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NOISE REDUCTION IN COMMERCIAL AIRCRAFTS

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Abstract **:** Aircraft noise has been a public concern since the beginning of commercial jet powered aviation. Historical progress in noise reduction has been significant and largely made possible through land use planning, noise certification, and investment into low noise technology development. More recent progress however shows increasingly diminishing returns and suggests that new avenues may need to be discovered to pursue the aggressive noise reduction goals of the present and the future. This paper focuses on the research efforts in noise reduction in commercial aircrafts by modelling and analysis of aircraft structures and in Propulsion Airframe Aeroacoustics (PAA) through advanced engine installations and configurations, which is offered as an avenue that has potential to provide significant noise reduction. Several aircraft configurations and engine installations, both conventional and advanced, that are designed to take advantage of airframe shielding of engine noise are presented and discussed from both a PAA and a general design perspective. Other, non-shielding related PAA opportunities are also presented. Challenges to the eventual introduction of advanced aircraft configurations are discussed.

Keywords— *PAA(Propulsion Airframe Aeroacoustics) , Airframe shielding.*

INTRODUCTION

From the beginning of commercial jet powered aviation, the impact of aviation generated noise on the surrounding communities and the traveling public has been a significant issue. The measures that have been implemented to mitigate the noise problem have included land use planning, aircraft noise certification regulations,and airport noise restrictions. The latter two measures in particular have contributed to motivating the research and development of noise reduction technology. Covering a period of several decades from the introduction of the first jet powered aircraft. The progress in net noise reduction from a variety of aircraft models and engines that have been certified.

Using the Effective Perceived Noise Level (EPNL) at the sideline certification point (normalized to 100,000 lb of thrust) as the metric, the overall reduction has been about 20 dB. The majority of the reduction which occurred in the first three decades was due primarily to the introduction of high bypass ratio turbofan engines. The progress since about 1980 however has not been as dramatic and a much slower rate of noise reduction is observed. Even though production aircraft meet certification requirements, continued growth in air traffic and the limited introduction of new airports results in strong demand for the continued implementation of noise reduction technology. Another obvious implication is that the difficulty and cost of introducing new technology that significantly impacts noise reduction is increasing as the bulk of the noise reduction from higher bypass ratio engines has been achieved. This implication leads to the question of what are the opportunities and challenges to enable the next substantial amount of noise reduction similar to that achieved by the high bypass ratio engine.

LITERATURE REVIEW

An important pillar of the Balanced Approach to Aircraft Noise Management is the reduction of noise at source. Aircraft noise ("noise at source") has been controlled since the 1970s by the setting of noise limits for aircraft in the form Standards and Recommended Practices (SARPs) contained in Annex 16 to the Convention on International Civil Aviation (the "Chicago Convention") . This continues to be the case today. The primary purpose of noise certification is to ensure that the latest available noise reduction technology is incorporated into aircraft design and demonstrated by procedures that are relevant to day-to-day operations, in order to ensure that noise reductions offered by technology are reflected in reductions around airports.

Types of noises

Airframe Noise :

An airframe noise occurs when air passes over the plane's body and it wings. This cusses friction and turbulence, and make noise. Even gliders make a noise when in flight and they have no engines at all. Planes land with their flaps down and their landing gear deployed. This creates more friction, and produces more noise, than when the flaps are up and the landing gear is stowed. The aerodynamic noise which is created by all the non-propulsive components of an aircraft is classified as airframe noise. For advanced high-bypass engine powered commercial aircraft, the airframe noise has the major role in the overall amount of flight noise levels during landing approach stages, when the high lift devices and the landing-gear are ready to be used. Five main mechanisms are known to significantly contribute airframe noise: (i) the landing-gear multi-scale vortex dynamics and the consequent multi-frequency unsteady force applied to the gear components, (ii) the flow unsteadiness in the re-circulation bubble behind the slat leading-edge, (iii) the vortex shedding from slat/main-body trailing-edges and the possible gap tone excitation through nonlinear coupling in the slat/flap coves, (iv) the roll-up vortex at the flap side edge, (v) the wing trailing-edge scattering of boundary-layer turbulent kinetic energy into acoustic energy. Since the Seventies most of these mechanisms have been addressed both empirically and theoretically.

