University of South-Eastern Norway

Master's Thesis 2022

Application of Design of Experiments for the Verification of a Hydro Power Plant

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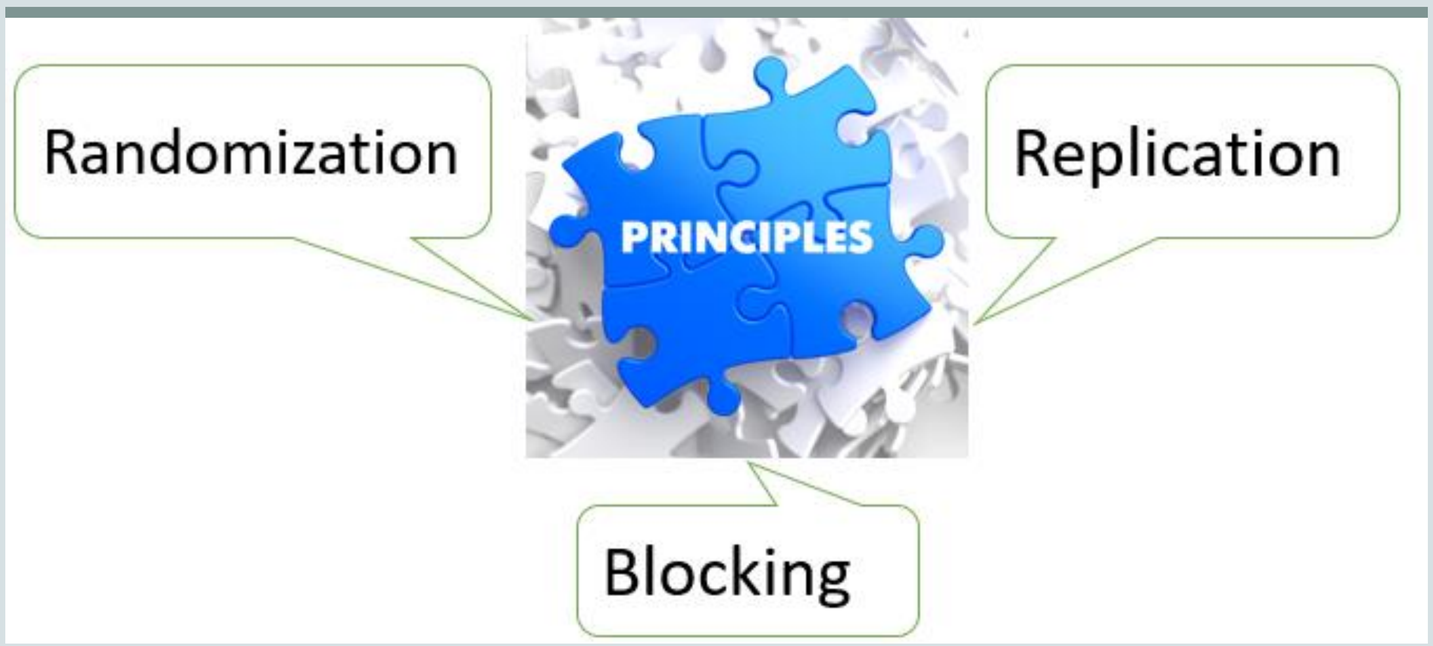
MSc. Electrical Power Engineering



Introduction

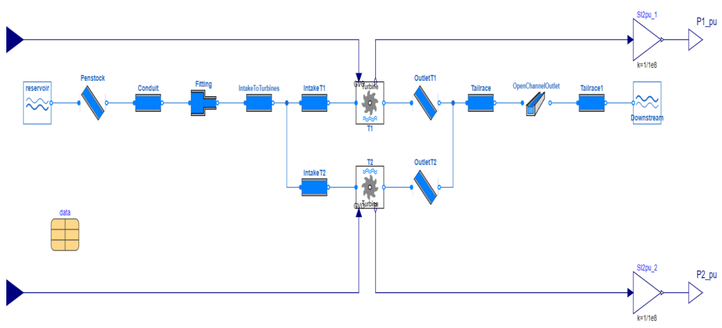
Hydropower is one of the top interest research in renewable energy towards the transition of clean and green energy, therefore, there are increasingly simulation models of hydroelectric power plant with the purpose of examining and predicting the characteristic and behavior of hydropower plant during the different operating conditions. In progress of modelling and simulating, these models need to be verified and optimized to give the high reliable simulation results.

