AIAA JOURNAL
Vol. 37, No. 8, August 1999

Book Reviews

Mechanics of Sandwich Structures

Edited by A. Vautrin, Kluwer Academic Publishers, Dordrecht, The Netherlands, 1998, 444 pp., $189.00

The proceedings of the Colloquium on Mechanics of Sandwich Structures includes five keynote papers and 49 extended abstracts arranged according to seven thematic subjects. These subjects are described in turn by four main themes: modeling of sandwich structures, dynamic properties of sandwich structures, identification of sandwich and core material mechanical properties, and industrial applications and manufacturing.

Thirteen papers were contributed in the modeling subject area. Six of these papers were dedicated to the use of finite elements as computational tools for describing the behavior of sandwich plates and shell components with both the static and dynamic behavior of the sandwich structures investigated.

In the paper by O. Potet and M. Touratier, a new triangular finite element, based on the linear elastic behavior of multilayered, moderately thick composite plates, is described. The triangular element introduced by the authors is representative of a new kind of kinematics built upon interpolation for bending, membrane displacements, and transverse shear rotations. Results obtained using this element are shown in this paper to compare favorably with exact three-dimensional elasticity solutions for sandwich plates. Some of the other finite element method papers focus on the determination of stresses between the skin and core, the use of different finite elements for evaluating the displacements and stresses, the introduction of a hybrid finite element, the use of refined multilayered finite elements, and shear deformation finite elements.

Other topics in the modeling section discuss the importance of material inhomogenieity and anisotropy as related to the application of Saint-Venant's principle to sandwich structures, the effects of thermally induced bending of sandwich panels with isotropic core and faces, and homogenization methods applied to metallic sandwich plates.

The thematic section on buckling and singularities includes six papers that examine the effects of boundary conditions on the buckling behavior of beams and plates, local buckling effects due to in-plane and biaxial loading of sandwich structures, and buckling and postbuckling behavior of sandwich structures considering geometrical nonlinearities.

The thematic section on the dynamic and impact behavior of sandwich structures consists of eight papers dealing with a variety of problem types. Included are such topics as modeling of double-walled panels separated by stiffeners subjected to impulsive loads, mixed numerical/experimental techniques for the determination of the complex moduli of sandwich plates, and solutions to the forced-vibration problems of layered rectangular viscoelastic plates. Impact problems, including small mass impact on sandwich panels, establishment of test methodology for defining the impact strength parameters important to the behavior of sandwich structures, and energy absorption characteristics of foam core sandwich panels, have been investigated.

The experimental test section consists of six papers, with a variety of materials used for sandwich facings and for core configurations. An interesting paper in this section, by J. C. Kneip, X. J. Gong, and S. Aivazzadeh, describes the principles and experimental processes associated with establishing moisture absorption effects in polymeric sandwich materials. The technique discussed uses microwave excitation to create local heating in the material, with an infrared camera used as the detection device by observing radiation emitted from the sample.

Seven papers deal with the subject of sandwich and constituent properties. Several papers deal with modeling of core properties of different sandwich panels consisting of fabric, small sphere fillers, and polymeric cores. One of these papers, by D. Phillips, I. Verpoest, and J. Van Raemdonck, deals with the subject of recent developments in three-dimensional knittings for sandwich panels. The focus in this paper is on increasing the stability of the knits and on the use of special yarns. The need to ensure correct and adequate impregnation of the knits with resin is discussed. A number of interesting applications of knitted materials include crash protective helmets, medical applications, and protective parts for sporting gear.

Five papers are devoted to sandwich design issues. The contribution by G. Eyraud and W. S. Han describes the Finite Element-Aided Design–Laminated and Sandwich Plates (FEAD–LASP) program as a software design tool for elastic composite sandwich plates, and the paper by D. Bassetti, Y. Brechet, G. Heiberg, I. Lingorski, and P. Pechamber examines the applicability of materials selection methods to the optimal design of structural sandwich material. Another paper, by R. Wallat and A. Eisenhut, describes the first steps in design of a surface-effect ship with a length approximately five times that of existing designs. The subject of design issues associated with potted inserts used in sandwich structures is covered by O. T. Thomsen, and the fifth paper of this section, by E. E. Theotokoglu, reports on design issues associated with failure modes of T joints.

In recent years, advances in polymer science and manufacturing processes have resulted in a number of symposia and conferences dealing with sandwich materials. Indeed, a new journal dealing with the subject of sandwich structures and materials has been initiated within the past year. This conference represents further testimony to the interest in sandwich materials and as such presents a number of interesting papers dealing with analysis, testing, and design issues. It should be a welcome addition to the library of every engineer with an interest in this technology.

