SELECTED TOPICS

In Aerospace Engineering

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IIUM Press

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CHAPTER FIVE

MODELING OF COMPRESSION SYSTEMS

5.1 Introduction

A mathematical model is needed in order to investigate the control of surge and stall.

Two types of models can be distinguished:

- Control model that predicts the time development of flow instabilities. It has to be compact and fast to be used in controller design
- Simulation model for system dynamic analysis

Since the nature of surge is different from stall, the approach to develop the model is different. Surge is associated with axisymmetric disturbances and involves mass flow and pressure variations in the entire compression system. Therefore, the plenum and throttle have to be incorporated in the model to study this unstable phenomenon. The model should capture the behavior of the entire compression system. On the other hand, rotating stall involves regions of stalled mass flow which rotate around the circumference of the compressor. In this flow regime, only the average mass flow and pressure rise interact with the plenum and throttle since the flow redistributes and pressure variations decay away from the compressor. As a result, the model has to account necessarily for the circumferential variations of flow within the compressor. This demands the modeling of fluid dynamics inside the compressor that will be discussed in next chapter.

Figure 16 shows an idealized compression system. The incompressible fluid is pressurized in the compressor and it is discharged to a closed tank which contains a compressible gas. This tank discharges via a throttle valve in another large reservoir. In this system, the throttle represents the system pressure requirements, i.e., dissipation loss and mass flow rate, and the closed tank represents mass storage capability.