Effect of Cavitator Geometry on the Ventilation Demand to Form and Sustain a Ventilated Supercavity

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Abstract

The present work reports some interesting behaviors regarding the formation and collapse of a ventilated supercavity while varying the cavitator geometries, including triangle, disk, and cone. Three cavitators with the same frontal area are fabricated with 3D printing in the experiments and mounted on a forward facing model. The ventilation requirements to generate ($C_{Qf}$) and sustain ($C_{Qc}$) a ventilated supercavity are tested over a wide range of Froude number ($Fr$) for each cavitator. Snapshots of cavity morphology under different experimental conditions are captured simultaneously. It is found that the ventilation hysteresis, i.e., the $C_{Qf}$ is substantially higher than $C_{Qc}$ at the same $Fr$, occurs for all three cavitators as reported by previous studies. Compared to the triangle and disk cavitators, the cone shaped cavitator requires the least amount of air to generate a supercavity in nearly all of the tested flow regime except very high $Fr$. It is suggested that the reduction of $C_{Qf}$ with the cone cavitator is due to a more stable flow separation favoring the bubble coalescence process which drives the formation of the cavity. The $C_{Qc}$ of disk cavitator does not display the similar decreasing then constant trend as the free-standing supercavity reported previously due to the presence of the ventilation pipe inside the cavity. The stable flow separation associated with cone cavitator also leads to a lower $C_{Qc}$ compared to the triangle and disk cavitators. Additionally, the $C_{Qc}$ is nearly independent of $Fr$ for the cone cavitator. A comparison of the cavity dimension shows that for all three cavitators, the maximum diameter is nearly independent with $Fr$ and half-length increases with increasing $Fr$. The cone-generated cavity yields a significantly smaller maximum diameter and a shorter half-length as a result of the lower differential pressure across the wake comparing to the other two cases. Our study sheds some light on the effect of cavitator shapes on designing ventilation strategy for a supercavitating vehicle in practice.

Keywords: Supercavitation, ventilation, cavity formation, cavity sustenance, cavitator shape

1. Introduction

Ventilated supercavitation, i.e. a special case of cavitation in which the cavitating object can be enclosed in a gas bubble generated by injecting gas behind the cavitator, has gained substantial attention for its potential capabilities in high speed underwater applications [1]. Traditionally, such
phenomenon can be characterized by using non-dimensionalized parameters such as ventilated cavitation number, $\sigma_c = 2(P_\infty - P_c)/(\rho_W U^2)$, Froude number, $Fr = U/\sqrt{g d_c}$, and air entrainment coefficient, $C_Q = Q/(U d_c^2)$, where $P_\infty$ and $P_c$ refer to the test-section pressure upstream of the cavitator and the cavity pressure, while $\rho_W$, $U$ and $g$ correspond to liquid density, the free stream velocity in the test-section and gravitational acceleration, respectively. In the definition of Froude number and air entrainment coefficient, $d_c$ denotes the cavitator diameter and $Q$ is the volumetric air flow rate (note that in our study we use the volumetric air flow rate under standard condition, i.e., $Q_{AS}$, to define air entrainment coefficient $C_{Qs}$).

The cavitating object in ventilated supercavitation study is usually referred to as a cavitator. Traditional investigations on the optimal designing of the cavitator have focused on the effects of the cavitator shapes on the drag reduction capability and morphology of the cavities. Specifically, Semenenko [2] described the semi-empirical correlations of the drag coefficient of different cavitator shapes. As for the cavity morphologies, Ahn et al. predicted the supercavity dimensions (i.e., length and diameter) for wedge cavitators and cone cavitators under different ventilation rates and flow velocities using numerical simulation [3]. The simulation results were also validated through the experiments under the same flow conditions [4]. This study employed disk, cone and wedge cavitators with different draft angles to investigate their influence on supercavity surface profiles and cavitation numbers [4]. They found that the disk cavitator could generate longer and thicker cavities comparing to cone and wedge shapes with the same frontal area as the disk one. However, this investigation did not have a systematic control of the ventilation rate in their experiments and did not report the cavity morphology changes upon varying ventilation rates. A recent investigation by Moghimi et al. [5] investigated cavitation number, dimension and overall drug reduction of the cavity generated by disk, cone and parabolic cavitators. This study showed that the parabolic cavitator can generate optimal cavities based on the drag reduction efficiency. However, no systematic analysis of the ventilation demand on the ventilated supercavities was reported in this work. A torpedo shaped model was employed by Chung and Cho to investigate the influence of strut inside the cavity on its characteristics including dimension, cavitation number and closure types [6]. The ventilated supercavity is generated by the model with no cavitator, 15 mm-in-diameter cavitator and 30 mm cavitator under different depths of submerge. Nevertheless, this investigation only used disk cavitator and did not undertake a systematic analysis of the influence of the ventilation rate on the cavity behaviors.

