Localization of cavitation areas using beamforming with acoustic emission sensors on a cavitation channel

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Abstract. Cavitation typically occurs in hydraulic turbines operating in off design conditions. Since direct investigation on prototype machines is very difficult, one approach is to measure the bubble collapse noise to localise the cavitation zone. To significantly reduce the complexity of the problem, this paper presents the results of a basic experiment on localizing cavitation using beamforming in a cavitation channel. Therefore, an array of acoustic emission sensors is installed on the top of a face-milled steel cover of a cavitation channel. The acoustic emission of a cavitating hydrofoil is captured by the acoustic emission sensors. Beamforming algorithms are used to determine the position of the cavitation by evaluating acoustic sensor signals. In addition, optical accessibility is ensured by an acrylic glass window. This allows the visual inspection of the cavitation positions determined via beamforming. The results of the investigation show that the method can be used to identify the location of the area with bubble collapse in the cavitation channel.

1. Motivation and Introduction

Cavitation typically occurs in hydraulic turbines operating in off design conditions. In addition to generating noise and vibration, cavitation can lead to material removal, thus limiting the operating range of the machine. To detect cavitation in hydraulic turbines, visual observation is usually performed during model measurements. The results of the model investigation are transferred to the prototype and thus, the operating range of the hydraulic turbine is determined. The direct investigation on prototype machines is very difficult because optical access and the necessary illumination are often impossible. To be able to locate cavitation areas other methods are necessary. As an alternative, acoustic signals are used to localize cavitation areas. Here, the noise generated by the bubble collapse is taken to localize the acoustic source.

The signals in the ultrasonic range are particularly suitable for analyzing cavitation noise separately from other machine noises. Schmidt et. al [1], for example, have shown that significant changes in the acoustic signal are observed in the ultrasonic range during cavitation. This signal is captured with an array of acoustic emission sensors. Using a number of sensors arranged in an array, the location of emitting sources can be calculated by a beamforming algorithm and displayed in so-called source maps using color-coded level values. The principle of beamforming is based on time differences between the sensor signals of the array for each measurement point of the noise source.