Flap noise:

It's too long that flap side edge flows have been recognized as important factor in airframe noise. Vertical flow around the side edge of a deployed flap is one of the most effective sources of airframe noise at landing and takeoff conditions. Additionally, vortex breakdown at high flap angles is observed as an additional noise source mechanism. The noise source mechanisms are the cause of the vortex structure of the cross flows in the flap side edge region. This concept has caused the concepts for noise mitigation like flap side edge fences, seeking to reform the properties of the vortex structure in a desirable approach to reduce the noise from these currents. While there are difficulties in the use of this concept in real aircraft, such as the cost and added weight, its effectiveness in reducing noise –associated with flap has been shown to be very clear . These successful demonstrations include both simplified flaps and realistic aircraft configurations. Typically, side edge fences can reduce noise by up to 4 dB in the middle to high frequency domain in which flaps are known to be major noise sources. It has been proved in wind tunnel experiments that the fences only alter the local flows in that the overall lift characteristics of the flaps and the high lift systems is not influenced by the fences in any significant way. The vortex structure in the cross flow will be appeared in the surface pressures in the form of distinct spectral humps.

Figure:Flap of wing

Jet noise:

Mixing of the high-velocity exhaust stream with the still air causes Jet noise, which causes friction. When these two Streams at different velocities are mixed, significant amount of turbulence is created, with the intensity of the turbulence, and hence the noise increases as eighth power of the velocity difference. Modern bypass engines, which introduce a layer of moderately fast moving cold air between the hot exhaust and the ambient air, are quieter than early jet engines, which didn't use this technology. Engine noise is created by the sound from the moving parts of the engine and by the air coming out of the engine at high speed and interacting with still air, creating friction. Most of the engine noise comes from the exhaust or jet behind the engine as it mixes with the air around it. Modern bypass engines introduce a layer of moderately fast-moving cold air between the hot exhaust and the still air. This makes them quitter than the engines on earlier jets, which didn't use the bypass technology. The degree to which people experience aircraft noise on the ground has a lot of do with atmospheric condition. Temperature wind speed and direction ,humidity ,rain, cloud cover all have a part to play.

Figure :Turbofan Engine

Fan noise:

Reduction of fan noise radiation to the far field can be followed by five general concepts: (i) reducing the interaction mechanisms between an optimal design of the rotor blades and the stator vanes, or to reduces the velocity deficit in the rotor wakes with the flow control techniques, (ii) reduce the aerodynamic response to an impinging gust by tuning of the stator cascade parameters in order to, (iii) to drive only few propagating (cut-on) duct modes by tuning of the rotor blades and stator vanes numbers, (iv) use of passive/active duct wall treatments in order to reduce noise during transmitting from the duct, (v) manipulation of sound diffraction mechanism in exhaust nozzle and at the inlet lip through advanced nacelle devices.

RESEARCH AND IMPLEMENTATION

In order to set a new noise Standard in future, an understanding of current research and technology development is imperative. Technological progress continues to push the aviation community to delivering on the ICAO goal of limiting or reducing the number of people affected by significant aircraft noise. ICAO continually monitors research and development in noise reduction technology, and this complements the Standard-setting process. As reported in the 2013 Environmental Report, CAEP conducted an independent expert review to evaluate expected commercial aircraft noise levels by 2020 and 2030. The review focused on new novel aircraft and advanced engine concepts. More information on the IE review can be found in ICAO Doc 10017. While a full independent expert review was not conducted during the past three years, CAEP has continued to undertake a comprehensive overview of ongoing worldwide aircraft noise reduction efforts and associated goals . As part of the technical monitoring effort, CAEP conducted a status review of the noise technology advancements of helicopters between 2000 and 2015 to highlight the developments since the last helicopter noise assessment report conducted in 2001 (during CAEP/5). The review included examining both noise reduction technologies and the costs associated with those technologies. The results of the helicopter status review was published on the ICAO website in 2016. The report includes an overview of international noise technology programs and research initiatives, key noise reduction technologies of modern helicopters, and the status of advanced noise reduction technologies currently being tested in research programs. Constraints and challenges to incorporate both current noise reduction technologies and promising new technologies are also considered.

