The present article describes the numerical work of cavitation vortex rope and inter-blade vortices typically observed in a hydraulic turbine, which is suitable for the scope of the journal. Few articles have reported the interactions between inter-blade vortices and the vortex rope. Thus, the reviewer found the present article useful for several readers especially in the field of hydraulic engineering.

However, some of the analyses presented in the article rely on the fact which is not sufficiently validated. The reviewer recommends the authors to revise the manuscript to make their analyses more rigorous and convictive. Specifically, the following comments should be considered by the authors to improve the manuscript.

Major comment

(1) Figure 5: If the normalized efficiency is defined by \(\frac{\eta}{\eta_{BLEP}}\), then this value should be 1 at \(\frac{Q}{Q_{BLEP}}=1\), which is not for EXP_EFF. Could you please explain why this value is lower than 1 for EXP?

(2) Figure 9: The authors show the calculation result of the swirl number \(S\) as a function of \(\frac{Q}{Q_{BLEP}}\) based on the equation (5). Given that \(n_{ED}\) is constant, the analytical value of \(S\) is obviously in inverse proportion to \(\frac{Q}{Q_{BLEP}}\) as shown in the figure. The equation (5) is derived based on the assumption of uniform distribution of axial velocity and rigid body rotation of the circumferential velocity. Even though this assumption is satisfied at the upper part load condition, it becomes unrealistic when the discharge is too low such as GVA=7, as clearly mentioned in reference [22]. The authors should present not only the analytical swirl number \(S\) from equation (5), but also the actual swirl number in the performed simulations, which can be calculated according to the definition of the swirl number using simulated velocity components at a given plane (for example the plane of p3 where observed line is) to validate the relation between \(S\) and \(\frac{Q}{Q_{BLEP}}\) in Figure 9.

(3) Figure 12: If the authors show \(C_2\cos(a_2)\) in Figure 12b, then it is not the radial velocity but the circumferential velocity. If this is the circumferential velocity, it would make sense that the high circumferential velocity is observed at GVA = 12.5 where the vortex rope is most significantly developed. However, the velocity distribution at GVA=7 conflicts with the velocity triangle shown in Figure 7, since it seems to rotate in the opposite direction as the runner rotation.

(4) The authors provide the value of normalized power and efficiency near the best efficiency discharge for the validations of performed simulations. However, the validation of the performed numerical simulations is not sufficient since the authors mainly focus on the vortex phenomena in off-design operations far from the nominal condition. Could you please provide more information from the experiments to validate these simulation results? For example, how close
the vortex precession frequency in the simulation with respect to the experiment? The authors impose the total pressure in the calculation domain inlet, then how close the simulated discharge value at a given guide vane opening with respect to the measurements? 

(5) Line312: ‘although the swirl intensity gradually increased as the flow rate decreased at the runner outlet’

This comment is related to the one above. This is validated only based on the “assumed” swirl number given in eq.(5). The authors should provide the actual swirl number that can be calculated by the velocity distribution in the simulated domain, to confirm the relation of the swirl number.

(6) Line310: ‘With the GVA of 7°, the flow stagnation regions developed similarly in the runner passages, with complicated flow; however, the flow at the runner outlet was relatively uniform, without the flow stagnation regions.’

This fact is hardly confirmed in Figure 15. The authors should provide an additional figure to indicate the velocity is uniformly distributed at GVA=7. According to Figure 13, the flow velocity appears to be pretty much stagnated near the runner outlet at GVA=7, since the normalized meridional velocity is close to zero.

(7) Line313: ‘when an inter-blade vortex developed in the middle of the runner passage, within the specific range of low flow rates, the internal flow in the runner passage affected the flow at the runner outlet and draft tube inlet, resulting in the development of the vortex rope.’

