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Energiforsk

Pipe vibrations in nuclear power plants

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FS Dynamics



FS Dynamics' Organization

- Founded in 2004 in Sweden
- Headquarters in Gothenburg
- 10 offices in 6 countries
- Corporation + 6 subsidiaries
 - FS Dynamics Denmark founded 2009
 - FS Dynamics Finland founded 2010
 - FS Dynamics Norway founded 2013
 - FS Dynamics Portugal founded 2016
 - FS Dynamics UK founded 2016
- 180 employees, 35 in Finland





- 1. Introduction
- 2. Workflow of DIAM-Matrix tool
- 3. DIAM-Matrices
- 4. Conclusions



1. Introduction

- 2. Workflow of the DIAM-Matrix tool
- 3. DIAM-Matrices
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Introduction

- The project was carried out as master's thesis
 - Finished in August

• Target of thesis was:

- Gather knowledge related to pipe vibrations
- Simple tool for solving pipe vibration problems
- Knowledge transfer to young professionals

Research methods:

- Literature review and interviews

Costs of pipe vibrations



- One day:
 - 24h * 1 158 000kW * 0,02€/kWh = 555 840€
- Half a year: 101,4 M€

YNAMICS



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"Detection"-phase

• An anomaly is detected by continuous monitoring

- Normal operation of the plant
- Inspections, measurements, checks

Anomalies are indicators of vibration problems

- Alarms, leaks, noises, cracks, damages

- · Already the anomaly can reveal a lot
 - Frequency range
 - Narrowband / broadband / impulse
 - Continuous / short-term









"Investigation"-phase

- Verification of the detected anomaly
 - What vibrates?
 - Problematic frequencies / frequency ranges
 - Correlation between variables and vibration
- Investigation methods
 - Simple measurements, tests and checks
 - Focus of the matrices in investigation



- Goal is to find out the phenomenon causing the problem
 - Rule out phenomena which did not cause the anomaly
 - In "Analysis"-phase it is possible to focus directly on right phenomenon







"Analysis"-phase

• More precise research

- Measurements (frequencies, modes, phases)
- Simulations
- Scale models
- Requires large amount of time and knowledge
- Goal is to find out the root cause and solution
 - Root cause is the design error causing the vibration problem
 - Root cause is required for effective mitigation
 - Also the solution (mitigation method) should be analyzed









"Mitigation"-phase

Choosing the mitigation method

- Best mitigation method depends on the phenomenon
- Some methods can be used even if the phenomenon is unknown

Goal is to mitigate the vibration to safe level

- Mitigation for excitation
- Mitigation for response
- Mitigation is not always needed
 - Safe operation ensured with analyses
 - Reinforcing the component suffering from vibration







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DIAM-Matrices



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Conclusions



• Main benefits of DIAM-Matrix tool:

- Systematic method for solving pipe vibration problems
- Tool guides the user through the process
- Faster solving of pipe vibration problems

Improvements:

- Developing the probabilities in the matrices
- Computer program with the matrices and thesis integrated