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ESDU University User Guide

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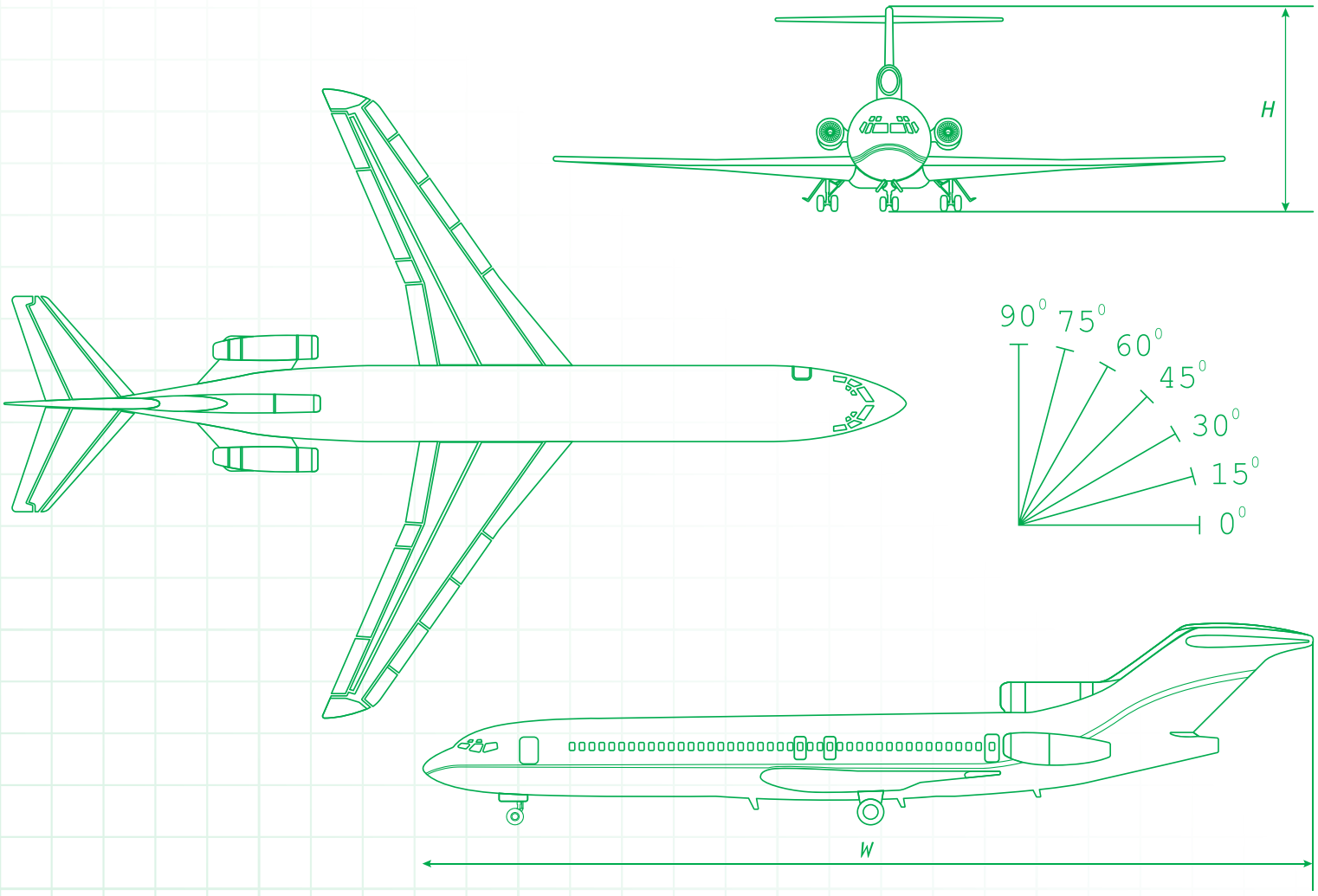

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ESDU OVERVIEW

(www.ihsesdu.com)

ESDU is a subscription based validated and authoritative design data and methods for Aerospace, Mechanical, Chemical, Civil, Structural engineering plus Environmental and Material Science. Formerly the technical department of the Royal Aeronautical Society, ESDU is the only collection of validated data of its kind in existence.

Significantly used by international aerospace companies, it is widely considered to be the most accurate, up-to-date and comprehensive collection of validated data and methods.

