

3 COMPRESSOR STABILITY

Introduction

We have seen that the Compressors in a Gas Turbine engine are basically unstable, attempting to push the gas against the pressure ratio. The safe, effective use of a gas turbine depends on suitable control of compressor operating positions in order to prevent any of the engine's compressors from stalling as this would cause a severe loss in engine thrust or power and may render the engine uncontrollable.

In this section we will consider the various operating modes and conditions of the gas turbine which may cause compressor stall. The behaviour of a compressor in stall is explained because the engineer, although designing to avoid stall, must consider the possibility of stall and what control measures must be taken to recover engine operability. A major cause of stall is inlet distortion i.e. a non-uniform pressure and/or temperature profile at entry to the compressor. The causes and effects of distortion are discussed in detail.

3.1 Causes of Stall

Fig 3.1 lists various causes of compressor stall. An acceleration is always a potential cause of stall on an HP compressor as there will always be an excursion towards the surge line. The effect of large tip clearances make a re-slam particularly susceptible to stall. Decelerations are not usually a problem as the initial move is away from stall, however there are some circumstances in which a deceleration can lead to a stall at low power towards the end of the deceleration. Very rapid decelerations as required by a vertical landing aircraft can cause the HP compressor working line to go above the normal steady-state line due to the mis-match of components caused by the delaying effects of the gas dynamics. The rapid deceleration in this case is needed to kill the thrust immediately the aircraft wheels touch the ground, thus preventing the aircraft rising again on the cushion of its own exhaust.

Afterburner light-up must be scheduled carefully to avoid pushing the fan towards stall. When there is a problem with the scheduling it is quite common for the fan flow to be disturbed and for this instability to adversely affect the engine core. This can result in the core compressor stalling before the fan.

Turbine damage or some form of blockage in the turbine will reduce the flow area and can cause the compressor to stall. It has been known for loose debris from a mechanical failure in the compressor or combustion chamber to lodge itself in the turbine nozzle guide vanes.

Distortion of the inlet air will have serious effects on the flow through a fan or LP compressor increasing the likelihood of stall.