The operation of a ventilated supercavitating vehicle depends on its ability to supply sufficient gas to fill the cavity at different flow conditions, e.g., steady and unsteady, and at different stages of vehicle motion, i.e., formation and sustenance [7]. The determination of gas storage of a ventilated supercavitating vehicle requires the knowledge of gas supply rate at the different flow conditions. However, such investigations have not been conducted under different cavitator geometries yet. Recently, a number of prior studies have investigated the gas entrainment behaviors of ventilated supercavity under a wide range of flow conditions for disk cavitators [7-11]. Based on the experimental results, Kawakami and Arndt [8] reported ventilated hysteresis which refers to a phenomenon that the ventilation demand to sustain a cavity is substantially lower than the requirement to form a cavity. Therefore, a design strategy diligently considering ventilation hysteresis can substantially decrease the air storage of a ventilated cavitating vehicles. Karn et al. [7] conducted a measurement of ventilation demand of a free-standing ventilated supercavity (using varying sizes of disk cavitators) generated by a backward facing model over a wide range of flow condition. The results demonstrated that the ventilation demand for cavity formation is much greater than its sustenance demand. Specially, the formation ventilation demand
($C_{Qf}$) displays increasing then decreasing trend over increasing range of $Fr$. They suggested that such results are correlated with the coalescence efficiency of the small bubbles to a supercavity during its formation. On the other hand, the sustenance ventilation demand ($C_{Qc}$) exhibits monotonic decreasing trend with the increasing $Fr$ which is closely related to the variation pressure difference across the cavity near its closure region [9]. A follow up study [10] reported the effects of the presence of a body inside the cavity on the ventilated demands through a comparison of the cavity generated by a backward-facing model and one generated by a forward-facing model with a ventilated pipe inside the cavity body. They suggested an increase of ventilation demand for both formation and sustenance of a cavity primarily due to the disruption of the body inside the cavity to the bubble coalescence efficiency and pressure distribution at the closure region of the cavity. The bubble coalescence hypothesis of the cavity formation mechanisms has been further verified by a comparison of the cavity formation ventilation demand from different facilities with the similar forward-facing model from Shao et al. [11]. They attributed the discrepancies in the $C_{Qf}$ from different facilities under same range of flow speed to the influences of the mismatched Reynolds number on the bubble coalescence.

Therefore, in the present paper, we report a systematic experimental investigation of the ventilation demands to generate and sustain a supercavity under different shapes of cavitators over a wide range of the flow conditions. The paper is structured as follows: Section 2 describes the methodology including the flow facility, prototypes of the cavitators, the experiment setup and the corresponding measurements. Section 3 presents the experimental results and the corresponding analysis, which is followed by a conclusion and discussion in Section 4.

2. Experimental Setup and Methodology

![Figure 1: Saint Anthony Falls Laboratory (SAFL) cavitation water tunnel used for the current experiments. This schematic is adapted from [11].]
Experiments are conducted to capture the formation and sustenance of a ventilated supercavity generated by different cavitators of varying shapes over a wide range of $Fr$. The experiments use the cavitation water tunnel in Saint Anthony Falls Laboratory (SAFL) (Fig. 1). The water tunnel has a test section of 1200 mm $\times$ 190 mm $\times$ 190 mm, and is capable of operating at flow speeds up to 20 m/s with a turbulence level at around 0.3 %. A large dome-shaped settling chamber upstream of the test section can remove extra gas bubbles ensuring a desired operation condition for cavitation and ventilation experiments. This facility has been used for a number of supercavitation [7-11] and hydrofoil aeration experiments [12] in the recent years.