Each series is produced and validated by committees of experts drawn from a broad range of industrial, academic and research backgrounds. Information is presented in a clear and concise format and is the result of careful distillation of large information sources. There is a strong emphasis on the use of unpublished information taken from sources only available to ESDU – a direct result of key communication links with industrial companies and academic institutions.

With the input and backing of many top industrial organisations, ESDU data is specified for use both within individual companies and their suppliers.

ESDU International was acquired by IHS inc.

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For technical queries regarding ESDU coverage and specific ESDU data, lecturers and researchers are encouraged to use the Engineering Service.

Inclusion in the University Curriculum

Many universities include ESDU Data in their curriculum as a means to equip students with the necessary tools and knowledge used extensively in industry. There are three areas in which ESDU data are included in the curriculum by a university:

1. By including data cut-and-pasted from Data Items into lecture notes, handouts, visual aids etc.
2. By setting course work assignments that use ESDU data and/or software
3. By carrying out project or thesis work (usually final year undergraduate or postgraduate) utilising the definitive industrial methods described in ESDU data.

The use of ESDU in teaching and its inclusion into the curriculum has grown significantly over the past two years. In part, this is due to our ability to provide training, awareness and discussion seminars. To take advantage of this facility, contact ESDU as detailed in the Contacts section.

The following section lists typical course disciplines and gives examples of potentially relevant ESDU Data Items.

Course Disciplines and suggested ESDU Data Items

INDEX

1. ENGINEERING MATERIALS AND PLASTICITY

Series - MMDH

Series - Stress & Strength

Series - Structures

Series - Fatigue: Endurance

Series - Fatigue: Fracture Mechanics

Series - Composites

Examples of relevant Data Items:

78020 - Local buckling and crippling of I, Z and channel section struts.

80036 - Introduction to the use of linear elastic fracture mechanics in estimating fatigue crack growth rates and residual strength of Components.

81002 - Guide to the use of Data Items on Bonded Joints

82025 - Failure modes of fibre reinforced laminates

83002 - Allowable stresses for helical compression and tension springs of round wire.

84018 - Failure analysis of fibre reinforced composite laminates

84041 - Properties of common engineering materials.

86040 - Selection of surface treatments and coatings for combating wear of load-bearing surfaces.

89031 - Guide to the selection of surface treatments for the improvement of fatigue strength of steels.

89052 - Construction of inelastic stress-strain curves from minimal materials data (computer program).

90022 - Struts: strength under flexural, local and inter-rivet buckling.

90026 - Inelastic bending moments, end loads, stresses and strains for beam sections of general polygonal shape.

91027 - Non-destructive examination – Choice of methods

92015 - Guide to the effect of shot peening on fatigue strength.

2. THERMO FLUIDS

Series - Internal Flow

Series - Physical Data (Chemical)

Series - Performance

Series - Aerodynamics

Series - Wind Engineering

Series - Heat Transfer

Series - Process Engineering

Series - Transonic Aerodynamics

Examples of relevant Data Items:

74028 - One-dimensional compressible gas flow in ducts.

77031 - Heat transfer by free convection and radiation - simply shaped bodies in air and other fluids.

82018 - The pressure distribution at zero incidences over selected families of blunt axisymmetric forebodies.

87027 - Computer program for the prediction of fluid transients in liquid-filled systems.

89030 - Pipeline vibrations. Fluid transients in non-rigid, unbranched planar piping systems.

90008 - Introduction to transonic aerodynamics of aerofoils and wings.

92013 - Selection and costing of heat exchangers.

93031 - Pipeline vibrations. Computer program for the prediction of fluid transients in flexible, unbranched three-dimensional piping systems.

97017 - Guide to wing aerodynamic design.

96028 - VGK method for two-dimensional aerofoil sections. Part 1: principles and results.

96029 - VGK method for two-dimensional aerofoil sections. Part 2: user manual for operation with MS-DOS and UNIX systems.

98003 - Design and performance evaluation of heat exchangers: the effectiveness-NTU method. Part 1: introduction.

3. SOLID/STRUCTURAL MECHANICS

Series - Stress & Strength

Series - Structures

Series - Mechanisms

Series - Dynamics

Series - Fatigue: Endurance

Series - Fatigue: Fracture Mechanics

Examples of relevant Data Items:

64001 - Guide to stress concentration data.

69017 - The deflections and slopes of shafts or beams of constant or stepped section

70018 - General principles of design in relation to fatigue.

