# ANK 315 AIRCRAFT MAINTENANCE

# LECTURE 6

## DEGRADATION PROCESSES, DAMAGES

KAMILA KUSTROŃ, Ph.D

# Failure Modes of Aerospace Materials

- Questions to answer in this module…
  - How can aircraft structural materials fail?
    - What are the materials used for aircraft structures?
    - How might materials failure affect aircraft?
    - What do these failure modes look like?
    - What are the root causes of these failures?

## What types of materials are used in aircraft structures?

- Metals
  - Aluminum
  - Steel/Stainless Steel
  - Titanium
  - Magnesium
  - Superalloys
- Ceramics
- Plastics/Elastomers
- Composites

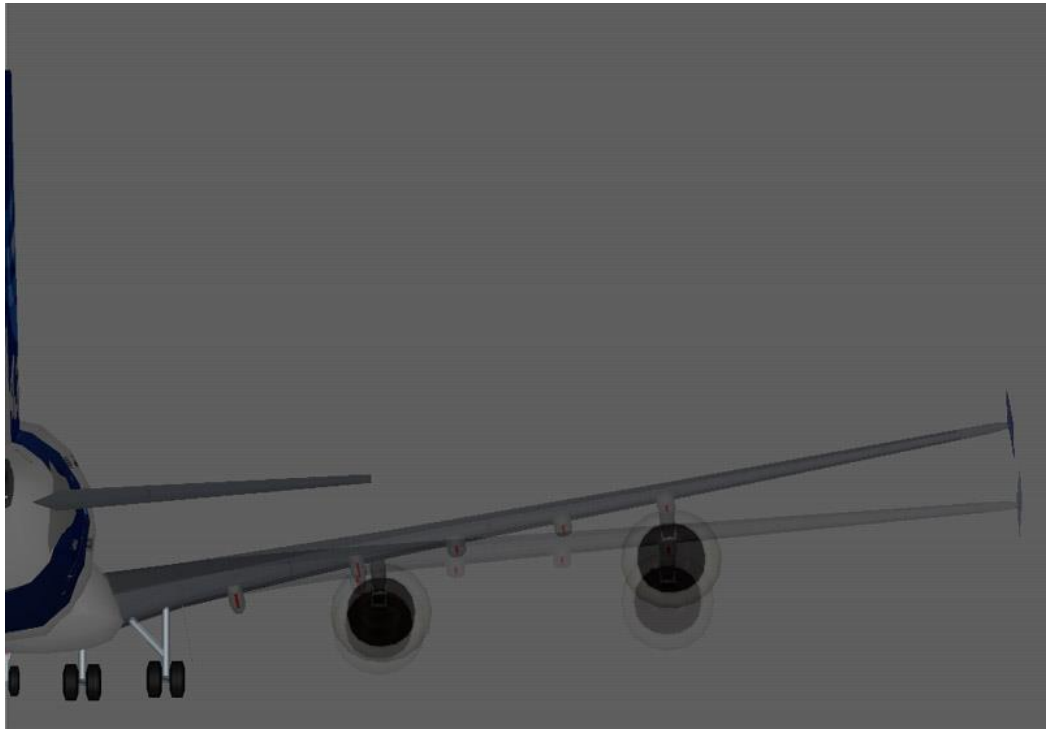
# What causes failure?

- In general, failures occur when a component or structure is no longer able to withstand the stresses imposed on it during operation commonly, failures are associated with stress concentrations, which can occur for several reasons including:
  - ❑ design errors, e.g. the presence of holes, notches, and tight fillet radii
  - ❑ the microstructure of the material may contain voids, inclusions etc.
  - ❑ corrosive attack of the material, e.g. pitting, can also generate a local stress concentration

# How do materials fail?

- Plastic Deformation/ Yielding
- Fatigue
- Abrasion/ Wear
- Corrosion
- Thermal Shock
- Fracture
- Melting
- Impact
- Buckling
- Creep

