Multi-objective optimization of operational variables in a waste incineration plant
Anderson et al. (2005)

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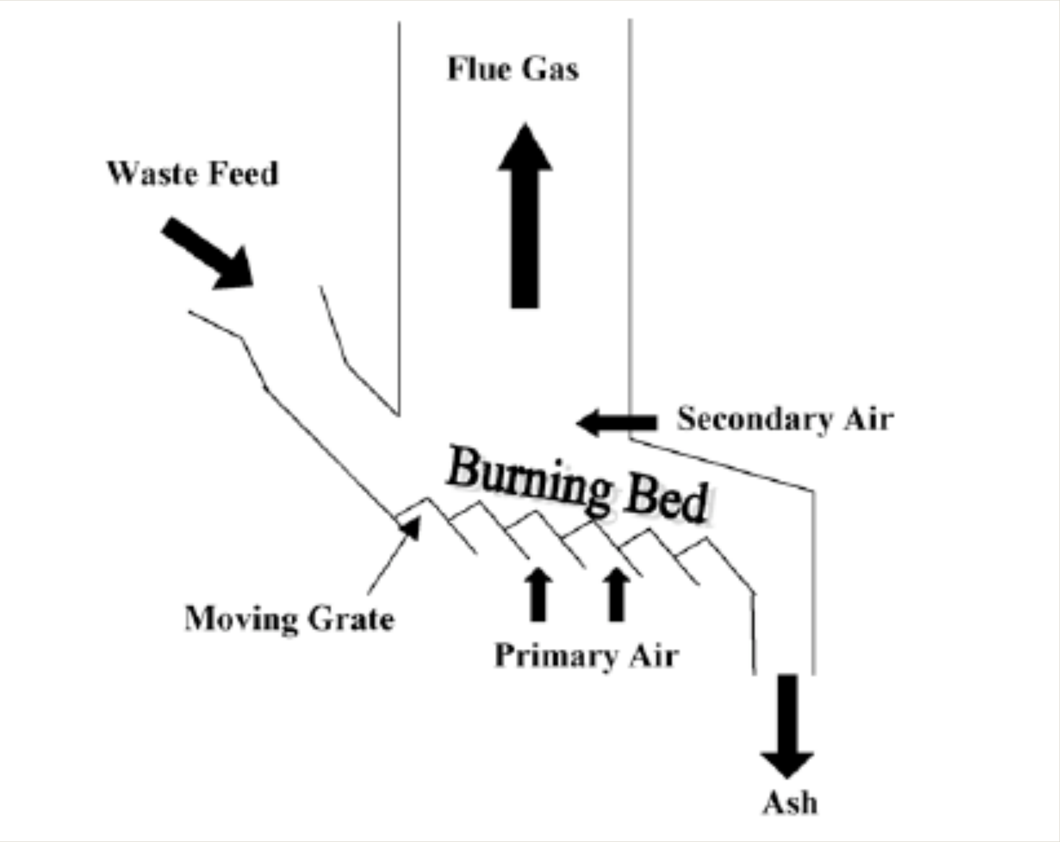
Overview

- Description of real life problem
- Motivation for choosing a multiple objective model
- Multiple objective model (decision variables, objectives, constraints)
- Technique used to solve the problem
- Analysis of results
- Opinion about the proposed model and solution approach

Description of the real life problem

- We consider a waste incineration plant
- Input : Waste (cardboard, wood, glass, food wastes and tin cans) and air
- Output : Ash (Char) and flue gases (COx, NOx and SOx)



Motivation for choosing a multiple objective model

- Primary objective for the waste incineration plant is to maximize throughput (Economic performance).
    - Environmental and operational concerns are violated.
    - Necessary to minimize environmental and operational concerns and still maximize throughput.
    - This leads to multi-objective model.

