CHAPTER 1

INTRODUCTION

The axial flow compressor plays a very important role in generation of high power for aircraft and industrial applications. C.C. Koch [13] in his work considered General Electric’s low speed research compressor having four identical stages. In many power generation applications, Siemens’ compressors are used due to their high efficiency range of 88 to 92 percent. Fig 1.1 depicts the longitudinal view of multi stage axial flow compressor and turbine.

![Fig 1.1: Longitudinal Sectional View of Axial Flow Compressor and Turbine](image-url)
To produce high power, high pressure ratios are required at the end of the compressor. These pressure ratios can be produced by designing the compressor with multiple stages. The use of multiple stages develop the pressure ratios up to 40:1 in some aerospace applications and a pressure ratio of 30:1 in some industrial applications.

The overall pressure ratio at the end of the multistage compressor depends upon the inlet stage pressure, since the pressure ratio at the inlet stage influences the pressure ratios produced in subsequent stages.

The inlet stage pressure ratio is influenced by the stage performance parameters and mass flow rate of working fluid entering the compressor.

The performance parameters considered in this work are stage efficiency, stall margin coefficient, inlet stage specific area, and centrifugal stresses.

Using these performance parameters, the objective functions and constrained equations are formulated as multiobjective optimization problem.

The performance parameters depend on the design variables of the compressor. The selected design variables in this work are mean diameter of the stage ($D$), air angle at inlet to the compressor ($\alpha_1$), shaft rotational speed ($N$), flow coefficient of air ($\theta$) and hub-tip radius ratio of the blade ($r_t/r_i$).

The formulated multiobjective optimization problem is solved using weighing method in which the multiobjective problem is converted into
single objective. The constrained and unconstrained single objective problem is solved by using Nelder-Mead Simplex technique and Genetic Algorithm. Further NSGA-I and NSGA-II techniques are implemented to solve the multi objective problem consisting of the three objective functions. Also the sensitivity analysis has been performed to study the influence of the design variables on the objective functions.

1.1 OBJECTIVES OF THE WORK

With the advancement in evolutionary optimization techniques, many multi objective optimization problems are solved to find the best non-dominated solutions. In the present work, the axial flow compressor inlet stage is formulated as a multi objective optimization problem and optimized using various evolutionary optimization techniques.

The following are the main objectives of the present work.

- Formulation of the axial flow compressor inlet stage as a multi objective optimization problem.
- Comparison of the performance efficiency of classical Genetic Algorithm against Nelder Mead simplex technique in minimizing the transformed single objective function.
- To measure the performance of the evolutionary optimization techniques NSGA-I and NSGA-II against conventional Nelder Mead simplex technique.
To find the best non-dominated solutions for all objective functions simultaneously using NSGA-I and NSGA-II techniques.

To Study the sensitivity of objective functions by changing the values of design variables.

1.2 ORGANISATION OF THESIS

A brief introduction to optimum design of the first stage of axial flow compressor and methods adopted in optimizing the objective functions is presented in chapter 1.

In chapter 2, a review of literature related to the design and analysis of axial flow compressor, various multi objective optimization techniques and literature related to sensitivity analysis is presented.

Chapter 3, deals with the formulation of the multi objective optimization problem of axial flow compressor inlet stage using various stage design relations, fluid flow correlations and thermodynamic principles.

A brief introduction to various optimization techniques used in this work and their implementation procedures are discussed in chapter 4.
The results obtained by implementing the optimization techniques on the multi objective optimization problem and the results pertaining to sensitivity analysis are presented and discussed in chapter 5.

Chapter 6, presents the conclusions drawn based on the results obtained. This chapter also discusses the scope for carrying further work.