Hot Design

University of Sussex

Professorial lecture

University of Sussex

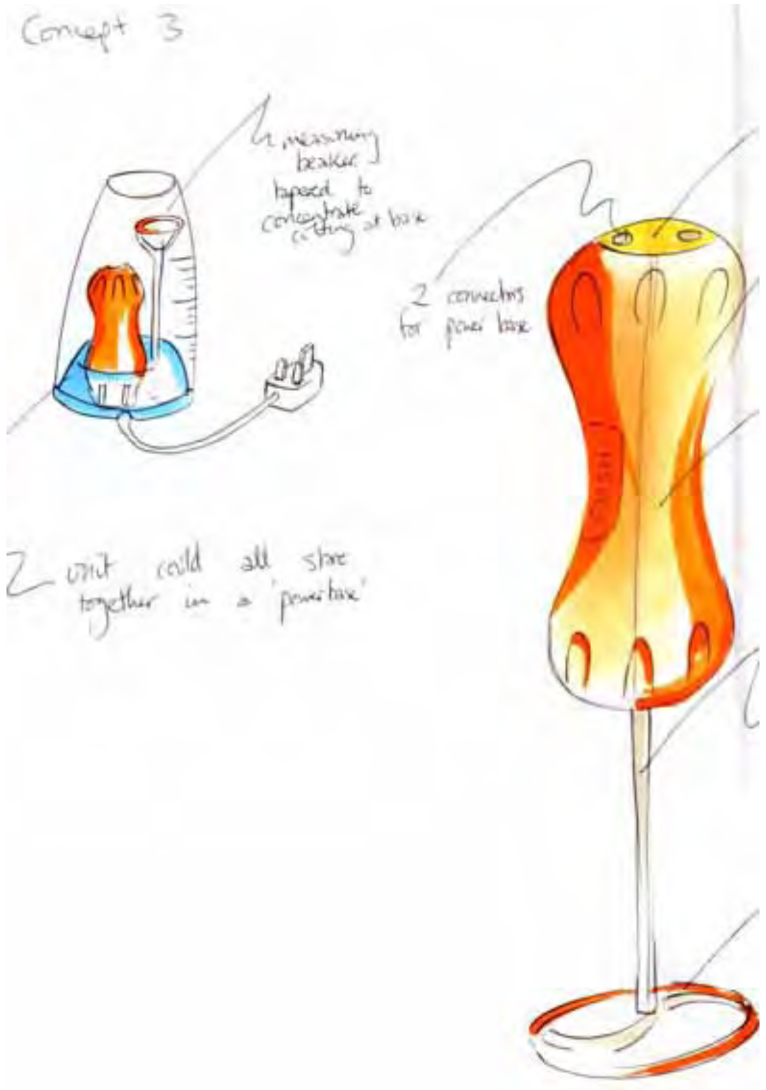
28th November 2006

Design

The term design is popularly used to refer to an object's aesthetic appearance.

Design

The word design comes from the Latin ‘designare’, meaning to designate or mark out.



Design

Design generally begins with either a need or requirement or, alternatively, an idea.

It ends with a set of drawings or computer representations and other information that enables a product to be manufactured and utilised.

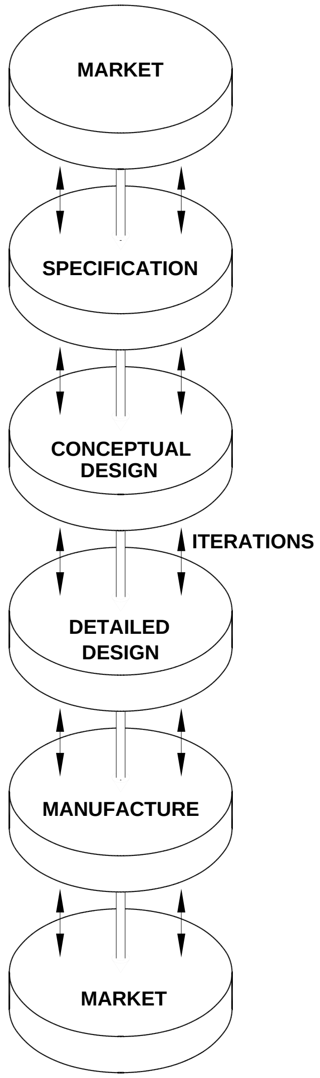
Here design is defined as ‘the total activity necessary to provide a product or process to meet a market need’ (Pugh (1990)).

Design

The process of design has been the focus of detailed study with approaches being proposed for design methods.

A design method is a framework within which the designer can practise with thoroughness.

One such approach is called ‘total design’



Agenda

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- Principles of product styling
- Creativity
- Detailed design
- Rotating flow
- Conclusions/Global challenge

Styling

Styling involves developing and giving a product an attractive visual form.

Although the appreciation of a product's aesthetic appeal is subjective and each person will judge it individually, there are a number of principles that are helpful in the development and realisation of style and form.

Styling

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The principles of product styling include:

- exploration of the design space
- consideration of human behaviour
- ergonomics
- technology selection
- colour
- metaphor
- use of organic and inorganic forms
- form follows function
- visual identity/branding
- material selection

Styling

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A product's visual form is a generated by the designer.

Visual form may be non-descript, inelegant or ugly.

Alternatively a design may produce an item of beauty and a product that is admired for its form rather than its function.

Styling is a means by which value can be added to a product without necessarily impacting on the function.

Visual Perception

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When an image is first seen, our brain will extract certain visual patterns and construct these into a meaningful image.

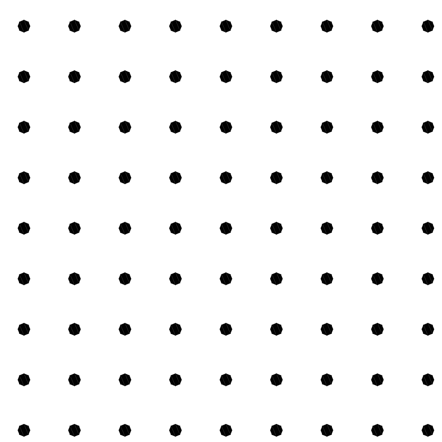
The process by which this is performed develops according to the visual stimuli that we are exposed to.

The Gestaldt rules are the operational rules for this process of visual perception in our brains.

Rule of Proximity

One of the most important factors determining the visual perception organisation of a scene is the proximity of the elements in it.

Items that are close together are grouped together.



Implications for Product Styling

- The effective integration of product components or product features can be derived from the Gestalt rules of patterning.
- Product features which are related functionally can be made to appear grouped together using these rules.
- To comply with the most powerful Gestalt rules, products should be symmetrical and comprise clean lines which go together to make up simple geometric forms.

Visual Perception

The implication of the Gestaldt rules for product styling is a tendency towards visual simplicity.

Manifesto for minimalism

Visual perception

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In contemporary product styling minimalism is a dominant theme.

Elegant simplicity is the aspiration of many modern designers.

Products however that are either too simple or too complex give rise to less feelings of attractiveness than those of an intermediate level of complexity.

Visual perception

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Visual perception is particularly refined in the detection of certain visual forms

- faces

Products can be made to smile, frown, be cross ….

Visual perception

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Styling

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Four main ways of making products attractive:

- Prior knowledge attractiveness
- Functional attractiveness
- Symbolic attractiveness
- Inherent attractiveness of visual form

Creativity

An essential element of the design process is creativity

Creativity can be viewed as the ability to imagine or invent something new of value.

It is not the ability to create out of nothing, but the ability to generate new ideas by combining, changing, or reapplying existing ideas

Creative Methods

There are 100s of creative methods available.

Some professionals tend to restrict their attention to less than 10 in their careers.

Creative approaches can be very useful in enhancing the generation and realisation of ideas.

Creative Methods

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- Activating the Variables
- Active Crisis Generation
- AIDA
- Algorithmic Composition/Generation
- Alternative Seeking
- Analogy
- Analytical Techniques
- Ask 'Why' Five Times
- Assumption Smashing
- Assumption Surfacing
- Attribute Listing
- Attribute-Value Chain
- Boundary Examination
- Boundary Relaxation
- Boundary Shifting
- Brain Sketching
- Brainstorming
- Brainwriting
- Brainwriting 6-3-5
- Brainwriting Game
- Browsing
- Brutethink
- Bud Listing
- Bullet-Proofing
- Bunches Of Bananas

Creative Methods

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- Card Story Boards
- Catwoe
- Causal Analysis
- Causal Mapping
- Change Matrix
- Charrette
- Checklists
- Cherry Split
- Circle Of Opportunity
- Clarification
- Collective Notebook
- Combination, Transformation, Exploration
- Component Detailing
- Concept Evaluation and Selection
- Concept Variants
- Concepts Fan
- Consensus Mapping
- Constrained Brainwriting
- Context Modifying
- Controlling Imagery
- Copying/Parametric
- Crawford Slip Writing
- Creative Problem Solving
- Creative Target List
- Creativity Challenge
- Creativity Template
- Criteria For Idea-Finding Potential
- Crossed Segmentation

The Create Methodology Phases

- Predisposition
- External mapping
- Internal mapping
- Idea generation
- Evaluation

Creative Methods

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Techniques/Methods?

- Predisposition - Training
- External Mapping – Attribute value chain
- Internal Mapping – SWOT analysis
- Idea Generation - Brainstorming/Morphological analysis/Synectics/TRIZ
- Evaluation – Criteria Matrix/Six Hats

Creative Methods

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- ✓Brainstorming
- ✓Morphological Analysis
- ✓Boundary Shifting
- ✓Gallery Method
- ✓Directed Search Method
- ✓Reverse engineering
- ✓New combinations
- ✓Analogies
- ✓Checklists
- ✓Objective Trees
- ✓Synectics
- ✓Six Hats

These methods are now being explored here as part of the research and teaching in the Department of Engineering and Design, the wider University and in InQbate.


InQbate

Creativity

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The Higher Education Funding Council for England has recently awarded about £4.1 million to the University of Sussex and the University of Brighton to set up InQbate, the Centre of Excellence in Teaching and Learning (CETL) in Creativity.

Creativity

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Creativity is perhaps the most prized human attribute and an essential element of the design process.

It is unsurprising therefore that we have attempted to enhance and mimic our creativity with technology.

The CETL in Creativity includes within its remit the effective use of technology in the creative process.

Creativity zones

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The centrepieces of the CETL in Creativity are two Creativity Zones, one at the University of Sussex and one at the University of Brighton.

Although physically separate, these are networked to enable individuals to interact within a range of shared physical and virtual spaces, each embedded with appropriate technologies to support the communication of ideas and collaborative generation of ideas and designs.

Creativity zones

The zones draw their inspiration from operating theatres associated with the explosion in understanding of surgeons, by comprising observation capability, enabling students to experience the activity under way.

Creativity zones

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Educational spaces are long term resources and their design needs to be:

- Flexible – to accommodate both current and evolving pedagogies
- Future-proofed – to enable space to be re-allocated
- Bold – to look beyond current technologies and pedagogies
- Creative – to energise and inspire learners and tutors
- Supportive – to develop the potential of all learners
- Enterprising – to extend capability for different purposes

JISC

Creativity zones

Creativity zones

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Creativity zones

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Creativity zones

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Creativity zones

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Creativity zones

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Creativity zones

Time to do ….

Any one who has ever been to one of my lectures or teaching sessions will know that I cannot resist the opportunity of getting everyone to do something ….

You have two post-it notes:

1) On the pink one write down up to three of the biggest challenges facing the World.

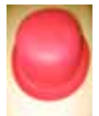
2) On the green one write up to three of the best things about the World.

Six hats

The six hat technique was developed by Edward de Bono to assist in applying a range of perspectives routinely in decision making and evaluation.

Each hat is symbolic of a particular approach and way of thinking.

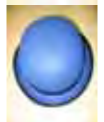

White hat - neutral and objective. It is concerned with facts and figures.


Red hat - gives the emotional point of view.


Black hat - cautious and careful. It is critical and identifies weaknesses in an idea.


Yellow hat - sunny and positive and gives positive and optimistic points of view.

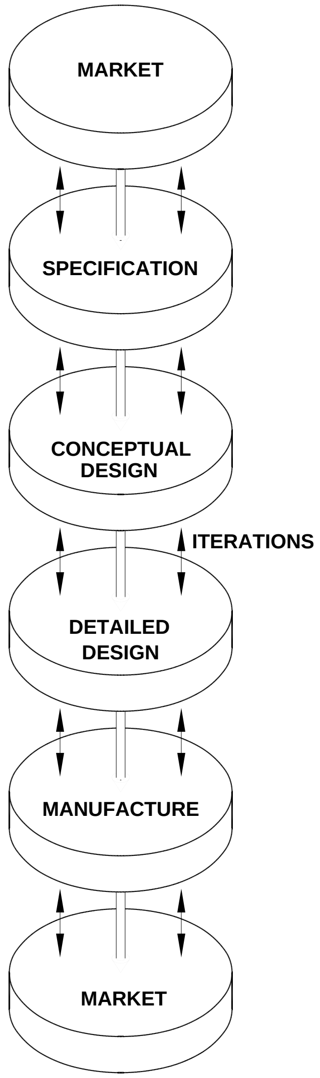

Green hat - indicates creativity and new ideas.


Blue hat - represents control and organisation of the other hats.

Detailed design

Idea and concept generation are just part of the design process.

The detailed design phase consists of the determination of the specific shape and size of individual components, what materials should be used, how they fit together and the method of manufacture.



