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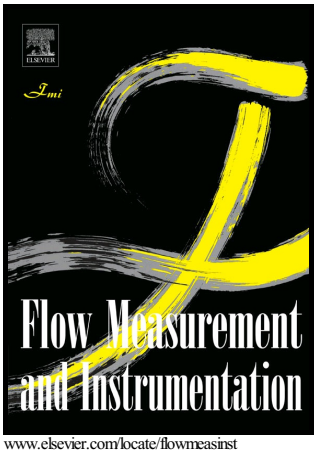

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Data fusion for integrated planar and cylindrical tomographic flame sensing

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ABSTRACT

Electrical capacitance tomography has unique advantages in combustion visualization, such as finding flames in opaque spaces and revealing the inner structure of the flames. However, the severe non-uniformity of the sensor sensitivity distribution is detrimental to the quality of the images over a large portion of the integral zone. To alleviate this problem, in this study an alternative sensing strategy integrating a circular planar electrode array with a cylindrical electrode assembly is proposed. Analyses of the 3D sensitivity maps show complementary properties of the new sensor, as by positioning the cylindrical sensor the combined sensitivity map can be more uniform and originally weak portion be enhanced. Meanwhile, a data fusion algorithm based on the Newton–Raphson method and expansion by Taylor series is derived to facilitate the integrated advantage of the two sensor assemblies. Simulations are performed and better images are produced by the new algorithm with the new sensor. Also data analysis shows that the error of the reconstructed image can be 50-60% smaller by the new method than a traditional sensor of the equal number of the electrodes. Experimental visualization of the flames is carried out and the data fusion algorithm applied to verify the new sensing strategy. The results demonstrate the effectiveness of such a strategy, as the whole length of the flames over the entire visualization zone, particularly up to 170mm, is well presented by the 3D images using the derived data fusion algorithm, which is in sharp contrast to the conventional 3D image methods without data fusion.

Keywords Electrical capacitance tomography, data fusion, 3D sensitivity maps, flame detection, image reconstruction

1. INTRODUCTION

Electrical capacitance tomography (ECT) is a branch of process tomography based on capacitance measurements. Its merits include fast response, low cost, easy implementation, non-intrusiveness, and the ability to reconstruct 2D or 3D parameter distributions. One of its most distinctive features is the capability of imaging flames in opaque spaces. ECT has been widely applied in process parameter measurement, such as phase distribution measurements in gas-liquid two-phase flows [1-3], flow pattern recognition and pneumatic conveying [4-6], fluidized bed visualization [7, 8], and flame visualization [9,10].

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