This fact is not evidently confirmed in the present study. The authors imply that the development of inter-blade vortices modifies the velocity distribution inside the runner, which leads to the vortex rope development as a consequence. To validate this description, the authors should present how the velocity distribution is modified by the presence of inter-blade vortices, and how this velocity modification links with the vortex rope development in the draft tube. Some of the authors have indicated that the key for vortex rope development is the velocity distribution at the inlet of diffuser, and the vortex rope structure is present even without the runner; for example:

Study on Flow instability and countermeasure in a Draft tube with Swirling flow (2015), Nakashima, T., Matsuzaka, R., Miyagawa, K., Yonezawa, K., Tsujimoto, Y.

(8) Figure14: At GVA11, the vortex rope structure is reduced, but it appears to have twin vortex structure. In the lower part load condition, these multiple vortex rope structures may be observed. Although the authors concluded that the vortex rope disappears “visibly” in Figure 10 based on iso-surface of pressure, there may still remain some vortical structures at GVA=7 leading to pressure fluctuations (for example, the peak of 3.2fn in Figure 18 could be the peak related to the multiple vortex rope precession, not the one from inter-blade vortices). At GVA = 11 and 8, are there no frequency peaks in FFT result related to vortex rope structures? The
relevant description in these conditions would be helpful to support the fact that the vortex rope is disappeared at GVA=7.

**Minor comment**

1. Line 123: ‘Water and vapor at 25 C were considered as the working fluids in a two-phase flow …’. What kind of the mixture model is used for this two-phase calculation? Is it a homogeneous model?
2. Line 134: ‘A numerical grid dependency test was conducted …’ The test for grid convergence is conducted at QBEP? How the authors change the number of total nodes? Change the mesh density homogeneously? The value of yplus is modified, too? Please explain it in the text.
3. Line 145: ‘The resolution during the unsteady-state analysis was 3° per time step’ This resolution 3 degree is based on what value? Is it based on runner revolution or vortex rope rotation?
4. Figure 6: The authors indicate the iso-surface of the normalized velocity, but which value this iso-surface indicates? Is this the region where velocity is zero?
5. The definition of the normalized velocity is not clear. Although the authors indicate normalized velocity = V/Vmax, which Vmax does this indicate? Is it the maximum velocity in the entire domain? For instance, there is no high normalized velocity region (or region close to V/Vmax = 1) in Figure 13 (same in Figure 6 and Figure 11). If Vmax indicates the maximum velocity at the selected plane shown in the figure, the region of V/Vmax=1 should exist in the figure.

4. Figure 13: It is not obvious to see where the inter-blade locations are in the figure. The authors could present for example the tangential streamlines on the plane to help the readers see the vortex locations on the plane.
5. Figure 14: What pressure value of the iso-surface does this figure indicate? Does it correspond to the vapor pressure? Since the authors conducted two-phase simulations including cavitation, it would be interesting to see how the cavitation in performed simulations is developed according to the vortex rope in different discharge.

6. Even though the velocity triangle at the runner inlet is slightly affected by the change of discharge, the major factor to change the velocity triangle is the head (or value of nED). The inter-blade vortex development is largely affected by the inlet velocity triangle, and thus the turbine head generally has a large impact on its developing location and intensity. These are specifically investigated in the recent article:

The reviewer suggests that the authors should provide the value of beta at each operating condition to indicate the influence of the discharge value on the flow incident angle at the turbine inlet.

**General comment**

The reviewer would like to ask the authors to thoroughly read the manuscript again to polish English sentences for some grammatical aspects. In addition, the reviewer requests the authors to carefully revise references to include more relevant references. For example, the following articles describe fundamental characteristics of vortex ropes with respect to different flow regimes as well as inter-blade vortex development, which must give a better insight for flow distributions and vortex development in hydraulic turbines described in the present article:

- Operating Problems of Pump Stations and Power Plants (1982) by Doerfler, P.
- LDV survey of cavitation and resonance effect on the precessing vortex rope dynamics in the draft tube of Francis turbines (2016) by Favrel, A., Muller, A., Landry, C., Yamamoto, K., and Avellan, F.
- Comparison of model measured runner blade pressure fluctuations with unsteady flow analysis predictions (2016) by Magnoli, M. V.