**Numerical investigation of cavitation and erosion in a venturi section for particle-laden flow**

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**Abstract.**

In engineering hydraulic systems cavitation can occur in the presence of particles. Due to the presence of the particles cavitation dynamics can change which causes a change in cavitation erosion. In this study the effect of particles on cavitation dynamics and subsequent cavitation erosion in a venturi test section is investigated via Computational Fluid Dynamics (CFD). For the particle-laden flow vapour volume is reduced, however earlier separation and faster collapse of cavitation clouds point to a more aggressive cavitation. By comparing cavitation erosion results from CFD simulation, it is concluded that particles used in this study increased cavitation erosion.

**Keywords:** cavitation; cavitation erosion; particles

1. Introduction

In engineering hydraulic systems, cavitation is often an undesirable phenomenon as it can cause erosion of the surface exposed to cavitation. Sometimes the flow also contains particles which can influence the development of cavitation and subsequent cavitation erosion. Research is mostly focused on an interaction between particles and cavitation bubbles at a smaller scale [1, 2], where it has been observed that particles can either reduce or increase cavitation erosion, depending on the particle size [2].

 In this study a comparison is made between cavitating flow without and with particles to identify potential difference in cavitation erosion on a surface of venturi test section.

1. Methods

For the numerical simulation of a two-phase flow consisting of liquid water and water vapour, a homogeneous mixture approach is adopted within commercial CFD software ANSYS Fluent 2021 R2 [3]. Cavitation is modelled with Schnerr-Sauer cavitation model [4]. Spherical glass particles with diameter of 55 μm are considered as point particles and are tracked in Lagrangian frame within a Discrete Phase Model (DPM) methodology [3]. Two-way coupling between particles and continuous phase is considered due to drag, force of gravity and buoyancy acting on the particle. Assessment of cavitation erosion is achieved with a cavitation erosion model by Schenke et al [5].

 Venturi channel with a rectangular cross-section of 10 $×$ 150 mm is considered, with a venturi throat corss-section of 10 $×$ 10 mm. On the inlet of the domain, mass flow rate of 1.603 kg/s is prescribed and on the outlet static pressure of 1 bar is prescribed. At the inlet particles are injected into domain at a rate that 5 % volume fraction of particles is achieved. All walls of the channel are modelled as no-slip walls. For the particles, wall rebound model by Grant and Tabakoff is used [6].

1. Results

Evolution of vapour volume over time for cavitating flow without particles and for cavitating flow with particles is presented in figure 1. Two full shedding cycles are shown. During the first cycle particles are not yet fully present in the venturi section, which is why vapour volume is similar in both cases. For the second cavitation shedding cycle, total vapour volume is lower when particles are present in the flow.



Figure 1 Vapour volume over time for flow without and with particles.

|  |  |
| --- | --- |
| (a)1 | (b)1 |
| (c)2 | (d)2 |
| (e)3 | (f)3 |
| (g)4 | (h)4 |
| (i)5 | (j)5 |

Figure 2 Comparison of cavitation shedding cycles for (a), (c), (e), (g) and (i) flow without and for (b), (d), (g), (h) and (j) flow with particles. Cavitation is represented as a blue iso-surface of 20% of vapour volume fraction. Particles are represented as black points. Flow is from left to right.

A more detailed presentation at five moments in time is given in figure 2, where cavitation structures are drawn as iso-surfaces of 20% vapour volume fraction. Vapour structures are smaller when particles are present in the flow. Due to particles, pressure is locally increased in the area of cavitation, inhibiting the process of evaporation. Since particles are transported upstream under the cavity via the re-entrant jet, separation occurs earlier in time and at a point further upstream when compared to the cavitating flow without particles.

 Towards the end of the shedding cycle, cavitation cloud is observed to collapse faster in the case of particle-laden flow. Faster collapse can be considered as an indicator of a more aggressive cavitating flow. A consequence of that is a more pronounced zone of cavitation erosion in the middle of the bottom venturi wall as shown in figure 3.

|  |  |
| --- | --- |
| (a) | (b) |
| [J/m2] |

Figure 3 Comparison of cavitation erosion in the case of (a) flow without particles and (b) flow with particles. Cavitation erosion is represented by contours of accumulated specific energy on the surface of the venturi. Flow is from left to right.

1. Conclusion

Cavitating flows without and with particles were numerically simulated. From a comparison of cavitation development in both cases, it was evident that particles used in this study caused a reduction of vapour volume. Overall cavitation dynamics was similar in both cases, however in the case of flow with particles separation of the cavitation cloud occurred earlier and the following collapse was faster. This was reflected in a change of cavitation erosion pattern, where more specific energy released by collapsing cavitation clouds was accumulated in the middle of the venturi surface when particles were present in the flow. From this it can be concluded that the particles used in this study caused an increase in cavitation erosion.

1. References

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**Acknowledgments**

The authors wish to thank the Slovenian Research Agency (ARRS) for the financial support in the framework of the Research Programme P2-0196 Research in Power, Process and Environmental Engineering.