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Multi-mode Combustion Process Monitoring through Flame Imaging and Soft-computing

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Abstract for poster presentation

Reliable monitoring and diagnosis of combustion stability in combustion systems such as fossil-fuel fired boilers, gas turbines and combustion engines are crucial to maintain the system safety, combustion efficiency and low emissions, particularly under variable operation conditions. Considerable efforts have thus been made in developing techniques for online monitoring and diagnosis of the stability of a combustion process. Among those, flame imaging conjoined with image processing and soft computing techniques has been paid much attention for both laboratorial and industrial applications. Some imaging and soft computing techniques have been proposed for combustion state monitoring, but most of them can only detect a single-mode condition. However, modern combustion systems often operate under variable conditions (i.e., multi-mode process). Due to the dynamic nature of the combustion process, single-mode monitoring methods often mistakenly determine some normal combustion behaviours as abnormal ones. The recent trend of using a variety of fuels, including low quality coals, coal blends, and co-firing biomass and coal, has further deteriorated this issue.

In this study, a method based on flame imaging and soft-computing techniques for multi-mode combustion process monitoring is proposed. Flame images are acquired using a flame imaging system. Mean intensity values of RGB image components and texture descriptors are extracted and computed from the grey-level co-occurrence matrix. Such features are then used as inputs to a combined PCA-KSVM (principle component analysis-kernel support vector machine) model for multi-mode process monitoring. In this method, the PCA serves for eliminating the impact of noise and instabilities on the mode recognition. The KSVM identifies the combustion mode by using the scores of the features in the principle component subspace. Finally, two multivariate statistic indices, T^2 and SPE, are computed and used to assess the stabilities of the combustion process. The proposed approach has been examined by using flame images obtained on the UKCCSRC PACT 250kW PF (pulverised fuel) test rig under different operation conditions (e.g., variations in the primary air and secondary-territory air split). Test results have shown that the computed image features represent well the dynamic behaviours of the flame, and that the PCA-KSVM model has outperformed conventional methods in monitoring the multi-mode combustion process.

Keywords: pulverised fuel, flame imaging, monitoring, multi-mode process, flame stability, principle component analysis, kernel support vector machine

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