Technologies for noise reduction:

Shape Optimization:

It has been shown that shape optimization tools can be used effectively to design the inlet duct to reduce the radiated sound in distant area. The main idea of the shape optimization is to minimize the far field acoustic radiation by Novel acoustic treatments and shape design of turbofan engine ducts to attenuate such noise are vital for the noise reduction of modern aircraft engines. These designs usually depend on extensive empirical tests, which are very expensive and time consuming. In the past, research activities in the field of noise optimization systems have been carried out. It has been shown that in the case of noise reduction of radiated sound in the far field, these shape optimization tools can be effectively used. The controlling the geometry of an engine duct, could be main idea of the shape optimization in order to to minimize the far field acoustic radiation. Chenais had examined the mathematical aspect of the problem. For the existence of an optimal shape for systems, He mentioned the conditions necessary by coercive elliptic partial differential equations. More recently, there had been research in minimization of viscous through shape modifications in . Extensive research work had been done on shape identification for acoustic scattering problems.

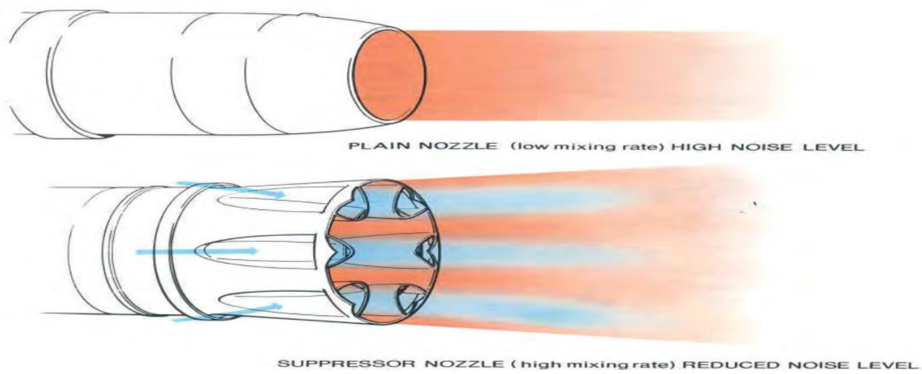


Figure:Nozzle jet flows

Active noise control:

Active noise control, also known as active noise cancellation is the reduction of sound wave by adding reverse sound wave. A noise cancellation speaker send out sound with amplitude as same as the noise sources but with inverted phase . waves combine to constitute new wave and effectively cancel each other out. ANC has become more and more popular in recent years. At 1991 J. C. Stevens and K. K. Ahujat in Georgia Institute of Technology, Atlanta, Georgia worked in active noise control. This popularity is due, in part, to the advancement of electronics and signal-processing techniques which take advantage of increased computer power. In particular, adaptive filtering method has natural applications in active noise control.

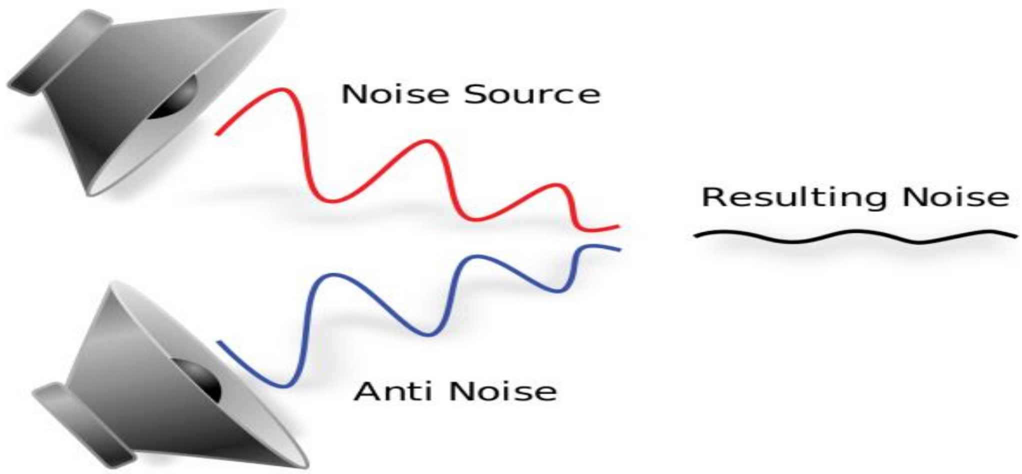
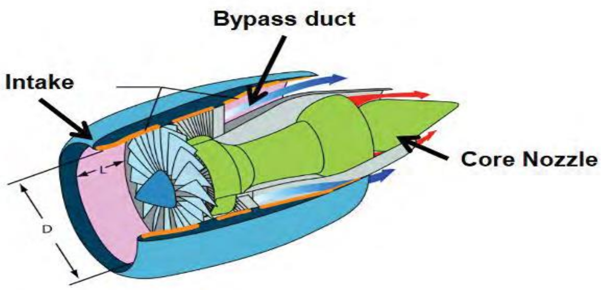


