TEACHING

ROTORDYNAMICS IN HYDROPOWER APPLICATIONS

Developments and Future in SVC

Prof. Jan-Olov Aidanpää, LTU

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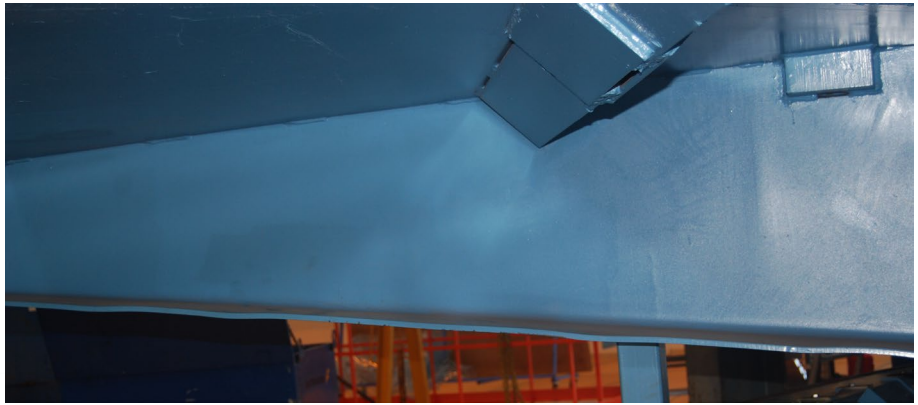

