A Method to Evaluate the Lifetime of a High Head Francis Runner

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Long Abstract

Introduction

The history of the European electricity market shows over the past twenty years a more and more changing behavior. Drivers for this changing situation are manifold. At the beginning opening and liberalization of the market caused a lot of uncertainty and an investment stop into new hardware. This change had more impact on the economical than on the technical side. One of the next important key points in the development was the implementation of the Kyoto protocol by 2005 aiming to reduce CO_2 emissions around the world. At around that time all around Europe new incentives to promote renewable energy sources like wind or solar have been established. Many countries followed the fed-in tariff system to encourage investors to build new electricity supplier by using renewable energy sources. Additionally to these increasing installations of small power production units Germany decided to shut down their nuclear power stations within the next twenty years. These activities had a big impact on the technical as well as on the economical side. Side effect of this electricity market change was paradoxically an increased investment in Hydropower as well because load dispatchers needed storage and grid control capabilities. And the consequences of these market changes are even today remarkable. Today we are dealing with faster response time at the electro-mechanical units in our Hydropower plants as well as some kind of standby operation which means that the units are running for hours at very low load conditions and far away from the design point. Some resulting effects have already been published [1] but many researchers all around Europe investigate these impacts onto the hydraulic machines and the corresponding reduction of lifetime. The following paper will explain the method to evaluate the lifetime of a High Head Francis runner.

1. Methods

Two years ago the Institute for Energy Systems and Thermodynamics at the Vienna University of Technology started a research project to investigate the impacts of these new operational demands onto the hydraulic units. Part of this research project is the development of a life time calculation method for components of a machine unit. At first the runner will be examined and afterwards all other stationary parts.

For this purpose transient Computational Fluid Dynamics (CFD) calculations have to be performed to get the pressure distribution within the flow domain. With this information we can feed the harmonic response analysis. Additionally we need the information regarding the Eigen modes and frequencies of the runner itself which will be contributed to the system by a modal analysis. Having these information together we perform the harmonic analysis to get the input parameter (dynamic load) for the subsequent life time calculation.

One additional task of this research project is the usage of OpenSource software. For the transient CFD calculations the OpenFOAM 2.3 package on a homologous prototype model is used. Beside this package we use some commercial code to get another valid input to the system.

Modal analysis and harmonic response calculation are done by a Finite Element (FE) solver called Code Aster which is a OpenSource software developed by EDF the French power utility.

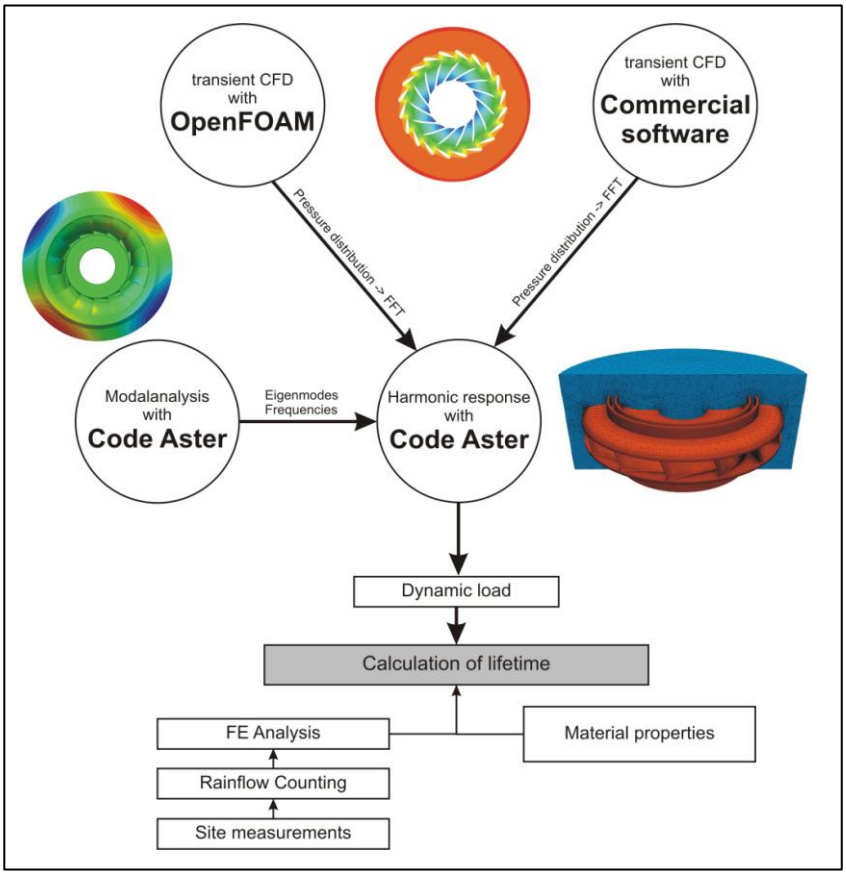

Figure 1. Method of component life time investigation

Finally we get the dynamic loads and can step forward to the life time calculation. The whole method is validated and compared by site measurements which have already been made. For this purpose a common pumped storage power plants was selected to appear as the test facility. Stresses at the runner itself have been measured by using applied strain gauges. The complete data set includes operational parameters as well so that it gives a good basis for all steps needed at the computational side of this project. Figure 1 gives a graphical overview about the method and needed steps to perform such kind of investigation.

Basic idea of this research project is the predictability of component life time without performing these extensive site measurements. Also questions of transferability of the results to other specific speed runners will be part of this research work.

Within the full paper we would like to give more information about the computational method itself - as briefly described above - and of course the underlying models and boundaries. By dealing with OpenSource software one challenging task is always the interface between each single program. Far too often the main tasks are overlaid by solving the problems of data exchange. After a induction phase we overcome these problems and run now mentioned OpenSource softeware in that way that we are able to perform the needed results. Also aspects of this tool development will be discussed at the full paper.

References

[1] E. Doujak. Effects of Increased Solar and Wind Energy on Hydro Plant Operation. *Hydro Review Worldwide*, 22:28–31, 2014.