# •Failure Modes- Yielding



Airbus A380 Wing Deflection Simulation

# •Failure Modes- Fatigue


De Havilland Comet with square windows

# •Failure Modes- Abrasion/ Wear

Alaska Airlines Flight 261 Horizontal Stabilizer Jackscrew

# .Failure Modes- Corrosion


Aloha Airlines Flight 243

# •Failure Modes- Thermal Shock

Internal Combustion Engine
Spark Plug

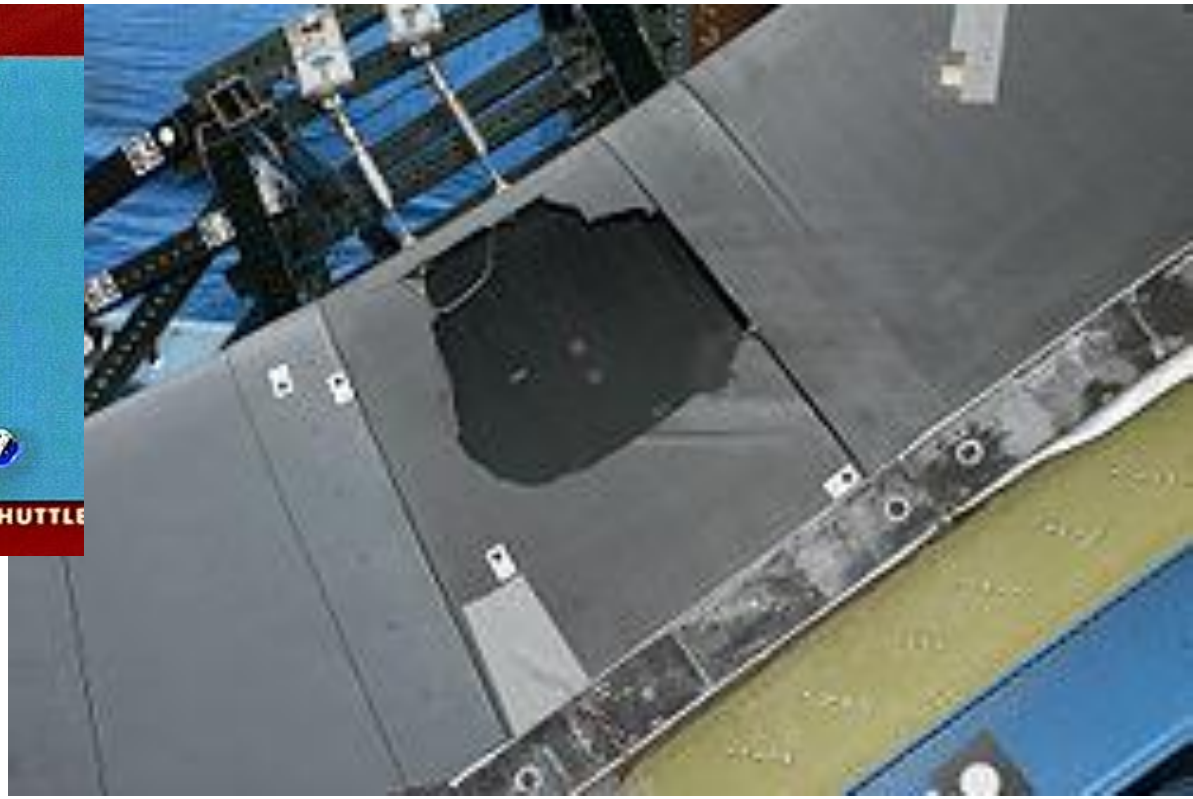
# •Failure Modes- Fracture

American Airlines Flight 587 Vertical Stabilizer

# •Failure Modes- Melting

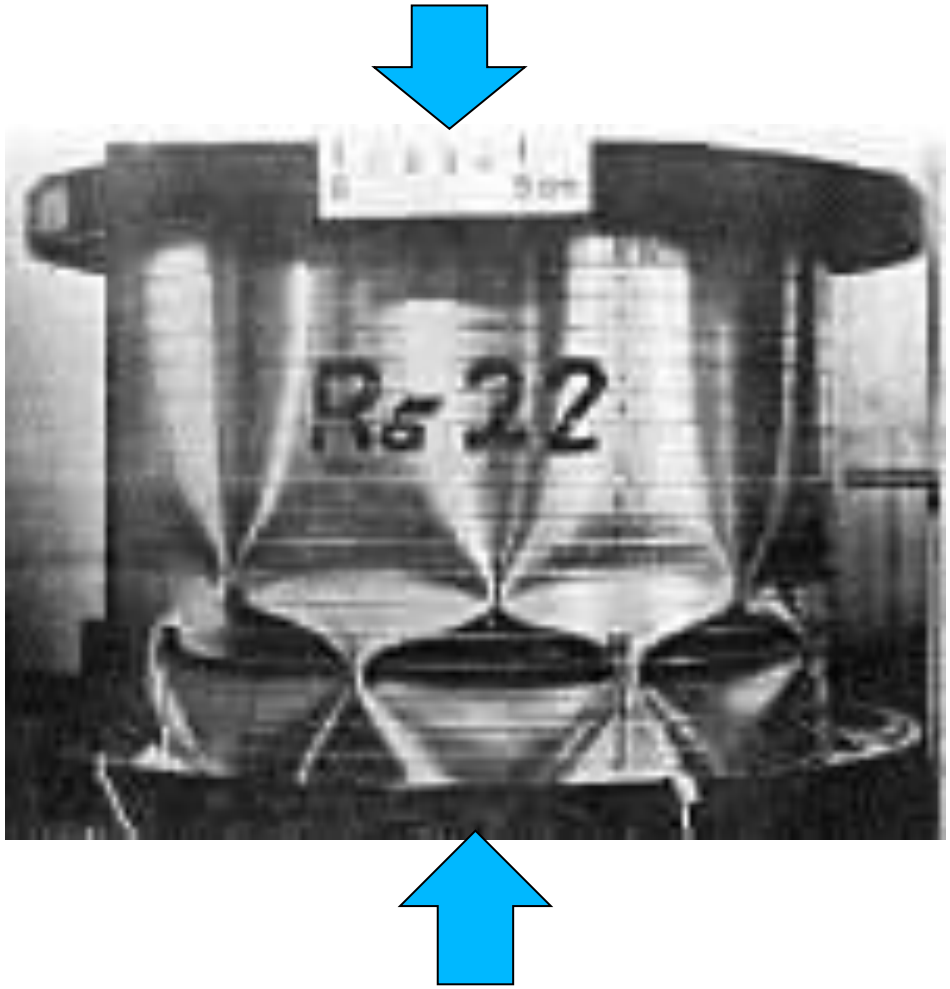
Internal Combustion Engine Piston

# .Failure Modes- Impact

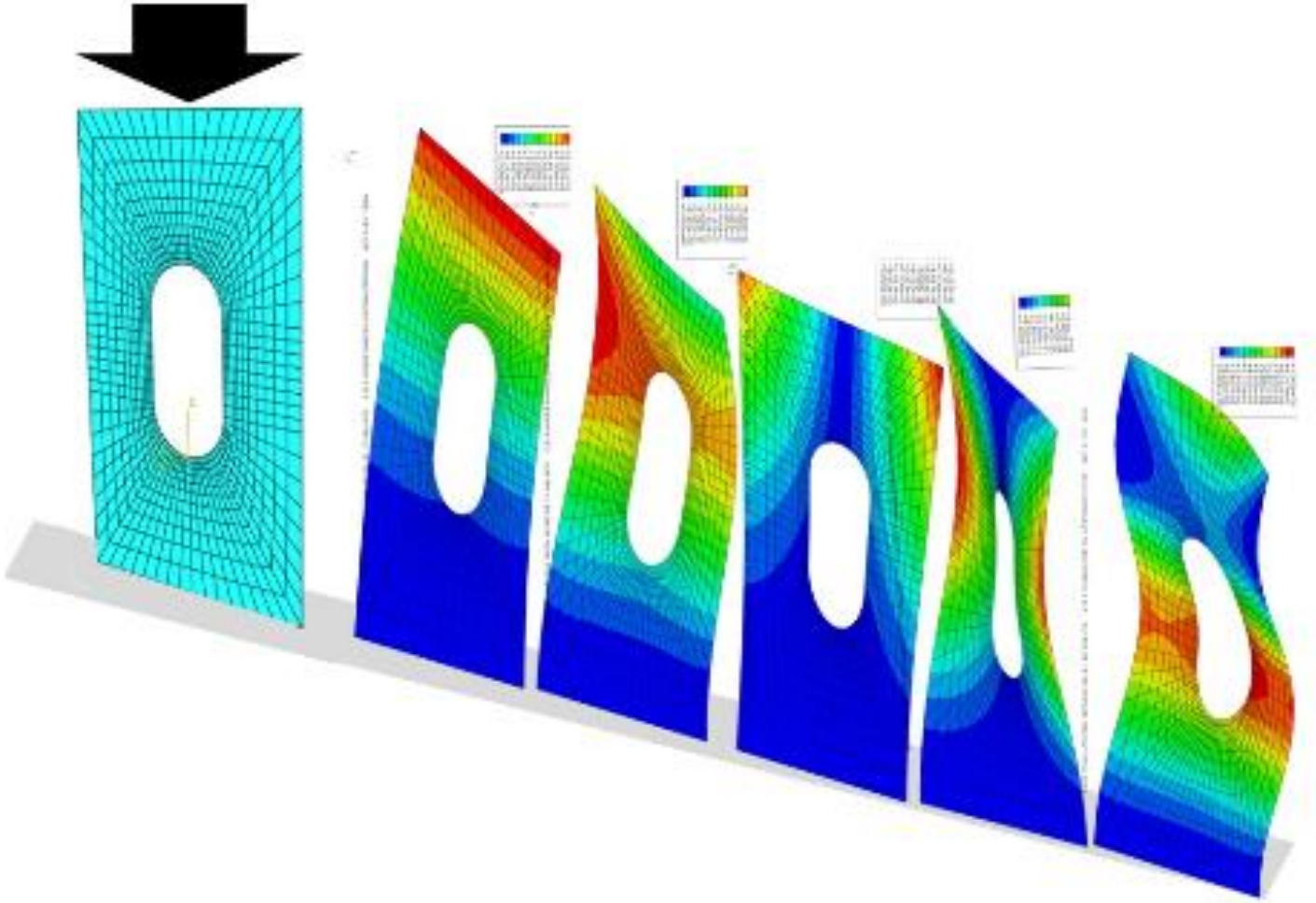
Space Shuttle Columbia Re-entry and Simulated Leading Edge