71009 - Design against fatigue. Design principles.

72012 - Information on the use of Data Items on the buckling of plates and compression panels manufactured from isotropic materials.

75022 - Design against fatigue. Basic design calculations.

75033 - Elastic stress concentration factors. Double radius fillets in shouldered shafts in torsion.

78021 - Guide to Items on the strength and stability of struts.

79008 - Elastic stress concentration factors. Rectangular notch in the edge of a wide flat plate in tension.

79032 - Stress concentrations at grooves for retaining rings or seals (with notes on design against fatigue).

80027 - Elastic stress concentration factors. Single reinforced and unreinforced holes in infinite plates of isotropic materials.

80036 - Introduction to the use of linear elastic fracture mechanics in estimating fatigue crack growth rates and residual strength of components.

81006 - Stress concentration factors. Axially loaded lugs with clearance-fit pins.

82037 - The response of two-degree-of-freedom systems (computer program).

85004 - Fatigue strength of steel stud threads under axial and combined axial and bending loading.

85021 - Analysis of pre-tensioned bolted joints subject to tensile (separating) forces.

85045 - Stress concentrations: interaction and stress decay for selected cases.

87036 - Elastic stresses and deflections for square plates with small initial curvature under uniform pressure on the concave or convex face.

64001 - Guide to stress concentration data.

89007 - Flexural and torsional-flexural buckling of thin-walled open section struts.

89048 - Elastic stress concentration factors. Geometric discontinuities in rods and tubes of isotropic materials.

90007 - Procedures for balancing planar linkages using rotating counterweights.

93030 - Three-dimensional elastic stress concentration factors. Plain or countersunk hole in a wide plate subjected to tension, bending or pin loading.

97026 - OSMEC: Computer-aided mechanism design: user manual.

98023 - OSMEC: Computer-aided mechanism design: basic examples

SS3 - Guide to items on struts, beams and shafts

4. DESIGN FOR MANUFACTURE/ADVANCED MACHINERY DESIGN

Series - Stress & Strength

Series - Tribology

Series - Mechanisms

Series - Composites

Series - Fatigue: Endurance Data

Series - MMDH

Examples of relevant Data Items:

65007 - General guide to the choice of journal bearing type.

67019 - Static strength of screwed fasteners.

67033 - General guide to the choice of thrust bearing type.

82024 - A guide to the selection of cam and follower type.

83002 - Allowable stresses for helical compression and tension springs of round wire.

83003 - Notes on the design of helical compression and tension springs of round wire.

83031 - Dynamic sealing of fluids. 2: guide to selection of reciprocating seals.

84041 - Properties of common engineering materials.

85013 - Design of disc cams and their followers: examples.

86040 - Selection of surface treatments and coatings for combating wear of load-bearing surfaces.

87023 - Lock nuts and other thread locking devices.

89031 - Guide to the selection of surface treatments for the improvement of fatigue strength of steels.

92015 - Guide to the effect of shot peening on fatigue strength.

93001 - Contact stress in disc cams with roller followers.

94008 - Lubricant film thickness between disc cams and followers.

95001 - Kinematic analysis of disc cams.

97023 - OSMEC. Computer-aided mechanism design: installation.

97026 - OSMEC. Computer-aided mechanism design: user manual.

98023 - OSMEC. Computer-aided mechanism design: basic examples.

00013 - OSCAM. Computer-aided cam mechanism design. Part 1: installation.

00014 - OSCAM. Computer-aided cam mechanism design. Part 2: user manual.

00015 - Disc cams: Tribological analysis using computer program A0015.

5. DESIGN OF MACHINE ELEMENTS/POWER TRANSMISSION

Series - Stress & Strength

Series - Mechanisms

Series - Tribology

Examples of relevant Data Items:

65007 - General guide to the choice of journal bearing type.

67019 - Static strength of screwed fasteners.

67033 - General guide to the choice of thrust bearing type.

68002 - Shafts with interference-fit collars. Part I: some factors affecting the design of an assembly.

75022 - Design against fatigue. Basic design calculations.

77002 - Design of parallel axis straight spur and helical gears: geometric design.

83003 - Notes on the design of helical compression and tension springs of round wire.

83021 - The kinematic design of epicyclic gear trains.

84031 - Calculation methods for steadily loaded axial groove hydrodynamic journal bearings.

84041 - Properties of common engineering materials.

85021 - Analysis of pretensioned bolted joints subject to tensile (separating) forces.

