Common wares and failures on F-Class gas turbines

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Abstract

The **F-Class gas turbine** has been a key player in the energy world. It powers important infrastructure and helps us move towards a sustainable future. Now, with new tech, this reliable engine is ready to perform even better. This turbine is known for its high **efficiency**, **reliability**, and flexibility. Knowing the details and possible problems with this turbine is key for those who work with it. This article explores the main issues with the **F-Class gas turbine**. It offers insights and solutions to boost its **performance** and cut down on downtime.

Key words

Gas Turbine, Fact finding, Wear, Tiles and Tile holders, Vanes and Blades

Introduction

The F-Class gas turbine is a powerful tool used in many industries. It has impressive specs and is great for power generation, combined cycle plants, and industrial processes.

Furthermore, it is a top-notch, heavy-duty gas turbine. It can produce up to 330 megawatts of power. Its design, with a multi-shaft setup, makes it perfect for combined cycle power plants.

The turbine's advanced compressor and combustion systems work well together. They ensure the turbine runs smoothly and efficiently. Its strong build also means it can handle tough industrial environments.

The turbine's advanced compressor and combustion systems work well together. They ensure the turbine runs smoothly and efficiently. Its strong build also means it can handle tough industrial environments.

It can face fact-finding issues during operation, maintenance, and performance optimization. Understanding these common challenges is crucial for maintaining the turbine's efficiency and longevity.

Main Body

One of the primary F-Class gas turbine routine required inspections is the combustion chamber elements inspection. Over time, the intense heat, pressure and vibration, can cause these critical components to wear down. This leads to combustion chamber elements failure such as ceramic tiles crack and breakdown, ceramics, metallic heat shields and tile holders overheating. Proper maintenance and timely replacement of these elements, is essential for ensuring the reliability of the SGT5-4000F.

Another common troubleshooting concern is the burners inspection and cleaning, in order to prevent the fluctuations in fuel flow, air-to-fuel ratios, and other factors, which can result unbalance combustion dynamic, instability, and even potential damage to the turbine. Proactive monitoring and adjustments to the combustion system are necessary to maintain optimal performance.

Understanding why turbine components fail is key to keeping them running well. For the Ansaldo Energia AE94.3A gas turbine, finding the root cause, helps prevent wear and damage. This includes issues with vanes, blades, and tiles.

Classification of the common wear on different gas turbine components and root cause analysis of these findings helps us to have a better periodic preventive and corrective maintenance planning to keep the reliability and availability of the F-Class gas turbines.

Classification of the common wears :

- Crack and break down
- Overheating and Oxidation
- Erosion
- Corrosion
- LCF and HCF
- FOD
- Rubbing
- Adhesion

Explore the common wear and failure mechanisms affecting the vanes, blades, and tiles of the F-Class gas turbines, also understanding the root causes behind these issues and their impact on turbine performance and discovering preventive maintenance strategies and repair techniques to address these challenges, will help us to turbine component lifespan extension and management and avoid costly downtime. It also keeps power generation reliable and efficient.

What are the root causes of these wears and failures? What are the common wears on the main components of F-class gas turbines?

First, let us explain about the root causes of these wears, more detailed.

Cracks and break down:

Cracks are commonly found on different parts and components of gas turbine. Thermal fatigues, vibration and FOD are the main root causes of the crack formation on the major components of the gas turbines including tiles and holders, blades and vanes, burner and burner insert.

Overheating and Oxidation

“Overheating” refers to a situation in which a component operates at a temperature that is higher than what is considered or designed safe or normal, which can be caused by a variety of factors such as excessive heat generation, inadequate protection or cooling.

“Heat soak” from the turbine side of the gas turbine through to the compressor side, causing discolouration to the turbine shaft and bearing housing may happen due to the insufficient lubrication.

Erosion

Removal of material due to interacting of component surfaces with particles in working media.
Erosion is the destruction of a material starting out from the surface by the mechanical effect of flowing gasses and steams containing solid matter and/or liquid particles or of liquids containing with solid particle.

Corrosion

Gas turbine corrosion is a common phenomenon experienced by operators. It can be traced to contaminants through the air inlet system, water systems (from evaporative cooler carryover, compressor wash solutions, NOx control injection water, and dual fuel injector purging), and fuel (gaseous and liquid).
Common forms of Corrosion on gas turbine components are:

- Surface / Uniform corrosion
- Pitting Corrosion
- High temperature corrosion

Surface corrosion, caused by either direct chemical or electrochemical attack, it appears as a general roughening, etching, or pitting of the surface of a metal, frequently accompanied by a powdery deposit of corrosion products.
Pitting is a localized form of corrosive attack. Pitting corrosion is typified by the formation of holes or pits on the metal surface.
High-temperature corrosion is a mechanism of corrosion that takes place when gas turbines or other machinery come in contact with hot gas containing certain contaminants including vanadium compounds or sulfates, which can form low melting point compounds during combustion. These liquid melted salts are strongly corrosive to stainless steel and other alloys normally resistant with respect to corrosion at high temperatures.