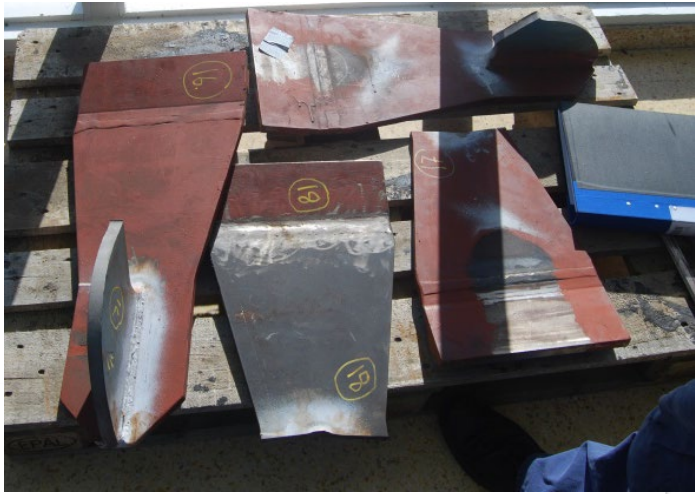

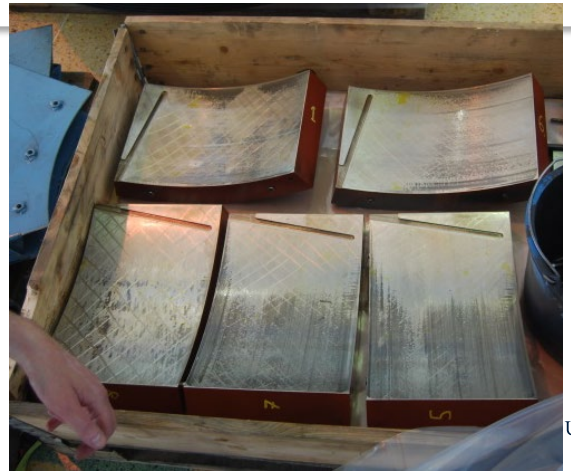

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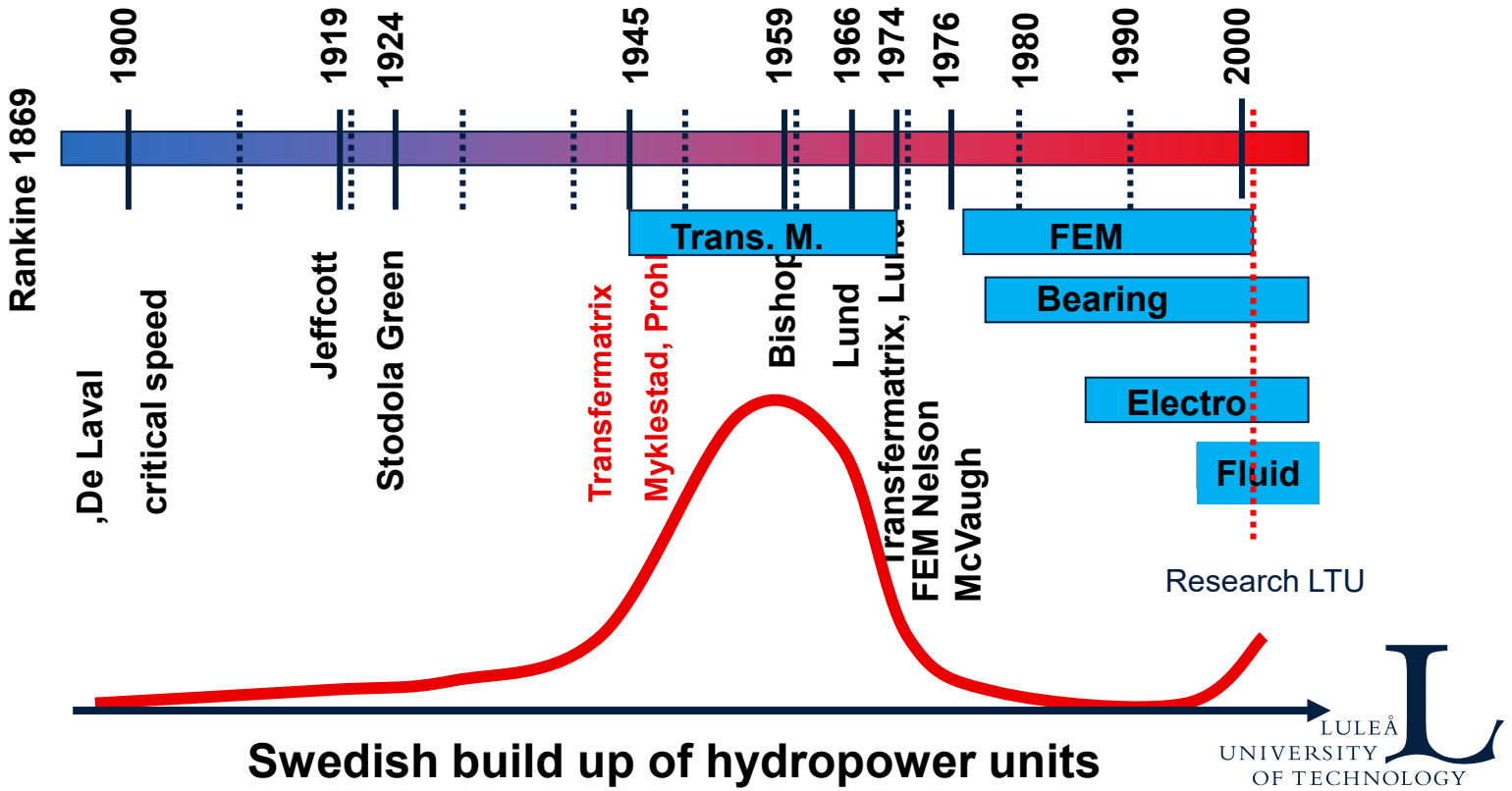
Rotordynamic History and Hydropower