Three cavitators including triangle, cone and disk shapes are fabricated with a Lulzbot Taz 6 3D printer (Fig. 2). The polylactic acid (PLA) filament was chosen as the cavitator fabricant because of its water corrosion and leakage resistance and high resolution in layer height of 0.25 mm. Additionally, the cone cavitator has a draft angle $\theta = 31^\circ$. The projection of the frontal area of all the cavitators is the same as a circle with 30.0 mm-diameter. The cavitators are then mounted on a forward facing model or FFM for brevity (Fig. 3). As shown in Fig. 3, for the FFM, the cavitator is mounted with the frontal surface facing the flow [8, 11]. Note that in the current investigation, the cavitator size ($d_c$) is 30.0 mm for the calculations of $Fr$, $C_Q$, and the corresponding cavity geometric parameters.

During the experiments, the ventilation demand for the formation ($C_{Qf}$) and sustenance ($C_{Qc}$) of a ventilated supercavity are measured for all three cavitators covering a large range of $Fr$ from 5.6 to 18.4 (corresponding to a flow speed from 3 m/s to 10 m/s). The air flow rate is measured by an FMA-2609A mass flow controller with a unit of standard liter per minute (SLPM), which is the volumetric flow rate at the standard temperature (273.15 K or 0 ºC) and standard pressure (101.15 kPa or 1 atm). The uncertainty in the mass flow rate measurement is ±1 % with a full-scale reading up to 40 SLPM. During the experiments, two Rosemount 3051s pressure sensors are used to measure the test section pressure as well as the pressure difference across the settling chamber and
the test section, respectively. The bulk flow speed inside the test section is derived from the pressure difference measurement. The standard error of the pressure measurement is around 0.1 kPa for both sensors yielding a maximum error of 0.11 m/s in instantaneous flow velocity and a mean error around 0.02 m/s. Overall, during the experiments, the maximum uncertainty of the $C_{qs}$ and $Fr$ is around 2%. To measure the geometry of the supercavity, a Nikon D610 DLSR camera is employed to capture snapshots of the cavity with a 28-mm focal length lens. The resulting images are transferred to grayscale first then corrected by un-distortion algorithms based on the camera parameters in MATLAB™.

3. Results

![Figure 4: The cavity formation ventilation demand $C_{Qf}$ under different Froude numbers $Fr$ for the triangle, cone, and disk cavitator. For the disk, data is presented for both the forward facing (FFM) and backward facing model (BFM).](image)

Fig. 4 describes the dependence of the $C_{Qf}$ upon $Fr$ for all three cavitators. It is worth noting that for the triangle cavitator, the ventilation demand data are only plotted up to the flow speed of 6 m/s (i.e., $Fr = 11.1$) because the ventilation demand to form the cavity at higher velocity exceeds the operational range of the mass flow controller. At each $Fr$, the $C_{Qf}$ is measured multiple times to ensure statistical robustness, and the uncertainty corresponding to each $Fr$ measurement is estimated through the standard deviation of all the measured values. As shown in Fig. 4, $C_{Qf}$ initially increases then decreases with increasing $Fr$ for both disk and cone cavitators. As for the triangle cavitator, the trend of $C_{Qf}$ follows that of the disk cavitator for in the range of $Fr = 5.6 \sim 11.1$. Similar $C_{Qf} - Fr$ curves were observed in previous investigations for disk cavitator with a backward facing model as shown in Fig. 4 [7]. As suggested by Karn et al. [7], in the low Froude number regimes ($Fr = 5.0 \sim 10.0$), the increasing flow speed is detrimental to the bubble coalescence process of forming a cavity due to the stronger flow turbulence associated with increasing Reynolds number [12]. Therefore, with increasing $Fr$, a higher ventilation rate is necessary to form the supercavity. After reaching a critical $Fr$ value (i.e. the $Fr$ corresponding to the peak $C_{Qf}$), further increases of flow velocity causes an increase of small bubble density in the
flow as shown in [12]. This favors the bubble coalescence process which results in a monotonic decreasing of the $C_{Qf}$ with further increase of the $Fr$.

