Gas Turbine Engine

Thrust Augmentation and Thrust Reverser

Introduction

- Thrust Augmentation
  - Water Injection
  - Afterburning
- Thrust Reverser
Thrust Augmentation

- Thrust augmentation:
  - Satisfy occasional higher thrust demands
  - Without incurring undue size and weight penalty

- Common means of thrust augmentation:
  - *Water injection*
  - *Afterburning*

Water Injection

As density of air reduces due to lower pressure or increased temperatures, engine thrust reduces.
**Water Injection**

- Water or water/methanol mixture sprayed into:
  - compressor
  - combustion chamber

- Effects:
  - Mass flow rate increases due to coolant mass
  - Incoming air temperature reduces, increasing the density and air mass flow rate (for injection into compressor)
  - Turbine temperature reduces,
    - Allowing more fuel to be added
    - Higher combustion chamber pressure and higher engine thrust
  - If methanol is added, it will burn and add to gas energy

**Afterburning**

- Afterburning (or reheat)
  - thrust augmentation for short periods
  - to improve the aircraft take-off, climb and (for military aircraft) combat performance

- Alternative is a larger basic engine
Afterburning

- Additional fuel is burned after the turbine, resulting in
  - exhaust gas temperature rise,
  - higher exit velocity and thrust
- Gas exiting the turbine is still oxygen-rich
- Afterburner consists of a duct section, fuel injectors, flame holder and variable nozzle

Variable Exhaust Nozzle

- Variable nozzle for proper pressure and temperature control
  - Normally closed during non-afterburning operation
  - Opens during afterburning operation to
    - Accommodate the increased gas volume
    - Prevent excessive back pressure
Afterburning

Watch video: F-16 afterburning operation (http://www.youtube.com/watch?v=GcFWP_TvNjM)

• Notice the variable exhaust nozzle opening up when afterburner is activated

Thrust Reverser

• Supplements the wheel brakes

• Reduces the landing run by using engine power as a deceleration force

Thrust Reverser Operation

- Operation is possible only when aircraft is on ground, after engine power is retarded first to idle
- Diverts the exhaust such that there is a forward velocity component of engine thrust
- On turbofan engines, only bypass air (cold stream) is reversed

Thrust Reverser Configurations

Source: The Jet Engine (1986) by Rolls Royce plc, page 165-166

Source: The Jet Engine (1986) by Rolls Royce plc, page 161
Summary

- Water injection thrust augmentation
- Afterburner thrust augmentation
- Thrust reverser systems

Reflection Question

- Research and discuss the benefit-penalty trade-offs of a water injection thrust augmentation system.