LCF and HCF

Low cycle fatigue (LCF) refers to the situation where a material or component fails after a relatively small number of cycles, usually less than 10,000. LCF is typically associated with high strain amplitudes, plastic deformation, and crack initiation and propagation.
As an example, we know turbine blades and vanes usually have a configuration at the base referred to as a dove tail or fir tree. This feature is used to attach the blade to the turbine disk. As engine rotational speed increases, centrifugal forces result in local plastic strains at the attachment surfaces resulting in LCF damage.
High cycle fatigue (HCF) refers to the situation where a material or component fails after a large number of cycles, usually more than 10,000. HCF is typically associated with low strain amplitudes, elastic deformation, and crack initiation and growth.
An example would be an airfoil subjected to repeated bending. One source of this bending occurs as a compressor or turbine blade passes behind a stator vane. When the blade emerges into the gas path it is bent
by high velocity gas pressure. Changes in rotor speed change the frequency of blade loading.
The excitation will at some point match the blade's resonant frequency causing the amplitude of vibration to increase significantly.

FOD

Foreign Object Damage (FOD) is damage caused by foreign objects entering machinery or systems, notably in aviation and power industry. These objects, like debris or tools, can lead to equipment failure or structural damage

Rubbing

Rubbing, is a kind of wear due to contact between rotating blades and stator components.

Adhesion

Material transfer from one material to the other.
Consequences of adhesion are cold welding, scuffing, scoring, pits, seizing, built-up material.

There are different theories for adhesion:

- Mechanical interlocking
- Diffusion (only at elevated temperatures)
- Transfer of electrons (material dependent, smooth surfaces in close contact)
- Chemisorption (e.g.,attraction due to chemical reactions, irreversible)
- Physisorption (e.g., attraction due to van der Waals forces,

Turbine different components in the F-class gas turbine face several issues which can affect the turbine's performance. What are the common wear and failure mechanisms affecting the turbine parts in the F-class gas turbine?

Here we want to explore the common wares, which lead each turbine component to fail in F-class gas turbine.

Compressor vanes and blades:

The most common wear on compressor section are Erosion, Corrosion, Rubbing, FOD, LCF and HCF.



Fig 1. Rubbing mark between compressor stator and rotating blades



Fig 2. Rubbing mark between compressor stator and rotating blades



Fig 3. Erosion on the compressor rotating blades



Fig 4. Erosion on the compressor rotating blades

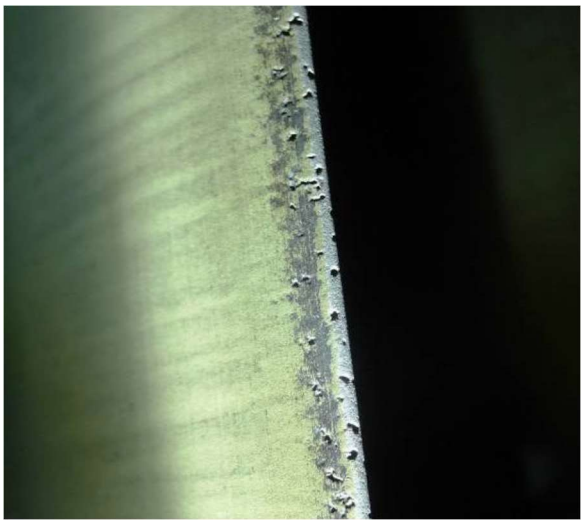


Fig 5. Pitting corrosion on the compressor rotating blades

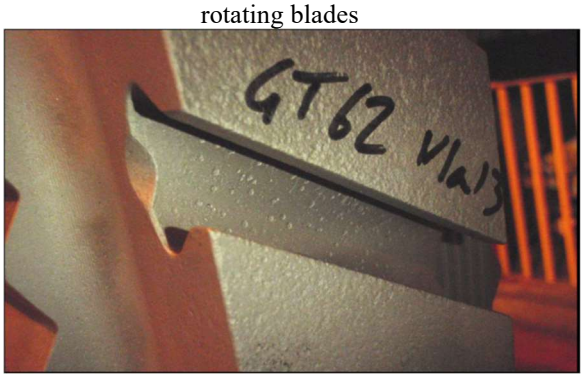


Fig 6. Pitting corrosion on the compressor rotor disk



Fig 7-A. VLa3 fracture due to high circle fatigue

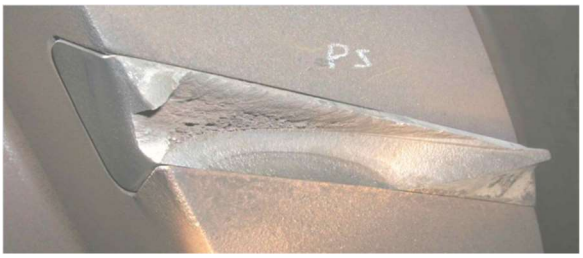


Fig 7-B. VLa3 fracture due to high circle fatigue



Fig 8. FOD on compressor vanes

Burners:

The most common wear on the burners are Cracks, Overheating, Erosion and Corrosion.

