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School of Engineering

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Detection of harsh operating conditions on a Francis prototype based on in-situ onboard and non-intrusive measurements

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Motivation

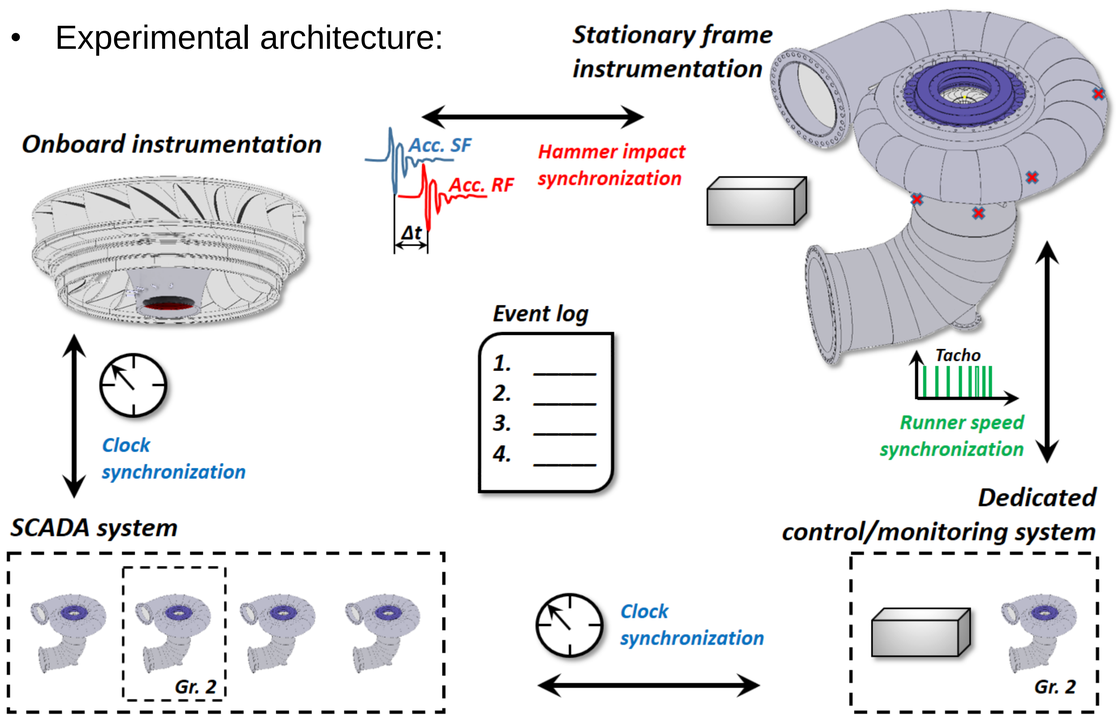
- Pumped-storage power plants: key components of a successful integration of renewable energy sources into electrical grid.
- Hydraulic turbines and pump-turbines:
  - operation in a wide range to offer power regulation flexibility;
  - subject to frequent start-up and/or stand-by operating regimes;
  - facing harsh structural loadings with impact on their lifetime.

Objectives:

- Establishment of a hydrodynamic instability level hill-chart of the machine based on several experimental monitoring parameters;
- Proposal of an alternative less-harmful start-up path and stand-by position with direct effect on the long-term maintenance costs;
- Elaboration of a diagnosis protocol to redraw hydrodynamic instability level hill-charts on different hydropower units, using only a simplified instrumentation set.

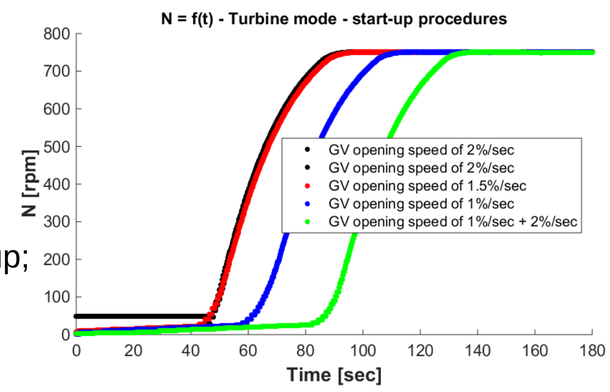
Experimental instrumentation architecture

- Case study: a 100 MW Francis turbine prototype, part of one of the four horizontal ternary groups of Grimsel 2 pumped-storage power plant.
- Experimental architecture:



