inter·noise 83

MEASUREMENTS OF PROPELLER-DRIVEN AIRCRAFT NOISE

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INTRODUCTION

After the years of rich development commercial aviation which is connected with the large and the rather rare aerodromes in the seventies of general aviation noise control was not limited to this type of aviation. General aviation makes use of small air fields which are positioned near cities. For example more than 280 of these fields are in West Germany. West Germany and Switzerland were the first countries which introduced noise limits for the light propeller aircraft. Currently, all over the world, one of the conditions for the issue of an airworthiness certificate for civil propeller--driven aircraft, is measurement of their noise levels and issue of a special noise certificate, based on internationally approved standard Annex 16 ICAO. The rules are permanently growning more strict.
The A-weighted sound pressure level compared to Annex 16 Chapter 6 Noise Limits are shown in Fig. 1.

RESEARCH

In Poland the research are carried out to help designers in their difficult duties. The difference between the noise levels generated by the propeller--driven aircraft with the same gross weight evidence the scale of this problem. During the investigation which was bound with the identification of the main noise sources in light aircraft it is noted that the dominant source is propeller on the condition that the exhaust of gasses was equipped with the effective muffler. The sound pressure level was measured around the airplane on the ground at the radius R = 50. The first harmonic of the propeller in comparison with the first harmonic of the exhaust and the overall sound pressure level explicitly testify to dominante of the propeller noise. The investigations were realized in three directions.

1. The distribution of the sound field around the motor glider was compared for two cases when it was equipped with two types of the piston engines: Limbach, Franklin.
2. The one-third octave band sound pressure levels were confronted with the agriculture aircraft equipped with the reduction gear and without it.
3. Noise generated by the light airplane which was flown at 305 m was measured for two cases:

a/ the aircraft was equipped with the standard and with the modified propeller

b/ the aircraft was equipped with the effective muffler and without it.

STUDY OF THE PROPELLER NOISE

Recent increases in interest in propeller noise generation and reduction have resulted in number of research and development studies. Results from these investigations were reviewed with a view to determining noise reduction methods which could be applied to study aircraft noise. Propeller noise control approaches considered were:

- reduction of Tip Mach Number
- change of Airfoil Section
- reduction of Propeller Diameter
- increase in Number of Blades
- reduction of Blade Loading
- Blade Sweep
- change of Tip Shape
- irregular Blade Spacing
- Ducted Propeller

Change of the above parameters are not always sensible. The propeller performance characteristics are always finally the factor to selection of the correct method of the conduct.

STATISTICAL ANALYSIS

Several flight test programs have been conducted recently with the objective of obtaining empirical relationships between far field noise levels, particularly A-weighted levels, and propeller geometry or operational conditions. A recent test program by ICAO Committee on Aircraft Noise /CAN/ Working Group C has been reported in /1/. On the grounds of this data they were tested with the help of the regression analysis.

Relationships between Helical Tip Mach Number of propeller's blade and A-weighted sound level are shown in Fig. 2. Analysis of the results in /2/ shows that not only Helical Tip Mach Number scores the high value of the correlation coefficient. Power coefficient and the advance ratio clear construction parameters of the propeller have the high value of the correlation coefficient too /Fig. 3 and Fig. 4/. These factors were put to the equation of the multiple regression.

FLIGHT TEST DATA

The standard for aircraft up to 5700 kg take off weight limits the noise level during overflight at the altitude H = 300 m /above ground/. The experience got out of practice evidence that this kind of measurement does not describe noise produced by all sorts of propeller aircraft. The issue lies in that certification limits ought to produce an effect in the best possible manner on improving a new design. The realization should take noise control into account right in the source.
In these days now our attention is fixed on propeller's noise characteristic. The peculiarity of propeller noise is taken as a point of issue to unify the certificate procedures for all types of propeller-driven aircraft /general aviation, agriculture aviation, aerobatic aircraft, etc./. Usage of adequate calculations based on these measurements can give a definition of optimal noise control flight.

REFERENCE

1 ICAO Committee on Aircraft Noise /CAN/, Working Group C, Meeting March 3-5, 1982, Working Paper of U.S. Representative.

2 A.Chyla, "Some Mathematical Models for Describing the Acoustic Properties of Airscrews", Works - Institute of Aviation, no 91/1982, Warsaw, 29-62

3 A.Chyla, "Akustyczna ocena śmigieł lotniczych", Instytut Lotnictwa, GE-059, Warszawa, 1982.

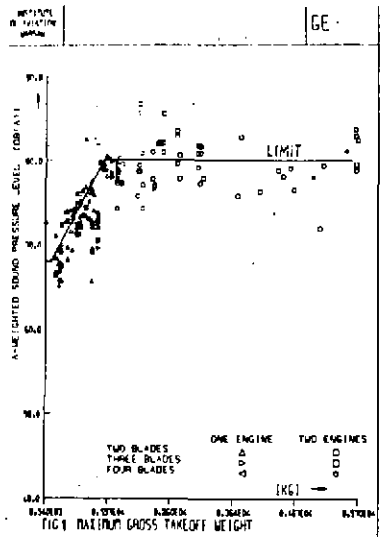

FIG 1 MAXIMUM GROSS TAKEOFF WEIGHT

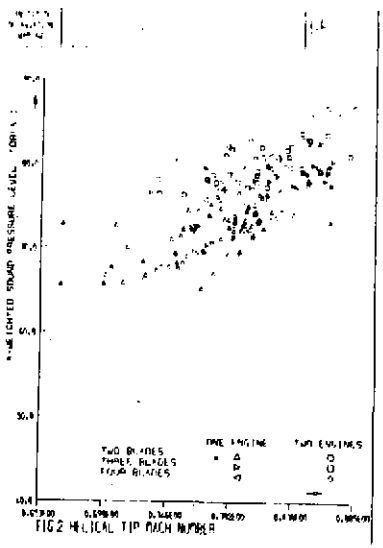

FIG 2 HELICAL TIP MACH NUMBER

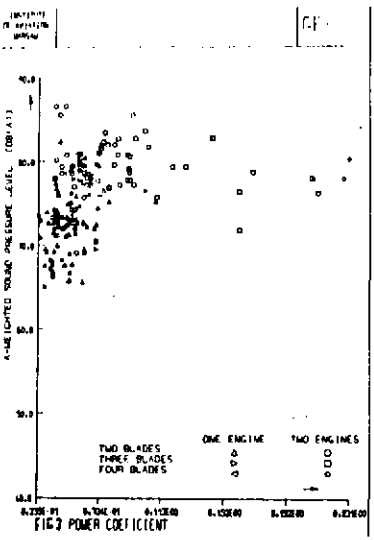

FIG 3 POWER COEFICIENT

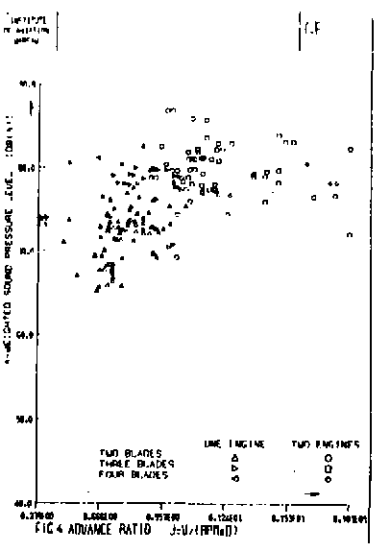

FIG 4 ADVANCE RATIO