

# NOISE SUPPRSSION IN AIRCRAFT

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## ABSTRACT

Noise is something which is unwanted. Today, the problem of noise has been increasing day by day. From taking household equipment's like music systems, washing machines to Transportation like AIRCRAFTS, noise pollution has reached its topmost level. The main purpose of this research is to review how noise can be suppressed in aircrafts. The main reasons which are producing noise in aircrafts are high turbulence structure created in the jet shear (aerodynamic noises), noises from the aircraft engines and various other mechanical noises. Here in this paper we will mainly focus on the noises generated by the aircraft engines. Various methods of suppressing this noise has also been discussed like: - By changing the shape of the nozzle, larger bypass ratio, introduction of some special kind of liners and many more.

## Keywords

JET ENGINES NOISE, BYPASS RATIOS, NOISE SUPPRESSING TECHNOLOGIES.

## 1. INTRODUCTION

Aircraft noise has always been a headache, and even though some piston-engine plane generated noise that many found disturbing, it was the arrival of jet engines that increased the level of noise on many aircraft. The noisy turbojet engines prompted complaints about "noise pollution" from surrounding communities. Airport rules and regulations, aircraft noise certification requirements, all of which govern the maximum noise level aircraft are permitted to produce, have made jet engine noise suppression one of the most important fields of research. The unit that is commonly used to express noise annoyance is the Effective Noise decibel (EPNdb).

The data that depicts how much a noise a turbojet plane can generate: -

Source	Decibels (dB)
Turbo jet airplane	150
Truck without muffler	90
Noisy class, gymnasium, alarm clock, police whistle	80
Average residence	40
Quiet room	20
Lowest audible sound	0

Airframe self-generated noise is a factor in an aircraft's overall noise signature, but the principal noise source is the engine.

## 2. SOURCES OF NOISE FROM VARIOUS PARTS OF JET ENGINE

### 2.1 Engine Noise

The significant sources which plays role in generating noise are fan or compressor, turbine and the exhaust jet or jets. These noise sources follow different types of laws of generating noise but the major role is of relative airflow velocity. There is a lot of variation of noise intensity as compared to noise produced by compressor or turbines compared to exhaust jet velocity.

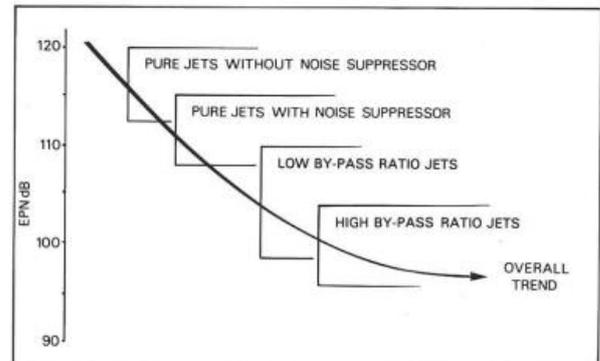
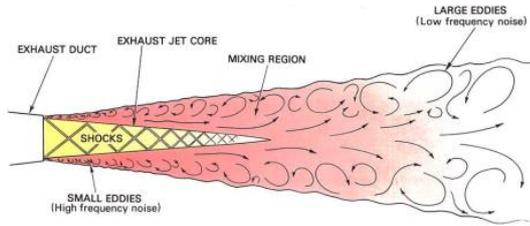


Figure 1: Comparative noise levels of various engine types

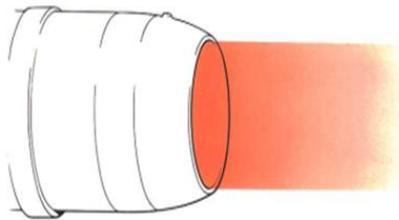
Jet exhaust noise forming principle works in the way that when there is turbulent mixing of exhaust gases with atmosphere and there is shearing action which is caused by the relative speed between the exhaust jet and atmosphere, huge noise is produced. Near by the end of exhaust duct formation of eddies take place. The smaller eddies near the duct causes high frequency noises whereas the larger eddies down the downstream results in low frequency noise.

Also, when the exhaust speed exceeds the speed of sound shock generation takes place. This produces a single frequency tone and also there is amplification of the mixing noise.

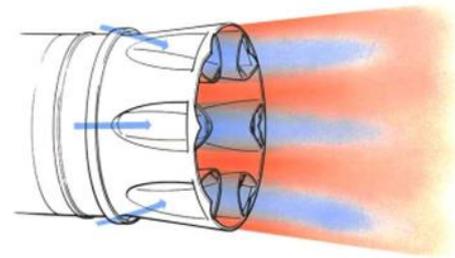


**Figure 2: Exhaust mixing and shock structure**

To overcome this problem an effective method can be adapted like changing the shape of the nozzle which can ensure the higher mixing rate.