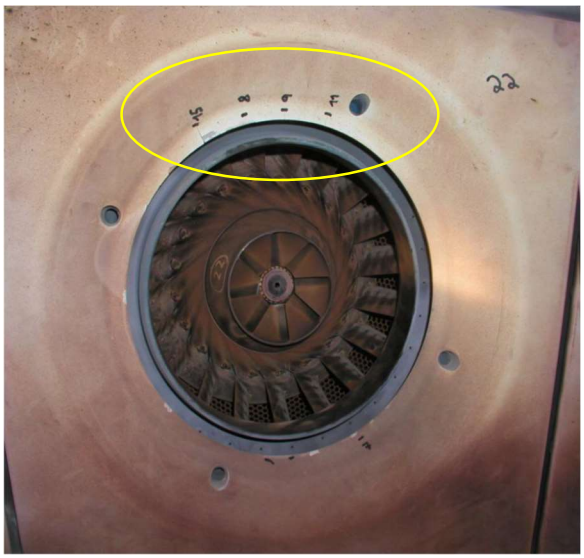


Fig 9-A. Cracks on burner insert



Fig 9-B. Cracks on burner insert

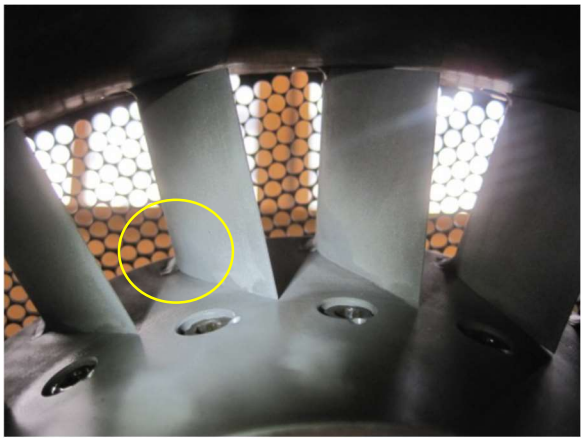


Fig 10-A. Cracks on diagonal swirler



Fig 10-B. Cracks on diagonal swirler



Fig 11-A. Cracks on fuel oil burner cap



Fig 11-B. Cracks on fuel oil burner cap



Fig 12. Cracks on CBO


Fig 13. Sign of Overheating on the swirler

Combustion Chamber:

The most common wear on the combustion chamber are Cracks, Overheating, Erosion, Corrosion and LCF.



Fig 14. Surface corrosion on the Hub



Fig 15. Erosion at hot side of CHS

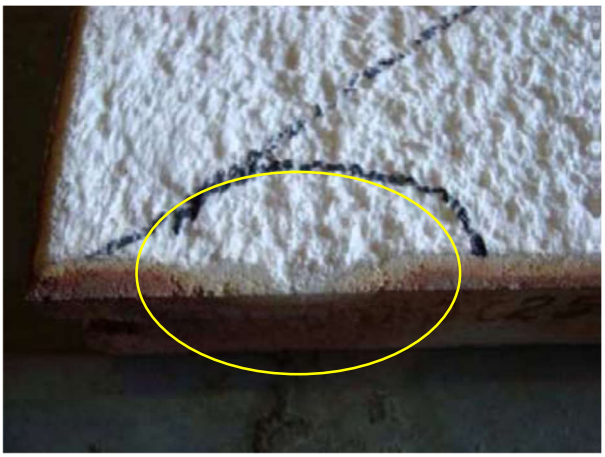


Fig 16. Erosion at hot side of CHS



Fig 17. Coating spallation, overheating and crack on metal heat shield

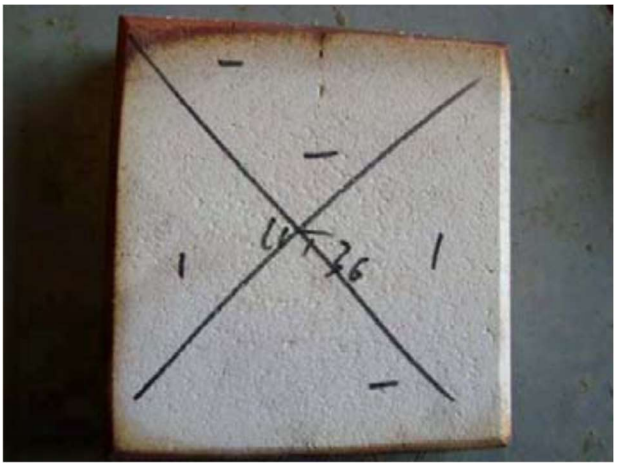


Fig 18. Deep crack on CHS

Turbine:

The most common wear on the turbine are Cracks, Coating Spallation, Overheating, FOD, Erosion, Corrosion and LCF.