Gas Turbine Engines

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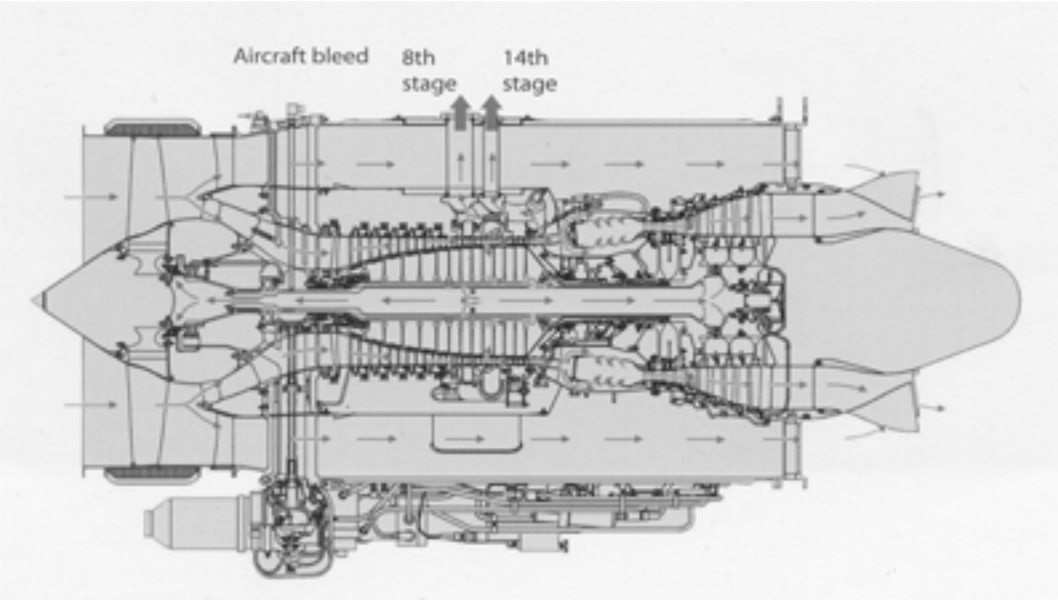
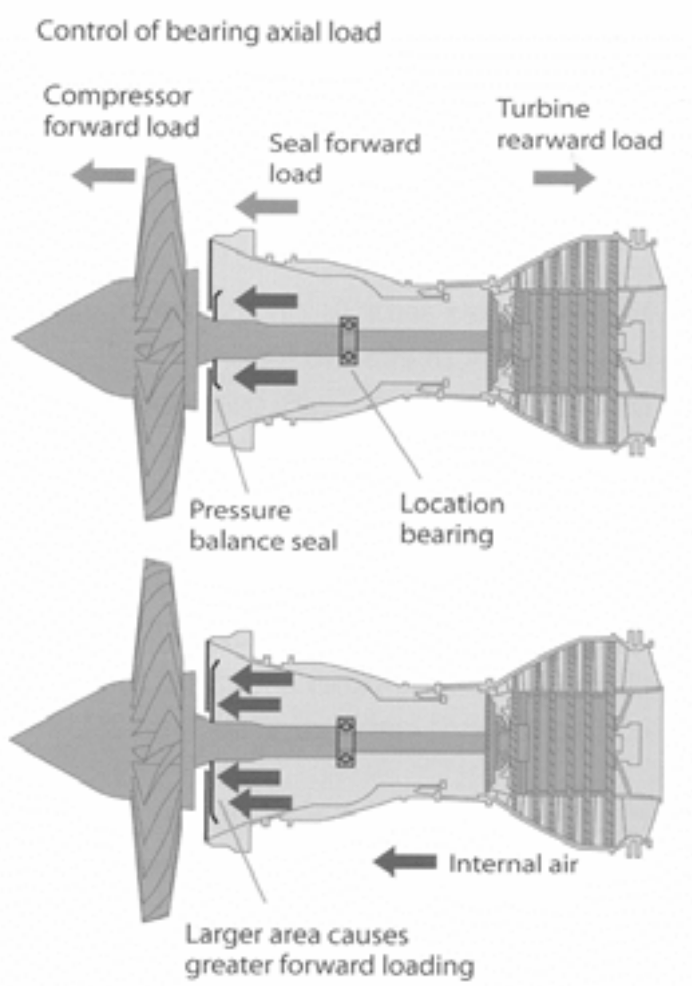
A particularly challenging application in today's society demanding the highest levels of sophisticated detailed design is the gas turbine engine used for power generation and aircraft.

Essential to the functioning of a gas turbine engine is the internal air system.

Internal air systems

The gas turbine engine internal air system provides cooling to various critical components, sealing for bearing chambers and flow paths and controls bearing axial loads.





Images courtesy of Rolls-Royce plc

Internal air systems

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In order to supply the internal air system flow requirement, up to 20% of the engine core flow is extracted from the compressor.

This can consume up to 5% of the fuel and it is therefore important to minimise the quantity of air required for the internal air system whilst maintaining functionality of the engine, acceptable component life, robustness and acceptable manufacture costs

Internal air systems

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For a large passenger aircraft a 1% reduction in specific fuel consumption could save 560 tonnes of fuel per annum and reduce direct operating costs by 0.5% (Smout et al. (2004)).

Image courtesy of Rolls-Royce plc

Internal air systems

A typical internal air system will include a compressor bleed take off, transfer tubes and passages to deliver the cooling and sealing air to critical components and use of differential pressure across disc surfaces to balance bearing loads.

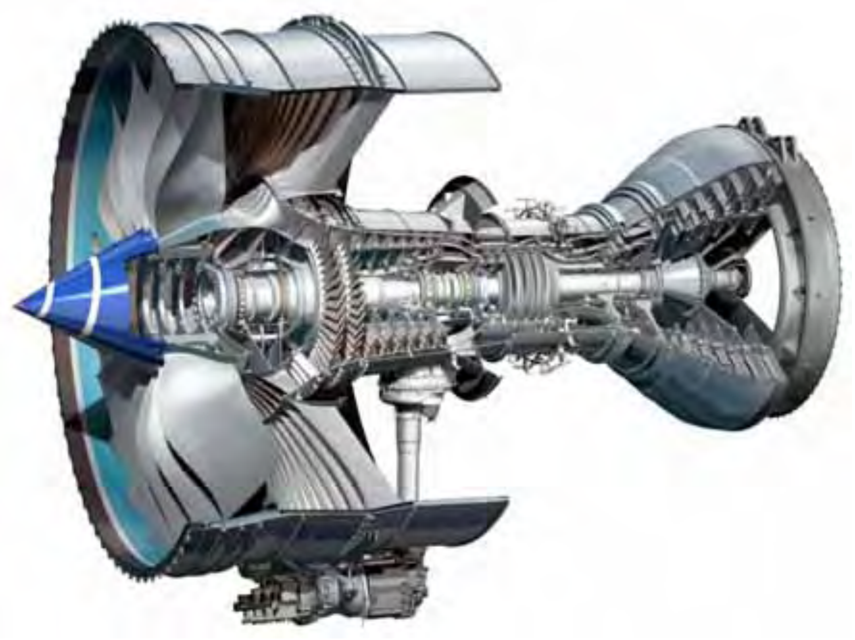


Image courtesy of Rolls-Royce plc

Internal air systems

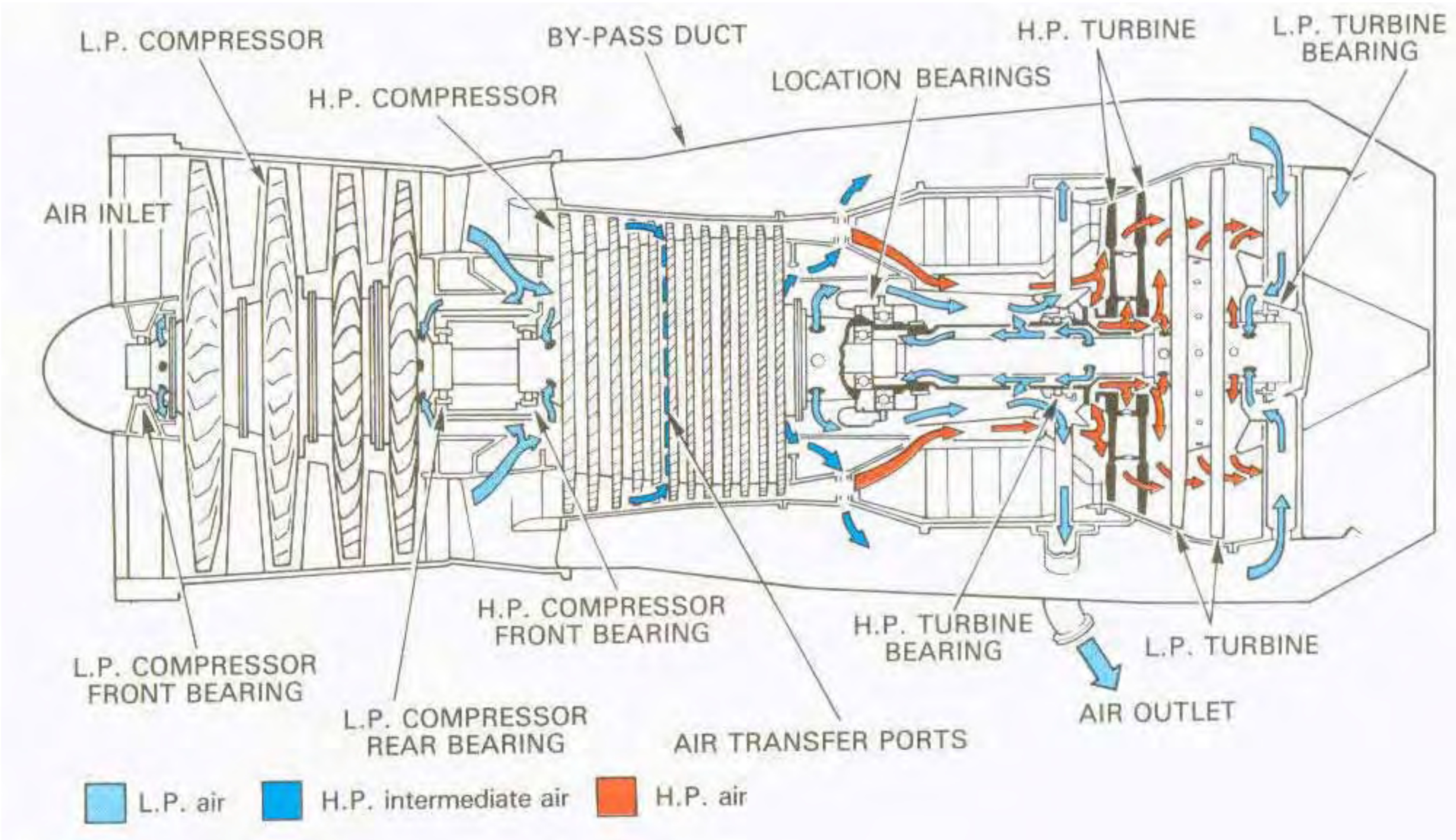
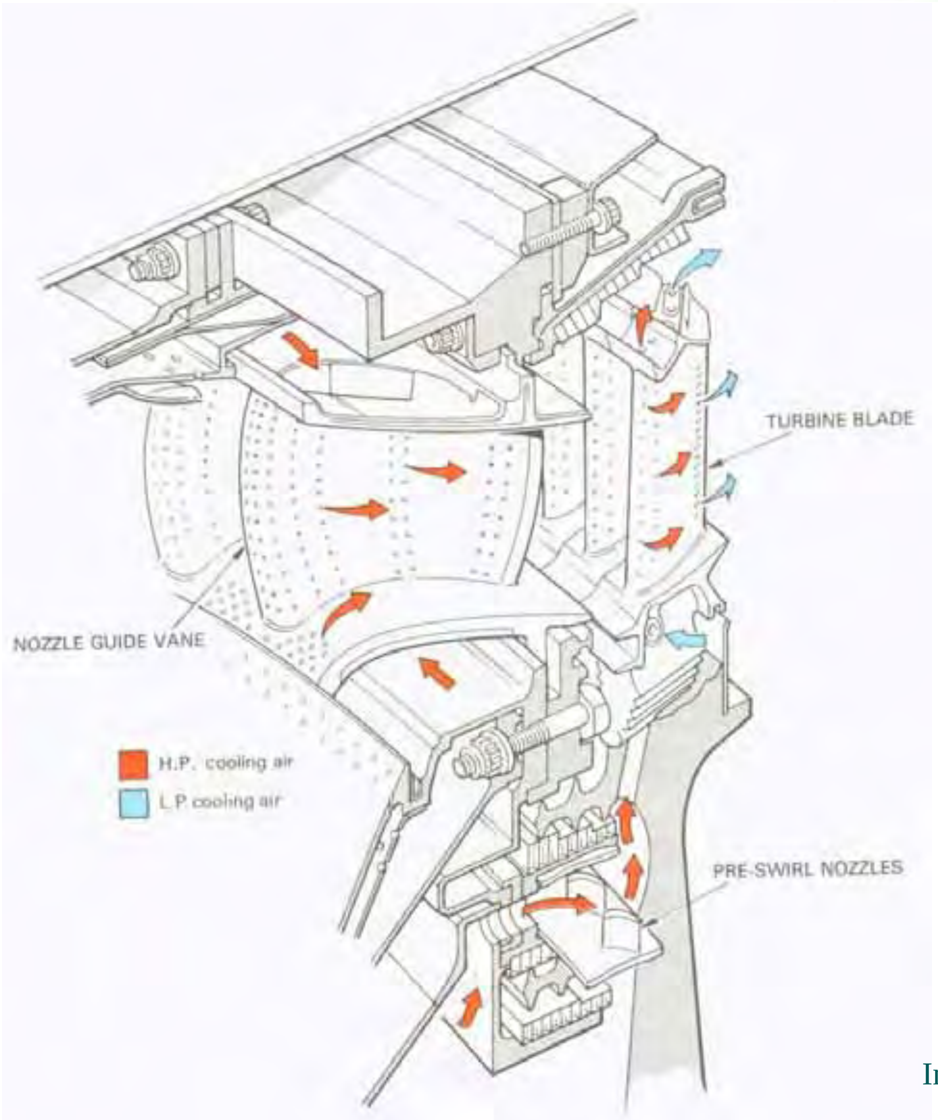


Image courtesy of Rolls-Royce plc

Internal air systems



Imags courtesy of Rolls-Royce plc

Failure risk

There is a saying in the gas turbine community…

Annual Accident Statistics

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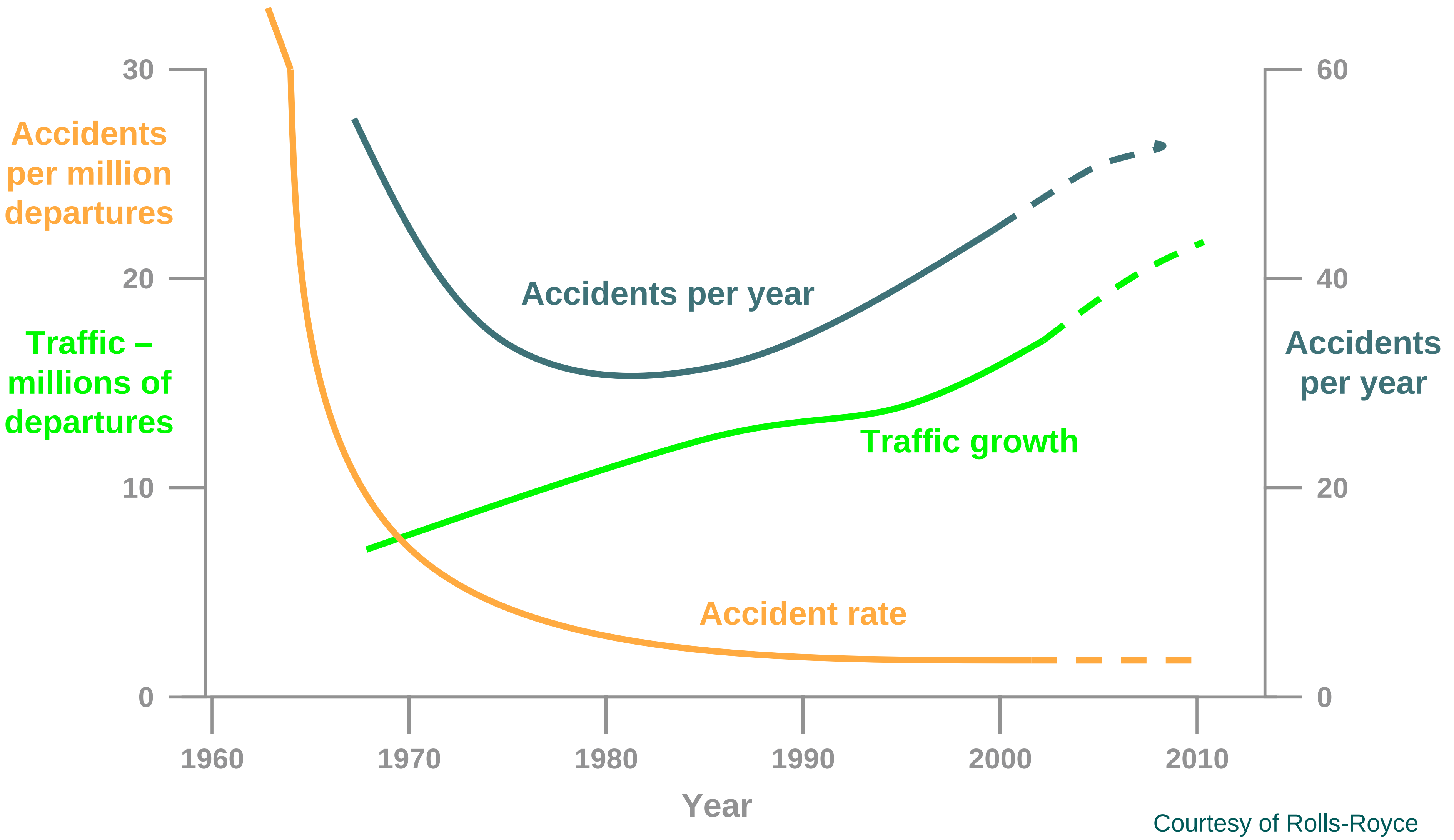


Courtesy of Rolls-Royce

Rotating flow

There are fundamental differences between rotating and linear flows and it is the Coriolis terms that are responsible for the differences between the dynamics of non-rotating and rotating fluids.

