculated from the near field primitive variables as generated by NASPROP-E computer code using a method involving a perturbation velocity potential as suggested by Hawkings[7] in the calculation of the acoustic pressure time-history at a specified far field observed location. The methodologies described are valid for calculating total noise levels and are applicable to any propeller geometry for which a flow field solution is available.

References

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*This work is supported by NASA Lewis Research Center Grant NAG 3-354.
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