**Figure 3: Plain Nozzle (low mixing rate) HIGH LEVEL NOISE**



**Figure 4: Suppressor Nozzle (high mixing rate) REDUCED NOISE LEVEL**

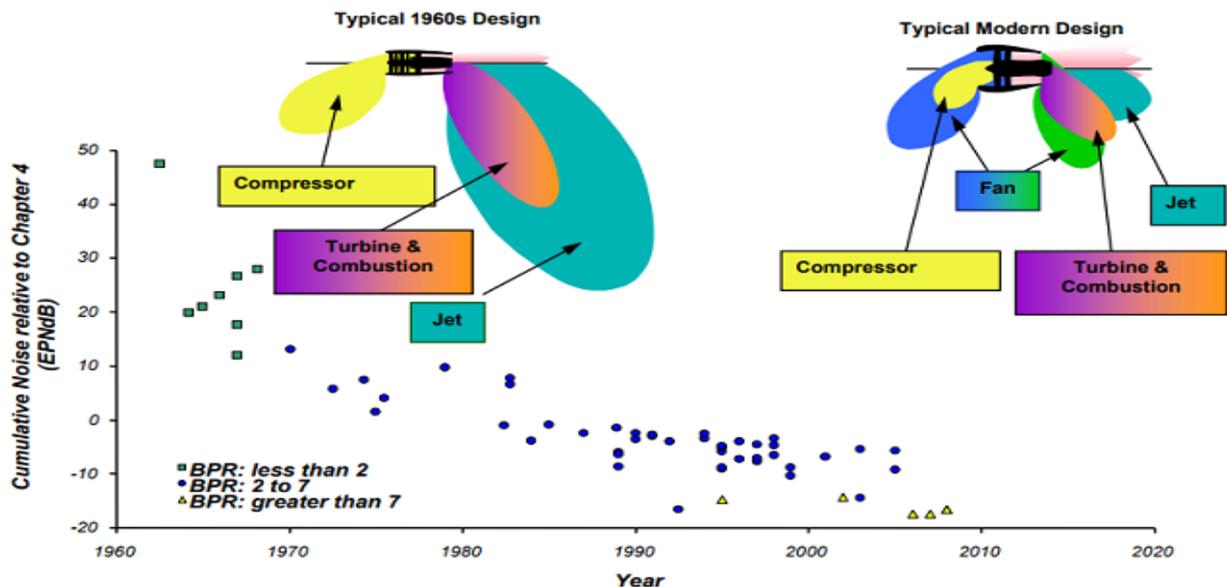
### 2.2 Compressor and Turbine Noise

Compressor and turbine generally not plays a huge role in generating noise, but they also produce a healthy amount of noise. For compressors, the rotor-stator interaction plays a major role especially due to the close rotor/stator coupling which may excite the potential field interaction between the adjacent blade rows in addition to the viscous wake interaction. This wake intensity is largely dependent upon distance between the rows of blades and vanes. If the distance is short then there is an intense pressure field interaction which results in a strong tone being generated. The turbine works on the same principle and moreover the bypass ratios plays a huge role.

### 2.3 Miscellaneous Noises

These noises include the combustor noise which is of least attention to research. It is of least importance as it is situated in the core of the engine, hence difficult to examine. Along with these various mechanical noises are that during the landing or take-off approach.

## Significant progress in reducing aircraft noise



**Fig 5: Significant progress in reducing jet noise by achieved by the introduction of high by-pass ratio engines**

### 3. METHODS OF SUPPRESSING NOISE

Noise suppression of internal sources can be mainly minimized in two ways: -By changing the basic design to minimize the noise originating within or propagating from the engine and by introducing the various types of acoustic liners. Noise can be minimized by reducing airflow disruption which causes turbulence. This is achieved by using minimal rotational and airflow velocities and reducing the wake intensity by appropriate spacing between the blades and vanes. The ratio between the number of rotating blades and stationary vanes can also be advantageously employed to contain noise within the engine.

#### 3.1 Shorter or rapid mixing region

Low bypass engines and exhaust jet are the main reasons of generating noise. To overcome this problem, we have to introduce the shorter or rapid mixing region. Although it reduces the low frequency level and increases the high frequency level but luckily high-level frequencies are readily absorbed by atmosphere and the noises which are not absorbed are beyond the audible range. This can be achieved by increasing the contact surface of the atmosphere with the exhaust gas stream by using a special type of propelling nozzle.

##### 3.1.1.1 Corrugated Nozzle

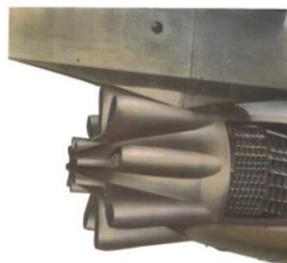
In the corrugated nozzle, freestream atmospheric air flows down the outside corrugations and into the exhaust jet to promote rapid mixing.