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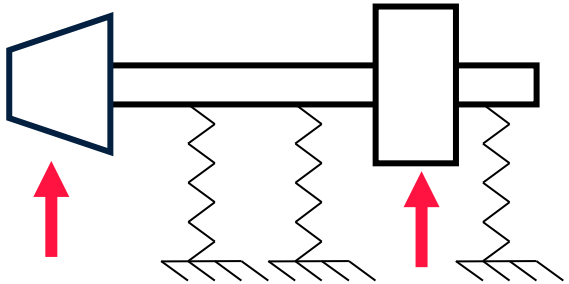
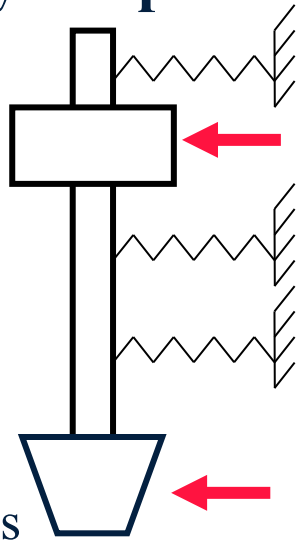
Why are Hydropower Rotors Different

Ordinary rotating machines



Known loads
known bearing prop
large air gap
small shape deviations

Hydro-power



Unknown loads
no relevant bearing models
small air gaps
large shape deviations

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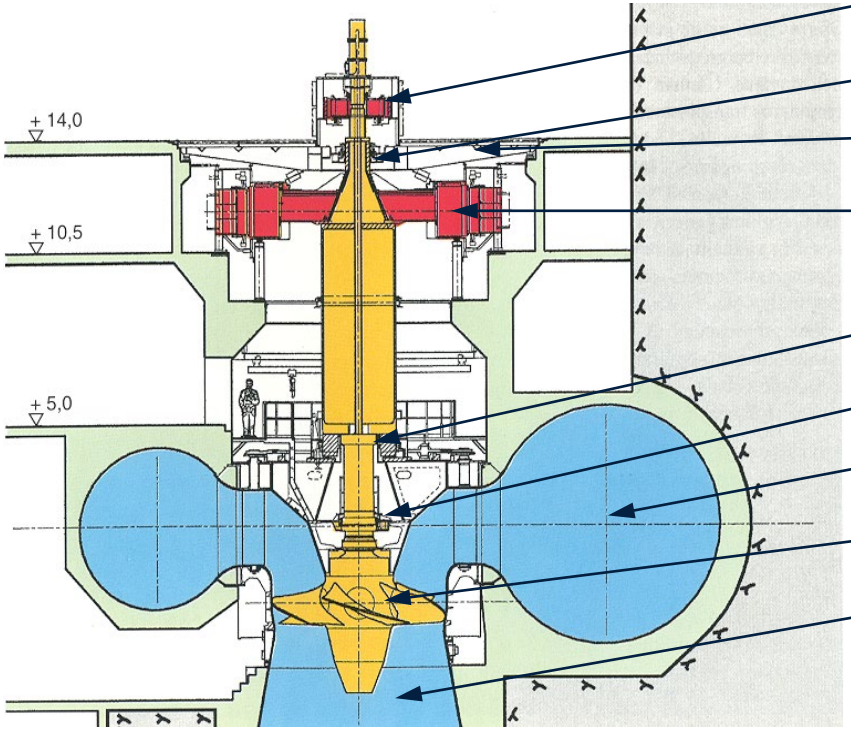
Hydropower Rotors are Unique