85028 - Calculation methods for steadily loaded axial groove hydrodynamic journal bearings. Superlaminar flow. (To be used in conjunction with Item No. 84031.)

86008 - Calculation methods for steadily loaded axial groove hydrodynamic journal bearings. Low viscosity process fluid lubrication. (To be used in conjunction with Items Nos. 84031 and 85028.)

86013 - Guide to the use of Data Items on the fatigue strength of welded joints in steels.

86028 - Fatigue strength of keyed assemblies.

87023 - Lock nuts and other thread locking devices.

90027 - Calculation methods for steadily loaded central circumferential groove hydrodynamic journal bearings.

91039 - Static and fatigue strength of butt welded joints in aluminium alloys.

97019 - Equilibrium temperatures in self-contained bearing assemblies (use of computer program A9719).

SS3 - Guide to Items on struts, beams and shafts.

6. MECHANICAL VIBRATIONS AND NOISE

Series - Aircraft Noise

Series - Sound Propagation

Series - Vibrations & Acoustic Fatigue

Series - Internal Flow

Examples of relevant Data Items:

74003 - Normal incidence absorption coefficients and acoustic impedances of typical single layer fibrous lining materials.

74004 - Normal incidence absorption coefficients and acoustic impedances of single layer perforated sheet liners.

79011 - Estimation of noise shielding by barriers.

82001 - An introduction and guide to noise in ventilation, air-conditioning and other ducting systems.

82003 - Example to illustrate the use of Data Items on noise from ducted ventilation and air-conditioning systems.

97033 - Methods for analysis of the dynamic response of structures.

99009 - An introduction to Statistical Energy Analysis.

7. AIRCRAFT PERFORMANCE AND DESIGN

Series - Performance

Series - Aerodynamics

Examples of relevant Data Items:

69006 - Introduction to the measurement of thrust in flight. (Air breathing ducted-flow engines.)

76011 - First approximation to take-off field length of multi-engined transport aeroplanes.

76034 - Estimation of take-off thrust using generalised data for turbo-jet and turbo-fan engines.

79018 - Example of performance analysis using data obtained concurrently in air-path, body and Earth axes.

80009 - The use of Data Items on aircraft performance measurement.

80026 - The use of Data Items on aircraft performance estimation.

81009 - Estimation of windmilling drag and airflow of turbo-jet and turbo-fan engines.

82033 - First approximation to take-off distance to 50 ft (15.2 m) for light and general aviation aeroplanes.

83029 - The correction of flight-test anemometric data.

85011 - Pitot and static errors due to non-steady flight.

85029 - Calculation of ground performance in take-off and landing.

85036 - Conversion of air-data system pressure errors into height and speed corrections.

86031 - Introduction to air data system parameters, errors and calibration laws.

90012 - Energy height method for flight path optimisation.

92019 - Estimation of rate of climb.

93021 - Examples of flight path optimisation using a multivariate gradient-search method.

94012 - Application of multivariate optimisation techniques to determination of optimum flight trajectories.

95024 - Example of analysis and representation of static pressure correction data in steady flight.

8. AEROSPACE STRUCTURES AND AEROELASTICITY

Series - Dynamics

Series - Fatigue – Fracture Mechanics

Series - Stress & Strength

Series - Structures

Series - Composites

Examples of relevant Data Items:

65002 - Elastic stresses and deflections for flat circular plates with D/t greater than or equal to 4 under uniform pressure.

65003 - Elastic stresses and deflections for flat circular plates with D/t greater than or equal to 20 under uniform pressure.

71005 - Buckling of flat plates in shear.

72012 - Information on the use of Data Items on the buckling of plates and compression panels manufactured from isotropic materials.

77023 - Shear centre and primary warping constant for lipped and unlipped channel and Z-sections.

80036 - Introduction to the use of linear elastic fracture mechanics in estimating fatigue crack growth rates and residual strength of components.

82020 - Introduction to unsteady aerodynamics.

96037 - A qualitative introduction to static aeroelasticity: controllability, loads and stability.

97032 - Static aeroelasticity: a formal analysis using assumed modes.

97033 - Methods for analysis of the dynamic response of structures.

99033 - Static aeroelasticity: a formal analysis using normal modes.

9. AIRCRAFT DYNAMICS, STABILITY AND CONTROL

Series - Dynamics

Series - Aerodynamics

Examples of relevant Data Items:

67003 - The equations of motion of a rigid aircraft.