# •Failure Modes- Buckling



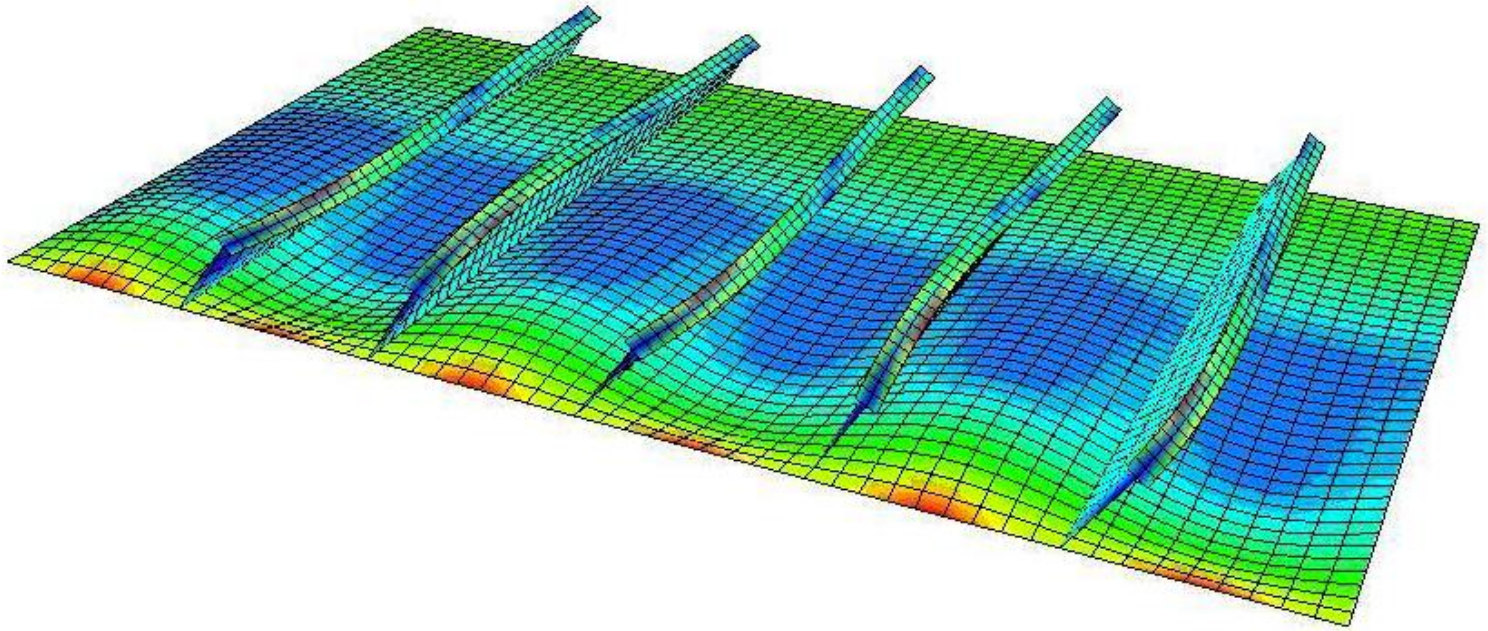

A Large Test Cylinder Under Compressive Load

# .Failure Modes- Buckling



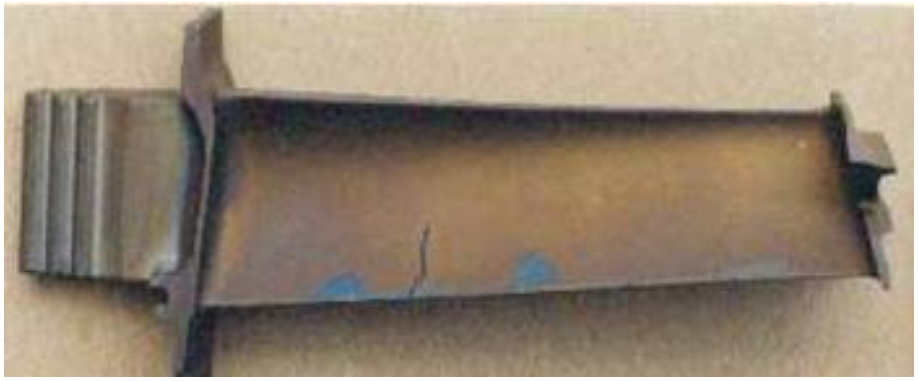
Buckling analysis of a [0/+-45]2s laminate plate with an oblong hole.

# •Failure Modes- Buckling



Buckling analysis of a stiffened wing panel

# .Failure Modes- Creep



The turbine blade cracked due to creep (creep is deformation of a material subjected to tensile stresses at high temperature)

Southwest Airlines Fan Disk Failure

From records and case histories data, an assessment can be made of the frequency of failure modes

# •Frequency of failure mechanisms

| | Percentage of Failures | |
|---|---|---|
| | **Engineering Components** | **Aircraft Components** |
| Corrosion | 29 | 16 |
| Fatigue | 25 | 55 |
| Brittle fracture | 16 | - |
| Overload | 11 | 14 |
| High temperature corrosion | 7 | 2 |
| SCC/Corrosion fatigue/HE | 6 | 7 |
| Creep | 3 | - |
| Wear/abrasion/erosion | 3 | 6 |

# Root Causes of Materials Failures

- Misuse, mishandling
- Assembly errors
- Processing/ manufacturing errors
- Improper material choice
- Non-optimized geometry design
- Improper maintenance
- Unforeseen operation conditions
- Inadequate quality control
- Inadequate environment control

# Root Causes- Misuse, mishandling

- Damaged during handling, storage, use
- Stressing parts by using them outside their designed envelope

# Root Causes- Assembly errors

Incorrect torque

Incorrect sequence

Omitting or adding unspecified components

# Root Causes- Processing/ Manufacturing errors

- Improper heat treating
- Incorrect surface finish
- Processing could affect the strength and corrosion resistance

- Root Causes- Improper material choice

The chosen material can’t do the job!

- Root Causes- Non-optimized geometry design

The part is the wrong shape, stress risers are created

# Root Causes- Improper maintenance

- Aircraft components must be cared for and have a finite life.
- Fatigue is one of the largest concerns, parts must be replaced after a calculated safe period of use, other parts must be routinely inspected for cracks.

# •Root Causes- Unforeseen operation conditions

- Changing the mission or environment of the aircraft and its components, modifications.
- The materials were properly chosen and designed for, but the aircrafts use changes.

# Root Causes- Inadequate quality control

- We need to control the quality of the materials.  There must be controlled environments for creating, storing, shipping, tracking, and ultimately using the parts.
- Documentation must accompany these parts and materials every step of the way.

- Root Causes- Inadequate environment control

Improper paint, coatings, corrosion prevention maintenance