Axial Compressor

Please note that the content of this book primarily consists of articles available from Wikipedia or other free sources online. Pages: 47. Chapters: Axial compressor, Centrifugal compressor, Centrifugal fan, Centrifugal pump, Flow through cascades, Francis turbine, Gas turbine, Industrial fans, Jet engine, Mechanical fan, Mixed flow compressor. Excerpt: A gas turbine, also called a combustion turbine, is a type of internal combustion engine. It has an upstream rotating compressor coupled to a downstream turbine, and a combustion chamber in-between. The basic operation of the gas turbine is similar to that of the steam power plant except that air is used instead of water. Fresh atmospheric air flows through a compressor that brings it to higher pressure. Energy is then added by spraying fuel into the air and igniting it so the combustion generates a high-temperature flow. This high-temperature high-pressure gas enters a turbine, where it expands down to the exhaust pressure, producing a shaft work output in the process. The turbine shaft work is used to drive the compressor and other devices such as an electric generator that may be coupled to the shaft. The energy that is not used for shaft work comes out in the exhaust gases, so these have either a high temperature or a high velocity. The purpose of the gas turbine determines the design so that the most desirable energy form is maximized. Gas turbines are used to power aircrafts, trains, ships, electrical generators, or even tanks. Gases passing through an ideal gas turbine undergo three thermodynamic processes. These are isentropic compression, isobaric (constant pressure) combustion and isentropic expansion. Together, these make up the Brayton cycle. In a practical gas turbine, gases are first accelerated in either a centrifugal or axial compressor. These gases are then slowed using a diverging nozzle known as a diffuser; these processes increase the pressure and temperature of the flow. In an ideal system, ..

The results of an analytical study of compression system forced response and an experimental investigation of the reversed flow performance of a three-stage axial-flow compressor are presented. A one dimensional lumped parameter description of the dynamics of a simple compression system was found to be capable of simulating the circumstances under which the imposition of a periodic external excitation can 'force' a normally surging compression system into a small amplitude oscillation about the nonrecoverable stall point. This forces oscillation can then decay into a system stagnation upon termination of the external excitation. It was also found, however, that predictions of compression system forced response behavior were heavily dependent upon the model used for defining compressor post-stall performance, both steady state and transient, especially in the reverse flow and mass flow and shutoff operating regimes. The complete set of pressure rise and torque characteristics of a three-stage axial-flow compressor are presented. Two stable stalled flow modes have been observed in the multi-stage axial compressor builds tested: 1) rotating stall, and 2) full annulus stalled flow. The transition to each of the two stalled modes is accompanied by a discontinuous drop in overall time-averaged pressure rise and torque performance. Although a large hysteresis is associated with the unstall-rotating stall transition (which occurs at a relatively large positive flow coefficient), the transition from rotating stall to the annulus stall mode (which occurs at a negative flow coefficient near shutoff) has no hysteresis.

The transition from centrifugal-flow compressors to axial-flow compressors in the jet engines of the late 1940's and early 1950's provides an illuminating case study of the evolutionary nature of technological change. A look at the development of the turbojet in light of engineering design reveals that incremental changes came about in response to changing needs. The iterative nature of engineering design, whereby a designer repeats a step until he arrives at an acceptable solution, allows the designer to take into account new needs and new information. The first two turbojets, invented independently in England and Germany in the mid-1930's, both used centrifugal compressors. The inventors built upon the two hundred year-old tradition of centrifugal-flow turbomachinery to design a successful turbojet compressor. In contrast, all attempts at designing and building an axial-flow compressor prior to the twentieth century failed. Yet, researchers in four different countries persisted in their efforts because of their faith in the potential of the axial compressor to produce a higher pressure ratio at a better efficiency than the centrifugal compressor. Theses. (mjm).

The report describes the results of a program to redesign the exit stators of a 2.8:1 pressure ratio supersonic axial compressor, and to fabricate and test the redesigned stators to evaluate the effect of the redesign on the overall stage performance. This compressor is intended to serve as a boost stage in axial centrifugal compressors with overall pressure ratios of 16:1 for small gas turbine engines. The redesign was undertaken to provide an essentially cylindrical flow path aft of the rotor. This redesign eliminates an 'S' shaped duct in the exit stator assembly of the original design. The measured performance showed no improvement over the original design, and indicated a two-point degradation in efficiency. The demonstrated exit stator and duct total pressure loss at design speed and stator setting was consistent with that demonstrated by the previous exit stators. Variation in the angle setting of the adjustable stator blades caused some movement of the surge line and flow range of the compressor, but offered no improvement in peak performance relative to the design setting. (Author).