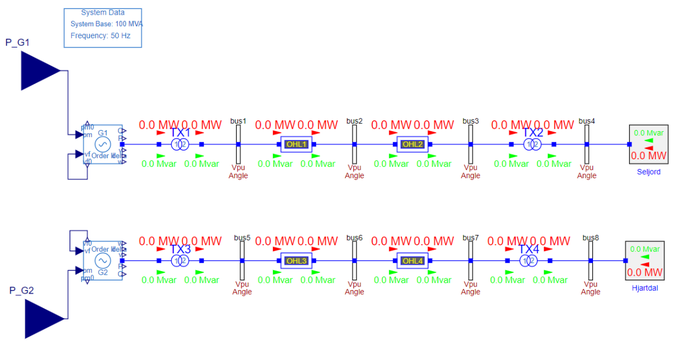
Under the vast amount of data, there are some difficulties to filter out the necessary parameters for the simulation and realize unknown source leading to difference between simulation results and reference values, therefore, it is required an organized and systematic method where "Design of Experiments" (DoE) method are applied.

Background

The main subject of DoE application in this thesis is simulation model of Grunnåi hydropower plant that has been built before (previous work) by Dymola/Modelica in combination with OpenHPL and OpenIPSL.

To obtain the high reliable simulation results, this model needs to be verified and optimized.





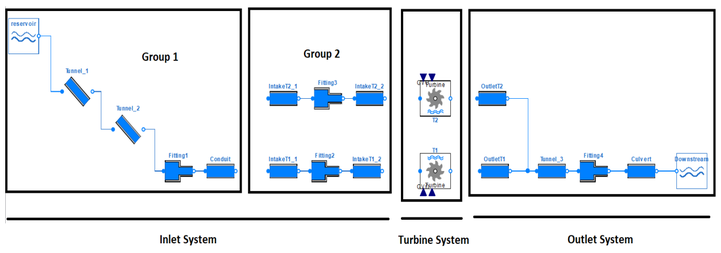
Methods

Design of Experiments (DoE) principles:

- Blocking
- Replication
- Randomization

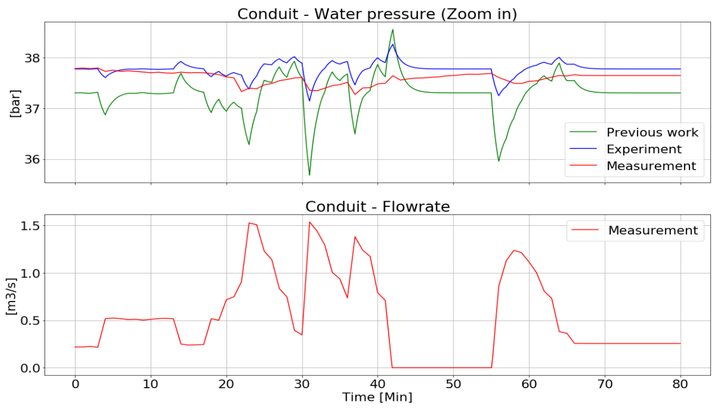
Experimental design steps:

1. Objective recognition
2. Selection of response
3. Selection of process variables
4. Evaluation criteria recognition
5. Selection of experimental design
6. Performing the experiment
7. Interpreting experimental results
8. Conclusions and recommendations