These give rise to complex flow phenomena that are often non-intuitive.

It is these flows that make the subject area interesting and an on-going challenge despite advances in modelling and data available.

Internal air system

A gas turbine engine generally comprises a series of discs for the rotating blades and a stationary casing and support structure.

A common feature is the cavity formed between coaxial rotating and stationary discs, which is known as a wheelspace or a rotor-stator cavity.

In addition cavities are also formed between co-rotating discs

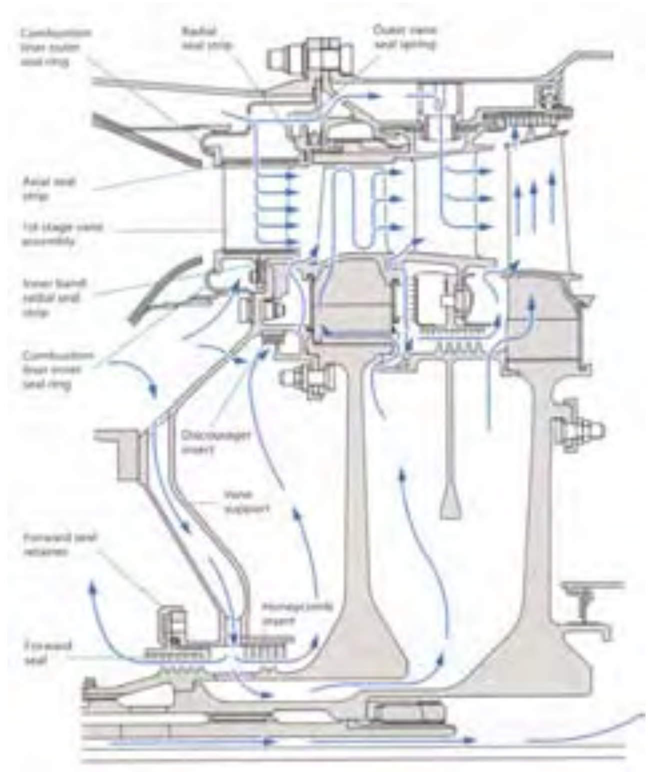
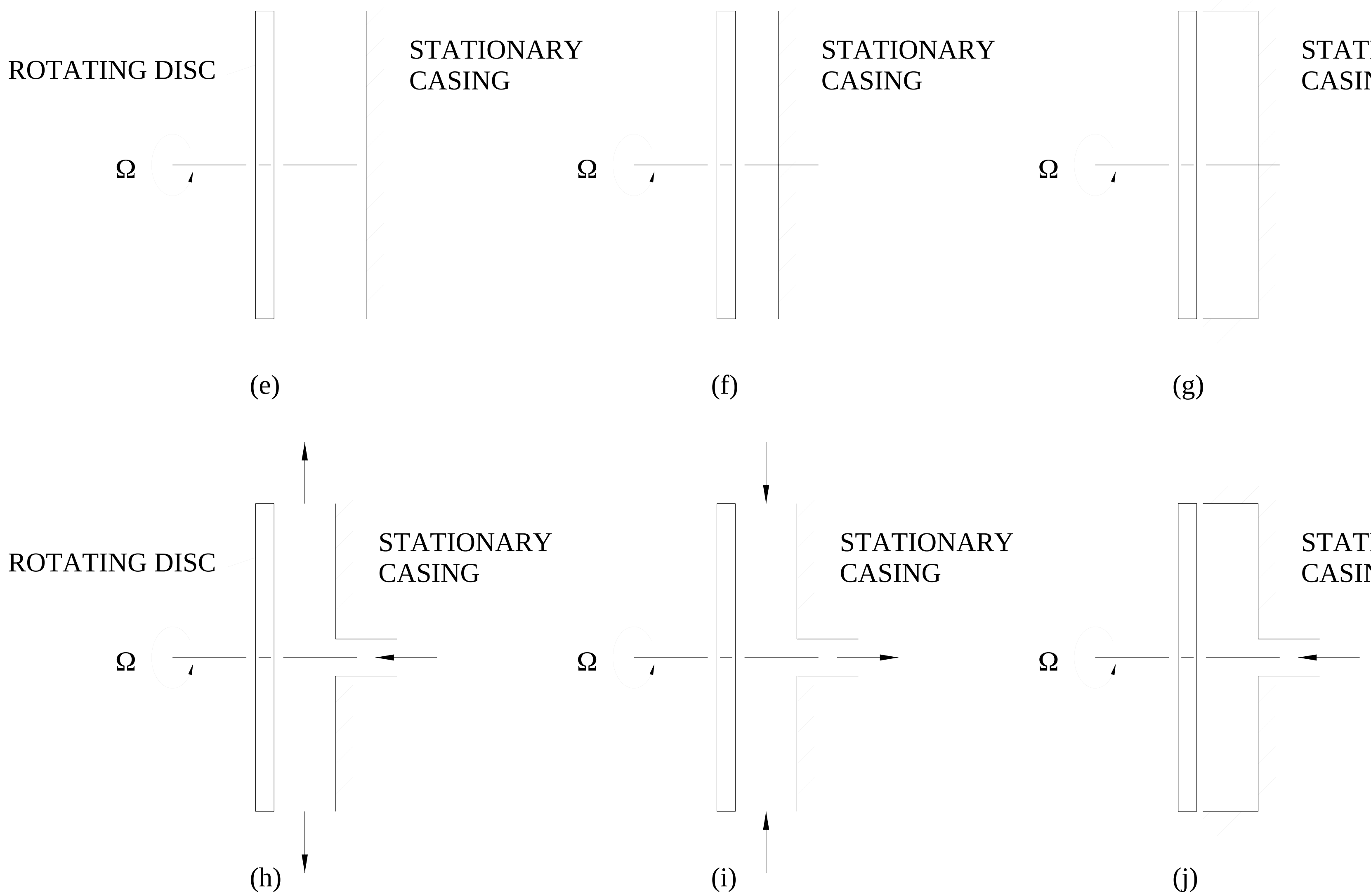


Image courtesy of Rolls-Royce plc

Rotating discs and rotor-stator cavities



Free disc

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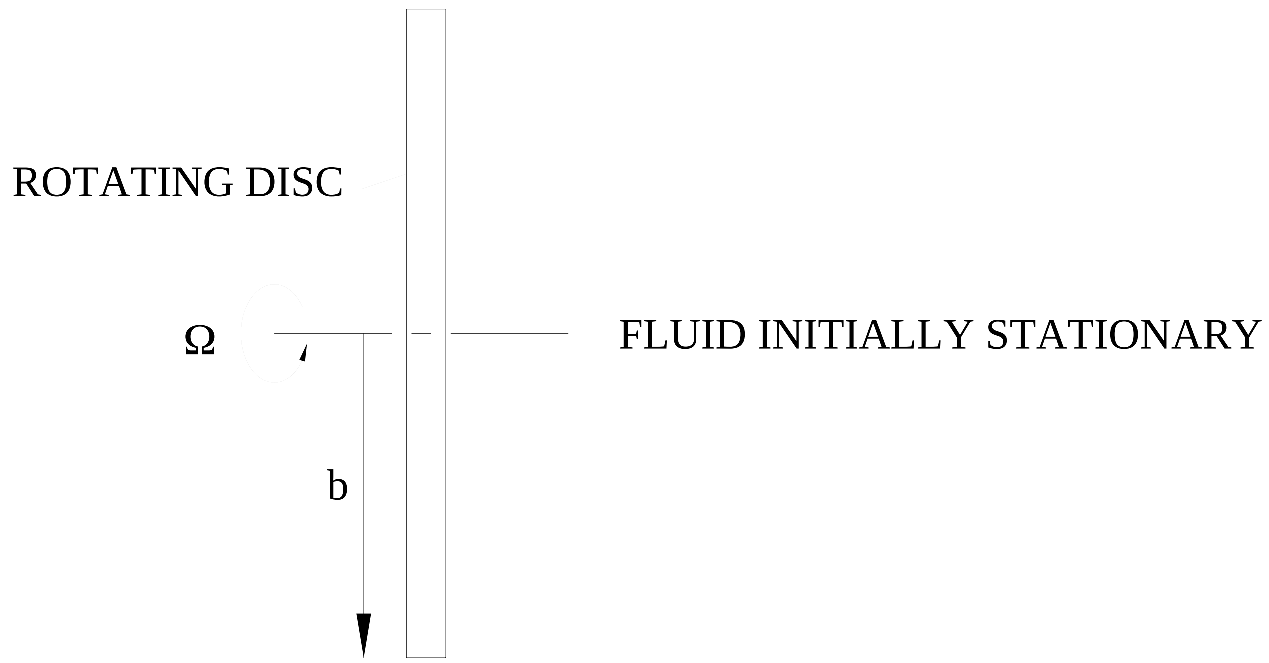
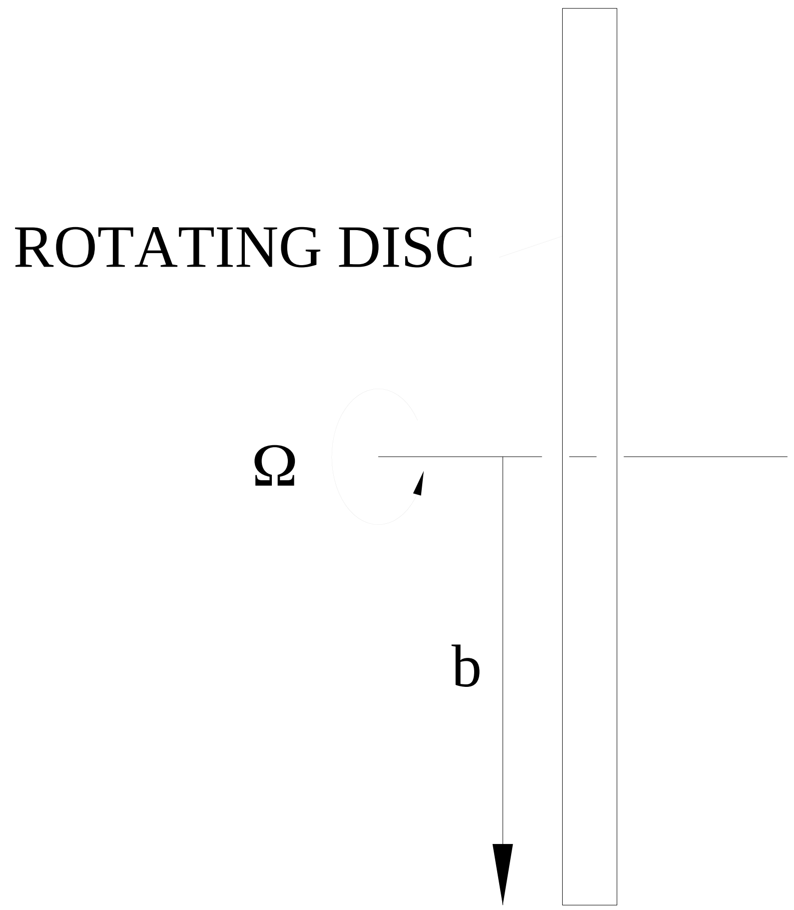
The case of a single disc rotating in an initially stationary fluid is known as the 'free disc'



Free disc

The ‘centrifugal forces’ generated by the shear between the rotating disc and the fluid cause a radial flow of fluid in the boundary layer.

As the radial component of velocity is zero at the disc surface and is also zero in the free-stream, in order to satisfy conservation of mass and provide the radial outflow, fluid must be entrained axially into the boundary layer.