Exciter

Generator journ

Upper generato

Generator roto

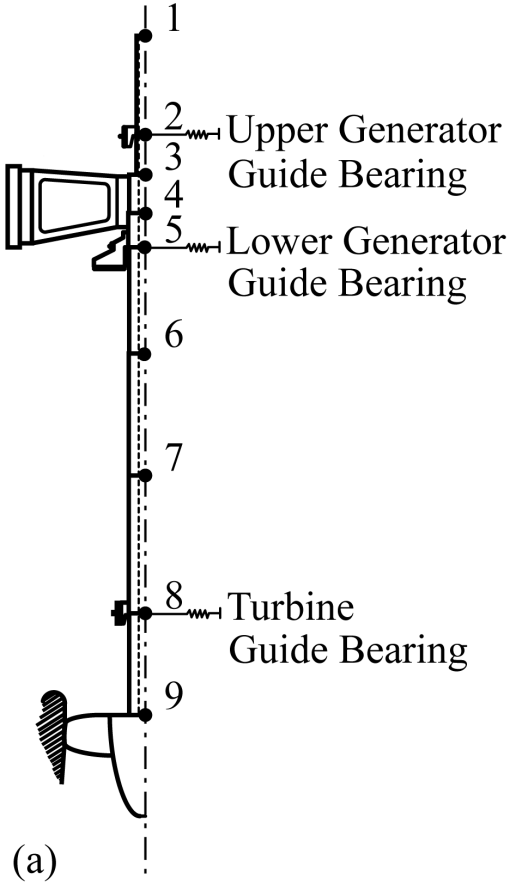
Trust bearing

Turbine journal

Spiral casing

Turbine

Draft tube



$$\frac{1}{K_{tot}} = \frac{1}{K_{film}} + \frac{1}{K_{mek}} \qquad (1)$$

Driftvarvtal			
	Upper guide bearing	Lower guide bearing	Turbine guide bearing
K_{film}	2.6×10^6	1.16×10^6	0.90×10^6
K_{mek}	1.17×10^6	7.5×10^6	3.0×10^6
K_{tot}	0.8×10^6	1.0×10^6	0.69×10^6

Tabell 2.1.1. Minsta beräknade lagerstyvheter vid driftvarvtal [N/mm]. Oljefilmens styvheter för övre och nedre styrlager är tagna från [1]. Turbinlagerdata har erhållits från turbinleverantören.

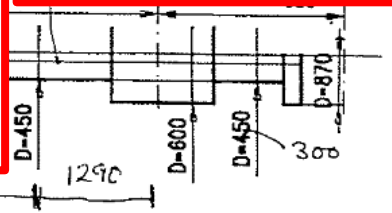
Rusvarvtal			
	Upper guide bearing	Lower guide bearing	Turbine guide bearing
K_{film}	2.7×10^6	1.6×10^6	∞
K_{mek}	1.17×10^6	7.5×10^6	3.0×10^6
K_{tot}	0.82×10^6	1.32×10^6	3.0×10^6

Tabell 2.1.2. Minsta beräknade lagerstyvheter vid rusvarvtal [N/mm]. Oljefilmens styvheter för övre och nedre styrlager är tagna från [1]. Turbinlagerdata har erhållits från turbinleverantören.

No Damping

Unsure Stiffnesses

No Reliable Results



F. Exciter rotor

Total weight = 1000 kg

D. Turbine guide bearing

Radial stiffness (proposed values by ABB)

Normal speed = 600 r/min

Runaway speed = 1450 r/min

Mechanical	~~1.7E6~~ 3.0E6 N/mm	Mechanical	1.7+E6 3,0E6 N/mm
Oil film	0.6+E6 N/mm	Oil film	~~0.8+E6~~ ∞ N/mm
Total	~~0.44+E6~~ 0.69E6 N/mm	Total	~~0.544+E6~~ 3.0E6 N/mm

E. Turbine runner

Total weight 1850 kg

Weight incl. water ??? kg 2600

Moment of inertia (incl. water?)

Polar 200 kgm² 310

Diametrical ??? kgm² 230

Max. radial force on turbine runner= kg

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Component Analysis: Model/Eigenvalue - Rotor [Example Industrial Rotor - SI-m]