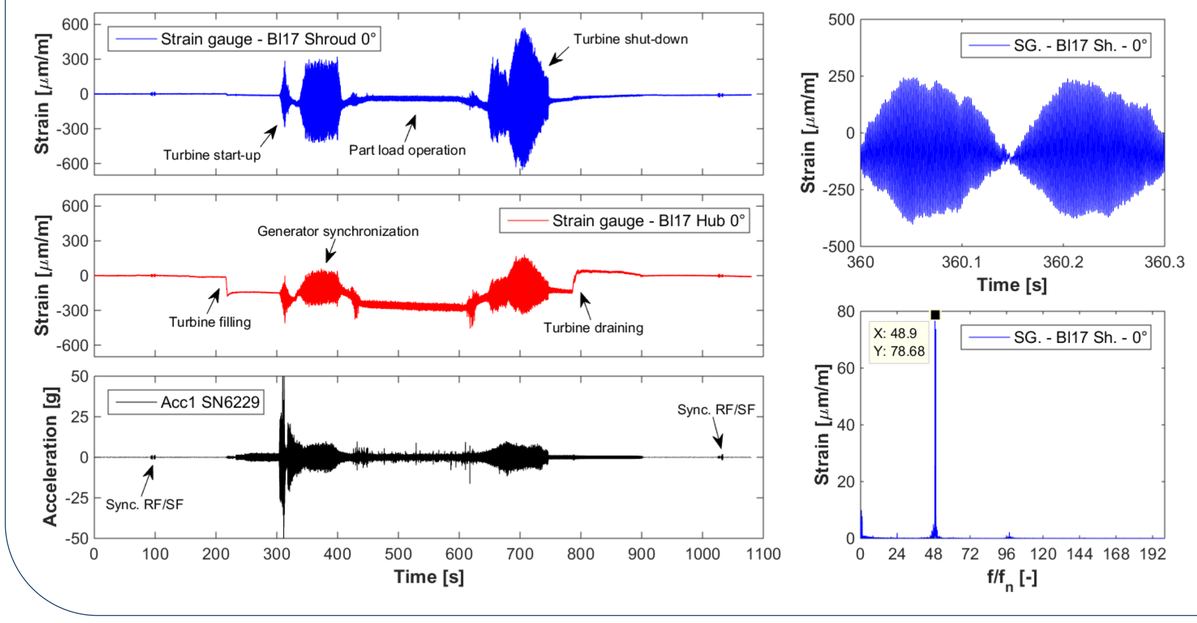
Experimental results

- Conducted tests focused on:
  - Turbine full operating range;
  - Turbine deep part-load;
  - Turbine normal start-up;
  - Modified slower turbine start-up;
  - Pump start-up.



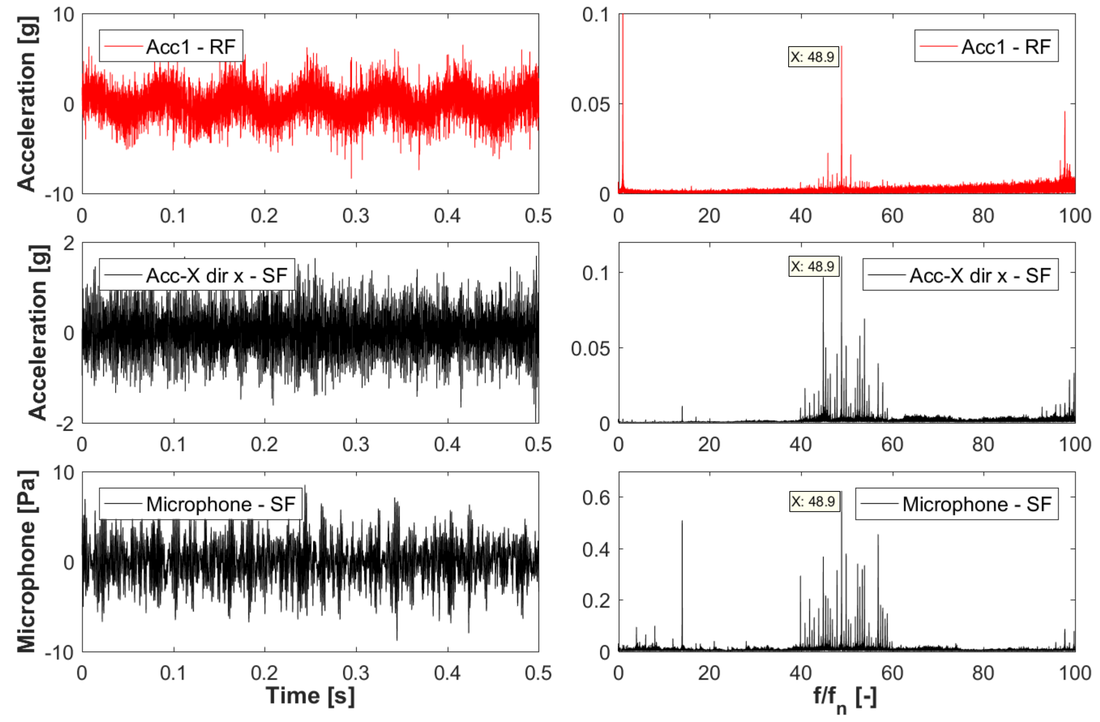
Evidence of harsh turbine start-up and shut down procedures

