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Flow Generation by Piezoelectric Fan near Side Wall

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Extended Abstract

A thin vibrating plate by piezoelectric materials can generate sufficient airflow to cool a heated surface, and this device is called a piezoelectric fan. Since Toda [1, 2] demonstrated the applicability of piezoelectric fans in cooling small electronic components, many researchers have tried to comprehend the underlying mechanism of the airflow generated by a piezoelectric fan. Kim et al. [3] measured the 2D unsteady flow around a wide piezoelectric fan using a high-resolution PIV (particle image velocimetry) technique and clearly showed the cyclic generation of counter-rotating vortices from the fan tip, where strong jets were formed between the counter-rotating vortices. Choi et al. [4] conducted 2D unsteady flow simulations around a piezoelectric fan and identified the pressure difference across the fan tip as a crucial factor in the formation of counter-rotating vortices. They also accurately predicted the moment when each vortex separates from the fan tip based on the pressure difference. Oh et al. [5-6] simulated the 3D flow around a piezoelectric fan confined with two end walls with hexahedral elements only, revealing a clear vortical structure around the fan. In a subsequent study, Ko et al. [7] evaluated the cooling effectiveness of a piezoelectric fan on a heated flat plate and found that the 3D vortical structure significantly affects the local heat transfer on the heated surface. This study is a continuation of the previous works and presents 3D unsteady numerical simulations to evaluate the effects of the side wall on the flow around a piezoelectric fan. It was observed that the jet flow generated by a piezoelectric fan adhered to a side wall when the wall was parallel to and sufficiently close to the fan. The jet flow from a piezoelectric fan differs from a continuous uniform jet in that it is formed between two counter-rotating vortices and its direction changes periodically. Unlike the continuous uniform jet, the Coanda effect in the jet flow from a piezoelectric fan is influenced by the side wall in two ways. Firstly, the side wall changes the pressure difference across the fan tip, causing the size of the vortex far from the wall to be larger than the size of the vortex near the wall. Secondly, the vortex near the wall interacts significantly with the wall and the wall friction weakens the vortex quickly. Consequently, the left and right movements of the jet flow do not cancel each other, leading to a bias in the overall direction of the jet flow.

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