Command Help

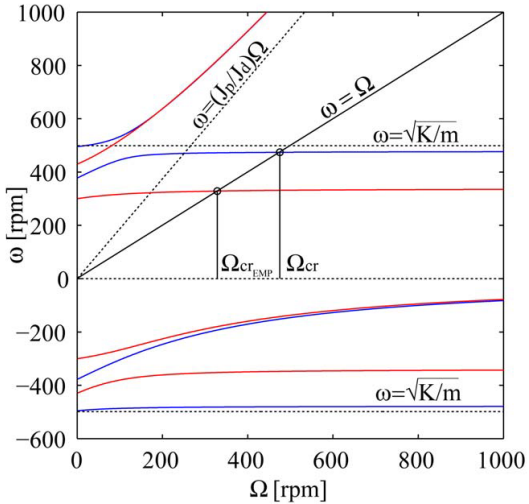
Simple model of an industrial rotor

Cambell diagram and mass unbalance response

Insert | Copy | Move | Delete | Import

Restore
Move
Size
Minimize
Maximize
Close Alt+F4

Node #	ID Text	Intercon-nection	Connectivity	X (m)	Y (m)	Z (m)			Added It (kg-m^2)	Active Load Paths 1
1	Disk D1		View	0	0	0	1.2	0.0012	0.0024	
2			View	0	0	0.035	0	0	0	
3			View	0	0	0.045	0	0	0	
4	Bearing P1		View	0	0	0.07	0	0	0	
5			View	0	0	0.1025	0	0	0	
6			View	0	0	0.135	0	0	0	
7			View	0	0	0.1675	0	0	0	
8	Bearing P2		View	0	0	0.2	0	0	0	
9			View	0	0	0.225	0	0	0	
10			View	0	0	0.25	0	0	0	
11			View	0	0	0.275	0	0	0	
12	Disk D2		View	0	0	0.3	1	0.001	0.002	



Component Analysis: Model/Eigenvalue - Rotor [Example Industrial Rotor - SI-m]

Command Help

Simple model of an industrial rotor

Cambell diagram and mass unbalance response

Insert | Copy | Move | Delete | Import

Beam #	Left Node	Right Node	Material	Beam Type	Left O.D. (m)	Left I.D. (m)	Right O.D. (m)	Right I.D. (m)	ID Text
1	1	2	Steel	Conical	0.04	0	0.04	0	
2	2	3	Steel	Conical	0.07	0.01	0.07	0.01	
3	3	4	Steel	Conical	0.04	0.01	0.04	0.01	
4	4	5	Steel	Conical	0.04	0.01	0.04	0.01	
5	5	6	Steel	Conical	0.04	0.01	0.04	0.01	
6	6	7	Steel	Conical	0.04	0.01	0.04	0.01	
7	7	8	Steel	Conical	0.04	0.01	0.04	0.01	
8	8	9	Steel	Conical	0.04	0.01	0.04	0.01	
9	9	10	Steel	Conical	0.04	0.01	0.04	0.01	
10	10	11	Steel	Conical	0.07	0.01	0.07	0.01	
11	11	12	Steel	Conical	0.07	0.01	0.07	0.01	

Page: Beams | < Previous | Next > | Done | Run | View | Plot | Cancel | Help

Component Analysis: Journal Bearing - 2-D Fixed Geometry, Basic [Manual Example 5]

Command Help

Manual Example 5

2 lobe Pressure Dam Bearing

Type

Fluids Model: Incompressible

Fluid Name:

Linked? No | Define... | Fluids Library...

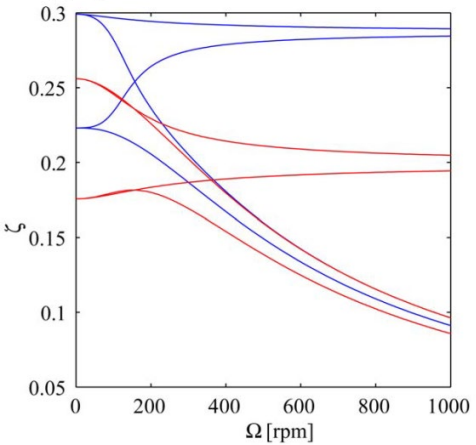
Properties

Density (lbm/ft^3)	54.17
Thermal Expansion Coef. (1/R)	0.0004
Bulk Modulus (psi)	30000
Specific Heat (BTU/lbm-R)	0.494
Thermal Conductivity (BTU/h-ft-R)	0.073
Cavitation Pressure (psi)	0