- Evidence of harmful structural loading of the turbine runner blades during the normal start-up and shut down procedures – signals recorded with the onboard instrumentation.



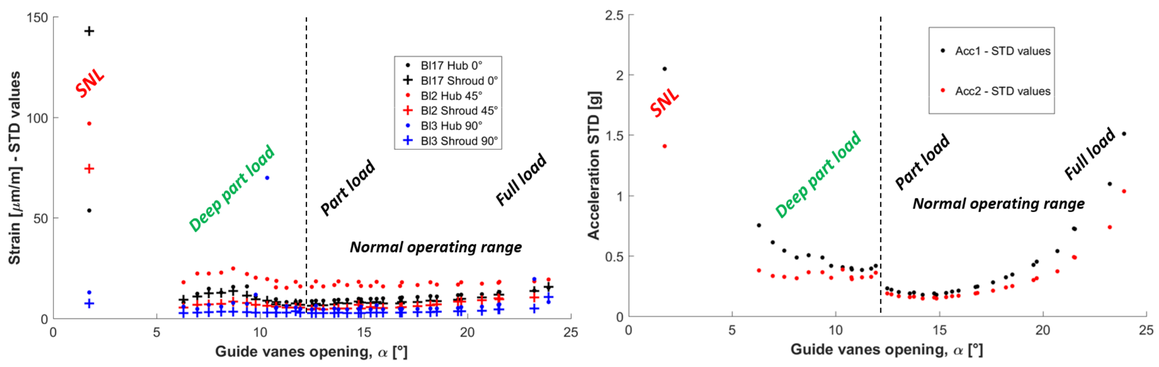
Non-intrusive instrumentation detection capabilities

- Identification of the harmful structural loading fluctuation of the runner blades at SNL condition using the non-intrusive instruments.



Strain and vibration fluctuations charts

- Fluctuations STD of the runner blades strain and the runner vibrations at SNL, deep part load, and the full normal operating range.



Conclusions & Perspectives

- Two successful experimental measurements campaigns conducted on a 100 MW high-head Francis turbine prototype;
- A 3rd experimental campaign based only on non-instrumentation successfully driven in 2018 on a different machine.

- Still seeking for a feasible simple technical solution to avoid harsh turbine runner blades loading during start-up and shut down;
- Final analysis of results ongoing;
- Diagnosis protocol based on a simplified instrumentation set to identify harsh operating conditions on a different hydropower unit ongoing.

References

[1] Hasmatuchi V., Titzschkau M., Decaix J., Avellan F., Münch-Alligné C., 2017, "Challenging onboard measurements in a 100 MW high-head Francis Turbine prototype", SCCER-SoE Annual Conf., Birmensdorf (ZH), Switzerland.
[2] Decaix J., Hasmatuchi V., Titzschkau M., Rapillard L., Manso P., Avellan F. Münch-Alligné C., 2018, "Experimental and numerical investigations of a high-head pumped-storage power plant at speed no-load", Proceedings of the 29th IAHR Symposium on Hydraulic Machinery and Systems, Kyoto, Japan, 2018
[3] Hasmatuchi V., Decaix J., Titzschkau M., Münch-Alligné C., 2018, "A challenging puzzle to extend the runner lifetime of a 100 MW Francis turbine", Hydro 2018, Gdansk, Poland.

Acknowledgements

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