Free disc

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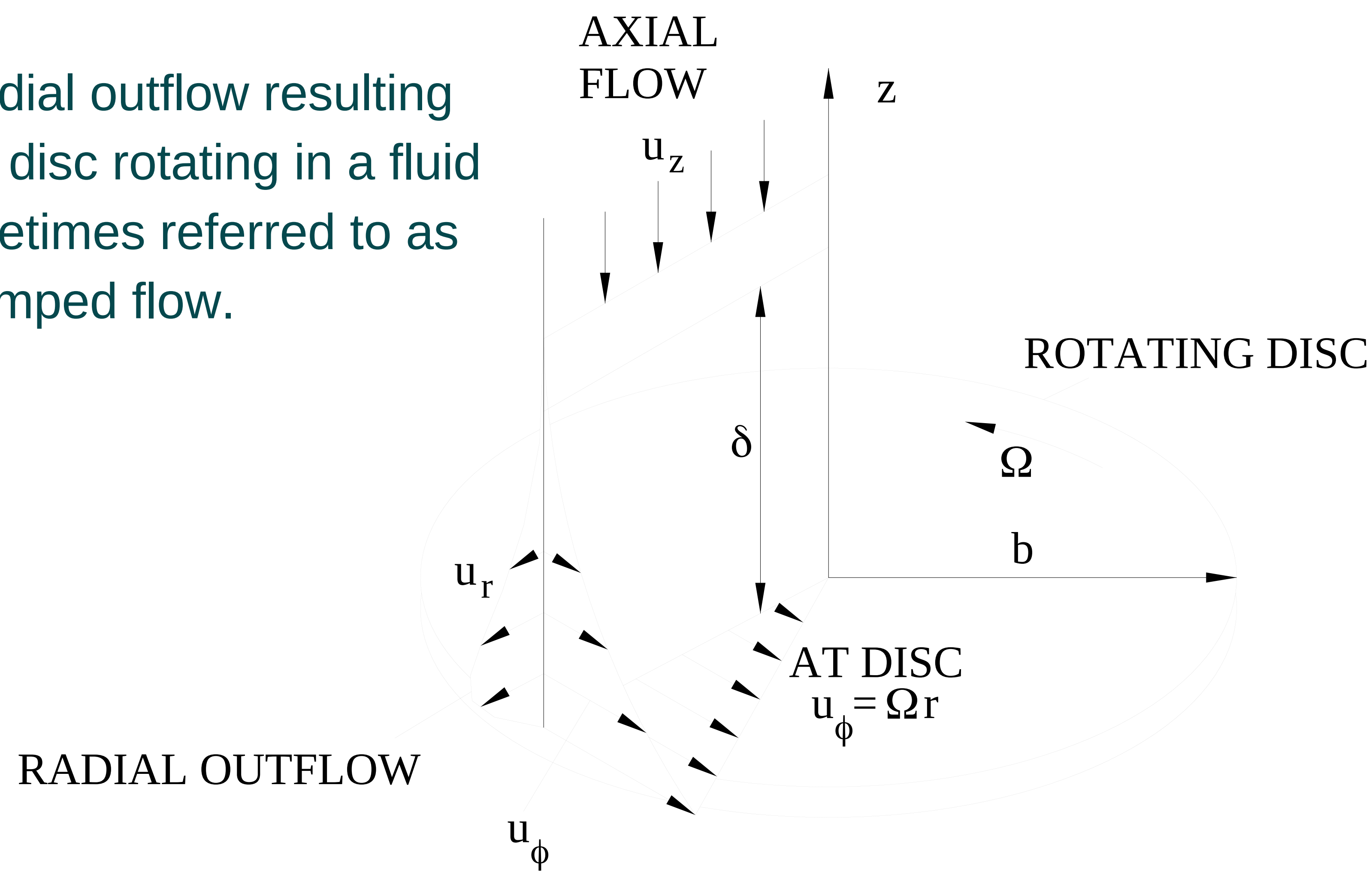
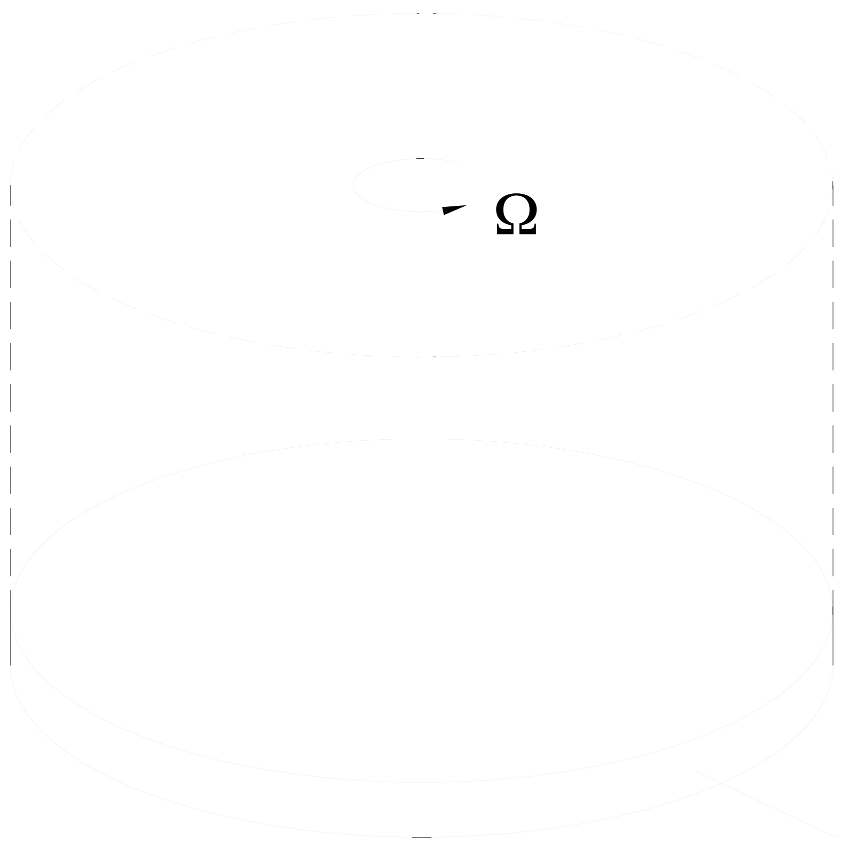
The radial outflow resulting from a disc rotating in a fluid is sometimes referred to as the pumped flow.



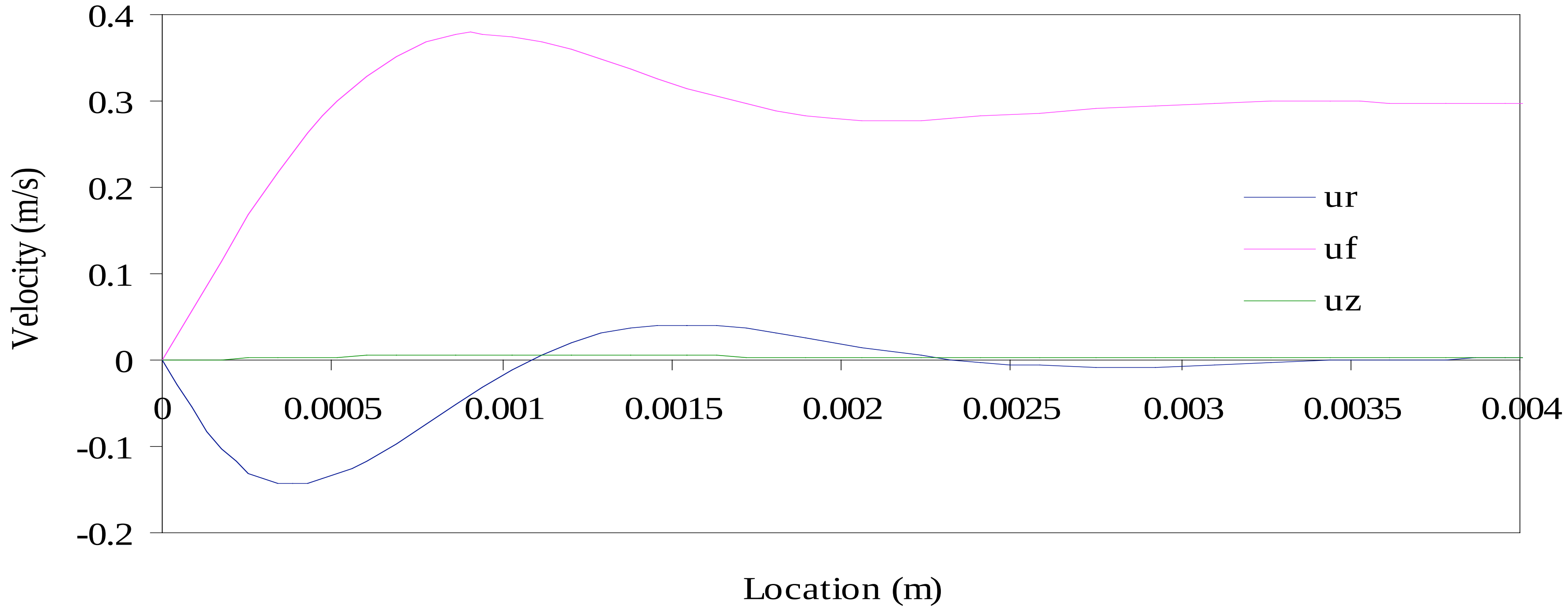
Rotating fluid above a stationary disc



ROTATING FLUID

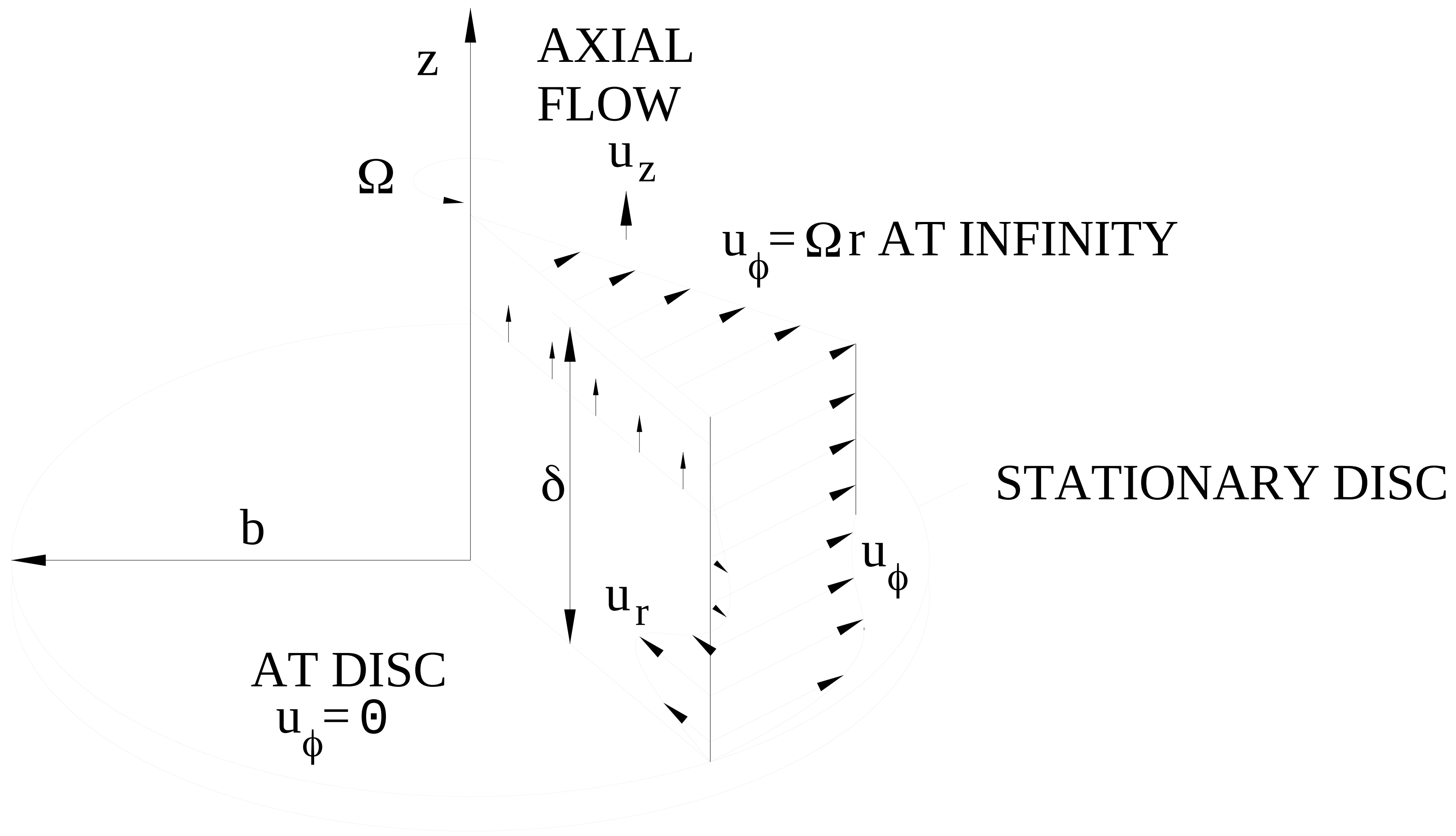
STATIONARY DISC

Rotating fluid above a stationary disc



Example velocity profiles for a stationary disc in a rotating fluid. b=0.035 m, Ω=60 rpm = 8.442 rad/s, ρ=1000 kg/m^3, μ=0.001 Pa s. Conditions equivalent to those for a stirred cup of tea

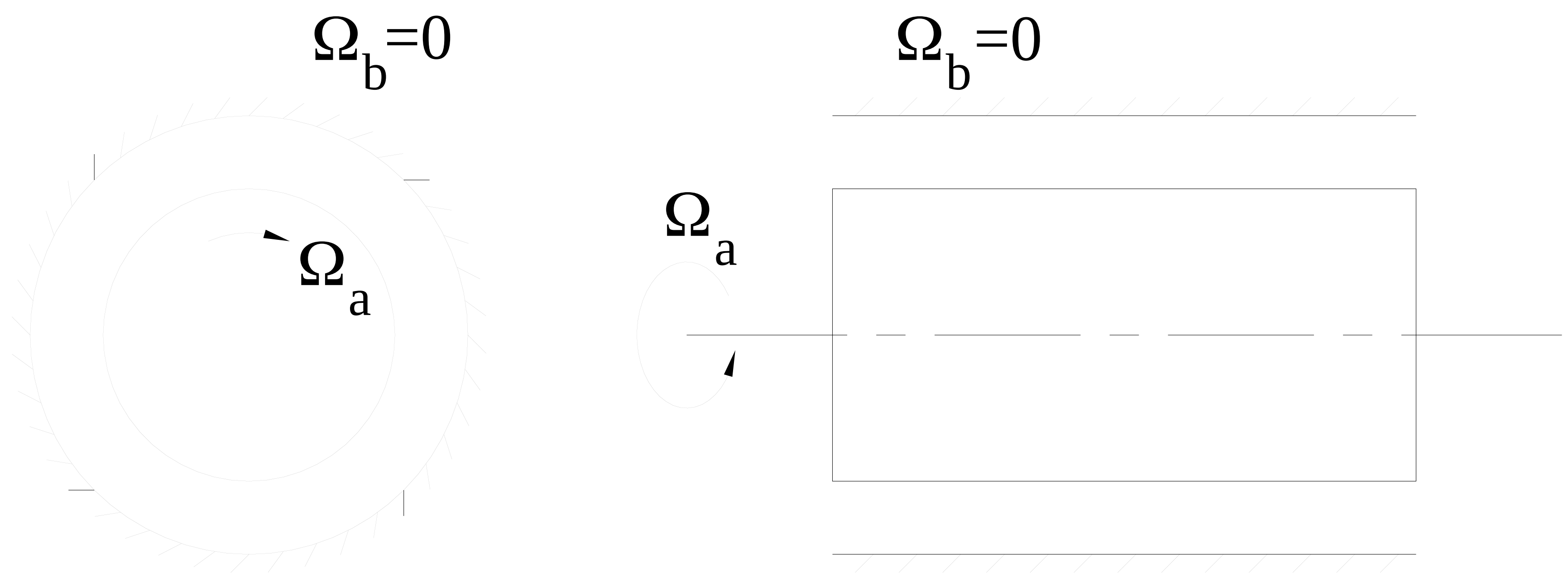
Rotating fluid above a stationary disc



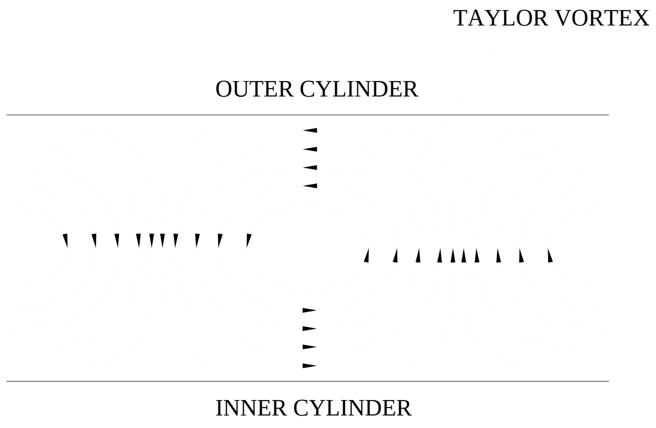
Your turn …

- Working in small groups of two or three you should have a glass tumbler with some sugar water, a teaspoon and sachets of sugar.
- Empty a sachet of sugar into the water.
- Stir at 1 revolution per second (about 60 rpm) for about ten seconds.
- Remove the spoon.
- You should see the accumulation of a few granules of sugar near the centre of the tumbler at the bottom.
- This is a practical demonstration of the counter-intuitive nature of rotating flow.