Tip clearance has long been known to be a source of losses in axial compressors with cantilevered blades. The reasons for the losses, however, are not well understood and current practice in engine design still requires extensive effort to maintain constant minimal operating clearances over a wide range of conditions. The emphasis on clearance control may be appreciated by the typical observation that a ten percent change in peak static pressure rise in a compressor stage may occur for a fifty percent change in clearance. Clearances are typically in the one to five percent of major passage dimension range, and thus a small change in passage dimensions represents a large change in clearance. It is clear that, in general, it would be desirable that blading performance be less sensitive to changes in clearance. Less sensitivity would allow a general relaxation of the mechanical tolerances on a compressor assembly and provide more consistent transient performance. The aerodynamics of achieving such a situation are a challenge as the underlying requirement is improved performance at larger clearances. Work toward understanding the basic mechanisms of tip clearance effects with an emphasis on designing for clearance has been commenced at the Naval Postgraduate School turbopropulsion Laboratory (NPS/TPL). This report summarizes the preliminary work on the Multistage Compressor (MSC) facility at the Laboratory.

This report, in two volumes, describes a computer program that has been developed for the design of axial compressors. The principal purpose of the program is to enable a single computer program to determine the geometry of the compressor blading, details of the flow within the compressor, and the design point performance of the machine. Some optional calculation routines will also enable effects of mixing of the flow to be investigated. The program consists fundamentally of three sections; two alternative means of determining blade geometry, and an aerodynamic computation for the flow through the compressor.

The report is a collection of experimental unsteady data acquired in the first stage of the NASA Low Speed Axial Compressor in configuration with smooth (solid) wall treatment over the first rotor. The aim of the report is to present a reliable experimental data base that can be used for analysis of the compressor flow behavior, and hopefully help with further improvements of compressor CFD codes. All data analysis is strictly restricted to verification of reliability of the experimental data reported. The report is divided into six main sections. First two sections cover the low speed axial compressor, the basic instrumentation, and the in-house developed methodology of unsteady velocity measurements using a thermo-anemometric split-fiber probe. The next two sections contain experimental data presented as averaged radial distributions for three compressor operation conditions, including the distribution of the total temperature rise over the first rotor, and ensemble averages of unsteady flow data based on a rotor blade passage period. Ensemble averages based on the rotor revolution period, and spectral analysis of unsteady flow parameters are presented in the last two sections. The report is completed with two appendices where performance and dynamic response of thermo-anemometric probes is discussed.

A multiphase axial compressor is described. It is characterized by the fact that the vanes are placed immediately in the passage channel or along this channel, bent in meridion section, and the centrifugal forces of the meridion passage are directed toward the axis of the compressor. (Author).

Throughout the last decades, centrifugal compressor research and development have been revolutionized. Computational fluid dynamics have provided a better understanding of the flow and physical phenomena, and the design of new cen trifugal compressor components has been transformed from an "art" into a "sci ence". New materials and manufacturing techniques now create new geometries that could only be dreamed of in the past, and new challenging applications have pushed the limits beyond what was considered the state of the art. This new book presenting a comprehensive look at industrial compressors is therefore very timely. Readers will find a large amount of information based on extensive experience, a clear and well-founded approach to real-gas handling and solutions to many practical problems. It will provide engineering contractors and users of industrial compressors with a better insight into the "how" and "why" of different design features thus allowing a more profound basis for discussions with manufacturers. It will also cast a light on the day-by-day design practice to academia by revealing the limitations and requirements of practical applications and economics. This book combines a strict mathematical approach with practical experience and is illustrated with many examples. It fills in the gap between academic text books and encyclopaedic descriptions of industrial compressors. I have no doubt that this book, based on several decades of experience in the industry, both in the USA and Europe, will be well received by the centrifugal compressor community.

Please note that the content of this book primarily consists of articles available from Wikipedia or other free sources online. Pages: 40. Chapters: Affinity laws, Axial compressor, British Thomson-Houston, C. A. Parsons and Company, Centrifugal compressor, Centrifugal fan, Centrifugal pump, Charles Algernon Parsons, Corrected flow, Corrected speed, Degree of reaction, Elliott Company, Ellipse Law, Euler's pump and turbine equation, Gas turbine, Hydrogen-cooled turbo generator, Hydrogen turboexpander-generator, Industrial fans, Laboratory for Energy Conversion, Malibu Hydro, Mechanical fan, Metropolitan-Vickers, Mixed flow compressor, Radial turbine, Solar fan, Steam turbine, Tesla turbine, Turbine engine failure, Turbine hall, Turbine map, Turbomachinery, Turbopump, Variable geometry turbomachine, Wells turbine.

