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Bunsen flame analysis using simultaneous tomographic images and PIV in the fresh and burnt gases.

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ABSTRACT

Particle Cross-correlation Image Velocimetry (PIV) technique, is used in order to measure simultaneously the instantaneous velocity field and the instantaneous flame front position with a high accuracy on laminar and low turbulent premixed flames stabilised at the exit of a Bunsen burner. The geometrical simplicity of those flames enables basic knowledge on laminar and turbulent combustion characteristics such as the flame speed, the curvature, the velocity field, and the flame stretch. A double seeding is required to determine precisely the flame front location and the instantaneous velocity field in the fresh and burnt gases. Indeed, when considering a tomographic image made with Zirconium oxide particles only, it is not possible to determine precisely the flame front location since the grey-level histogram does not show any threshold. Thanks to the use of incense smoke, the fresh gases area can be determined with accuracy. Flame contours are systematically extracted from the tomographic recordings using an automatic detection procedure of the threshold based on grey level histogram thresholding by index of fuzziness. Since the Zirconium oxide seeding density is sufficient for processing data both upstream and downstream the flame front position, the velocity field can be directly obtained. An improvement in the basic PIV technique is to separate the pair of PIV images according to the fresh and burnt gases since the flame contour position is determined with a high accuracy. Fresh and burnt gases are processed separately using a 'mask' in order to improve the accuracy of the PIV measurement. On top of that, this masking technique can reduce the influence of the measured velocity of the fresh gases, because the greater density of particle images on this side tends to dominate the correlation. The PIV calculation will be done in both regions, taking into account only the local phenomena and not the influence of the other side of the flame front. Thus, the local flame properties such the flame curvature, the flame speed and the flame stretch could be determined thanks to the coupling of the velocity field and the flame front location. That is why the accuracy and the simultaneousness in the measurements of the flame front location and the velocity field for both side of the flame are of first importance.