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Prediction of Syngas yield from municipal solid waste in a fluidized bed gasifier- A novel approach

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The disposal of solid waste is an ever-increasing problem in the European Union (EU) and other developing countries. Since recent European legislation is trying to enforce a socially, environmentally and economically sustainable system, there are good reasons why feedlot manure and solid wastes should be addressed to thermal treatment. Incineration has been extensively used in EU and other developed countries for disposal and energy recovery from wastes. The problem associated with incinerator plants i.e. high operating cost, emission level and low energy efficiency has led researchers to exploit other thermochemical conversion process, indicating that gasification may offer a sustainable solution.

Gasification provides flexibility for the distributed energy generation and controlled particulate emissions, while converting biomass into useful energy. Taking into consideration the complexity involved with the gasification system, conducting experiments on a large scale gasifier is relatively expensive and time consuming. At the same time, simulating the municipal solid wastes is computationally expensive and fast meta-models are required.

In this study a multi-gene genetic programming (MGGP), a novel approach, has been proposed to predict the calorific value and yield of the produced gas from municipal solid wastes. The advantage of the MGGP based model was that it automatically evolves a mathematical expression in symbolic form. There were nine process parameters that have been used for model development.

The input parameters were carbon (x_1, wt%), hydrogen (x_2, wt%), nitrogen (x_3, wt%), sulphur (x_4, wt%), oxygen (x_5, wt%), moisture content (x_6, wt%), ash (x_7, wt%), equivalence ratio (x_8) and the temperature of the gasifier (x_9, T^0C). The output variables were lower heating value (kJ/Nm^3) (y_1) and gas yield (Nm^3/kg) (y_2). The equivalence ratio is defined as the ratio between the oxygen content in the oxidant supply and that required for complete stoichiometric combustion.
The experimental dataset were obtained from the published literature. The available datasets were randomly divided for training (70%) and testing (30%) purpose of the model. The accuracy of the model was tested against the literature datasets. The prediction accuracy of the model was in good agreement with the experiments. Figure 1 shows the variation explained (R^2) and root mean square error on the training and testing dataset. It can be evident that the prediction accuracy of solution B was excellent on the both training and testing datasets. It was concluded that MGGP models offer an alternative approach to currently available empirical modelling and data analysis approach. These models can be further exploited for the similar kind of gasification process.

Reference:

Pandey, D.S., Pan, I., Das, S., Leahy, J.J., Kwapinski, W. (2015): Multi-gene genetic programming based predictive models for municipal solid waste gasification in a fluidized bed gasifier. Bioresource Technology. Volume 179, 524-533.

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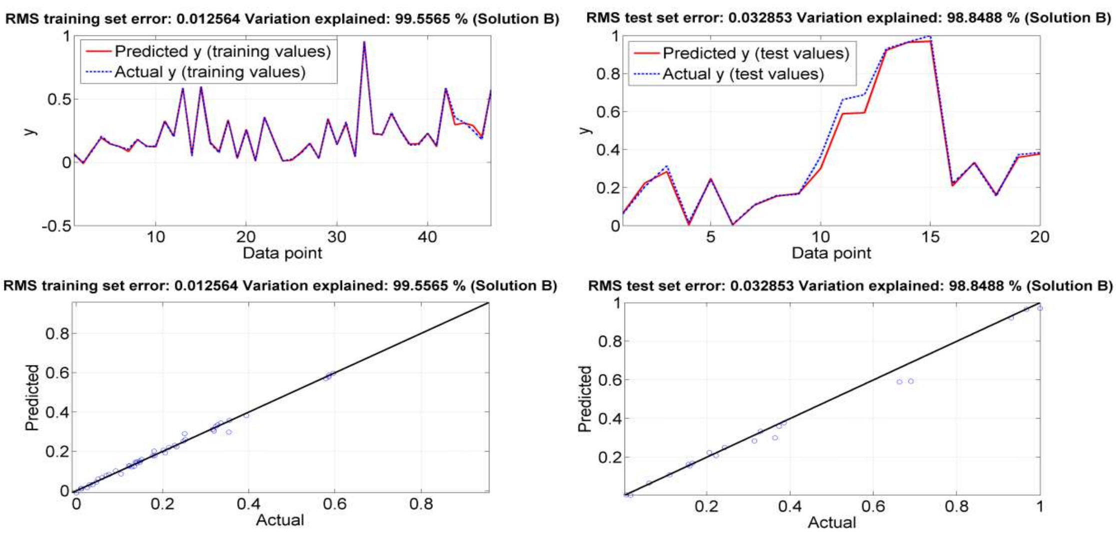

Figure 1. Prediction results with MGGP (Solution B) on the training and the testing dataset for Syngas yield production