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Unsteady Aerodynamics and Aeroelasticity of Turbomachines

Edited by T. H. Fransson, Kluwer Academic Publishers, Dordrecht, The Netherlands, 1998, 847 pp., $350

Over the past quarter century there has been a growing awareness of the importance of unsteady aerodynamic and aeroelastic effects on the design, development, and operation of jet engines and power plants. In response to this recognition, the specialists working in this field felt a need to get together every two or three years for the purposes of discussing the latest results and exchanging ideas for further work. The first such meeting was held in Paris in 1976, followed by meetings in Lausanne (1980), Cambridge (1984), Aachen (1987), Beijing (1989), Notre Dame (1991), and Fukuoka (1994). The present volume contains the 54 papers presented at the eighth meeting in this series, held at the Royal Institute of Technology in Stockholm. As in the past, the major concerns addressed in this symposium were the blade flutter and forced-response problems. Therefore, most of the sessions were devoted to computational and experimental studies of the flow around oscillating blades and of blade-row interactions. Additional sessions were allocated to aeroelastic analysis methods and to theoretical and experimental investigations of compression instabilities. A comparison with the approaches presented in the meetings held in the 1980s shows the great advances achieved in computational fluid dynamics and in measurement techniques. In fact, in the last comprehensive review of the field of turbomachinery unsteady aerodynamics and aeroelasticity, edited by F. O. Carta and myself and published as AGARDograph No. 298 in 1988, the analysis methods were largely limited to two-dimensional linearized methods. In contrast, Euler and Navier–Stokes codes are now widely applied to the computation of unsteady turbomachinery flows.

For example, Verdon and Montgomery (United Technologies Research Center) presented a three-dimensional linearized Euler analysis of the flow through oscillating blade rows; Holmes, Mitchell, and Lorence (General Electric Company) presented a three-dimensional linearized Navier–Stokes code; Marshall and Giles (Rolls–Royce Company) presented a time-linearized, three-dimensional Euler method; He and Ning (University of Durham) presented a nonlinear harmonic method for the solution of the Euler or Navier–Stokes equations; Weber, Gallus, and Peitsch (Technical University of Aachen) presented a Navier–Stokes method for unsteady quasi-three-dimensional flow; Hoehn and Fransson (Royal Institute of Technology of Stockholm) presented a two-dimensional Navier–Stokes method; Cizmas and Subramanya (Westinghouse Corporation) presented a parallelized Navier–Stokes code for rotor–stator interactions; and Kato, Outa, and Chiba (Waseda University, Japan) presented Navier–Stokes computations of rotating stall cells. Viscous–inviscid interaction approaches were presented by Wolff and Fleeter (Purdue University) and Florea, Hall, and Cizmas (Duke University). Using a novel reduced-order modeling technique, the latter authors were able to identify the onset of rotating stall. Shibata and Kaji (University of Tokyo) used a linearized two-dimensional Euler analysis to investigate the role of shock structures in transonic fan flutter, whereas Isomura (IHI Company, Japan) studied the effect of the blade vibration mode on transonic fan flutter using a quasi-three-dimensional, thin-layer Navier–Stokes code. Namba, Yamasaki, and Otsuka (Kyushu University, Japan) applied both Euler and Navier–Stokes calculations to the analysis of supersonic oscillatory cascade flows and compared the results with earlier predictions using Namba's double-linearization theory.

Several papers were also presented that demonstrated the recent advances in aeroelastic analysis methods made possible by computing the aeroelastic behavior in the time domain. Rzadkowski, Gnesin, and Kovalyov (Polish and Ukrainian Academies of Sciences) computed cascade flutter using a two-dimensional Euler code. Imregun and associates (Imperial College, London) showed the feasibility of extending the time-domain flutter calculations to the analysis of turbine and fan blades using a three-dimensional Navier–Stokes code. Kahl (MTU-Munich) assessed the effect of mistuning on the resonant amplitudes of turbomachinery bladings using an Euler analysis and showed the necessity of including mistuning effects in a forced-response analysis.

Experimental investigations presented at the symposium included oscillating-compressor or turbine-blade-row measurements at Purdue University (Frey and Fleeter), the Ecole Polytechnique Lausanne (Norryd and

Boelcs), and three Japanese universities (Fujimoto et al., Watanabe et al., and Shiratori et al.); measurements of blade-row interactions at Osaka Sangyo University, Japan (Adachi and Yamashita), General Electric (Manwaring and Kirkeng), German Armed Forces University Munich (Acton and Fottner), Technical University of Hannover (Sentker and Riess), and Central Institute of Aviation Motors (Saren et al.); measurements of the rotating stall characteristics due to distorted inlet flow into a high-pressure, five-stage compressor at the German Armed Forces University Munich (Jahnen et al.); measurements of centrifugal impeller and diffuser interactions near stall at the Japanese National Aerospace Laboratory (Yamane and Nagashima); and measurements of acoustic pulse propagation and reflection in a 10-stage axial compressor at the University of Cincinnati (Sajben and Freund).