Turbomachines are used extensively in Aerospace, Power Generation, and Oil & Gas Industries. Efficiency of these machines is often an important factor and has led to the continuous effort to improve the design to achieve better efficiency. The axial flow compressor is a major component in a gas turbine with the turbine's overall performance depending strongly on compressor performance. Traditional analysis of axial compressors involves through flow calculations, isolated blade passage analysis, Quasi-3D blade-to-blade analysis, single-stage (rotor-stator) analysis, and multi-stage analysis involving larger design cycles. In the current study, the detailed flow through a 15 stage axial compressor is analyzed using a 3-D Navier Stokes CFD solver in a parallel computing environment. Methodology is described for steady state (frozen rotor stator) analysis of one blade passage per component. Various effects such as mesh type and density, boundary conditions, tip clearance and numerical issues such as turbulence model choice, advection model choice, and parallel processing performance are analyzed. A high sensitivity of the predictions to the above was found. Physical explanation to the flow features observed in the computational study are given. The total pressure rise verses mass flow rate was computed.

The design of a single stage axial supersonic compressor with a predicted performance of 2.8:1 stage pressure ratio at 82% adiabatic efficiency and 4 lb/sec airflow is discussed. The results of a gas generator performance study to evaluate non-regenerated designs with 16:1 pressure ratio compressors and turbine inlet temperatures between 2500 F and 3000 F are presented and discussed. The design point specific fuel consumption of the engines studied ranged from 0.415 to 0.438 lb/hp/hr. At 50% power this range increased to 0.465 and 0.534 respectively. The engine configuration which indicated the lowest specific fuel consumption has a two spool gas generator and variable stator free power turbine. The preliminary designs of a two stage axial/centrifugal compressor and an advanced gas generator which incorporates this compressor are discussed. The predicted performance of the compressor is 16:1 pressure ratio at an adiabatic efficiency of 77.5% and an airflow of 4 lb/sec. The predicted design point specific fuel consumption and power at a 2500 F turbine inlet temperature are 0.431 lb/hp/hr and 785 hp respectively. The results of a preliminary design study for a variable geometry axial compressor rotor concept are also discussed. This concept offers the potential for improved part speed compressor performance and stage matching. (Author).

Advances in Axial Compressor AerodynamicsMay 15-18, 2006NASA Low-speed Axial Compressor for Fundamental ResearchAnalysis of an Axial Compressor Stage with Infinitesimal and Finite Blade Spacing

Compressor Performance will be appreciated as a handy reference book by compressor design engineers and compressor maintenance engineers as well as engineering students. As its title suggest, this book covers the full spectrum of information needed for an individual to select, operate, test and maintain axial or centrifugal compressors. This book includes everything necessary to the mechanical engineer and student. There is a basic overview of aerodynamic theory, a troubleshooting guide, and numerous example problems. The example problems, covering everything from gas properties to flow meter calculations, will provide easy analysis of compressor performance. This is the ideal reference on the topic of compressor performance.

High efficiency axial and centrifugal compressors are important in fields as diverse as aircraft engines, superchargers and turbochargers, process and refrigeration compressors. Compressors must achieve high efficiency in blade rows in diffusing flow fields. Of equal and sometimes greater importance is the range os stable operation of the compressor. Blade row stall characteristics determine the limit os stable operation. Blading can stall uniformly with symmetric flow breakdown or asymmetrically in rotating stall, wich propagates around the periphery of the blade row. Depending on aerodynamic conditions, surge may occur instead of, in concert with, or subsequent to blade row stall. The transient breakdown and recovery of aerodynamic loading not only limits compressor performance but also leads to mechanical failures caused by the vibrational loads imposed on the blades. There is no need to know what initiates these performance limits so that surge and stall margins can be optimized and control strategies can be planned. the first step toward understanding is to be knowledgeable about he physical processes occurring during surge and stall. This will permit the designer to anticipate variable geometry needs such as variable inlet guide vanes, variable statuors, and bleed port strategies. Theoritical treatment is far from being well established, however, there are many approaches discussed in the literature. This book is a unique reference to the subject matter. Physical descriptions of the phenomena are given, test results are presented, and analytical studies are discussed. There has been much written about the experimental investigations and theoretical treatments related to surge and stall. To assist those who would pursue advancements in furthering ou knowledge of surge and stall, it seemed appropriate to have a resource that contains a compendium of information on this subject. That is the purpose of this book. [Source : d'après la 4e de couverture].

