

# CFD for added mass and damping effects on a model Kaplan turbine

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**Abstract.** This paper evaluates the use of CFD to compute added mass and moment of inertia, in addition to added damping, on a model scale Kaplan turbine for different types of oscillatory motions and openings of runner blade angles at still surrounding water. The motions investigated are radial and axial translation, as well as radial and axial rotation. Different oscillatory frequencies (or maximum accelerations) are considered. The added mass and moments of inertia obtained are compared against structural acoustic simulations (SAS) results for the same geometry [Gustavsson et al, 2022]. Both CFD and SAS results show good agreement and similar trend for varied runner opening angles in both open water and with waterways. Added mass (or moment of inertia) as well as added damping parameters from CFD are included in a rotor dynamic analysis. A comparison is made by including added damping and only considering added mass (or moment of inertia) in the analysis. It is shown that the addition of added damping does not influence the extent of natural frequencies, but gives more stability to the system. Given that SAS is computationally faster and cheaper than CFD and since added damping has little effect on varying eigenfrequencies, SAS method can therefore be considered a more precise alternative than traditional methods when it comes to design purposes and the calculation of added mass and moment of inertia.

## 1. Introduction

Traditional methods that are currently used to predict added mass and moment of inertia for turbine runners are based on rule-of-thumb guidelines that do not take into account the runner geometry nor the enclosing waterways. Jasper (1956) first investigated the effect on the natural frequencies of a ship propeller shaft due to the surrounding water. The author suggested an increase of 10% extra mass over dry mass, 25% extra moment of inertia and a surplus of 50% over the diametrical moment of inertia. Later, Benkö and Holmén (1966) recommended an increase of virtual mass of 25% and 50 % extra moment of inertia for a water submerged hydropower turbine. Lately, Hofstad (2014) proposed to consider the mass to increase by 25%, whereas maintaining the moment of inertia unchanged.

Today's operation range outside the designated best efficiency point increases the vibration level and risk of resonance of the turbine's shaft train [Gustavsson et. al., 2019]. The natural frequencies of a hydropower unit are affected by the extra mass and moment of inertia present as a result of the acceleration imposed on the fluid by the vibrating body.

As an alternative to traditional methods, structural acoustic simulation (SAS) has been used to predict added mass and moment of inertia of hydro turbine runners at varying blade angle openings [Gustavsson et. al., 2022]. The current study is an effort to validate that method against more precise CFD simulations.