69025 - Solution of ordinary linear differential equations by the Laplace transform method.

71017 - Aero-normalised stability derivatives: effect of wing on yawing moment due to yawing.

80018 - The stability and response of linear systems. Part V: control of dynamic systems.

82037 - The response of two-degree-of-freedom systems (computer program).

83041 - A summary of the concepts relating to random processes.

84020 - An introduction to time-dependent aerodynamics of aircraft response, gusts and active controls.

86011 - Numerical methods for the solution of ordinary differential equations: initial value problems.

86021 - Introduction to aerodynamic derivatives, equations of motion and stability.

89009 - Hinge moment coefficient derivatives for trailing-edge controls on wings at subsonic speeds.

92006 - A background to the handling qualities of aircraft.

94045 - Shear force, bending moment and torque of rigid aircraft in symmetric steady manoeuvring flight.

97032 - Static aeroelasticity: a formal analysis using assumed modes.

00025 - Computer program for prediction of aircraft lateral stability derivatives in sideslip at subsonic speeds.

10. COMPUTATIONAL FLUID DYNAMICS AND AERODYNAMICS

Series - Aerodynamics

Series - Performance

Series - Transonic Aerodynamics

Series - Wind Engineering

Examples of relevant Data Items:

68019 - The compressible two-dimensional laminar boundary layer, both with and without heat transfer, on a smooth flat plate, with application to wedges, cylinders, and cones.

68020 - The compressible two-dimensional turbulent boundary layer, both with and without heat transfer, on a smooth flat plate, with application to wedges, cylinders, and cones.

68021 - Foredrag of spherically-blunted conical forebodies at zero incidence in supersonic flow for Mach numbers up to 5.

74008 - Estimation of critical Mach number for an aerofoil from its low-speed pressure distribution.

75005 - Performance data for the critical operation of nominally two-dimensional double-ramp supersonic intakes.

80021 - Pressure drag of blunt forebodies at zero incidence for Mach numbers up to 10.

85020 - Characteristics of atmospheric turbulence near the ground. Part II: single point data for strong winds (neutral atmosphere).

85046 - Quadrature methods for the evaluation of definite integrals.

88019 - Calculation methods for a long-wind loading. Part 3. Response of buildings and plate-like structures to atmospheric turbulence.

90008 - Introduction to transonic aerodynamics of aerofoils and wings.

91028 - Simplified method for the prediction of aerofoil excrescence drag magnification factor for turbulent boundary layers at subcritical Mach numbers.

91043 - Mean wind speeds over hills and other topography.

92036 - Response of structures to atmospheric turbulence. Computer programs A9236 and B9236.

94037 - Leading-edge suction distribution for plane thin wings at subsonic speeds.

94038 - Computer program for estimation of leading-edge suction distribution for plane thin wings at subsonic speeds.

96028 - VGK method for two-dimensional aerofoil sections. Part 1: principles and results.

96029 - VGK method for two-dimensional aerofoil sections. Part 2: user manual for operation with MS-DOS and UNIX systems.

85020 - Characteristics of atmospheric turbulence near the ground. Part II: single point data for strong winds (neutral atmosphere).

AERO B.S.02.03.01 - Introductory notes on the drag at zero incidence of bodies at supersonic speeds.

AERO W.S.00.03.03 - Introductory Item on two-dimensional aerofoils at supersonic speeds.

11. HEAT TRANSFER

Series - Heat Transfer

Series - Physical Data (Chemical)

Examples of relevant Data Items:

68019 - The compressible two-dimensional laminar boundary layer, both with and without heat transfer, on a smooth flat plate, with application to wedges, cylinders, and cones.

68020 - The compressible two-dimensional turbulent boundary layer, both with and without heat transfer, on a smooth flat plate, with application to wedges, cylinders, and cones.

69004 - Convective heat transfer during forced crossflow of fluids over a circular cylinder including free convection effects.

69015 - Solar heating. Total direct irradiance within the Earth's atmosphere.

73031 - Convective heat transfer during crossflow of fluids over plain tube banks.

77031 - Heat transfer by free convection and radiation - simply shaped bodies in air and other fluids.

92013 - Selection and costing of heat exchangers.

97007 - Heat transfer enhancement in heat exchanger design and utilisation. Part 1: Tube inserts in single-phase flow.