However, the ventilation demand required to generate a cavity for the cone shape cavitator is substantially lower than the ones of disk and triangle cavitators under the same $Fr$ (or flow speed). Additionally, the critical $Fr$ for the cone cavitator is much higher compared to disk and triangle cavitators. As suggested by Calvert [13], the slender shape of cone cavitator could induce a more stable flow separation (i.e., a less developed wake flow) under the same $Fr$ compared to disk and triangle cavitators. Therefore, under low $Fr$, bubble interaction in the wake of a cone cavitator is more locally confined which is favorable of the coalescence process and the formation of the cavity. However, due to the less developed wake of the cone cavitator (i.e., less turbulent flow under same $Fr$ compared to the other two cavitators), the later occurrence of the high concentration bubbly wake causes the right shift of the critical $Fr$. The discrepancy in $C_{Qf}$ between the cone and disk cavitator eventually diminishes with increasing $Fr$ as shown in Fig. 4. Therefore, we suggest a negligible shape effect on the cavity formation process under high $Fr$ due to the high bubble concentration at high flow speed. As for the triangle cavitator, it is apparent that the ventilation demand to generate a supercavity is higher than the disk with increasing $Fr$. The sharp corners on the triangle cavitator may lead to unstable and turbulent wake flow in high $Fr$ regime which adversely affects the formation process of the supercavity driven by the bubble coalescence.

![Figure 5: The cavity collapse ventilation demand $C_{Qc}$ under different Froude number $Fr$ for the triangle, cone, and disk cavitator. For the disk, data is presented for both the forward facing (FFM) and backward facing model (BFM).](image)

Fig. 5 shows the ventilation rate of sustaining a supercavity, suggesting a much lower $C_{Qc}$ compared to $C_{Qf}$ in the current experiments. Such ventilation hysteresis phenomena have been reported in previous studies on a disk cavitator [7, 10, 11]. However, the $C_{Qc}$ of all three cavitators does not exhibit the same trend, i.e. a monotonic decrease and then plateau, as in [7]. Particularly, the mismatches in $C_{Qc}$ values from the disk cavitators under two mounting configurations (i.e., forward facing model or FFM and backward facing model or BFM) can be clearly observed from Fig. 5. Specifically, with $Fr < 10$, the cavity generated by the BFM requires a higher $C_{Qc}$ comparing to the FFM. We attribute such discrepancies to the presence of the ventilation pipe
inside the cavity. Because a twin vortex closure of the cavity generated by the FFM has a stronger backflow (pointed by the arrows in Fig. 6a) compared to the one generated by the BFM and the

(a)

(b)

(c)

Figure 6: (a) Images of the supercavity closure characteristics generated by the backward (BFM, adapted from [9]) and forward-facing models (FFM, adapted from [8]). (b) A schematic depicting the attachment of the cavity with the ventilation pipe and the resulting re-entrant jet closure under low Fr and (c) a schematic depicting the penetration of the ventilation pipe to the cavity surface and the resulting re-entrant jet closure under high Fr. The experimental observations of cavity-strut interactions under different flow regimes are presented as respective inset figures.

The presence of the mounting strut on the forward-facing model could promote this occurrence of re-entrant jet at lower ventilation rate as observed in the experiments. As depicted in Fig. 6 (b), with the ventilation rate decreasing, the shrinking cavity reattaches onto the ventilation pipe at the closure and the external water flow follows the cavity, generating a re-entrant jet. Both numerical [14] and experimental investigations [15] of hydrofoil supercavitation have shown the similar transitions at the closure. In comparison, without the support of the ventilation pipe, a free-standing cavity formed by a backward facing model is less prone to generate such kind of stable re-entrant jet closure under low ventilation rate which increases the ventilation demand to sustain a cavity in
low $Fr$ regime [7, 9]. Nevertheless, with $Fr > 10$, the FFM cavity has a higher $C_{Qc}$ compared to the BFM cavity under the same Froude number. With high $Fr$, the smaller surface curvature and more axisymmetric shape of the cavity due to attenuated gravitational effects results in augmented cavity-strut interaction at the closure region. As shown in Fig. 6(c), the ventilation pipe penetrates the cavity surface and water flow at the closure region gushes back into the cavity which leads to a strong re-entrant jet closure and a foamy region inside the cavity. Unlike the backward facing model [9], the twin vortex closure cannot be formed with a forward-facing model due to the presence of the ventilation pipe under high $Fr$. In terms of collapse mechanisms, Karn et al. [7] suggested the collapsing of the cavity is due to the inability of the ventilation gas to counterbalance the momentum carried by the water flow. Therefore, in this flow regime, the sustenance of the cavity requires a much higher ventilation gas rate to balance the momentum of the water jet which leads to the higher $C_{Qc}$ for the cavity generated by FFM comparing to the BFM.

