GAS TURBINE
USES OF GAS TURBINE ENGINES

• Aircraft Engines

• Main Propulsion
  – Arleigh Burke, Tichonderoga, Spruance, Oliver Hazard Perry LCACs, Pegasus

• Auxiliary Applications
  – Electric generators
ADVANTAGES OF GTE’s

- Weight reduction of 70%
- Simplicity
- Reduced manning requirements
- Quicker response time
- Faster Acceleration/deceleration
- Modular replacement
- Cleaner and safer fuels
- Less vibrations
- More economical
DISADVANTAGES OF GTE’s

- Many parts under high stress
- High pitched noise
- Needs large quantities of air
- Large heat source
- Must be in-port for major repairs
INTAKE DUCT SYSTEM

- Louvers
- 04 Level
- Demister
- High Hat Inlet Blow in Doors
- Gas Turbine Cooling Ducts
- 02 Level Cooling Duct Silencer
- 03 Level Anti-Icing Manifold Main Engine Silencer Vanes
- 01 Level Main Deck
- Main Deck
- FOD Screen
- FOD Screen
- Main Deck
INTAKE DUCTS

- Located to prevent ingestion of SW
- Contains
  - Demisters
  - Intake Heaters
  - Blow-in Doors
- Allows engine removal
  - FOD screen
  - Silencers
  - Separator Pads
4 COMPONENTS OF A GAS TURBINE ENGINE
(1) COMPRESSORS
Radial Flow
Axial Flow

Figure 16-9.—Axial compressor elements.
Axial vs. Radial

• Axial
  – Adv:
    • simple and inexpensive
    • light weight
  – Dis:
    • less efficient
    • large frontal area
    • limited compression ratio (4:1 ratio)

• Radial
  – Adv:
    • efficient
    • high compression ratios (20:1)
  – Dis:
    • complex
    • expensive
LM 2500 COMPRESSOR

- Compressor - 16 stage Axial flow 17:1 compression ratio
- Inlet Guide Vanes
- 1st 6 Stages of Stator Vanes – variable
  - Provides proper air flow for Rotor Vanes
COMPRESSOR STALL

• Occurs if for some reason air velocity decreases without a commensurate decrease in RPM or if RPM increases without the necessary air velocity increase.

• Similar to wing stall

• Can result in blade failure
GTE AIR

Compressed Air Distribution:

- **Primary Air** - 30% of the compressed air is supplied directly to the combustion chamber
- **Secondary Air** - 65% of the air provides cooling for the combustion chamber
- **Film Cooling Air** - 5% of the air provides cooling directly to the turbine blades
(2) COMBUSTORS
Figure 16-10
CAN-TYPE COMBUSTION CHAMBER
Figure 16-12.—Can-annual-type combustion chamber.
LM 2500 COMBUSTOR

- Annular = RING OF FIRE
- 30 Fuel Nozzles
- 2 Ignitors

- Allison 501-K17 (Gas Turbine Generator)
  - CAN ANNULAR - 6 Cans/6 Fuel Nozzles-Ignitors
(3) TURBINES
TURBINES
A SINGLE-SHAFT GAS TURBINE ENGINE
A SPLIT-SHAFT GAS TURBINE ENGINE

Figure 16-5
LM 2500 Turbine Section

- High Pressure Turbine
  - Maintains Compressor Rotation
- Power Turbine (Low Pressure)
  - 6 sets of nozzles/Blades
  - NOT Attached to Compressor Shaft
  - Directly Attached to Power Drive Shaft
EXHAUST DUCTS

• Routes exhaust gases to atmosphere (1200 F)
• Contains
  – Silencers – Like Muffler
  – Exhaust Gas Cooling – Air Ejector Nozzles (450 F)
• Higher than intake

• Auxiliary Uses: WASTE HEAT BOILER (GTG only)
  – Like Economizer
  – Heats water (650 F - Steam)/Cools Exhaust (400 F)
EXHAUST DUCT SYSTEM

EXHAUST NOZZLES

EDUCTOR

STACK

EXHAUST SILENCERS

FOUNDATION

EXPANSION JOINT

VIEW LOOKING FORWARD
EXHAUST EDUCTOR
Operating Principles

• Shipboard GTEs can be thought of in terms of thermodynamic processes:
  Steady flow
  Open cycle
  Unheated engine
  Working fluid = air that is compressed in the compressor and combustion chamber

• Unlike the steam plants and reciprocating engines, the gas turbines operate on the Brayton Cycle.
• Air is drawn into the compressor where it is compressed and sent to the combustion chamber. Fuel is injected into the combustion chamber where it is ignited by the compression (spark on startup). The gases are directed into the turbine where the thermal energy is converted into work.
Thermodynamic Relationships

\[ P_1 = Pr_1 \]
\[ P_2 = Pr_2 \]

\( P_1 \) = Inlet Pressure
\( P_2 \) = Outlet Pressure
\( Pr_1 \) = Inlet reduced Pressure
\( Pr_2 \) = Outlet reduced Pressure
Thermodynamic Relationships

Example:

T1 = 80 F
P1 = atmosphere = 14.7 PSIA
Compression ratio = 17:1
Efficiency = 92.5%
Gas Turbine Module

• A LM2500 engine is encased in a module to provide cooling, noise reduction, shock mounting, and safety CO$_2$ flooding.

• Modular in design facilitates easy replacement

• Inlet Duct has louvers and demisters

• Outlet duct has coolers and silencers
Safety Features

- High Temperature shutdown
- Topping governor limits speed to 104%
- Overspeed trip limits speed to 108%
Shafting Components

• GTE NOT Directly connected to Shafting
• GTE is connected to reduction gears via clutches => allowing for the locking of shafts
• Clutch is Screw Type
Shafting Components

• **Controllable Reversible Pitch Propeller** - allows for slower speeds and reverse
  - Engines/shaft turn in only one direction
  - Allow engines to work at constant speed
    • LM2500s can not operate at speeds < 5,000 RPM = 11 Kts
    • “Indicate Pitch and Turns”
Why Don’t We Use GTEs on all Ships?

• Some Disadvantages are:
  – inefficient at low speeds
  – large inlet and outlet ducting
  – CBR warfare problems
  – complex shafting (clutches and CRPs)
  – large fuel storage requirements
Summary

- Advantages and disadvantages of GTEs and some of their components
- The parts and operation of GTEs
- The different types of GTEs
- Air distribution
- Support systems
- Platforms that use GTEs