12. TRIBOLOGY

Series - Tribology

Examples of relevant Data Items:

81005 - Designing with rolling bearings. Part 1: design considerations in rolling bearing selection with particular reference to single row radial and cylindrical roller bearings.

81037 - Designing with rolling bearings. Part 2: selection of single row angular contact ball, tapered roller and spherical roller bearings

82014 - Designing with rolling bearings. Part 3: special types.

84031 - Calculation methods for steadily loaded axial groove hydrodynamic journal bearings.

85027 - Film thicknesses in lubricated Hertzian contacts (EHL). Part 1: two-dimensional contacts (line contacts).

85028 - Calculation methods for steadily loaded axial groove hydrodynamic journal bearings. Superlaminar flow. (To be used in conjunction with Item No. 84031.)

86008 - Calculation methods for steadily loaded axial groove hydrodynamic journal bearings. Low viscosity process fluid lubrication. (To be used in conjunction with Items Nos. 84031 and 85028.)

89045 - Film thicknesses in lubricated Hertzian contacts. Part 2: point contacts.

91037 - Film thickness in lubricated Hertzian line contacts. (Guide to use of computer program A9137.)

91038 - Film thickness in lubricated Hertzian point contacts. (Guide to use of computer program A9138.)

92026 - Calculation methods for externally pressurised (hydrostatic) journal bearings with capillary restrictor control.

92037 - Calculation methods for externally pressurised (hydrostatic) journal bearings with capillary restrictor control. (Guide to use of computer program A9237.)

94020 - Selection of synthetic oils.

00015 - Disc cams: Tribological analysis using computer program A0015

Undergraduate Projects

This section provides three examples of undergraduate projects performed at Universities that use ESDU Data. These examples may be used as described or as inspiration for similar projects.

Where the University is working in conjunction with industry (non commercial), ESDU data may be used.

Where industry may benefit directly from use of university-based ESDU Data, IHS Markit must be consulted.

If the liaising company already subscribe to the relevant ESDU Data, then no restrictions apply.

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Rudder design for a Commuter Aircraft

DESIGN EXERCISE SPECIFICATION

Introduction

Figures 1* and 2* show the basic outline geometry of the Rudder of a modern single-engined commuter aircraft currently in production. The Rudder is actuated via a flanged torque tube at the very base of the control surface. The Rudder is round nosed and the nose vent gap is nominally 2.5 mm.

Design

A structural design of the Rudder and its hinge attachments is required. Particular attention should be paid to load paths and detail design of the components involved. The use of fail safe philosophy must be adopted. Consideration must be given to ease of manufacture, assembly and inspection. All fittings must be readily replaceable. The Rudder is to be statically mass balanced to minimise the possibility of flutter.

Loading

Figure 3* shows the critical spanwise distribution of air loading acting on the Rudder surface. The chordwise distribution of this load is to be taken as linear from a maximum at the hinge line to zero at the trailing edge. Overall shear force, bending moment and torque must be calculated from these airloads.

For Rudder surfaces with multiple hinge supports, bending interaction between the fin and the Rudder must normally be considered. This is complex because it requires knowledge of the bending stiffness and deflected shape of the fin. Hence for the purposes of this exercise, such effects are to be ignored because of project time limitations.

Strength

(a) In accordance with the Joint Airworthiness Requirements JAR-23 'Normal, Utility, Aerobatic and Commuter Category Aeroplanes' Subpart C - Structure, your design is to be stressed to the Factor of Safety as specified in JAR 23.303.

(b) Loads parallel to the hinge line are to be obtained from JAR 23.393.

(c) The mass balance supporting structure and attachments must be designed to the requirements of JAR 23.659.

*Figures to be specified by the Faculty Member differently each time the assignment is presented

Requirements

(a) The Rudder is to be statically mass balanced by using a single concentrated mass at the tip (see also section 4.3 above).

(b) The Rudder must be easily removable.

(c) Loads parallel to the hinge line are to be reacted at the Rudder actuation only.

(d) The Rudder is to be manufactured from conventional metallic sheet material. Standard gauge material sheet sizes are only available in 2 m by 1 m sheets.

(e) For aerodynamic reasons, the Rudder structure is to remain unbuckled under limit load. Consider the use of ESDU 71005 for the shear buckling of flat plates. Also skin panels should not deflect by more than 2% of the hinge line local depth under limit load. Consider the use of ESDU 71013 for flat plates under pressure.

