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FAILURES OF COMBUSTORS & ITS VARIOUS METHODS OF HEALTH MONITORING

Suraj Khanke[1], Rahul Upare[2], Tushar Shinde[3]

[1]*Final Year, Mechanical Engineering, J.D.I.E.T., Yavatmal, Maharashtra, India,* ***khankesuraj@email.com***
[2]*Final Year, Mechanical Engineering, J.D.I.E.T., Yavatmal, Maharashtra, India,* ***rahulupare1@email.com***
[3]*Final Year, Mechanical Engineering, J.D.I.E.T., Yavatmal, Maharashtra, India,* ***tushar.shinde2496@email.com***

Abstract

Condition monitoring assesses the operational health of gas-turbine engines, in order to provide early warning of potential failure such that preventative maintenance action may be taken. Gas-turbine engine manufacturers are increasingly offering a “service-based" approach to marketing their products, in which their customers are guaranteed certain availability of the engine after purchase. To achieve this, manufacturers take on the responsibilities of engine condition monitoring, by embedding health monitoring systems within each engine unit and prompting maintenance actions when necessary. This report describes preliminary research into condition monitoring approaches for modern gas-turbine Aircraft engines, and outlines plans for novel research to contribute to machine learning techniques in the Condition monitoring of such systems. A framework for condition monitoring of aircraft engines is introduced, using signatures of engine vibration Across a range of engine speeds to assess engine health. Inter- and intra-engine monitoring approaches are presented, in which a model of engine normality is constructed using vibration data from other engines of its class, or from the test engine itself, respectively. Results of inter-engine analysis of final engine vibration tests prior to their release into service are presented, showing that the approach described within this report provides a more reliable estimate of engine condition than manufacturers' conventional engine vibration tests, leading to better discrimination between \good" and \bad"engines. Future research is planned in application of this condition monitoring framework to an engine currently Under development, improving upon existing methods and investigating new approaches, ultimately leading to the formulation of a general \black box" monitoring approach that can learn a model of system normality without prior knowledge of that system.

Keywords: Basic parts of gas turbine engine, Function of combustor & its types, Various failures of combustors, Prevention methods of combustor failures, Methods of health monitoring of combustor etc.

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1. INTRODUCTION

Gas-turbine engines are critical to the operation of most industrial plants, aircraft, and heavy vehicles such as military armour and transport ships, and their associated maintenance costs can be high. Traditionally, operators of gas-turbine engines have attempted to reduce these costs by performing preventative maintenance actions at fixed intervals, in an attempt to avoid potential engine failure. More recently, gas-turbine engine manufacturers have been adopting a condition monitoring approach instead, in which intelligent data analysis systems are employed to assess the health" of engine components. The engine's maintenance needs are determined according to its operating condition, rather than maintenance being performed at fixed periods of time. These engine health monitoring systems typically process data from engine-mounted sensors. Early warning of potentially hazardous engine conditions may result, the hope being that precursors of component failure may often be identified in advance of actual failure. This is a prognostic approach to condition monitoring, and is useful for types of faults that may be prevented if identified soon enough. Faults for which there are no such precursors (e.g., a \bird strike", in which a bird impacts an engine fan) require a diagnostic approach. Such systems automatically identify engine faults that have occurred, and may recommend restorative maintenance actions appropriate to the type of fault.

Gas-turbine engine manufacturers are increasingly offering a service-based approach to marketing their products, in which their customers are guaranteed certain availability of the engine after purchase. To achieve this, manufacturers take on the responsibilities of engine condition monitoring, by embedding health monitoring systems within each engine unit and prompting maintenance actions when necessary. Condition monitoring techniques are also applied to engines during the development process, and throughout product testing. During development, engines are typically re-built and tested many times. Assessment of component health during this process can avoid component damage and potential hazards. An insert ring is a part inside a combustion chamber on which the burner is installed. The function of this part is to position the burner in order to shape and direct the flame into the combustion chamber. There are eight insert rings for each combustion chamber of the gas turbine. These rings are positioned above the flame tube, and the combustion chamber divider sits on the top of it. In fact, this part forms a section of the flame tube plate. Each ring is held by 12 bolts on the flame tube plate and bears a portion of the divider's weight.

2. GAS TURBINE ENGINE

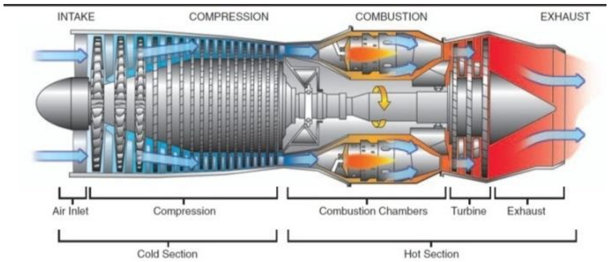

Fig-2.1:Gas turbine engines having different sections

A gas turbine, also called a combustion turbine a jet engine is reaction engines discharging a fast-moving jet that generates thrust by jet propulsion. This broad definition includes air breathing jet engines (turbojets, turbofans, ramjets and pulse jets) and non-air breathing jet engines (such as rocket engines).