Figure 7: Images of ventilated supercavities behind the triangle, cone, and disk cavitators (respectively) at $Fr = 11.1$. generated with their respective $C_{Qc}$. Contour features in the triangle cavitation generated cavity are marked by the red arrows.

Figure 8: Supercavity geometric profiles extracted from Fig. 7 with normalized half-length ($L_{1/2}$) and maximum diameter ($D_{max}$) labeled in the plot.

Additionally, regarding the cavitator shapes, the cone cavitator of the FFM has an overall lower $C_{Qc}$ when compared to the other two cavitators. Moreover, for the cone cavitator, $C_{Qc}$ is weakly
dependent on $Fr$ and we attribute this independency to the relatively stable flow separation in the wake [13]. It helps the cavity maintain a relatively low-pressure difference across its cavity surface except the closure region. Accordingly, in comparison to other cavitators, the lower pressure difference between the cone cavitator wake and external flow leads to lower $C_{Qe}$. This feature of the cavity generated by the cone cavitator appears to transcend the effects of the presence ventilation pipe inside the cavity as discussed previously. In addition, we suggest that the locally confined wake of the streamlined cone cavitator could generate a much smaller cavity around the ventilation pipe which attenuates the gravitational effects and eventually results in the independence of the $C_{Qe}$ on $Fr$.

To further investigate the cavity air entrainment behavior, a comparison of the cavity geometries of the three cavitators is conducted with $Fr = 11.1$ under the sustenance ventilation rate (i.e. $C_{Qe}$). As depicted in Fig. 7, the cavity behind the cone and the disk shows a smoother surface as opposed to cavity on triangle cavitator (marked by the red arrows). These contours originate from the sharp corners of the triangle cavitator. We suggest that such asymmetric features on the cavity surface are susceptible to the external flow variations contributing to the slight overall increase in ventilation demand to sustain the cavity generated from a triangle cavitator (Fig. 5). Additionally, under the same flow conditions, the comparison of the cavity frontal outline across different cavitator shapes (Fig. 8) clearly shows a noticeable difference especially its maximum diameter ($D_{max}$) and half-length ($L_{1/2}$)—defined as the streamwise distance between the cavitator and the location of $D_{max}$. Namely, all three cavitators have similar overall cavity length ($x/d_c$), but the cone cavitator is significantly smaller in terms of maximum diameter. These dimension differences between the cone and triangle/disc cavitators contribute to the varying $C_{Qe}$ under the same $Fr$ of different cavitators as a smaller volume cavity (i.e., cone cavity) needs less ventilation to sustain itself compared to its larger cavity counterparts.

Furthermore, Fig. 9 shows the variation of non-dimensionalized $D_{max}$ and $L_{1/2}$ of the cavity under the sustained ventilation rate over $Fr$ for the three cavitators. The cavity outline is extracted using edge detection based on the grayscale images of undistorted cavities. Then, $D_{max}$ and $L_{1/2}$ are measured and normalized by the cavitator diameter (30.0 mm) based on the method provided.
by [11]. The uncertainties of these parameters for the cavities generated from disk, cone, and triangle cavitators are estimated to be around 7.1 %. $D_{\text{max}}$ is nearly independent of $Fr$ and $L_{1/2}$ increases with $Fr$ for all three shape cavitators which have been reported in the previous investigations [11, 16, 17]. Nevertheless, in Fig. 9(a), $D_{\text{max}}$ shares similar values on the triangle and disk cavitator but is much less on the cone cavitator, leading to the smallest lateral cavity dimension. Additionally, with $Fr$ increasing, the cavities generated by disk and triangle cavitators have noticeable growth of the streamwise dimension compared to the cone cavitator. As suggested by Calvert [13], a stable flow separation in the wake of the cone cavitator leads to the lower pressure difference across the wake of the cavitator with the external flow comparing to the other two cases which result in the smaller cavity based on the theoretical analysis by Logvinovich and Serebryakov [11]. According to the control volume calculation of the cavity shape in a closed-wall water tunnel [11, 18], the $D_{\text{max}}$ and $L_{1/2}$ increase with increasing drag coefficient of a cavitator under same flow speed (i.e., $Fr$). In the current investigation, the triangle cavitator has a drag coefficient around 1.98 compared to 1.11 for the disk cavitator and 0.61 for the cone case based on the empirical relations [2]. Therefore, the triangle cavitator yields a slightly larger cavity in comparison with the disk shape and the cone shape has the smallest one. Additionally, comparing Fig. 5 and Fig. 9, one could observe similar trends, i.e., the cavity generated from the cone cavitator has a much lower $C_{Qc}$ and smaller shape under the same $Fr$ compared to disk and triangle cavitators. Therefore, we suggest that the general cavity geometry is well correlated with its $C_{Qc}$. The weak independence of the $C_{Qc}$ on $Fr$, of cone cavitator, is related to the attenuated gravitational effect on cavity morphology with smaller dimensions.