Multi-objective model

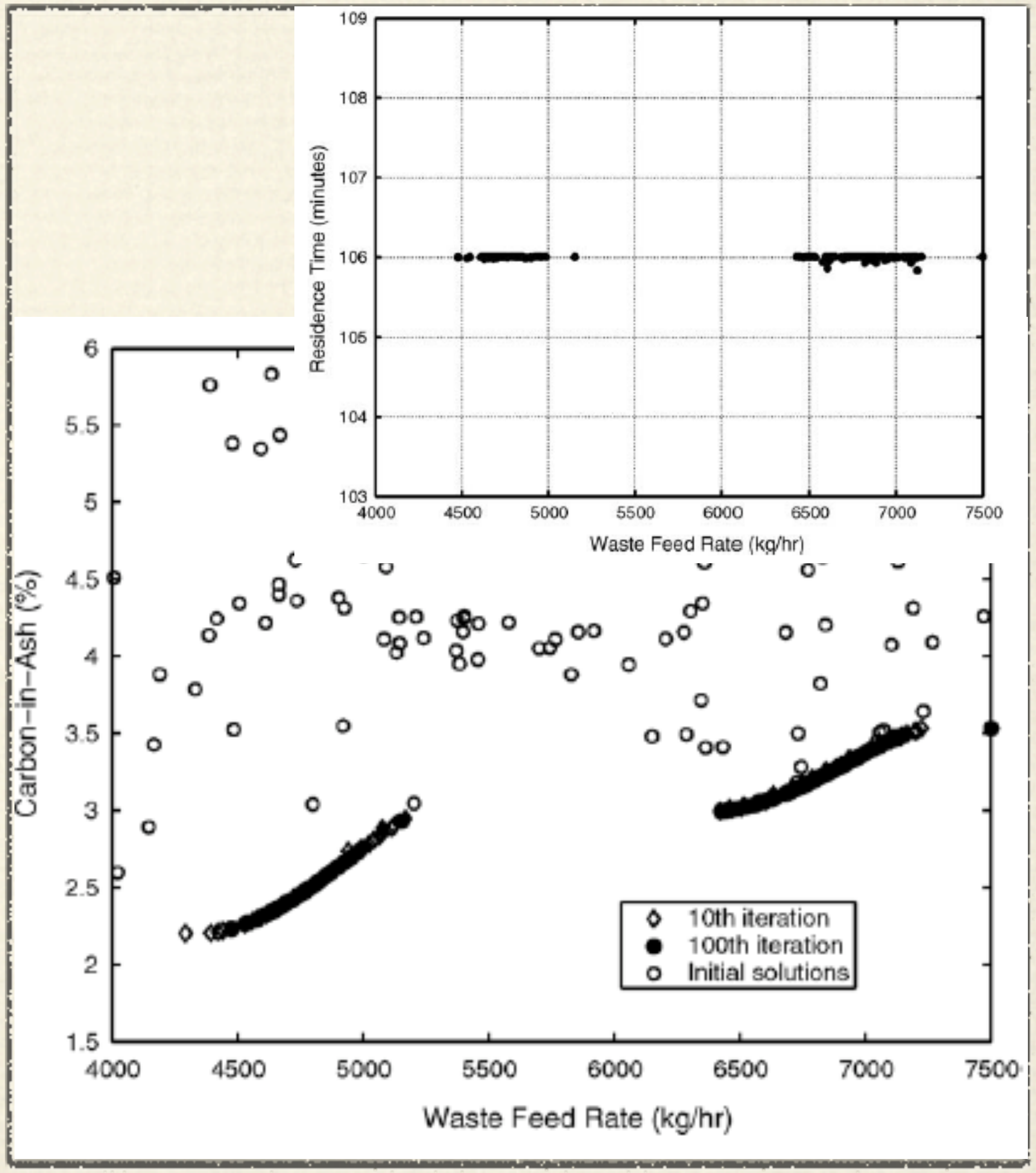
- Decision variables: Waste feed rate (x1), residence time (x2).
- Objectives:
  - Maximize waste feed rate, f1(x1).
  - Minimize carbon-in-ash, f2(x1,x2).
- Constraints:
  - Temperature constraints.

Technique used to solve the problem

- Multi-objective Genetic Algorithm (MOGA) proposed by Fonseca and Fleming (1998) used as optimizer.
- FLIC (FLuid dynamic Incinerator Code) used to generate data for the Radial Basis Function Network (RBFN)
  - FLIC simulator may be computationally expensive to use.