2.1: Gas Turbine Engines Are Basically Divided Into Two Sections

2.1.1 : Cold Section

a. Compressor or fan: compressor is made up of stages. Each stage consists of rotating blades and stationary stators or vanes. As the air moves through the compressor, its pressure and temperature increase. The power to drive the compressor comes from the turbine (see below), as shaft torque and speed.

b. **Diffuser section:** The diffuser slows down the compressor delivery air to reduce flow losses in the combustor. Slower air is also required to help stabilize the combustion flame and the higher static pressure improves the combustion efficiency.

2.1.2: Hot Section

a. Combustor or Combustion chamber : Fuel is burned continuously after initially being ignited during the engine start.

Fig-2.2:Combustion chamber

b. Turbine : The turbine is a series of bladed discs that act like a windmill, extracting energy from the hot gases leaving the combustor. Some of this energy is used to drive the compressor. Turboprop, turbo shaft and turbofan engines have additional turbine stages to drive a propeller, bypass fan or helicopter rotor. In a free turbine the turbine driving the compressor rotates independently of that which powers the propeller or helicopter rotor. Cooling air, bled from the compressor, may be used to cool the turbine blades, vanes and discs to allow higher turbine entry gas temperatures for the same turbine material temperatures.

Fig-2.3: Gas turbine

3.WHAT IS COMBUSTOR

A combustor is a component or area of a gas turbine, ramjet, or scramjet engine where combustion takes place. It is also known as a burner, combustion chamber or flame holder. In a gas turbine engine, the combustor or combustion chamber is fed high pressure air by the compression system. The combustor then heats this air at constant pressure. After heating, air passes from the combustor through the nozzle guide vanes to the turbine. In the case of a ramjet or scramjet engines, the air is directly fed to the nozzle. A combustor must contain and maintain stable combustion despite very high air flow rates. To do so combustors are carefully designed to first mix and ignite the air and fuel, and then mix in more air to complete the combustion process. Early gas turbine engines used a single chamber known as a can type combustor. Today three main configurations exist: can, annular and cannular (also referred to as can-annular turbo-annular). Afterburners are often considered another type of combustor. Combustors play a crucial role in determining many of an engine's operating characteristics, such as fuel efficiency, levels of emissions and transient response (the response to changing conditions such a fuel flow and air speed).

3.1 Annular Type Combustor

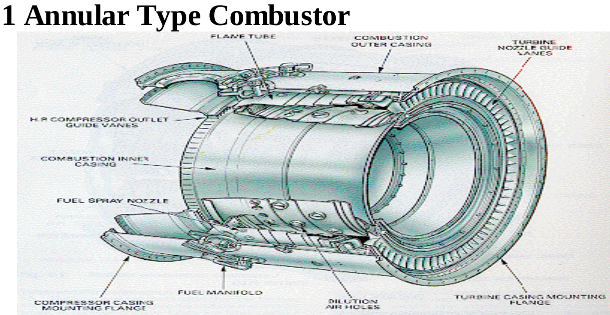

Fig-3.1:.Annular combustion chamber

Annular combustors do away with the separate combustion zones and simply have a continuous liner and casing in a ring (the annulus). There are many advantages to annular combustors, including more uniform combustion, shorter size (therefore lighter), and less surface area. Additionally, annular combustors tend to have very uniform exit temperatures. They also have the lowest pressure drop of the three designs (on the order of 5%).The annular design is also simpler, although testing generally requires a full size test rig. An engine that uses an annular combustor is the CFM International CFM56. Most modern engines use annular combustors; likewise, most combustor research and development focuses on improving this type.

4. MAJOR FAILURE OCCUR DUE TO FOLLOWING REASONS

Crack (fracture) in the housing, Erosion& Corrosion, combustion instability, combustor liner at the stops. Due to excessive temperature and pressure inside the combustion chamber. Insufficient coolant passes between the casing and chamber.

