Research on Resonance Mechanism and Collaborative Optimization of Double-cavity Self-Excited Oscillating Pulse Cavitation Jet Nozzle

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Abstract

The peak value and pulsation amplitude of the self-excited oscillating pulse cavitation jet nozzle are important indexes to evaluate the jet performance. It is of great significance in theory and engineering practice to predict the peak value of the self-excited oscillating pulse cavitation jet nozzle accurately. In order to investigate the evolution mechanism of the inner and outer flow field of a double-cavity self-excited oscillation pulse cavitation jet nozzle, a simulation model of the jet impact test of the nozzle was established. Before entrance rounded corners, former cavity cavity diameter, cavity cavity length, before the cavity under the nozzle diameter, cavity, the cavity cavity after entry the rounded, lumen diameter, cavity length and cavity after cavity under the nozzle diameter as design variables, and strike force to combat force peak pulse amplitude as the target variable, the orthogonal experiment method, back propagation neural network combined with non dominated sorting genetic algorithm, The collaborative optimization design method of self-excited oscillating pulse cavitation jet nozzle was determined. Based on the collaborative optimization results, the 3D printing technology was used to manufacture the visualization test model of the flow field of the self-excited oscillating pulse cavitation jet nozzle, and the experimental verification was carried out. The results show that when the inlet pressure is 2MPa, the main and secondary order of the influences of various factors on the jet performance of the nozzle is the nozzle diameter under the front cavity, the diameter of the back cavity, the diameter of the front cavity, the length of the front cavity, the nozzle diameter under the back cavity, the cavity distance, the fillet of the back cavity, the fillet of the front cavity and the length of the back cavity. Compared with the optimal result of orthogonal test, the amplitude of impact pulsation and the peak value of impact force are increased by 14.61% and 2.42% respectively. The optimal structure of the nozzle determined by collaborative optimization can produce obvious pulse cavitation jet, and the cavitation region of the nozzle cavity contracts periodically with time. The higher the inlet pressure, the higher the cavitation intensity and the higher the content of hollow bubble. This study can promote the development of jet performance calculation of self-excited oscillation pulse cavitation jet nozzles, and provide support for the design of self-excited oscillation pulse cavitation jet nozzles.

Full-text

Due to technical limitations, full-text HTML conversion of this manuscript could not be completed. However, the manuscript can be downloaded and accessed as a PDF.

Figures

Figure 1

Nozzle geometry model

Figure 2

Nozzle simulation calculation domain model

Figure 3

The overall and local mesh models of nozzle field were calculated: (a) The nozzle as a whole; (b) Cavity position; (c) Exit position

Figure 4

Test 2. Hit force curve of target surface

Figure 5

Test 7. Hit force curve of target surface

Figure 6

Experiment 2 Evolution process of cavitation vortex: (a) $t=0.0027s$; (b) $t=0.003s$; (c) $t=0.004s$; (d) $t=0.005s$; (e) $t=0.120s$; (f) $t=0.124s$; (g) $t=0.128s$; (h) $t=0.130s$

Figure 7

Experiment 7 Evolution process of cavitation vortex: (a) $t=0.002s$; (b) $t=0.003s$; (c) $t=0.01s$; (d) $t=0.011s$; (e) $t=0.151s$; (f) $t=0.154s$; (g) $t=0.156s$; (h) $t=0.160s$

Figure 8

Experiment 2 Cloud map of axial velocity distribution of flow field at different moments: (a) $t=0.120s$; (b) $t=0.124s$; (c) $t=0.128s$

Figure 9

Experiment 7 Cloud map of axial velocity distribution of flow field at different moments: (a) $t=0.151s$; (b) $t=0.154s$; (c) $t=0.156s$

Figure 10

Experiment 2 Radial velocity distribution cloud image of flow field at different moments: (a) $t=0.120s$; (b) $t=0.124s$; (c) $t=0.128s$

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Experiment 7 Radial velocity distribution cloud map of flow field at different moments: (a) $t=0.151s$; (b) $t=0.154s$; (c) $t=0.156s$

Figure 12

Experiment 2 Cloud map of turbulent kinetic energy distribution in the flow field at different moments: (a) $t=0.120\text{s}$; (b) $t=0.124\text{s}$; (c) $t=0.128\text{s}$

Figure 13

Experiment 7 Cloud map of turbulent kinetic energy distribution in the flow field at different moments: (a) $t=0.151\text{s}$; (b) $t=0.154\text{s}$; (c) $t=0.156\text{s}$

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Test results of BP neural network in collaborative optimization

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(a)

(b)

(c)

Figure 19

Evolution process of flow field of n ozzle at 0.5MPa : (a) Cavitation development stage ; b) Cavitation aggregation stage c) Cavitation collapse stage

Figure 20

Evolution process of flow field of nozzle at 3 MPa : (a) Cavitation development stage ; b) Cavitation aggregation stage c) Cavitation collapse stage

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