Figure :Active noise cancellation

Acoustic liners:

Novel acoustic treatments and design of turbofan engine shape ducts to attenuate such noise are important for the noise reduction of modern aircraft engines. These designs usually rely on extensive experimental tests, which are very time consuming and expensive. Acoustic liners are common to reduce noise within the turbofan bypass duct, and it is common practice to consider the effect of liner configuration as a noise reduction measure.



Duct flow:

The fan noise can be reduced effectively by the use of the equipment of an optimally designed acoustic liner in the engine nozzle. To this end, some design challenges must be addressed, including the choice of acoustic liner material and layer structure. To reduce noise within the turbofan bypass duct, the use of acoustic liners is already common, and it is usual practice to consider the effect of liner configuration as a noise reduction measure. The basic idea of the shape optimization is to minimize the far-field acoustic radiation by controlling the geometry of an engine duct. The embedded propulsion system allows smaller engine diameter and thus increased non-dimensional (length/diameter) duct length. The longer inlet and exit ducts causes engine noise reduction by allowing additional acoustic liners, compared to ordinary nacelles, to absorb the engine noise. Another promising technique for fan noise reduction is to increase the acoustic treatment area on the tip of the rotor. Existing engines only use acoustic liners in fan ducts and the inlet, and sometimes in the inter-stage region. To provide maximum insertion losses around a desired target frequency, they usually use honeycomb materials with porous or felt metal

face sheets.

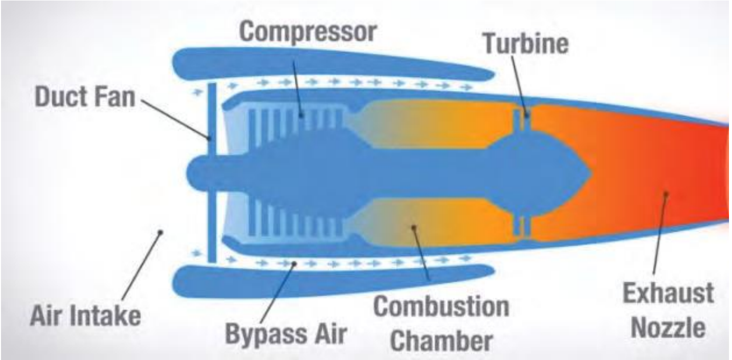


Figure 7**:** Duct flow in Turbofan engine.

Ultra High Bypass Ratio (UHBR):

In 1970 Boeing 747-100, the HBR turbofan engine was entered commercial service; soon, it was followed by McDonnell-Douglas, Lockheed who was other wide-body aircraft, and the newly formed Airbus consortium. A major advance in environmental protection was achieved, because these engines, which were produced by Pratt & Whitney, General Electric, and Rolls-Royce, they consume significantly less fuel. At the front of a turbofan engine there is a massive fan which creates the lion's share of thrust (up to 80 percent on an ordinary commercial jetliner) and accounts for two airflows : the main flow, that passes through the engine core and be involved in combustion, and the latter flow, which drives the engine core through the nozzle. By increasing this secondary flow, Increase of the BPR (the ratio of the cold airflow to the hot airflow) is achieved.

Figure 6**:** Ultra high bypass ratio.

CONCLUSION

This paper has reviewed the current state of noises which are produced in aircrafts, and main mechanisms involved in aerodynamic noise reduction. This review paper has focused on various methods to reduce aircraft noise. Examples of these technologies have been presented, such as Active noise control and to calculate optimized shape body of duct or wings, Acoustic boundary control can reduce noises of engine and also to consider Landing gear noise can be efficient, the installation of chevrons mixer on exhaust nozzles, effects of higher by pass ratio, and Micro-tab device also were investigated. This is especially valuable, for instance, to evaluate the effect of a noise reduction device on the aircraft operating cost. A review of the main role technologies for airframe, jet and fan-noise reduction and those currently under evaluation is also reported. While many scientific and technological elements have not been addressed, we believe that this work may be useful for a quick access to information in the field of aircraft noise reduction.

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