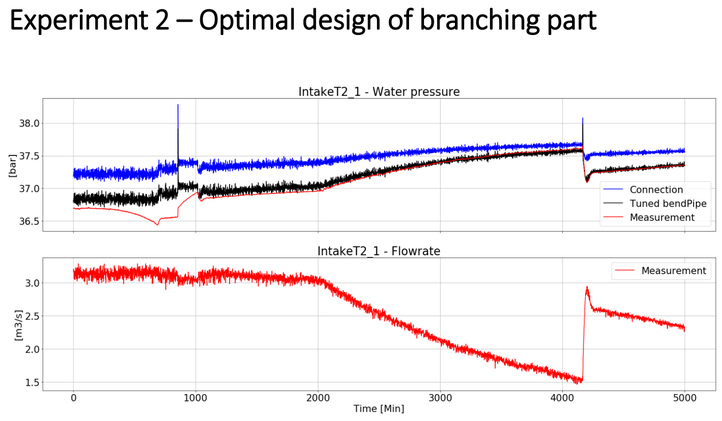


Experiment Results

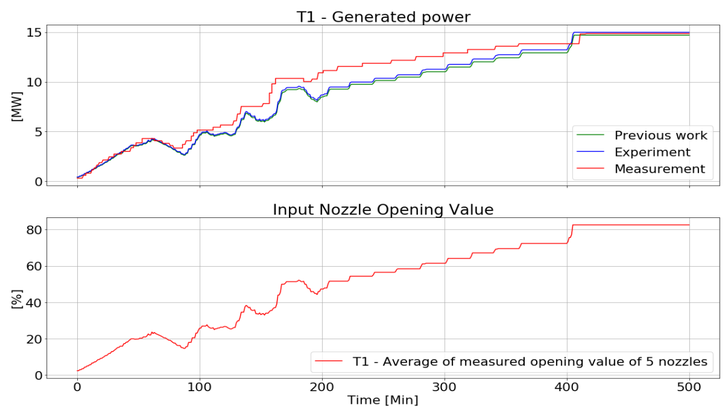
Experiment 1 – Verify elements in inlet system model



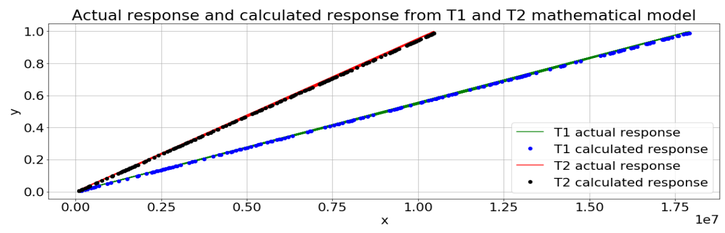
Experiment 2 – Optimal design of branching part



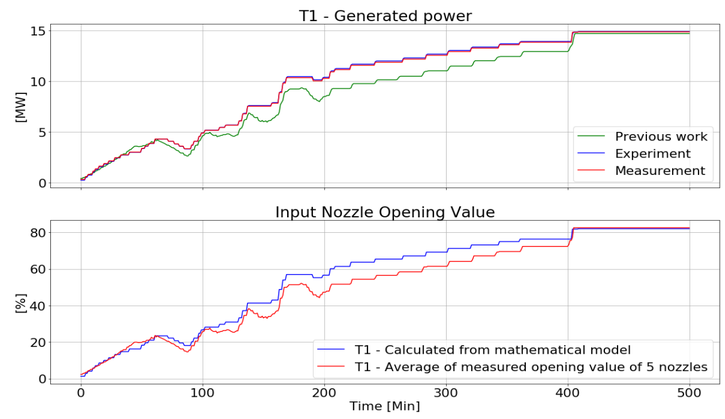
Experiment 3 – Hydraulic efficiency curves influence



Experiment 4 – Mathematical model of generated power of turbine and opening value of nozzle



Experiment 5 – Verify built mathematical model



Conclusions

1. Figure out DoE application on planning, performing sequence experiments to verify and optimize hydro power plant simulation model.
2. According to experiments, the variables which have strong or weak influences on the system were explored.
3. Contribute the simple, organized and systematic method to verify and enhance simulation model for various engineering field under vast amount of data.

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