5. PURPOSE OF HEALTH MONITORING OF GAS TURBINE COMBUSTOR

- To reduce the maintenance cost of the engine.
- To prevent accident of the aero planes..
- For providing the safety to the passengers and the cargo aero planes
- To generate acceptable power for efficient and safe performance

6. THERE ARE TWO METHODS TO MONITORING THE HEALTH OF COMBUSTOR AS UNDER LISTED

EXPERIMENTAL METHOD (PARTICLE-IMAGE-VELOCIMETRY)SIMULATION METHOD (NUMERICAL METHOD)

6.1Experimental-Method

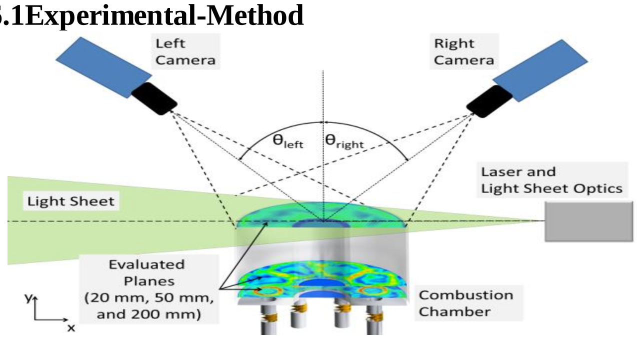

Fig-6.1: Particle Image Velocimetry Setup

Particle image velocimetry (PIV) method with a stereoscopic approach. One aspect is to prove, if the manipulated burner has a detectable Impact on the exhaust jet. A second aspect is to verify the hypothesis That a correlation between the failure source inside the combustor and The measurable failure pattern on the exit plane is given by applying The computational fluid dynamics (CFD) technique. The comparison Between measurement and simulation is of importance to see, if the Method of CFD simulation would be applicable also in complex aircraft Engine geometries, to locate failures inside the engine, that are identified Through the measured pattern in the exhaust gas jet.

PIV is a minimally invasive flow measurement technique that allows a two- or three-dimensional flow field to be acquired by tracking the movement of small particles that are added to the fluid. Within a light-sheet plane illuminated by a pulsed laser the particles are imaged in consecutive pictures with defined time-interval. With the cross correlation Method the velocity field can be determined. The measurement plane is aligned horizontally. As light source The Litron Nano L 135-15 PIV double pulse laser with a wavelength of 532 nm and pulse energy of maximum 135 MJ per cavity was used. A light sheet is formed with a suitable light sheet optic consisting of three lenses. The distance between the measurement plane and the Optics is 1000 mm. As tracer, inert tio2 particles are mixed to the flow, following the flow through the flame. For the PIV measurements two 14-bit CCD cameras with a resolution of 1600×1200 pixels (pixel size: 7.4 µm . 7.4 µm, sensor size: 11.8 . 8.9 mm2), equipped with 50 mm Lenses with a fixed focal length of f / 1.4 are used with laser line filters For 532 nm ± 3 nm. The lens and the camera are connected via manual Tilt adapters according to the Scheimpflug criterion, whereby the Camera axes are inclined by the angle θ=50° against the normal of the Measuring plane. The cameras are located approximately 830 mm above The measuring plane. The time interval between the pictures was 60 µs for the 200-mm evaluation plane and 20 µs for the 20-mm plane cutting the flame zone.

7. CONCLUSION

Detailed studies were done on combustion chamber where the operation condition of burner can be varied in a defined way. The studies discussed in this work show that defined failures can be detected in a measurement plane behind the combustion chamber. The failure analysis and lifetime prediction were investigated from distribution of temperature and thermal stress in combustor section of gas turbine. Analysis of gas turbine combustor tracked order crack, vibration, temperature conditions, pressure inside the combustion chamber is believed by engine developers to provide useful indication of engine operational health. Many modes of engine failure affect observed tracked order vibration, and thus the assessment of engine condition through analysis of tracked order vibration can provide an indication of these failures .a condition monitoring method in which the operational health of an engine combustor is determined with respect to the “normal” operation of a whole class of combustors.

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REFERENCE

[1] Shahandkargarnejad, vahidabbasi-chianeh. Failure analysis of a burner ring made of 20Cr32Ni1Nb alloy in gas turbine combustion chamber.

[2] Hennecke C Von der Haar H and Dinkelacker F. Failure Detection in an Annular Combustion Chamber with Experimental and Numerical Methods.

[3] Bobby Noble, Leonard Angello Advanced Gas Turbine Combustor Health Monitoring Using Combustion Dynamics Data

[4] Adamczuk RR, Buske C, Roehle I, Hennecke C, Dinkelacker F, et al. (2013) Impact of defects and damage in aircraft engines on the exhaust Jet. In: Proceedings of ASME Turbo Expo 2013. ASME, San Antonio, Texas.

[5] Vonder-Haar H, Hartmann U, Hennecke C, Dinkelacker F (2016) Defect detection in an annular swirl-burner-array by optical measuring exhaust gases. In: Proceedings of ASME Turbo Expo 2016 ASME.

[6] Hennecke C,Frieling D, Dinkelacker F (2013) Influence of combustion chamber disturbances to patterns in the hot gas path. Presented at the European Combustion Meeting 2013 , Lund, Schweden.