Cylinders and annulus flows



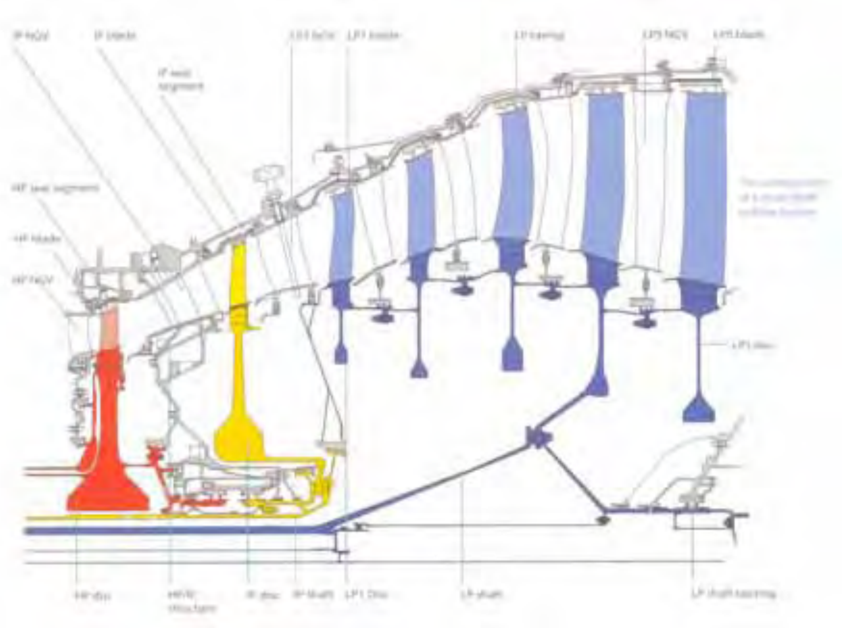
Cylinders and annulus flows



Rim sealing

In aircraft and electric power generation gas turbine engines alike, it is common practice for the cavity formed between a rotating turbine disc and a stationary disc to be purged with coolant air.

This air reduces the thermal load of the disc and prevents the ingress of hot mainstream gas into the cavity between the rotating disc and the adjacent stationary casing.



Rim sealing

However, use of this air is detrimental to engine cyclic performance, and turbine efficiency can be adversely affected by the seal air efflux into the main annulus.

The lifetime of the rotor, and the cyclic and component performance of the engine are therefore dependent on the efficiency with which the cavity is purged.

Rim sealing

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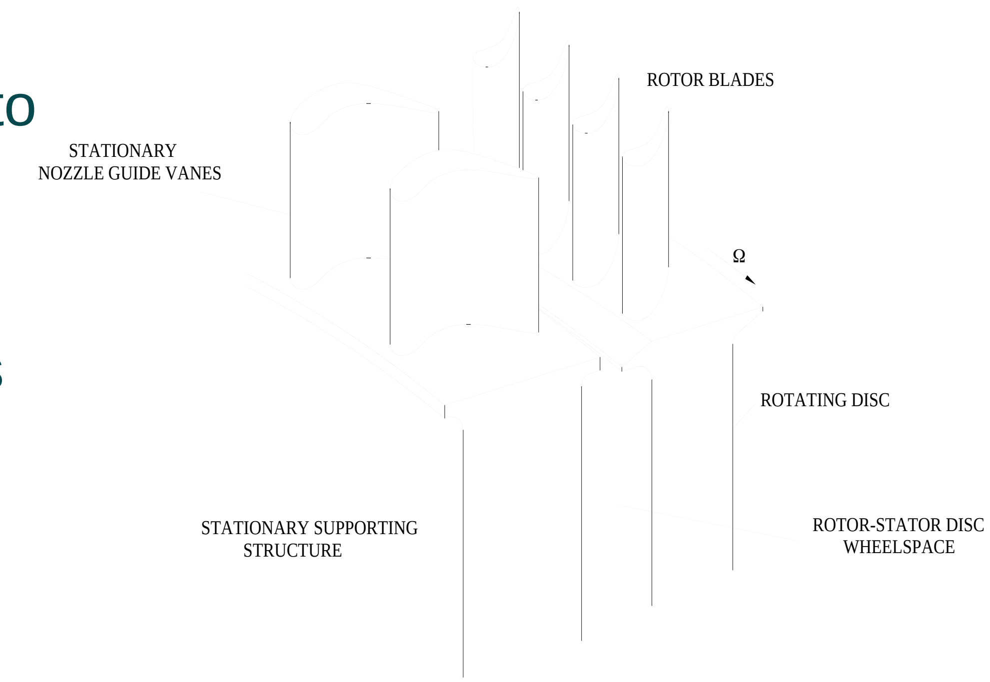
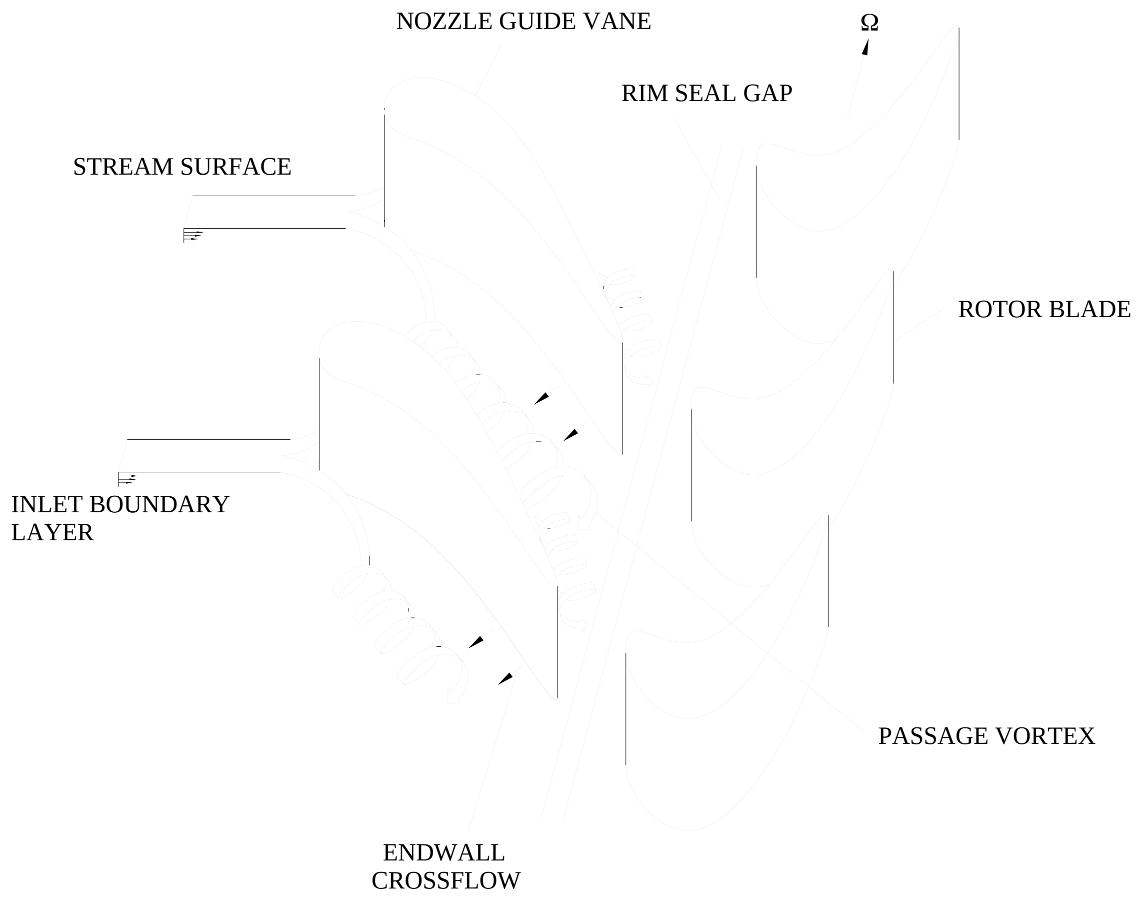
Typically some form of peripheral rim seal is provided to limit the flow ingress or egress and limit mainstream annulus flow spoiling due to interactions with flow in the rim seal region.



Rim sealing

The flow conditions are not axisymmetric, with, for instance, pressure and velocity varying with circumferential location and unsteady interactions between one blade row and another.



Turbine stator wells

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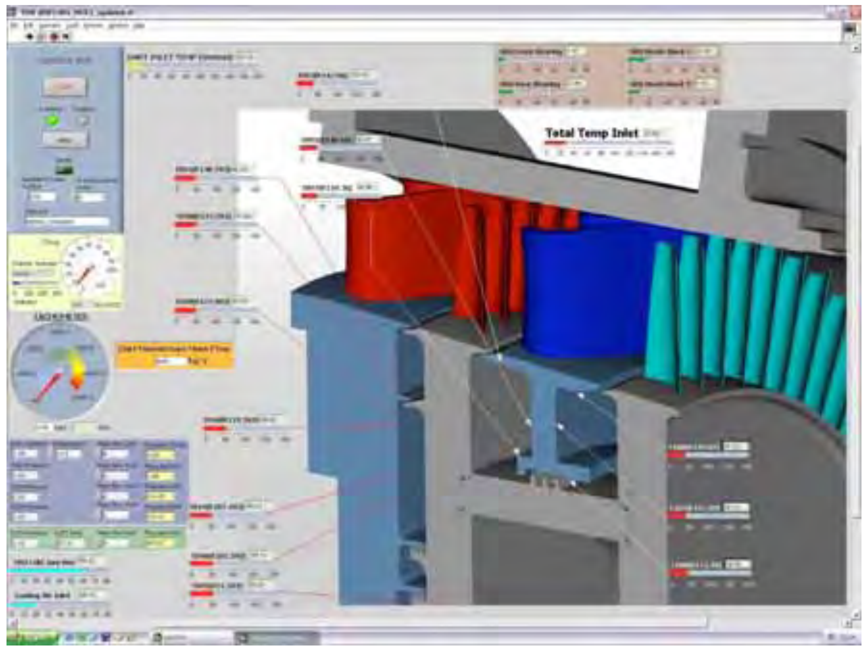