##### 3.1.1.2 Lobe-Type Nozzle

In the lobe-type nozzle, the exhaust gases are divided to flow through the lobes and a small central nozzle. This forms a number of separate exhaust jets that rapidly mix with the air entrained by the suppressor lobes. Deep corrugations, lobes, or multi-tubes, give the largest noise reductions, but the performance penalties incurred limit the depth of the corrugations or lobes and the number of tubes. For instance, to achieve the required nozzle area, the overall diameter of the suppressor may have to be increased by so much that excessive drag and weight results.



CORRUGATED INTERNAL MIXER



LOBE-TYPE NOZZLE

### 3.2 High By-pass Engines

These engines have mainly two exhaust streams to eject to atmosphere. However, the principle of both high and low by-pass engines is nearly the same i.e. minimize the exhaust jet velocity within overall performance objectives. High by-pass engines inherently have a lower exhaust jet velocity than any other type of gas turbine, thus leading to a quieter engine, but further noise reduction is often desirable. The most successful

method used on by-pass engines is to mix the hot and cold exhaust streams within the confines of the engine and expel the lower velocity exhaust gas flow through a single nozzle.

#### Bypass Ratios

It is defined as the ratio of the mass flow rate of the bypass stream to the mass flow rate entering the core. The introduction of a single stage low pressure compressor dominantly reduces the noise because the turbulence and interaction levels are diminished. Bypass ratios plays a huge role in reducing noise factor because if the bypass ratio is approximately more than 5, then the exhaust jet noise is reduced to such a level that the internal noise sources are more dominant. Along with this, high bypass ratios not only calm down the noise but also make the aircraft more fuel efficient.

### 3.3 Acoustic Liners

Noise absorbing 'lining' material converts acoustic energy into heat. The absorbent linings normally consist of a porous skin supported by a honeycomb backing, to provide the required separation between the face sheet and the solid engine duct. The acoustic properties of the skin and the liner depth are carefully matched to the character of the noise, for optimum suppression. The disadvantage of liners is the slight increase in weight and skin friction and hence a slight increase in fuel consumption. They do however, provide a very powerful

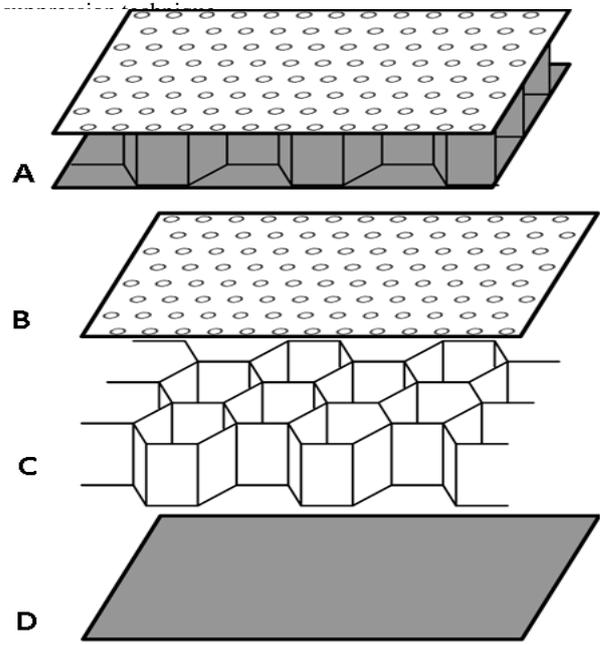


Figure 6: A composite sandwich acoustic liner (A) with perforate face-sheet (B) honeycomb core (C) and back-skin (D)

Along with this NASA Langley Research Center, in collaboration with Boeing and Lockheed Martin, has developed a new external acoustic liner for aircraft noise reduction. While the acoustic liner can be placed on any external aircraft surface, one attractive application is for open

rotor noise reduction. Airframe manufacturers are considering open rotor engines for future aircraft designs as they provide significant fuel savings. However, open rotor engines have no nacelle and, thus, do not allow the use of conventional nacelle liners for noise abatement. This technology strategically places acoustic liners on the external surface of the aircraft to reduce such engine noise.

#### **Benefits**

- Has minimal impact on aircraft weight
- Has minimal impact on aerodynamic characteristics
- Allows for noise reduction in space-constrained areas
- Uses proven noise reduction designs
- Can be easily retrofitted in some areas of the aircraft

#### **4. CONCLUSION**

Noise suppression in aircrafts being the major concern in today's scenario has a great scope of doing research. This paper is totally based on ways how the noise is produced in aircrafts and how the modern technologies deal with it. All the

technologies prevailing today has both pros and cons and that's the part and parcel of everything. Corrugated nozzles, lobe-type nozzles, acoustic liners are some of the ways used most drastically and many more other technologies are under research.

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