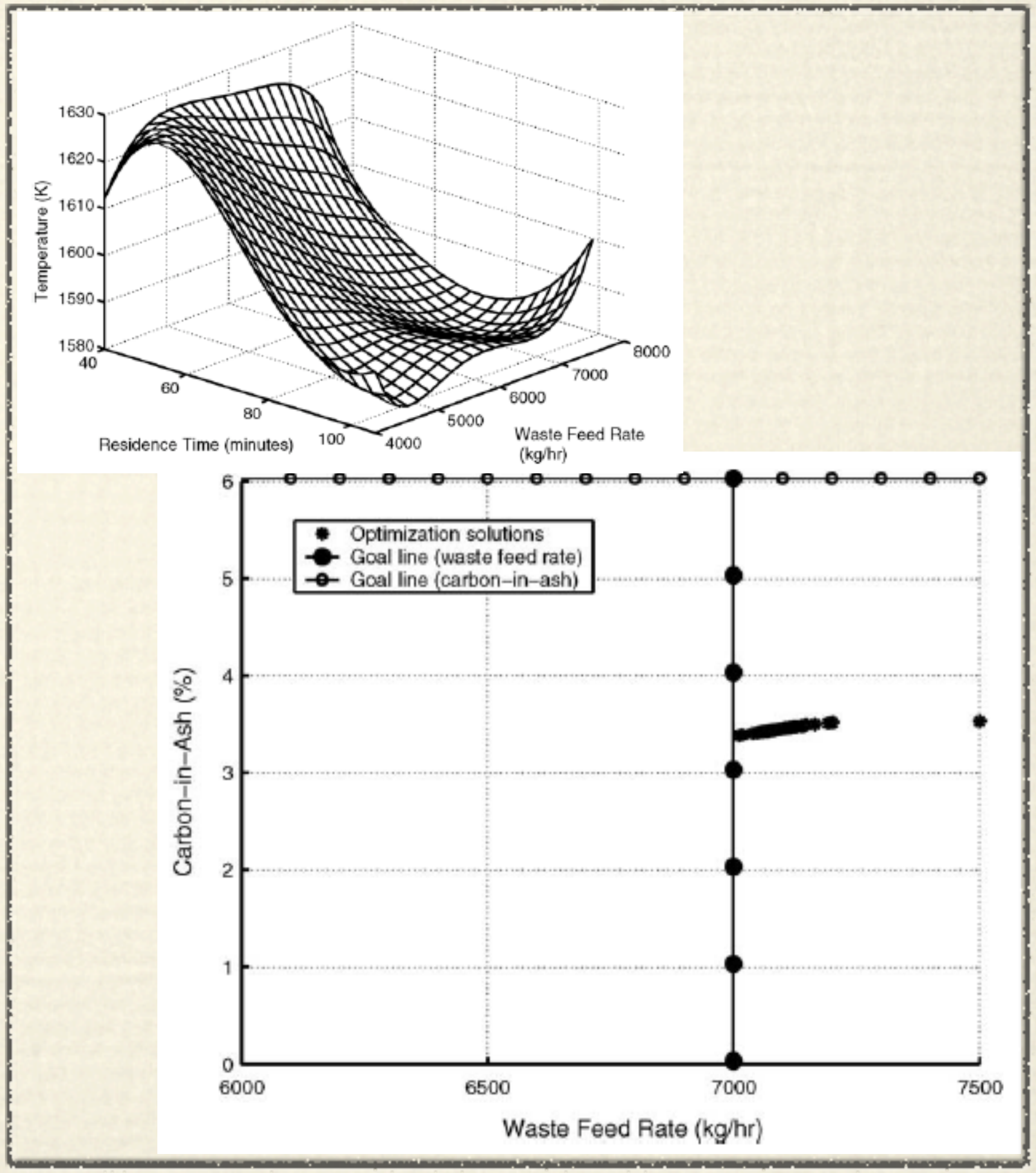
Analysis of the Results

- Parameters for MOGA are set heuristically.
- A large population is used to cover the whole Pareto front.
- Swift Convergence.
- Residence time reaches upper bound for all Pareto solutions.