Rotating cavities

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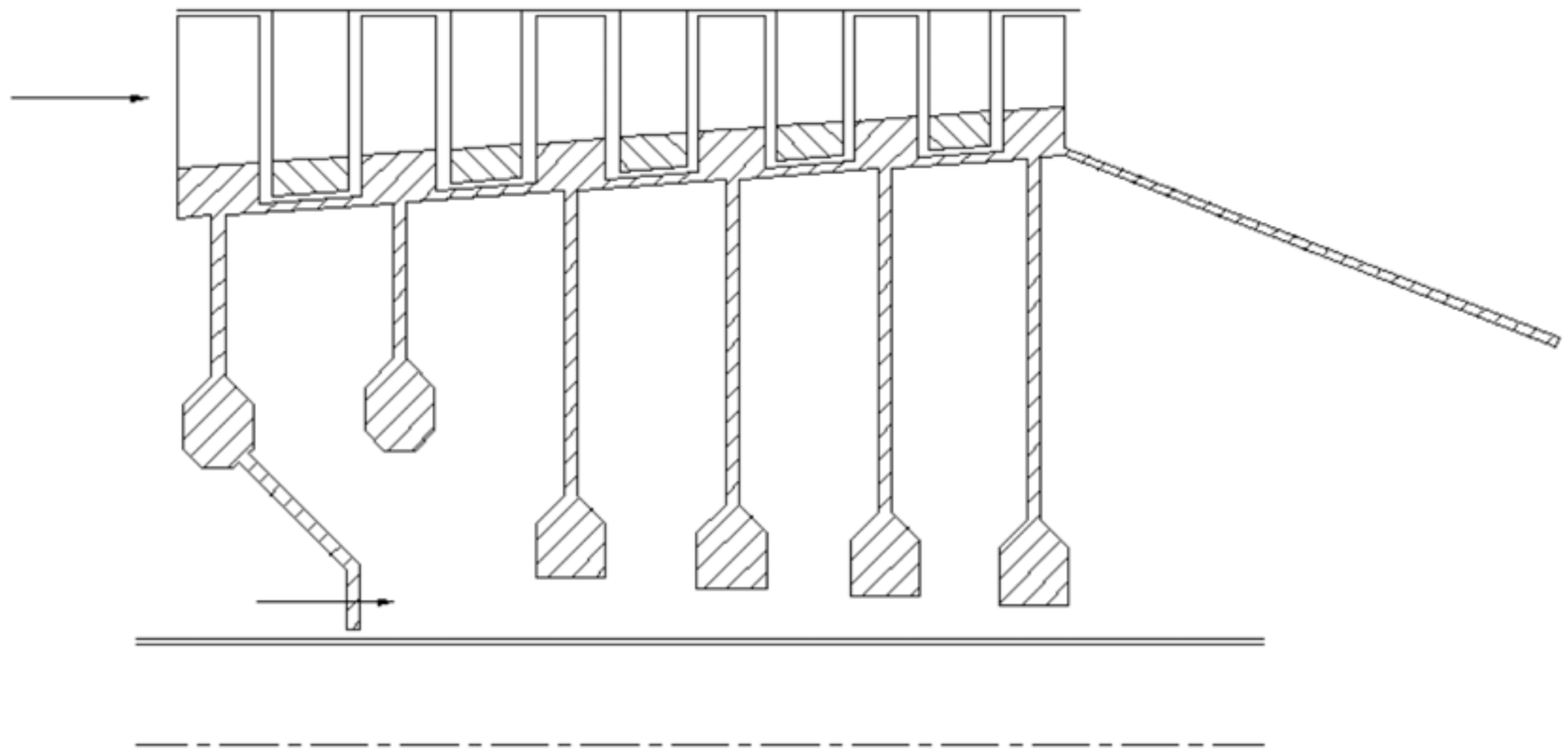
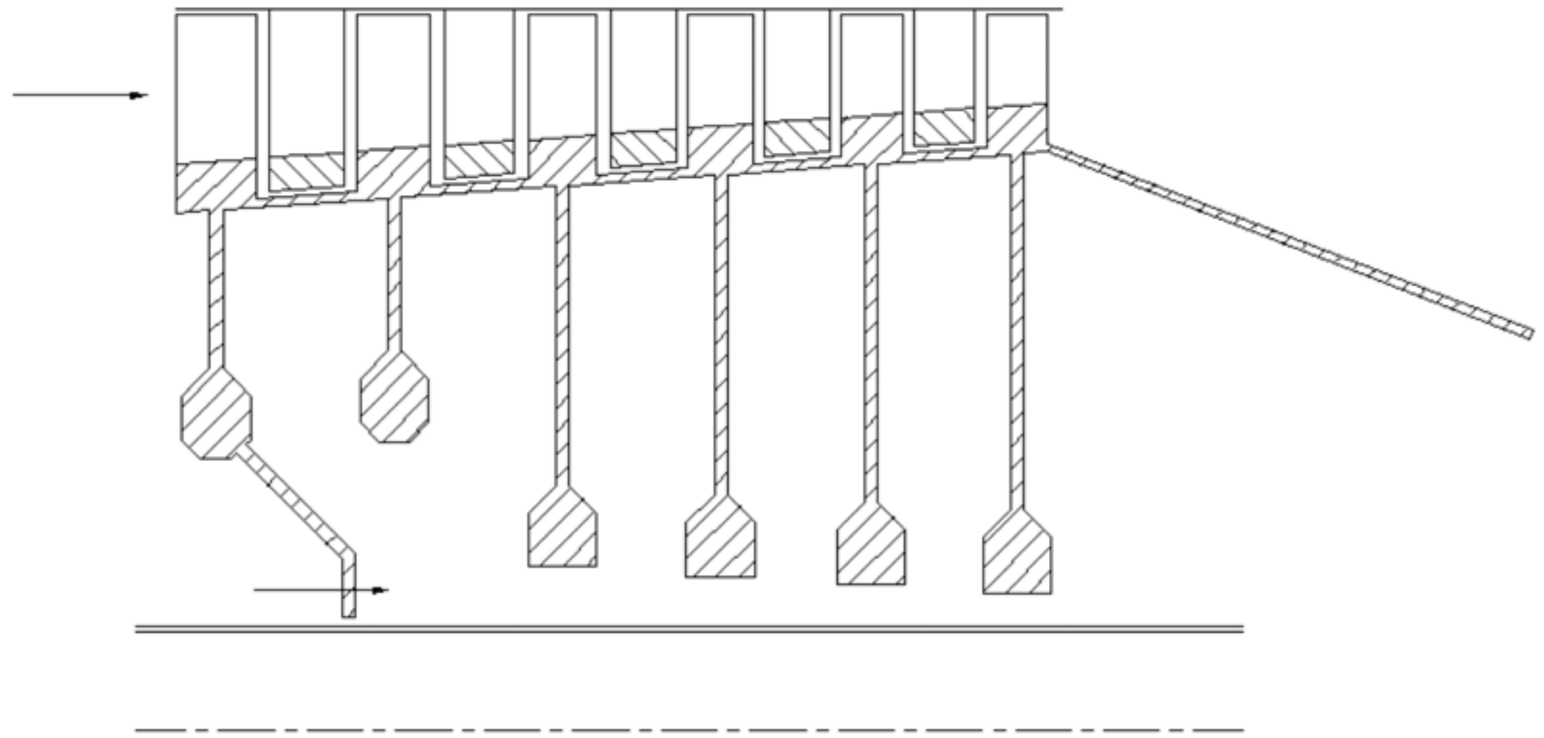
Air extracted from the compression system for turbine cooling and rim sealing is often led through the annular passage formed between disc bores and a central shaft.



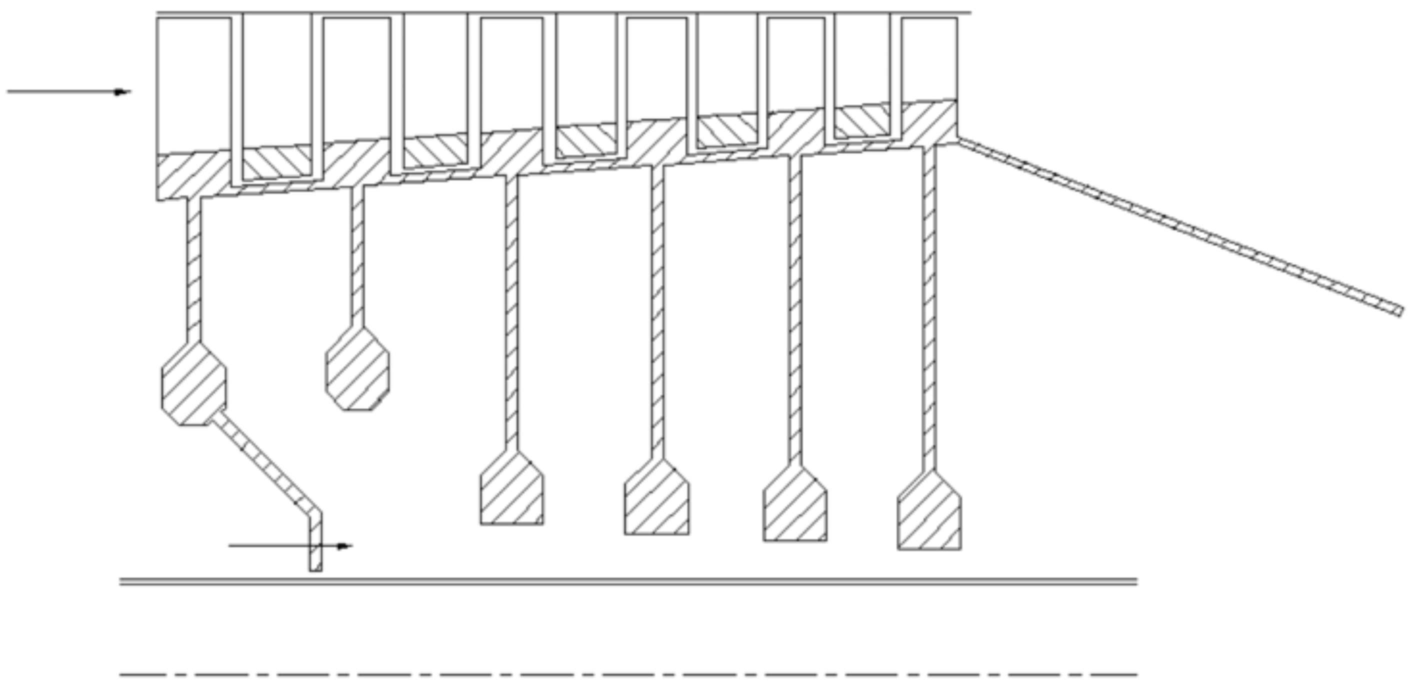
Rotating cavities

This air provides ventilation of the cavities formed between adjacent compressor discs and knowledge of the flow and heat transfer in these is needed for disc stressing and life calculations.

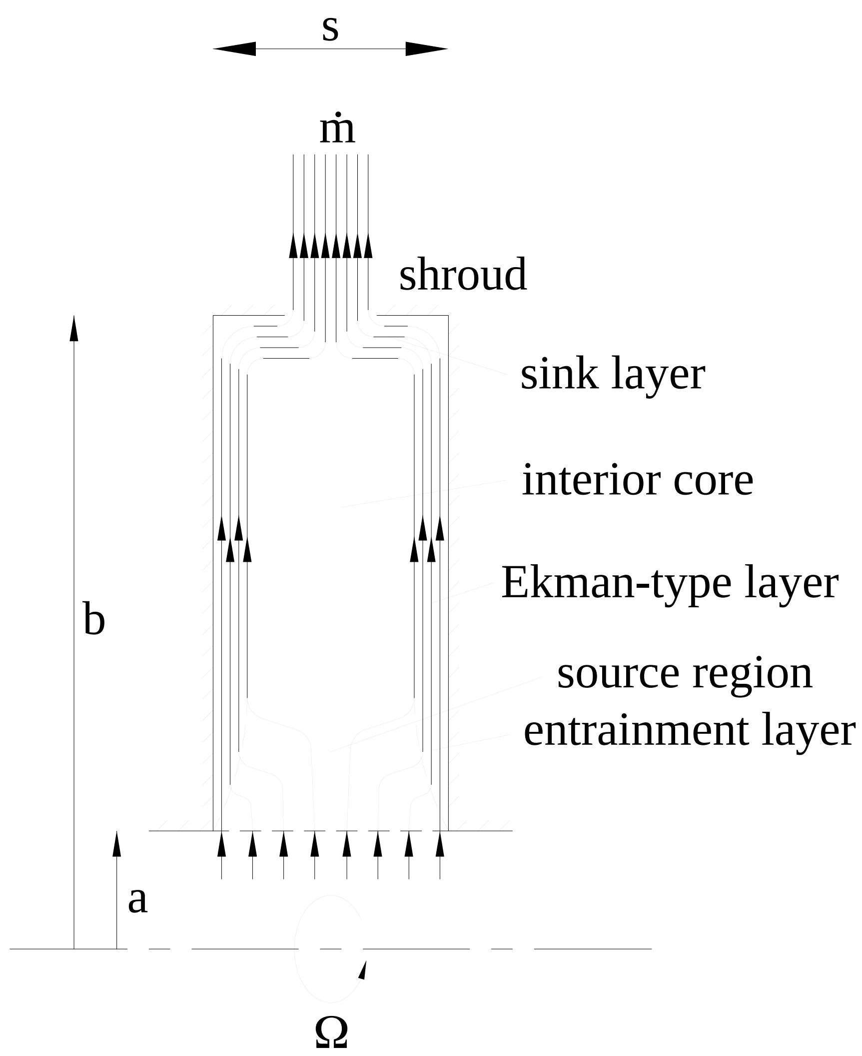


Rotating cavities

The flow behaviour in a rotating cavity is strongly dependent on whether there is a throughflow of air in the cavity and on the relative temperature between the components.

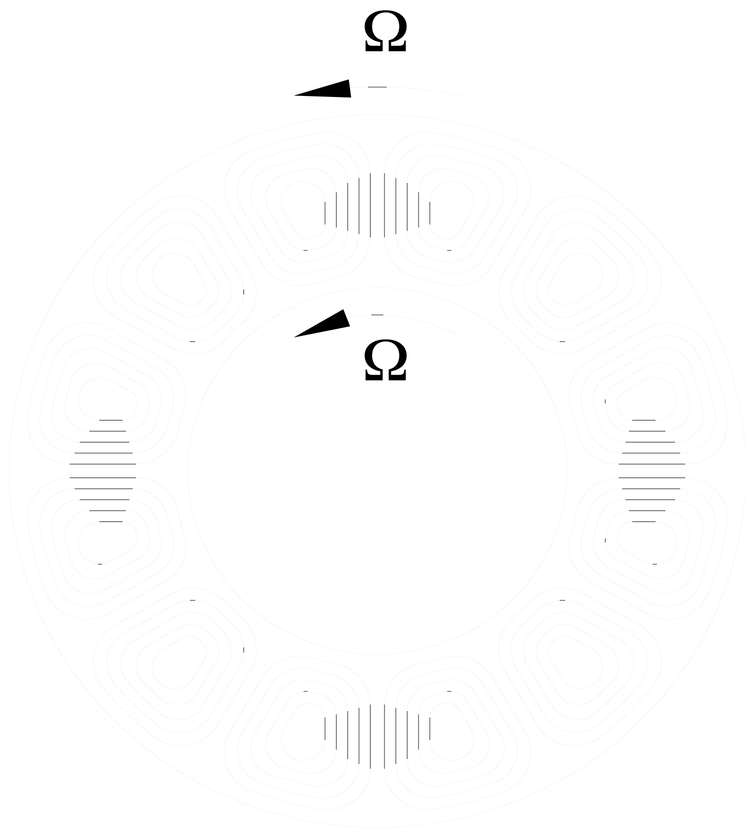


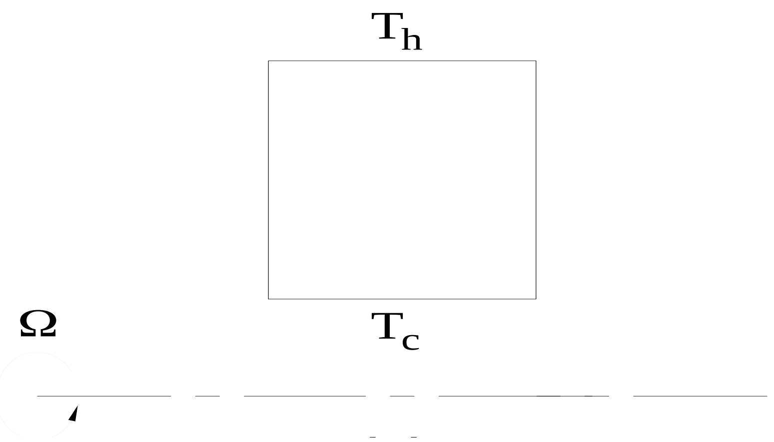
Rotating cavities



Rotating cavities

For the case of a radially directed heat flux where there is a temperature difference between the inner and outer peripheral surface, Bohn et al. (1993) and King et al. (2005) found a series of cyclonic and anti-cyclonic recirculations.





Rotating cavities

Practical engine geometric configurations can involve many rotating cavities with flow between successive rotating cavities and associated interactions.

Simultaneous measurements of the axial and tangential velocity components V_z and V_ϕ have been made inside using Laser Doppler Anemometry (LDA) for a rig with four rotating cavities.