(f) The Rudder movement is ± 20°. Mechanical stops are to be provided in accordance with JAR 23.675.

(g) The Rudder structure must satisfy the Torsional Stiffness requirements of BCAR Section D subsection D3 - Structures; Appendix to Chapter D3-9, to minimise the possibility of flutter.

(h) The weight of the Rudder must be kept to an absolute minimum consistent with a safe design. Consider the methods described in Data Items included in Section 22 of the ESDU Structures Series.

Drawings

Detail drawings to a suitable scale are required of your design. Two drawings are required:

(i) A GA drawing showing the overall layout and details.

(ii) A drawing showing hinge, torque tube attachment, and mass balance details.

Both drawings submitted with your final report must be CAD generated. Important details and sections should be shown on separate views. Principle dimensions must be given along with materials used, sheet thicknesses, bolt and rivet sizes, fastener pitch, etc.

Report

Only one report is required, divided into the following two main sections:

(a) Design.

Your report should contain the following:

I. Discussion of alternative designs and load paths considered, supplemented by han sked tches.

II. Discussion of the results of any trade off or optimisation studies.

III. Reasons for selection of your final design solution.

IV. Describe how each component will be manufactured.

V. Describe the method of assembly.

VI. Give reasons for your choice of materials.

VII. Describe corrosion protection of the materials you have selected.

(b) Stress Analysis.

Present a stress analysis of your design that should contain the following:

I. Input and output to any computer programs used.

II. Shear force, bending moment and torque diagrams.

III. Stre ass nalysis of - Main Spar
- skins
- attachments and hinge fittings.

IV. Only the most highly loaded hinge rib needs to be stressed.

V. Estimate the weight of your Rudder including the mass balance.

VI. Compile a Reserve Factor summary of your design.

VII. All loading calculations should be in an appendix.

Critical Design Review

At the end of the project, there will be a Critical Design Review (CDR). Students will be required to give a 15 to 20 minute presentation of their work. The presentation must contain as a minimum the following:

I. Results of any trade-off studies and any optimisation work undertaken.

II. Discussion (advantages and disadvantages) of any alternative design options considered.

III. Reasons for selection of your final design solution.

IV. Presenta otion f:
- your GA drawing describing the overall layout of your Rudder structure,
- a detail drawing of one of the hinge assemblies.

It is essential that the presentation be adequately supported with viewgraphs to convey each of the points required above. An overhead projector will be made available for your use.

There will be an opportunity for questions and discussion at the end of each presentation. All students must be present for the whole session.

Mechanism Design Project

Assignment Philosophy

Students are required to design a particular planar linkage mechanism capable of producing a specified output motion. Each student is given an individual set of design constraints and target output motion. (Lots are drawn to select projects to minimise moaning!) Therefore students may usefully work together without fear of plagiarism and the teacher will receive a variety of projects improving his/her "enjoyment" of the grading process.

Example

Students are required to design a six-bar planar linkage capable of driving the rear-windscreen wiper in a car. The mechanism is required to traverse an arc of ____(±1) degrees at nominally constant angular velocity. The global origin for the mechanism is defined as the centre of the motor and the pivot centre of the wiper blade is located at co-ordinates (___ , ___). The mass of the wiper blade is____kg and its mass moment of inertia is____kg m^2. The co-ordinates that define the rectangular zone within which the mechanism must operate are:

minimum x co-ordinate = _____mm maximum x co-ordinate = _____mm

minimum y co-ordinate = _____mm maximum y co-ordinate = _____mm

Phase 1 - Kinematic analysis

The six-bar linkage mechanism is modelled using the OSMEC software described in ESDU Data Items 97023, 97026 and 98023. The course lecturer will give a demonstration of the use of this software. Load either the mechanism model file M13.OS using the File option on the main menu. The motion of the linkage can be displayed using options on the Run menu. The arc traversed by the wiper blade (link 5) and the variation in its angular velocity are analysed and plotted using options on the Angle sub-menu of the Graphs menu. By editing the various options on the Dimensions sub-menu of the Edit menu, the link lengths and the positions of the fixed bearings can rapidly be changed. A design that traverses the specified arc may be quickly found. NOTE: when saving your mechanism model files do NOT overwrite M13.OS. The zone within which the mechanism must operate is displayed using the Frame option accessed via the Add sub-menu of the Edit menu.

