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論　文　内　容　要　旨

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学位論文題目	Study on Enhancements of Signal Profile Fitting Algorithms of CT -TDLAS for Temperature and Concentration Fields Measurements 温度・濃度分布計測におけるCT-TDLASの信号フィッティングアルゴリズムの高度化に関する研究		

内容要旨

CT (computed tomographic) – TDLAS (tunable diode laser absorption spectroscopy) is a non-intrusive diagnostic technique that allows for spatially resolved measurements of temperature and species concentration combustion fields such as burner, engine, gas turbine and furnace and so on. Also, temperature and concentration distribution on the cross-section of a combustion flame enable to analyze elaborately on the combustion phenomena. The purpose of this thesis is to optimize a reconstruction of temperature and H_2O number density distribution.

In this thesis, MART (multiplicative algebraic reconstruction technique) algorithm was chosen as calculation of data reconstruction. A performance of the ART (algebraic reconstruction technique) and MART algorithm was evaluated by using the burner experiment data. For the case of ART algorithm, the MSE (mean squared errors) was the smallest values when β (relaxation parameter) was set to 0.1. MSE was saturated within the iteration number 50. In case of MART algorithm, MSE was the smallest values when β was set to 0.5. MSE was saturated within the iteration number 10. A selection of initial value have influence on the performance of computed tomography during convergence calculation. MLOS (multiple line of sight) and PLOS (plus line of sight) methods were introduced to estimate an appropriate initial value. MLOS method was proposed to decide an initial value of algorithm.

It is important that more accurate theoretical broadening factors are investigated to make accurately the spectral fitting of theoretical and experimental absorption graphs. A flat plate burner can constantly maintain temperature of region passing a laser beam. An absorption experiment data would be ideally gathered under constant temperature conditions. A total of 3 times repeatability experiment at a range of 400K~700K similar to exhaust gas of engine was conducted. Changing of values collisional the broadening coefficient (γ_j) and coefficient of temperature dependence (n_j), fitting of graphs was calculated in the range of $0< \gamma_j <1$ and $0< n_j <1$. Reaching a minimum error of fitting, the selected broadening factors are finally $\gamma_j =0.16$, $n_j =0.37$. With using these factors, the calculation of the Voigh profile is used by Whiting.

Three new signal fitting algorithms, Two-Ratios of Three-Wavelength Fitting algorithm, Full-Profile Cross-Correlation algorithm and 6-Line-Profiles Fitting algorithm, were reported as a reconstruction of temperature and H_2O number density.

The methods of one-ratio method from two-wavelength (#1/#2) and two-ratio from three-wavelength (#1/#2, #1/#3) were calculated and compared. Two-ratio method was less a result of error rate than one-ratio method at virtual and experiment data. But this method gives unstable calculation convergence due to signal noise, bias error, and signal mis-matches because

of only using peak wavelength. Full-Profile Cross-Correlation method is to fit a spectral graph by using all wavelength. It was shown more stable calculation than Two-Ratios of Three-Wavelength Fitting algorithm methods. But the used wavelengths referred too much then needs during the curve fitting, temperature at the region of center seems not to be matched.

Full-Profile Cross-Correlation method was restricted when it was given information overload about wavelengths. 6-Line-Profiles Fitting Algorithm is to fit as LMS (Least mean squares) instead of template matching method and the selected 6 wavelengths which absorption intensity is strong are only utilized. A fundamentals concept is to fit by with n (number density) and α (absorption coefficient). These algorithms were theoretically investigated by using virtual data and experimentally demonstrated by utilizing the obtained engine experiments. The reconstructed 2D temperature and number density distributions are considerably matched at the virtual data of lower and high temperature region and also was shown good agreement with the thermocouple measurements of engine experiment. The relative error was 0048 at virtual of high temperature region and a performance was twice as good as J. Song et al. In conclusion, the performance of 6-Line-Profiles Fitting algorithm was best of all. Therefore, this method enables the real-time 2D temperature and species concentration measurement to be applicable in various fields.