4. Conclusion

We conducted an experimental investigation of the ventilation demand to form ($C_{Qf}$) and sustain ($C_{Qc}$) a ventilated supercavity using forward-facing cavitators of three different shapes, i.e. disk and triangle and cone shape of the same frontal area, over a wide range of Froude numbers ($Fr$). Our experiments have shown that similar to the disk cavitator [7, 8], ventilation hysteresis, i.e., $C_{Qf}$ is much higher than $C_{Qc}$ under the same $Fr$, is also observed with triangle and cone cavitator shapes. Similar to the previous observation [7, 10, 11], $C_{Qf}$ initially increases then decreases with increasing $Fr$ after reaching a critical $Fr$ for both disk and cone cavitators. As for the cavitator shapes, the experimental results suggest that compared to the disk and triangle cavitator, the cone shape cavitator requires less amount of air injection to generate a cavity. We attribute that the discrepancies in the $C_{Qf}$ of the cone cavitator to other 2D shaped cavitators are primarily due to a more stable flow separation in the wake of the cone cavitator which is in favor of the bubble coalescence process. As for the disk cavitator in the current experiments, the $C_{Qc} − Fr$ trend deviates from that of the backward-facing cavitator due to the strut differences. Specifically, under low $Fr$, the cavity generated with forward-facing disk cavitator reattaches onto the ventilation pipe with declining ventilation rate which results in a lower $C_{Qc}$ comparing to the case of backward-facing cavitator. However, under high $Fr$, the ventilation pipe penetrates the cavity surface and a water jet at the closure region pushes back into the cavity which leads to a strong re-entrant jet closure and eventually an increasing of $C_{Qc}$. Additionally, the more stable flow separation in the wake of cone cavitator mitigates the negative effects of higher-pressure difference across the cavity surface on its sustenance and results in a much lower $C_{Qc}$ compared to its 2D counterparts.
Moreover, the $C_{Qc}$ for cone cavitator is almost independent of $Fr$. A further comparison of the cavity dimension of three cavitators under $C_{Qc}$ shows that the cone-generated cavity yields a significantly smaller maximum diameter and a shorter half-length for the cavity generated by cone cavitator comparing to disk and triangle cases. This observation is in accordance with the theoretical calculation of the cavity dimensions considering the drag coefficients of three cavitators [11, 18]. It is connected with the lower pressure difference across the wake of the cavity and the external flow for the cone cavitator case. We also suggest that the cone-generated supercavity attenuates gravitational effects on cavity topology, which results in the independence of $C_{Qc}$ on $Fr$.

Our experimental results shed some light on the effect of cavitator shapes on designing ventilation strategy for a supercavitating vehicle in practice. Specifically, the cone shape cavitator with a lower drag coefficient not only drastically enhances the ability of drag reduction as previously reported [2, 5] but is also favorable for cavity formation and sustenance which could substantially decrease the need of gas carried by the supercavitating vehicles in the practice. Additionally, the differences in the experimental results in the current study, compared to previous investigations using the backward facing model [7], shed some light to the effects of the body inside a cavity on its internal flow distribution and formation and sustenance process. A recent investigation [19] has pointed out the importance of internal flow distribution on the cavity air entrainment mechanisms and sustenance of the cavity under different flow conditions. However, to date, no such internal flow measurements have been conducted on the cavity generated with a forward facing model or different shapes of cavitators other than a disk or a sphere. Therefore, future investigations of the cavity internal flow on the setup in the current investigation could reveal the fundamental flow physics behind the results we present here. Moreover, we suggest that an investigation of the influence of unsteady flow upon cavitators with different shapes similar to the one with the disk cavitator [20] will provide critical information for the operation of a ventilated supercavitating device in a practical environment by proper designing of ventilation strategy and cavitator geometry.

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