1st Temp./Viscosity P

2nd Temp./Viscosity F

Page: Fluids | < Previous | Next > | Done | Run | View | Plot | Cancel | Help



Rotordynamics within SVC in Close Collaboration with VRD

- Rotor Modelling
- Bearing Models for Vertical Rotors
- Electromagnetic Interaction (Uppsala Univ)
- Measuring Techniques (VRD/ Fluid Mech)
- Validations (2 Testriggs at VRD)
- Nonlinear Properties
- Added Turbine Properties (mass/ stiffness/ damping (Fluid Mech)
- Parametric Excitation
- New Components for Added Damping
- Elastic Rotor rim in Generators
- Analytical Bearing Models (speed/excentricity dependent

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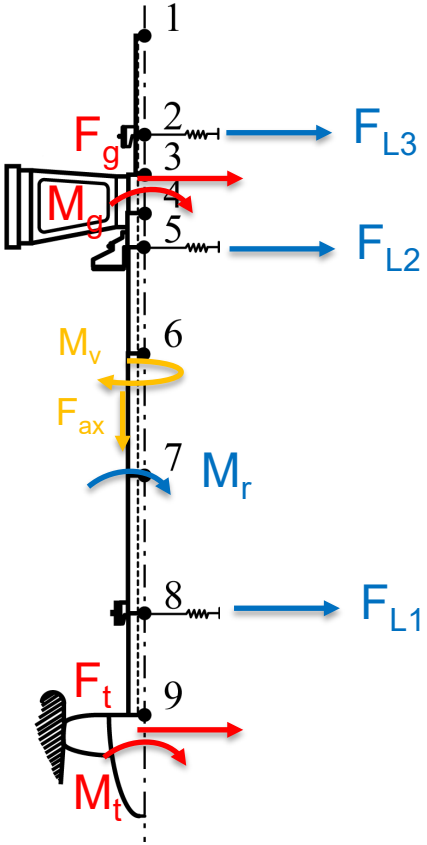
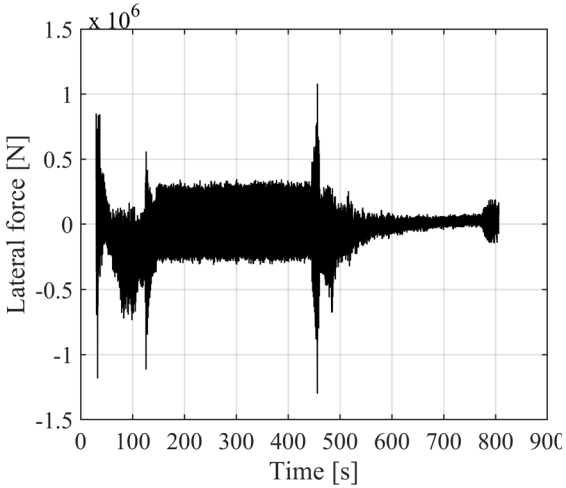
Measuring Techniques

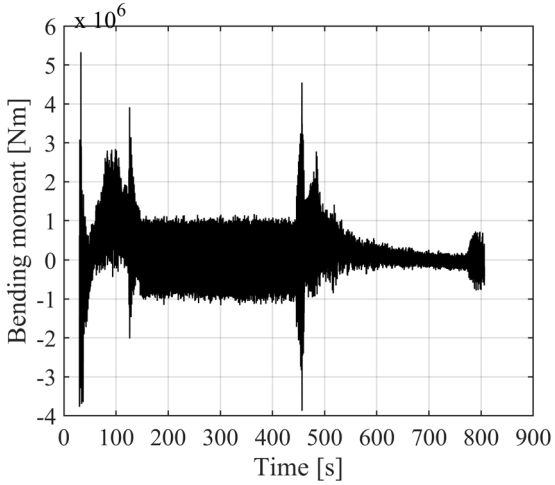
Quasistatic assumption

- 8 unknown forces
- 8 measuring points

Bearing displacements+ bearing model







Future

- 3D FEM for Generators including Electromagnetic Interaction
- 3D Rotordynamics & Fluid mech % Electro
- Loads on Turbine
- Simulation of Different Operating Conditions
- Life time evaluation

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