A method of designing circular blade systems of finite spacing is developed. First, the theory of flow and through a system of infinitesimally spaced surfaces is formulated by means of a continuous axially symmetric force field which is uniform in the cricumferential direction. This force field replaces the effect of the blade system, with its hub and shroud boundary surfaces. Second, the force field is the space between the blades, hub, and shroud is replaced in the equations of finite spacing by inertia and pressure terms, which were omitted in equations of infinitesimal spacing. These terms will change values of flow variables of infinitesimal spacing.

A comprehensive introduction to turbomachines and their applications With up-to-date coverage of all types of turbomachinery for students and practitioners, Fundamentals of Turbomachinery covers machines from gas, steam, wind, and hydraulic turbines to simple pumps, fans, blowers, and compressors used throughout industry. After reviewing the history of turbomachinery and the fluid mechanical principles involved in their design and operation, the book focuses on the application and selection of machines for various uses, teaching basic theory as well as how to select the right machine for a specific use. With a practical emphasis on engineering applications of turbomachines, this book discusses the full range of both turbines and pumping devices. For each type, the author explains: * Basic principles * Preliminary design procedure * Ideal performance characteristics * Actual performance curves published by the manufacturers * Application and appropriate selection of the machine Throughout, worked sample problems illustrate the principles discussed and end-of-chapter problems, employing both SI and the English system of units, provide practice to help solidify the reader's grasp of the material.

Control engineers, mechanical engineers and mechanical technicians will learn how to select the proper control systems for axial and centrifugal compressors for proper throughput and surge control, with a particular emphasis on surge control. Readers will learn to understand the importance of transmitter speed, digital controller sample time, and control valve stroking time in helping to prevent surge. Engineers and technicians will find this book to be a highly valuable guide on compressor control schemes and the importance of mitigating costly and sometimes catastrophic surge problems. It can be used as a self-tutorial guide or in the classroom with the book's helpful end-of-chapter questions and exercises and sections for keeping notes.

A cursory design study of the gas generator involving the preliminary design and analysis of a family of axial compressors was conducted. Each axial compressor was designed to be capable of match with advanced centrifugal technology. The minimum overall axial-centrifugal design pressure ratio for each compressor configuration was 16:1. The engine performance using the characteristics of the compressor designs was evaluated and an optimum gas generator configuration was selected. The axial compressor for the optimum gas generator configuration was detail designed for test rig evaluation. This axial compressor has two stages and a 3.0:1 design pressure ratio. The design flow rate is 5.0 pound-per-second and the inlet tip radius is 2.72 inches. (Author).

The rotating-stall characteristics of a single-stage axial-flow compressor were investigated. The number of stall cells and their propagation velocities were found with and without stator blades. The measured velocities were compared with those predicted by Stenning's theory (see NACA TN 3580), assuming the dounstream pressure fluctuations to be negligible, and correlation within 10 percent was obtained at the onset of stall. It was found that the pressure fluctuations cauased by rotating stall were less downstream of the rotor than upstream; the minimum reduction across the rotor was 40 percent with stator blades and 75 percent without stator blades. It was also that, for the compressor tested, the stator blades decreased the number of stall cells and tended to induce rotating stall at larger mass flow rates.

This paper describes the unsteady blade surface pressures on the first-stage rotor blades of a two-stage transonic axial flow compressor experiencing inlet flow distortion. This study was conducted to demonstrate the ability of a full annulus unsteady Reynolds-averaged Navier-Stokes numerical technique to predict unsteady pressures on the rotor blades operating in a distorted inflow. A total pressure distortion produced by a variable mesh screen mounted near the inlet was used to excite the unsteady blade loading on the rotor. On-blade pressure transducers were used to measure the unsteady blade surface pressure. These pressures and the resulting transient load on the rotor blades were compared to the numerical prediction. It is important to develop numerical techniques to predict these transient loads to better understand the response of compressor blades to forcing functions. With this enhanced understanding and ability to predict these transient forces, more robust compressors can be developed. In the study, a high definition of the inlet flow distortion was achieved by rotating the distortion screens. In this manner the inlet flow distortion and the distortion at the first stage stator leading edge were measured at approximately every 0.7 degrees. This full annulus high definition of the inlet flow distortion was used as the inlet boundary condition for the numerical technique. The experimental measurements and numerical analyses are highly complementary in this study. Detailed comparisons between the measurements and the numerical analyses indicate that the current numerical procedure calculates the unsteady aerodynamic pressure on the blade surfaces