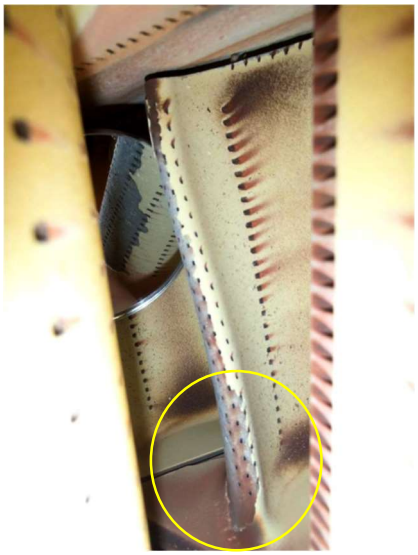


Fig 19-A. Coating spallation on turbine blades leading edge

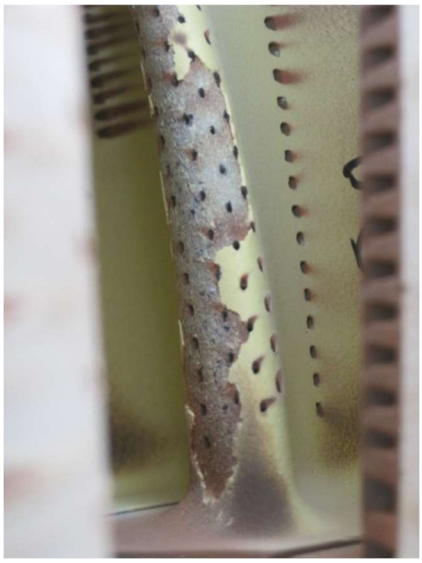


Fig 19-B. Coating spallation on turbine blades leading edge



Fig 20. Surface crack on turbine vanes

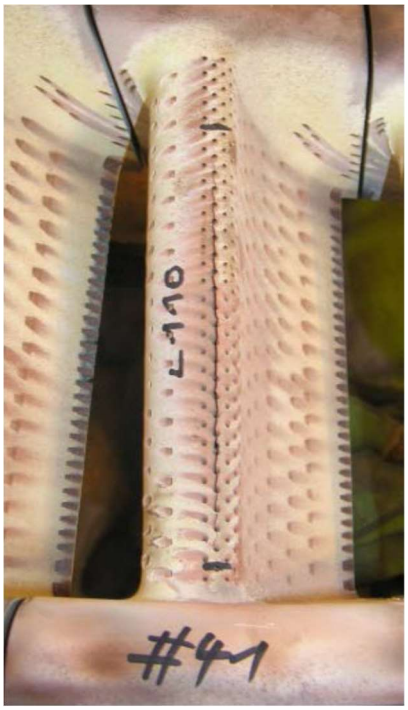


Fig 21. Surface crack on turbine vanes

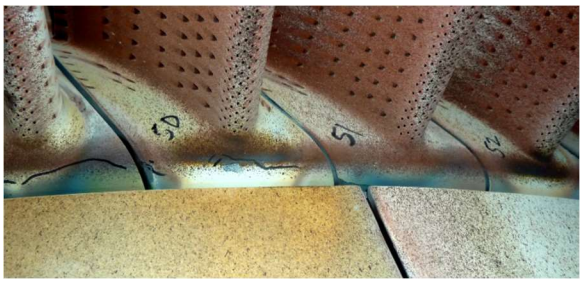


Fig 22. Turbine first stage vanes
overheating and base metal oxidation

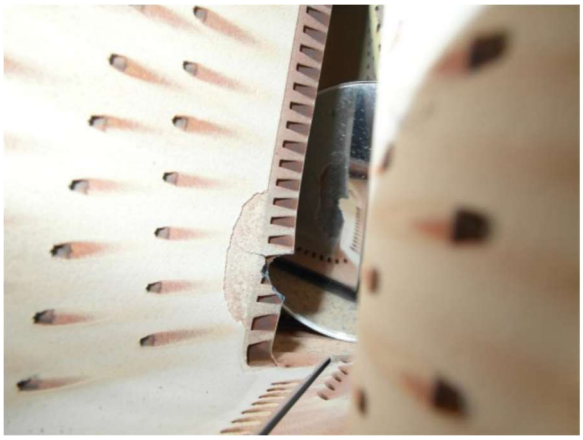


Fig 23. FOD on turbine first stage vane

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