Rotating cavities

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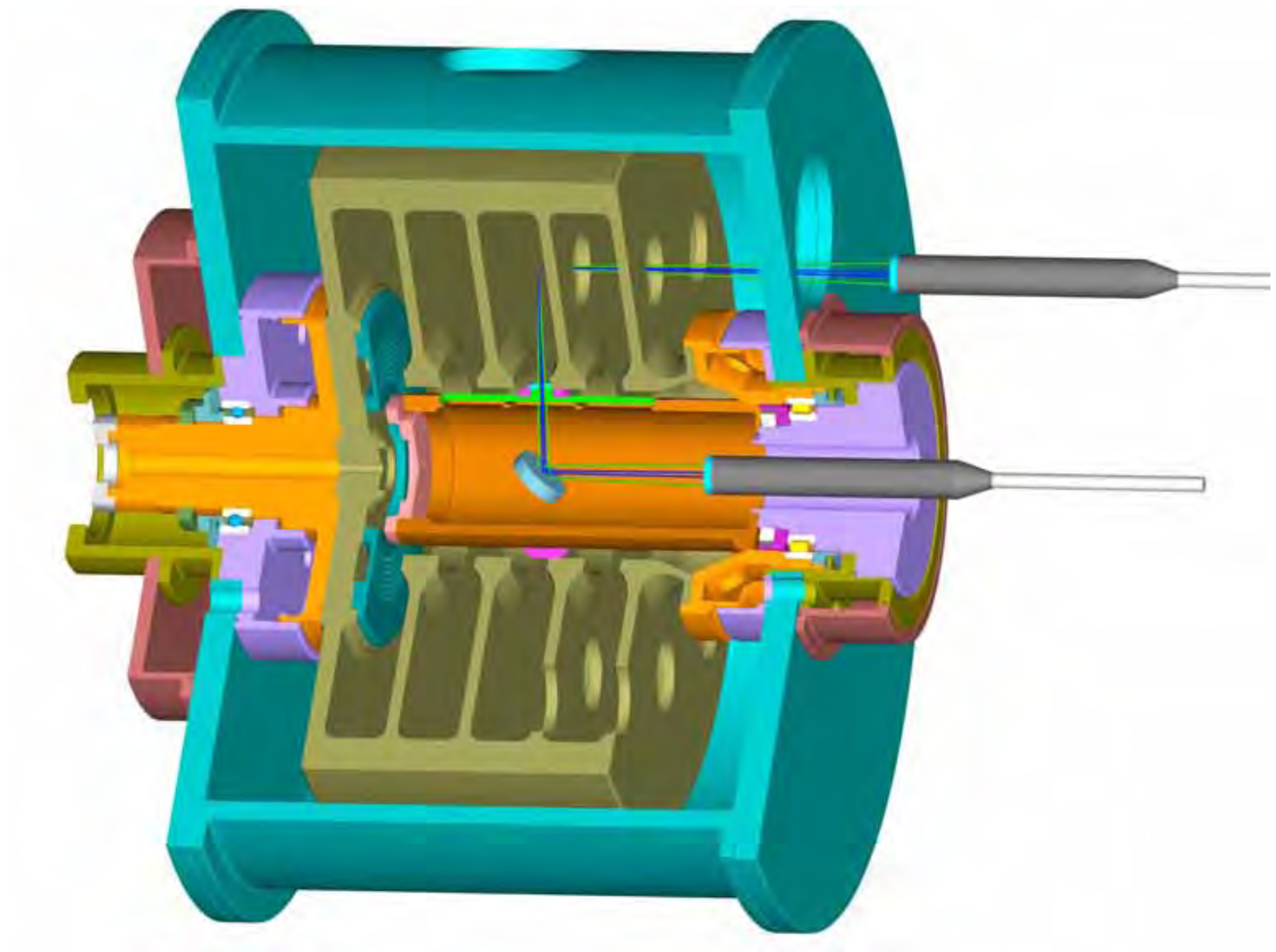

Radial variation of dimensionless tangential velocity with Rossby number (*wide annular gap*)

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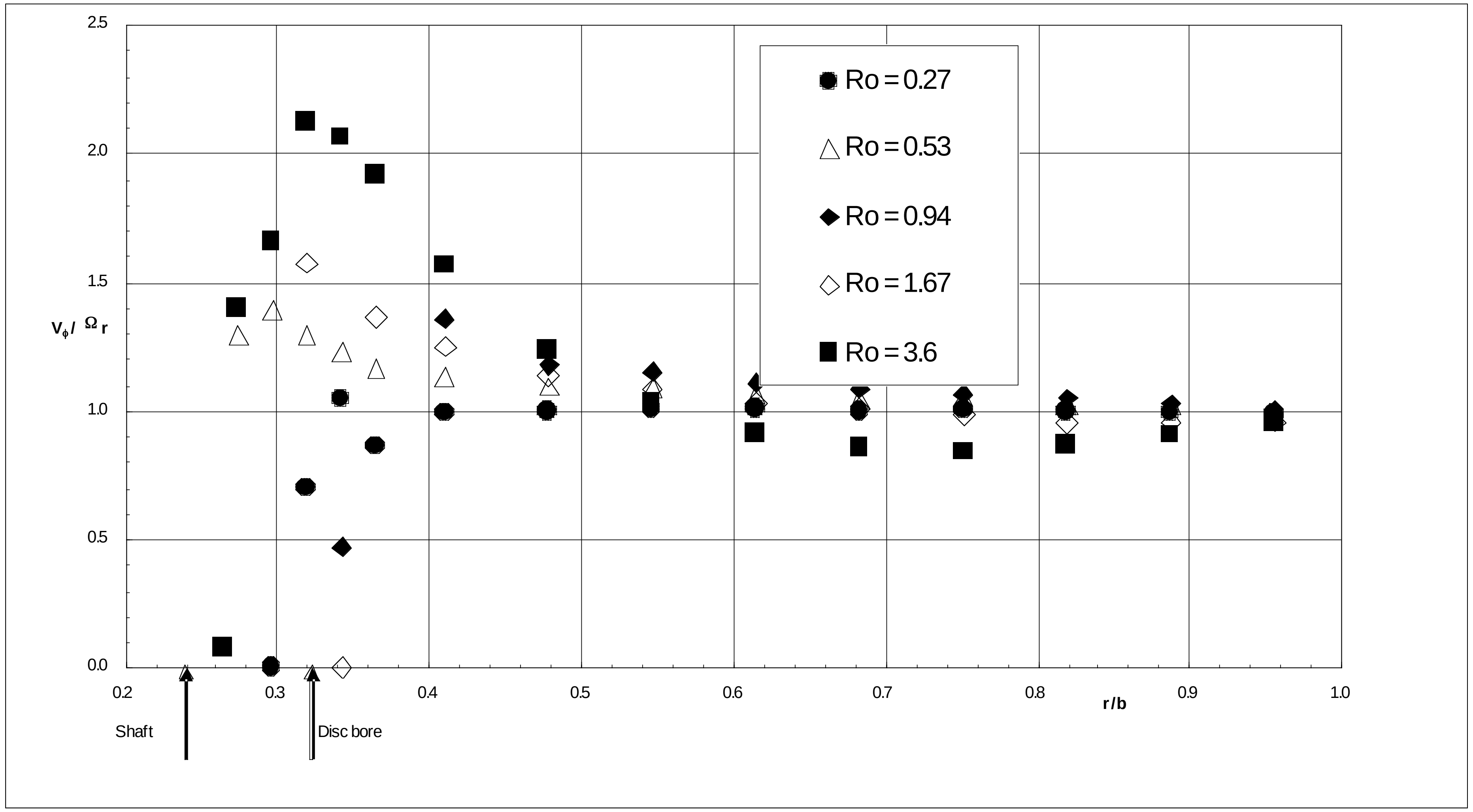
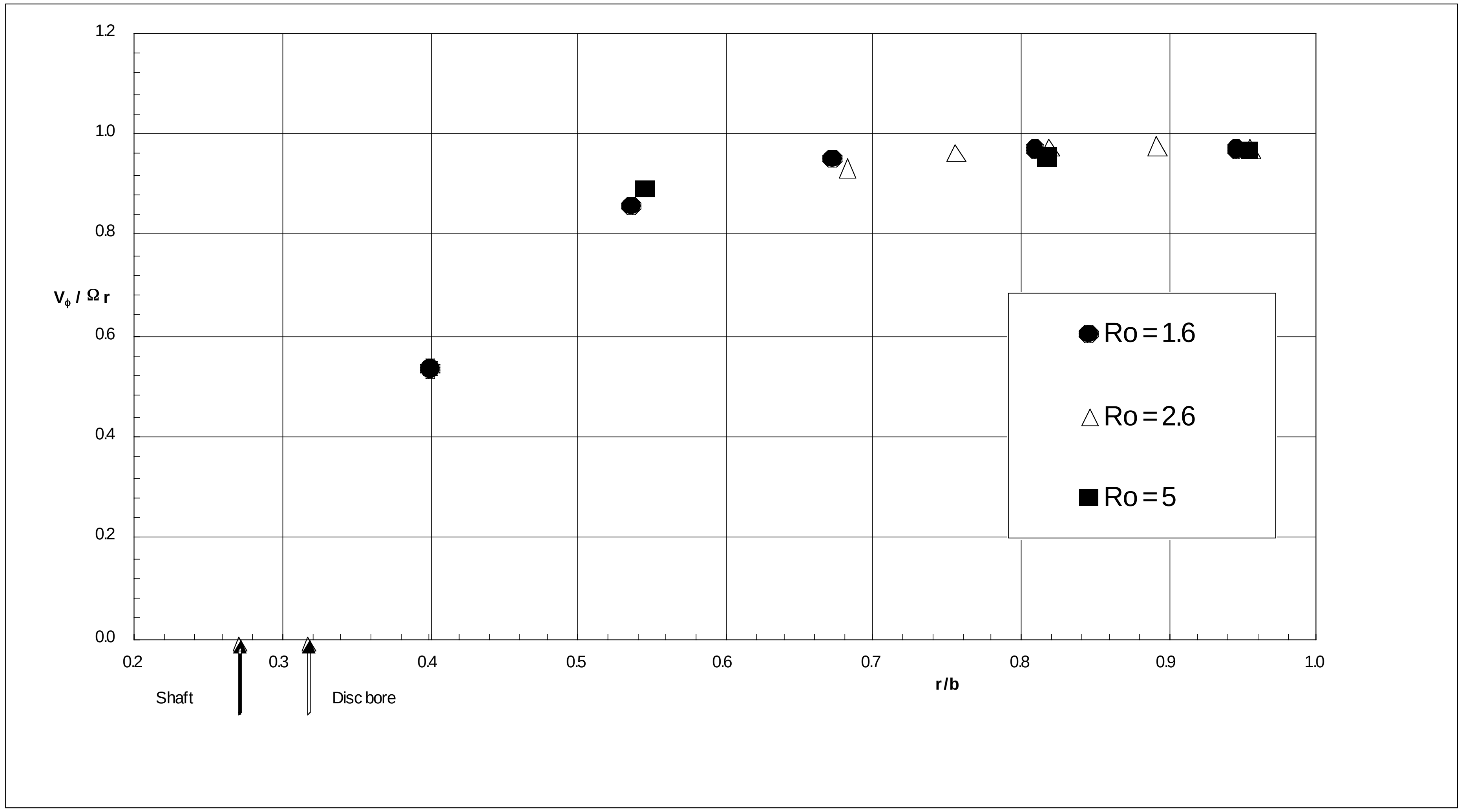
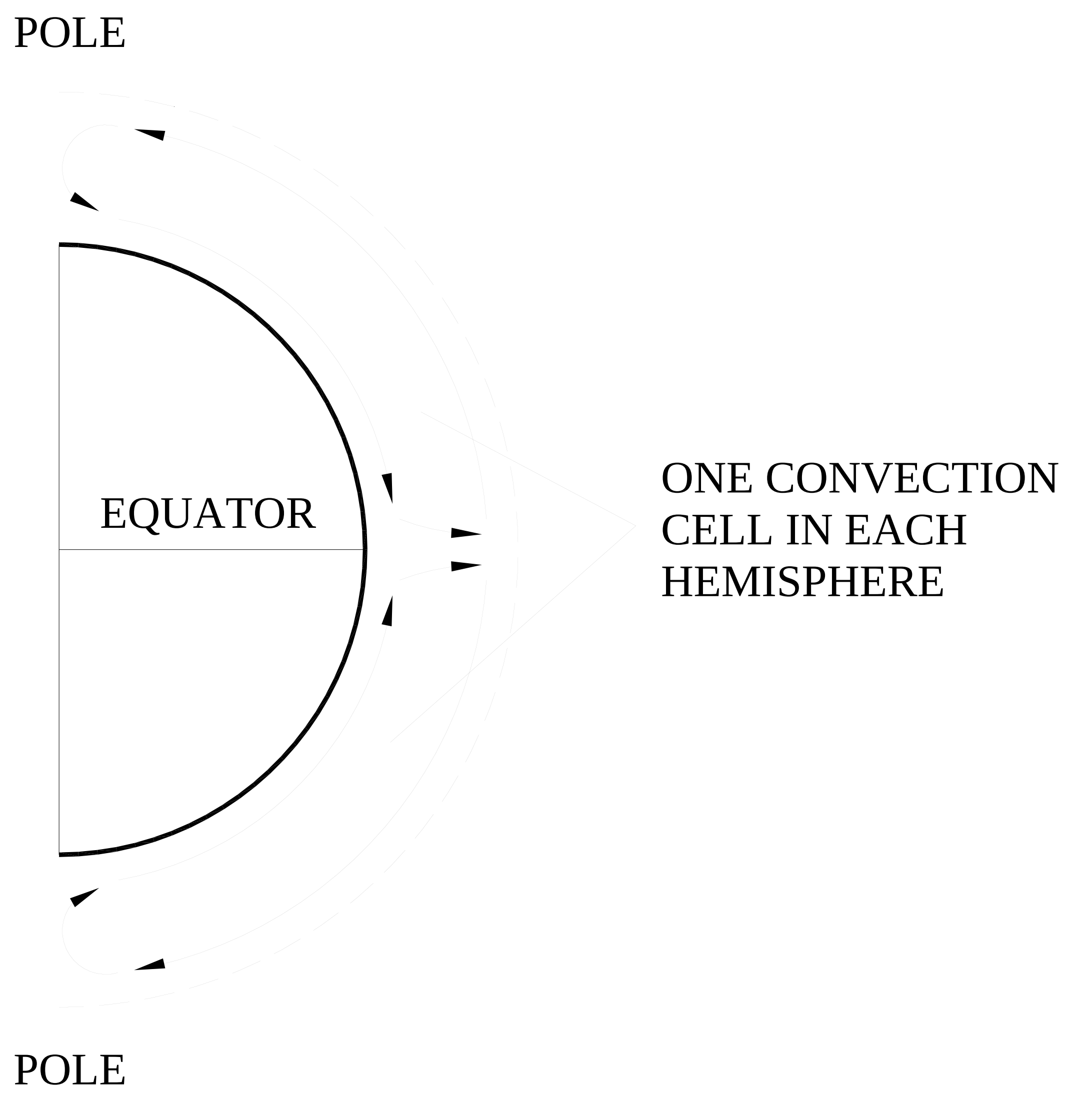