reasonably well. Further, the agreement of the measured and predicted rotor exit flow distortion at the first stage stator leading edge provides verification of the numerical technique.
The new edition will continue to be of use to engineers in industry and technological establishments, especially as brief reviews are included on many important aspects of Turbomachinery, giving pointers towards more advanced sources of information. For readers looking towards the wider reaches of the subject area, very useful additional reading is referenced in the bibliography. The subject of Turbomachinery is in continual review, and while the basics do not change, research can lead to refinements in popular methods, and new data can emerge. This book has applications for professionals and students in many subsets of the mechanical engineering discipline, with carryover into thermal sciences; which include fluid mechanics, combustion and heat transfer; dynamics and vibrations, as well as structural mechanics and materials engineering. An important, long overdue new chapter on Wind Turbines, with a focus on blade aerodynamics, with useful worked examples Includes important material on axial flow compressors and pumps Example questions and answers throughout
Please note that the content of this book primarily consists of articles available from Wikipedia or other free sources online. Pages: 38. Chapters: Air preheater, Axial compressor, Bimetallic strip, Cylinder (engine), Expander cycle (rocket), Gas turbine, Industrial fans, Jet engine, Mechanical fan, Mixed flow compressor, Moving bed heat exchanger, Plant efficiency, Recuperator, Sectional cooler. Excerpt: A gas turbine, also called a combustion turbine, is a type of internal combustion engine. It has an upstream rotating compressor coupled to a downstream turbine, and a combustion chamber in-between. The basic operation of the gas turbine is similar to the of the steam power plant except that air is used instead of water. Fresh atmospheric air flows through a compressor that brings it to higher pressure. Energy is then added by spraying fuel into the air and igniting it so the combustion generates a high-temperature flow. This high-temperature high-pressure gas enters a turbine, where it expands down to the exhaust pressure, producing a shaft work output in the process. The turbine shaft work is used to drive the compressor and other devices such as an electric generator that may be coupled to the shaft. The energy that is not used for shaft work comes out in the exhaust gases, so these have either a high temperature or a high velocity. The purpose of the gas turbine determines the design so that the most desirable energy form is maximized. Gas turbines are used to power aircrafts, trains, ships, electrical generators, or even tanks. Gases passing through an ideal gas turbine undergo three thermodynamic processes. These are isentropic compression, isobaric (constant pressure) combustion and isentropic expansion. Together, these make up the Brayton cycle. In a practical gas turbine, gases are first accelerated in either a centrifugal or axial compressor. These gases are then slowed using a diverging nozzle known as a diffuser; these processes increase the...
Experiments were performed on a low-speed multistage axial-flow compressor to assess the effects of shrouded stator cavity flows on aerodynamic performance. Five configurations, which involved changes in seal-tooth leakage rates and/or elimination of the shrouded stator cavities, were tested. Data collected enabled differences in overall individual stage and the third stage blade element performance parameters to be compared. The results show conclusively that seal-tooth leakage ran have a large impact on compressor aerodynamic performance while the presence of the shrouded stator cavities alone seemed to have little influence. Overall performance data revealed that for every 1% increase in the seal-tooth clearance to blade-height ratio the pressure rise dropped up to 3% while efficiency was reduced by 1 to 1.5 points. These observed efficiency penalty slopes are comparable to those commonly reported for rotor and cantilevered stator tip clearance variations. Therefore, it appears that in order to correctly predict overall performance it is equally important to account for the effects of seal-tooth leakage as it is to include the influence of tip clearance flows. Third stage blade element performance data suggested that the performance degradation observed when leakage was increased was brought about in two distinct ways. First, increasing seal-tooth leakage directly spoiled the near hub performance of the stator row in which leakage occurred. Second, the altered stator exit now conditions caused by increased leakage impaired the performance of the next downstream stage by decreasing the work input of the downstream rotor and increasing total pressure loss of the downstream stator. These trends caused downstream stages to progressively perform worse. Other measurements were acquired to determine spatial and temporal flow field variations within the up-and-downstream shrouded stator cavities. Flow within the cavities involved low momentum fluid traveling primarily in...