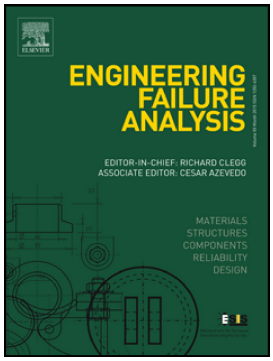

Numerical analysis of cavitation erosion and particle erosion in butterfly valve

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Numerical analysis of cavitation erosion and particle erosion in butterfly valve

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Abstract: The investigation of butterfly valve applied in the circulation water filtration system (CWF) of one pressurized water reactor (PWR) nuclear power station is performed in the paper. A coupling computational fluid dynamics model combined multiphase, cavitation and discrete phase model has been built to simulate the cavitation erosion and particle erosion. The validity and rationality of the coupling model is sufficiently verified with the experiment of flow coefficient and effects of different factors including inlet pressure and valve opening angle are discussed in detail. The results reveal that the erosion of butterfly valve mainly occurs at the forward and backward part of valve disc. With the increase of inlet pressure, max velocity, mass flow rate, wall shear stress, turbulent intensity and particle erosion would increase. Mass flow rate, wall shear stress, turbulent intensity and particle erosion decrease with the decrease of valve opening angle. The simulation results are well consistent with the failure feature of butterfly valve applied in actual operation. The numerical analysis is expected to improve the erosion condition and reliability of butterfly valve.

Keywords: Butterfly valve, Cavitation erosion, Particle erosion, Computational fluid dynamics (CFD).

1 Introduction

The circulating water filtration system (CWF) provides filtration water of essential service water system which cools the component of cooling system in the nuclear island, and is a nuclear safety related system (level 3). In the actual operation, the butterfly valve of CWF is encountered with severe erosion wear[1-2] frequently which can lead to functional failures, influence the cooling water supply and threaten the cool source safety of nuclear power station especially. Therefore, it is necessary to investigate the failure mechanism of butterfly valve, present effective preventive measures and improve operational security of CWF.

Erosion of butterfly valve is always a focus of concern for engineers and researchers [3-6], and erosion wear [7-10] is firmly one of the main failures for butterfly valves, which causes huge economic losses every year. Two main reasons causing erosion wear of butterfly valve are cavitation erosion [11-14] and particle erosion [15-16] which are also separately researched at present. Cavitation erosion and particle erosion coexist in the practical application [17] and should be taken into account in numerical simulation. It is not very accurate to only analyze the cavitation erosion or particle erosion. Meanwhile, considering cavitation erosion and particle erosion at the same time in numerical analysis is very rare and there is no relevant literature to study both erosions simultaneously at present. To accurately study the erosion wear of butterfly valve, it is necessary to research on the cavitation erosion and particle erosion of butterfly valve at the same time.

A type of butterfly valve applied in CWF of one pressurized water reactor (PWR) nuclear power station is chosen as research object. The cavitation erosion and particle erosion of butterfly valve is predicted by using the numerical method based on solid-liquid-gas three-phase flow theory and coupling erosion model. The validity and rationality of the coupling model is

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