Phase 2 - Kinetostatic analysis

The bearing forces and power requirement must now be found. An estimate of the inertial properties and the position of the centre of mass of each link must be estimated for the link lengths specified in Phase 1. These values are entered on the mechanism model using the Mass option on the Dimensions sub-menu of the Edit menu. The torque required to drive the mechanism can be analysed and displayed using the Torque option on the Graphs menu (and selecting link 1). The variation in the force in each bearing can be displayed using the Force option on the Graphs menu. (Consult Data Item 97026 for guidance on the distinction between Magnitude and Vector plots.)

Phase 3 - Design development

Typically, the drive torque and bearing forces will vary significantly during each rotation of the driving crank. A major design objective in the design of any mechanism is to minimise both the maximum power requirement and the variation throughout the motion cycle.

Using OSMEC, the analyses referred to in Phases 1 and 2 may be rapidly carried out as the student develops a mechanism that fulfils the kinematic objective with increasingly improved drive torque characteristics.

The performance of alternative six-bar linkages may be evaluated by changing the assembly modes of the dyads in the linkage modelled as M13.OS or by loading mechanism model file M12.OS.

Phase 4 - Component integrity

Various analyses can be carried out to assess the mechanical integrity of the links and bearings using Data Items in the ESDU Stress & Strength, Fatigue: Endurance and Tribology Series.

Pressure Vessel Design Project

Assignment Philosophy

Students are required to design a pressure vessel, containing a specified volume of fluid without leakage for a specified life. Each student is given an individual set of design constraints and performance objectives. (Lots are drawn to select projects to minimise moaning!) Therefore students may usefully work together without fear of plagiarism and the teacher will receive a variety of projects improving his/her “enjoyment” of the grading process.

Example

Students are required to design a pressure vessel to store _____m3 of oil maintained at a nominally constant operating pressure and temperature of _____ N/m2 and _____°C, respectively. The operating life of the system is _____years and the pressure vessel is filled and emptied _____ times a day.

To develop the design, use ESDU Data Items in the Structures, Fatigue: Endurance Data, Fluid Mechanics: Internal Flow and Stress & Strength Series. The MMDH series may also be consulted for material properties.

Phase 1 - Preliminary Design

Data Items 65002, 66010 and 67017 provide guidance for determining the elastic stresses in cylinders and pressure vessels of various shapes. Use the tools provided to gain an understanding of how the stresses and deformations in a pressure vessel vary for different combinations of vessel shape, size, thickness and material properties. Choose a set of dimensions for the pressure vessel, considering also the implications of the cost and method of manufacture.

Phase 2 – Pipe Design

Develop the pressure vessel design to include the inlet and outlet pipes. These pipes must be connected to other parts of the pressurised system by bolted flange joints to facilitate installation and replacement. Consider ESDU Data Items 74043, 75014 and 81041 to analyse the pipe stresses and Data Items 85021, 86014 and 87023 for the bolted joint. Data Item 64001 is the starting point for assessing the effect of any stress concentrations that may occur in the design.

Phase 3 – Assessing the possibility of Fatigue Failure

Consult the ESDU Fatigue: Endurance Data Series for data and analyses capable of assessing the potential for fatigue failure of the pressure vessel, its associated piping and bolted joints.

Phase 4 – Design Development

At least two alternative designs should be developed that demonstrate the worth of the final specification.

It is recommended that a linear-elastic finite element analysis (FEA) of the pressure vessel be carried out to determine the maximum stresses and deformations of the vessel for the specified pressure. Compare the results of this analysis with the relevant benchmark calculations carried out in earlier phases of the project.

A modal analysis may also be carried out using the same FEA model to estimate the fundamental natural frequency of the vessel. Refer to ESDU Data Items in Sections 17 and 18 of the Internal Flow Series for guidance on the significance, or otherwise, of pressure surges in the system.

Research and Industrial Collaboration

IHS understands the growing need for universities to increase funding through research. Under the terms of the CHEST arrangement which provide unlimited access of ESDU data to Universities and Colleges, each institution may use the data for internal research and collaboration with industry where data is subscribed to. Non-subscribing companies may not benefit from direct use of the academic institution's ESDU data without either seeking IHS permission or taking out a subscription.

ESDU Data is involved in many research programs with industrial and academic institutions worldwide. Where questions arise on ESDU's coverage or for specific data queries, researchers are able to take advantage of the Engineers' service. Should ESDU data not cover the requested topic, then the ESDU Engineers may be able to suggest further action through a wealth of contacts and knowledge.

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