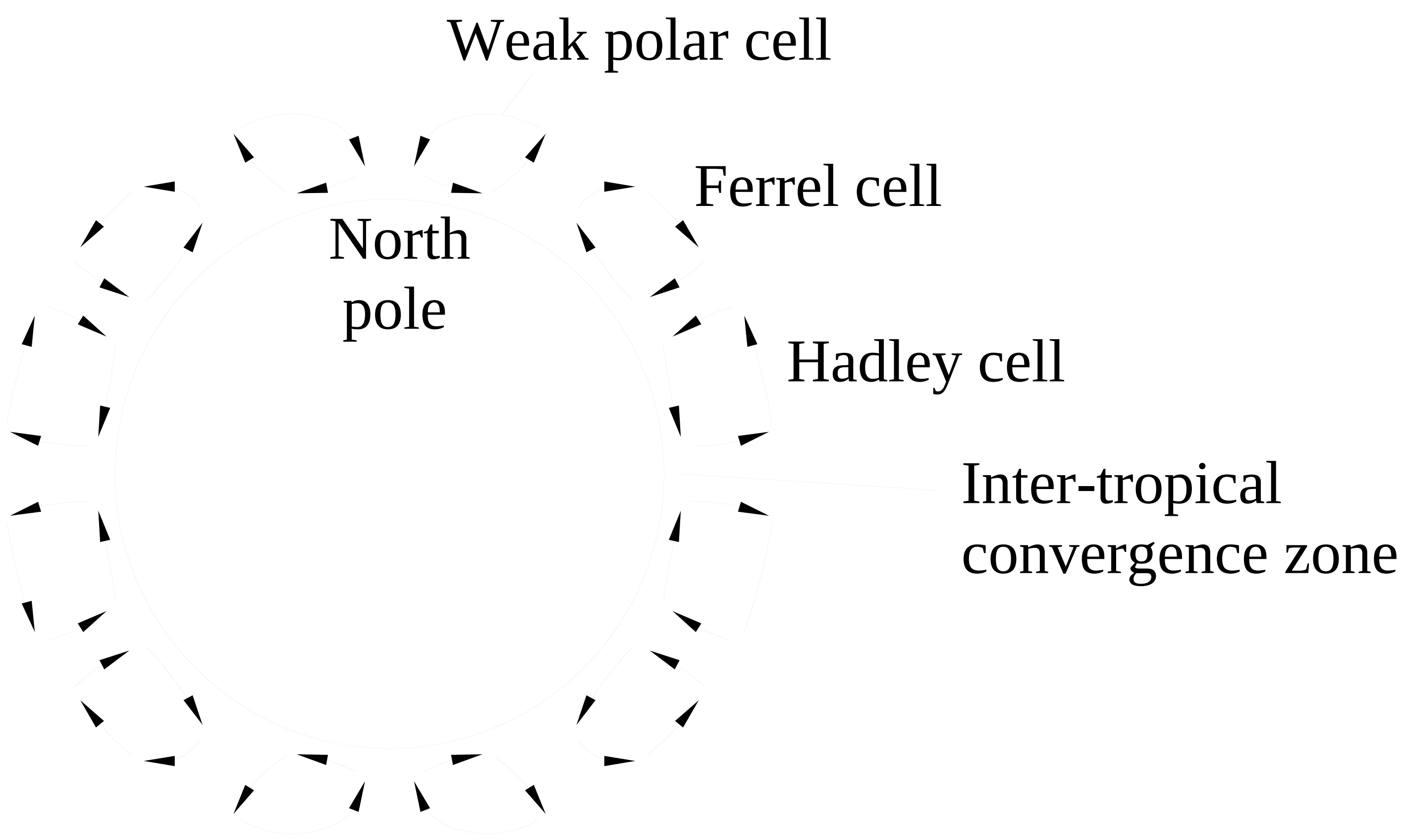
Radial variation of dimensionless tangential velocity with Rossby number (*narrow annular gap*)



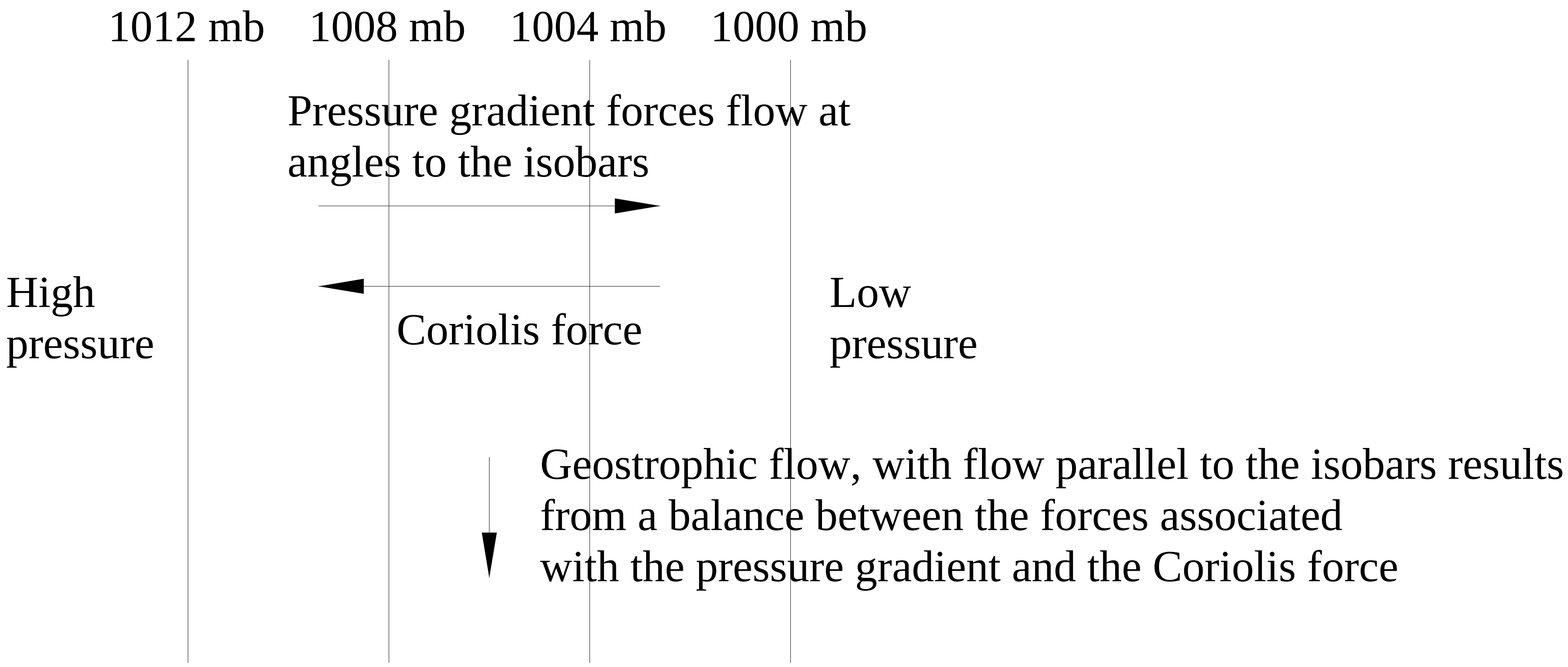
Rotating flow



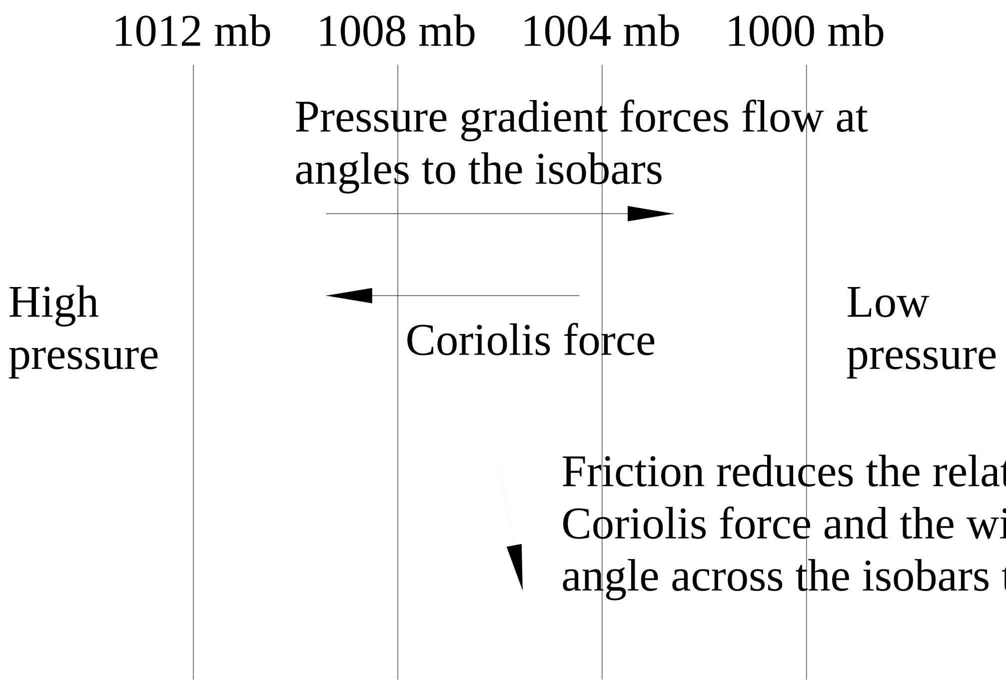
Rotating flow

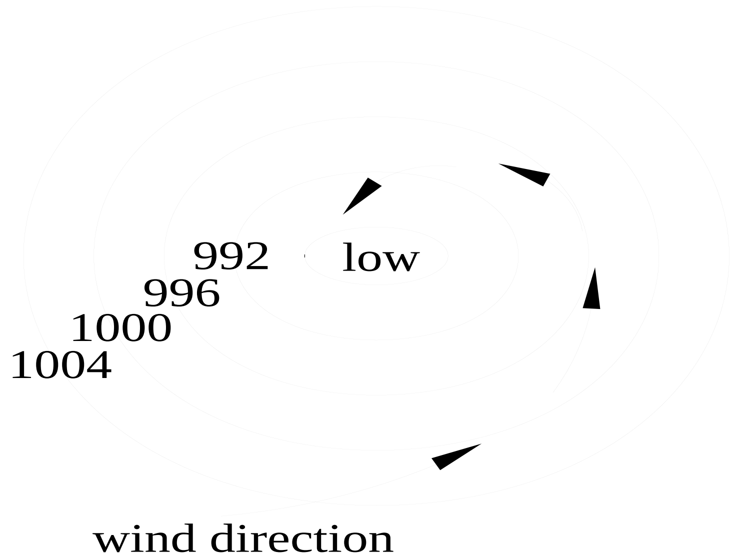


Rotating flow



Rotating flow





Friction reduces the relative magnitude of the Coriolis force and the wind blows at a gentle angle across the isobars towards the low pressure

Rotating flow

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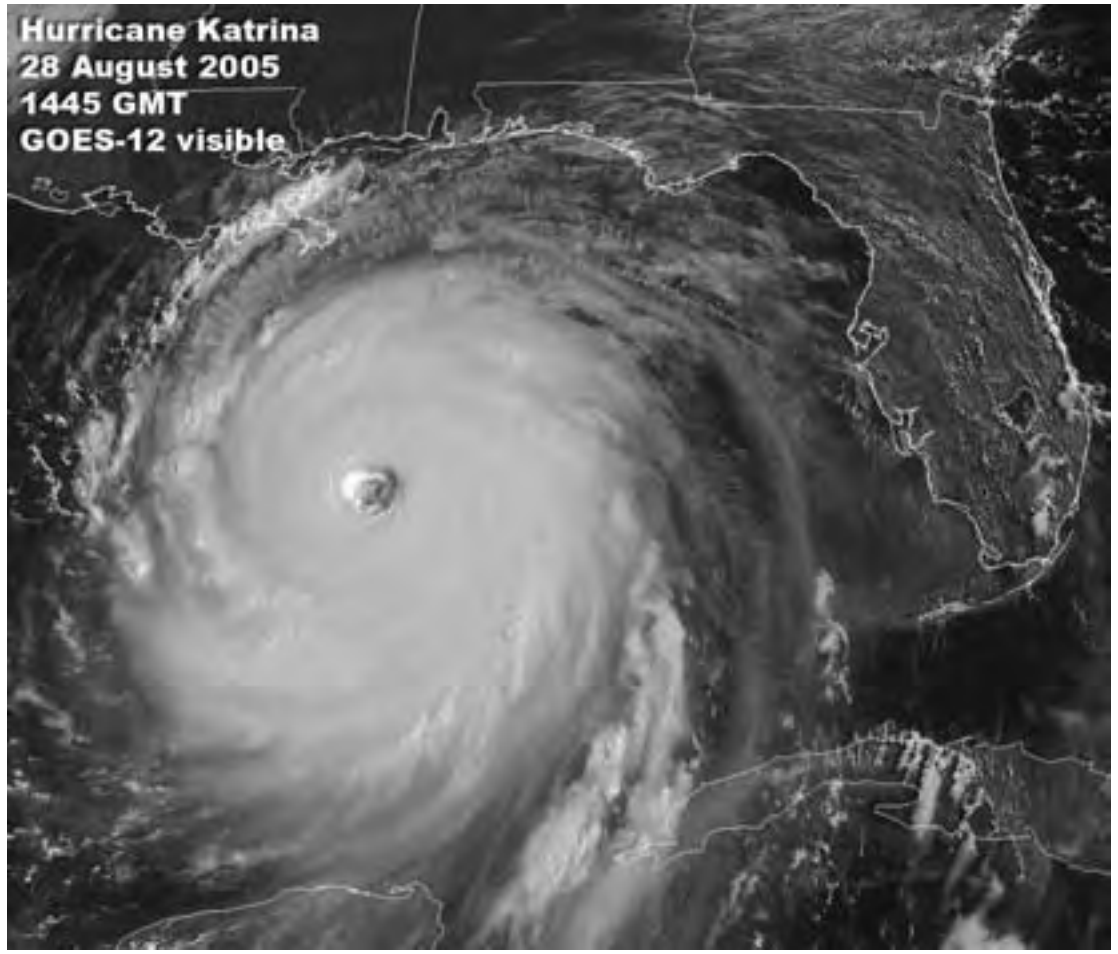

Hurricane Katrina, 28th August 2005.
Satellite image courtesy of NASA GSFC, data from NOAA GOES

Rotating flow

University of Sussex

The energy involved in such a hurricane is massive and of the order of 7.39×10^{18} J

This can be compared with the explosive energy of the Little Boy atomic weapon, which was approximately 6×10^{13} J

A hurricane can therefore have approximately 120000 times more energy than that of an atomic bomb.

Conclusions

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- Design involves concept development, styling and attention to details.
- A wide range of creative methods are available and can be readily applied to the design activity, the workplace and everyday life.
- The gas turbine engine is a highly demanding application requiring the highest levels of sophistication in detailed design and analysis.
- The science of modelling rotating flow in a gas turbine engine is the same science as for modelling flows affected by rotation in the Earth’s atmosphere and its oceans.
- It is possible that through innovative approaches and design, the science of rotating flow, that has enabled improvements in gas turbine engine technology, can also help us to understand further the impact of mankind’s activity on our world and also result in radically improved methods of power generation and transport.

Be still and know

Be active and do

Thank you