Computational analysis of cavitation at the tongue of the volute of a centrifugal pump at overload conditions

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ABSTRACT

Volute pump is the most common used centrifugal pump. As cavitation highly contributes to deteriorating the performance of the pump, anti-cavitation performance is one of its design specifications. To clarify the cavitation evolution at the tongue of the volute of a centrifugal pump at overload conditions and its influence on the flow field in the impeller, numerical simulation with ANSYS CFD and a hydraulic test were conducted on a volute pump at several flow rates above optimal value. The cavity distribution and the blade loading distribution were analyzed. And the characteristics of the pressure fluctuation of the monitoring points located in volute casing were obtained and compared with each other. Results showed that cavitation may first emerge at the tongue rather than the impeller inlet at overload conditions. The alternative stress resulting from periodical radial force increases obviously as the extent of cavitation at the tongue. Meanwhile, the mean cavity length grows as each blade comes close to the tongue, and causes a decrease in performance because of a reduction or closure of flow passages. The pressure pulsation in the volute is consistent with the blade passing frequency whether cavitation occurs or not, while the pulsation intensity increases obviously after cavitation inception. From the first section to the eighth section of volute, the pulsation intensity of impeller outlet decreases gradually. The results are then compared to provide a reference for the optimum design of the anti-cavitation performance of centrifugal pump.

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ARTICLE INFO

Keywords:
Centrifugal pump;
Numerical simulation;
Computational fluid dynamics (CFD);
Tongue;
Cavitation;
Blade loading;
Pressure fluctuation

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Article history:
Received 18 August 2020
Revised 14 September 2020
Accepted 16 September 2020

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Računalniška analiza kavitacije na jezičku ohišja centrifugalne črpalke pri pogojih preobremenitve

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POVZETEK

Volutna črpalka je najpogostejše uporabljena centrifugalna črpalka. Ker kavitacija v veliki meri prispeva k poslabšanju delovanja črpalke, je protikavitacijska zmogljivost ena izmed njenih konstrukcijskih specifikacij. Da bi razjasnili razvoj kavitacije na jezičku ohišja centrifugalne črpalke pri preobremenitvi in njen vpliv na tokovno polje na impelerju, smo na volutni črpalki izvedli numerično simulacijo z ANSYS CFD in hidravlični preskus pri pretokih nad optimalno vrednostjo. Analizirana je bila porazdelitev votline med jezičkom in lopatico in porazdelitev obremenitve lopatic. Značilnosti nihanja tlaka so bile merjene v nadzornih točkah v ohišju črpalke in med seboj primerjane. Rezultati so pokazali, da se pri preobremenitvi kavitacija najprej pojavi na jezičku ohišja in ne na vstopu v impeler. Obremenitve, ki so posledica periodične radialne sile, se povečajo s povečanjem obsega kavitacije na jezičku. Ko se posamezna lopatica približa jezičku, povprečna dolžina votline narašča, kar povzroči zmanjšanje zmogljivosti črpalke zaradi zmanjšanja ali zapiranja pretočnih poti. Tlačna frekvenca v ohišju je skladna s frekvenco prehajanja lopatic ne glede na to, ali pride do kavitacije ali ne, medtem ko se intenzivnost tlaka po začetku kavitacije poveča. Od prvega do osmega odseka na ohišju se intenziteta tlaka na iztoku iz impelerja postopoma zmanjšuje. Rezultate smo primerjali in predstavili referenco za optimalno oblikovanje protikavitacijskih lastnosti centrifugalne črpalke.

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PODATKI O ČLANKU

Ključne besede:
Centrifugalna črpalka;
Numerična simulacija;
Računska dinamika tekočin (CFD);
Jeziček;
Kavitacija;
Obremenitev lopatic;
Nihanje tlaka

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Zgodovina članka:
Prejet 18. avgusta 2020
Popravljen 14. septembra 2020
Sprejet 16. septembra 2020