It is apparent from this brief summary that research in the field of turbomachinery unsteady aerodynamics and aeroelasticity is vigorously being pursued in the major industrialized countries using sophisticated computational and experimental techniques. However, it is also apparent that much work remains to be done before an accurate prediction of most unsteady aerodynamic and aeroelastic turbomachinery phenomena is achieved. The uncertainties caused by the well-known transitional and turbulent flow modeling difficulties are greatly compounded by the complex flows typically encountered in turbomachines, especially at transonic and separated-flow conditions. Furthermore, there are insufficient data from carefully controlled experiments that can be used for the calibration of unsteady turbomachinery flow models. Therefore, active researchers in this field will appreciate the easy access to the latest developments collected in this book. Turbomachinery engineers and designers, project managers, professors, and graduate students of turbomachinery engineering who wish to inform themselves about the state of the art in this specialized field will find it an equally valuable source of information.

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Errata

One-Equation Turbulence Model of Spalart and Allmaras in Supersonic Separated Flows

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[AIAA Journal 37(3), pp. 391–393 (1999)]

THE numerical solutions in Fig. 1 of this paper were not fully grid converged and should be replaced by Fig. 1 shown here.

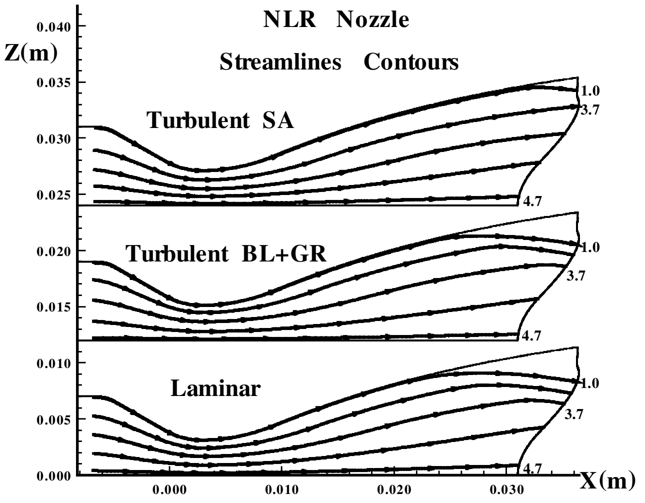

Fig. 1 Numerical streamlines inside a cold nozzle flow: GR, Granville theory.

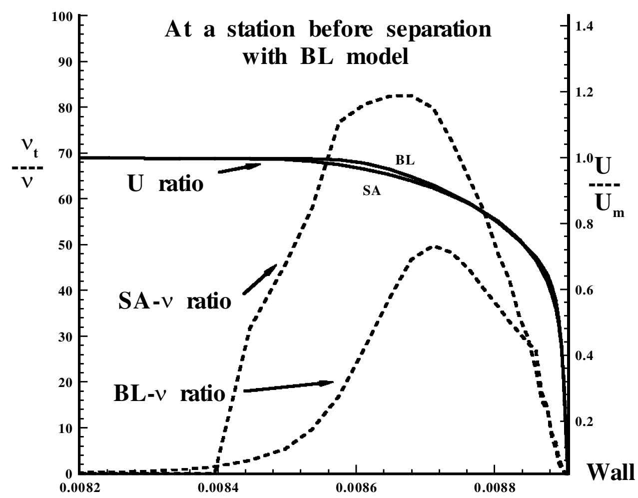

Fig. 2 Viscosity ratio comparison downstream from nozzle throat.

These solutions have been cross-checked by the Computational Fluid Dynamics Group at the von Karman Institute, Belgium. The sentence beginning on the 10th line in the second paragraph in the Results section on page 391 should read "The flow separation begins at 15 ± 0.4, 11 ± 0.4, and 4.5 ± 0.4 mm from the nozzle exit for the laminar, the BL (Baldwin and Lomax) turbulent, and the SA (Spalart and Allmaras) turbulent cases, respectively." The reverse flow after the separation is assumed to be laminar. The relaminarization capability in the SA model as shown in Fig. 3 in the paper remains unchanged. However, for the separation size, the tendency of the SA model to postpone the separation compared with the result from the BL model is attributed to the larger energy transfer from the core flow to the wall boundary, as shown in Fig. 2 here, with larger velocity gradients at the wall and a thicker boundary layer compared with those from the BL model. All other results and conclusions remain unchanged.