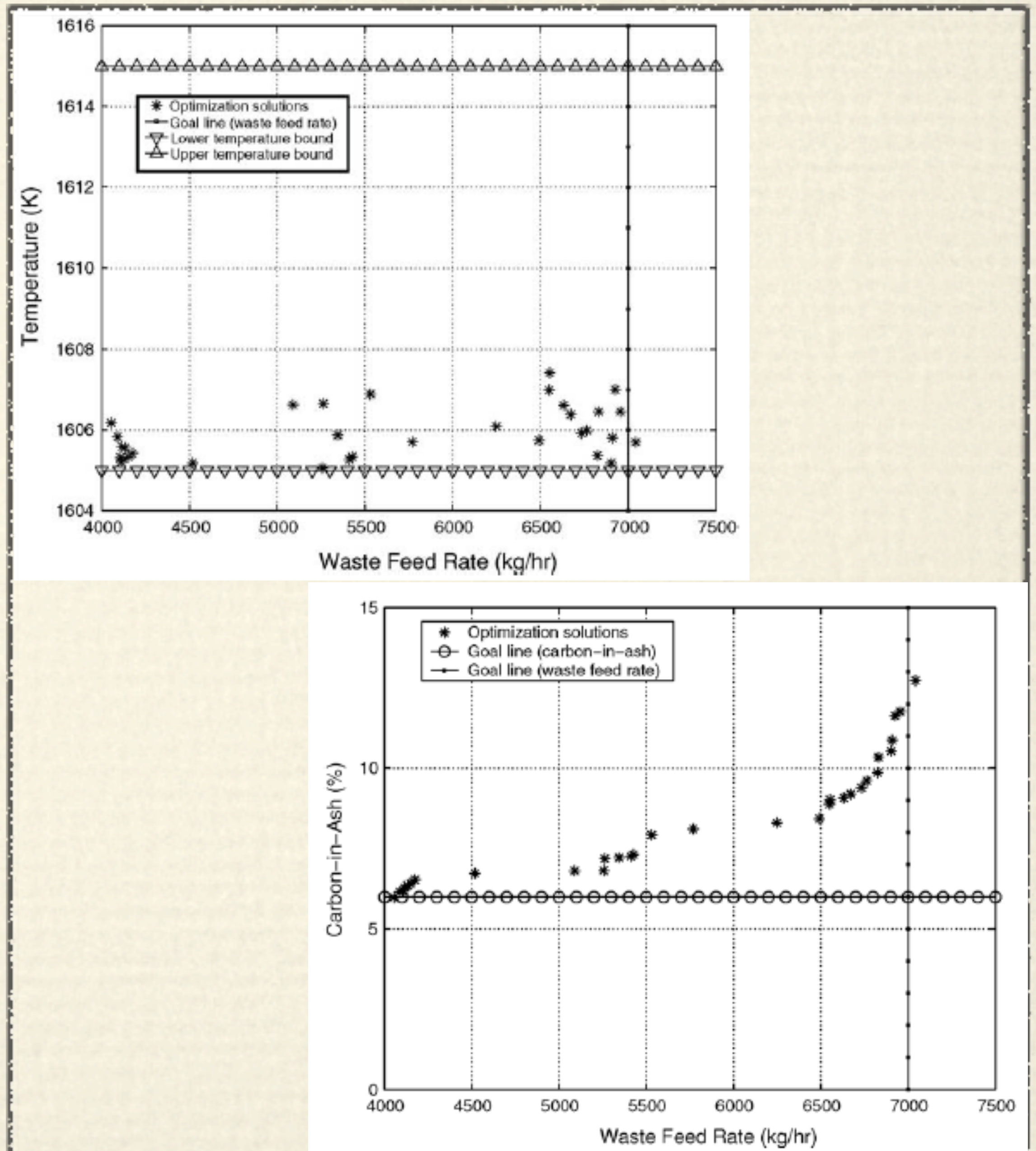
Analysis of Results (Contd.)

- Goals values fixed:
  - Waste feed rate ≥ 7000 kg/hr.
  - Carbon-in-ash ≤ 6%.
  - Objectives have same priority.
- High feed rate and residence time, the temperature increases and hence better combustion.



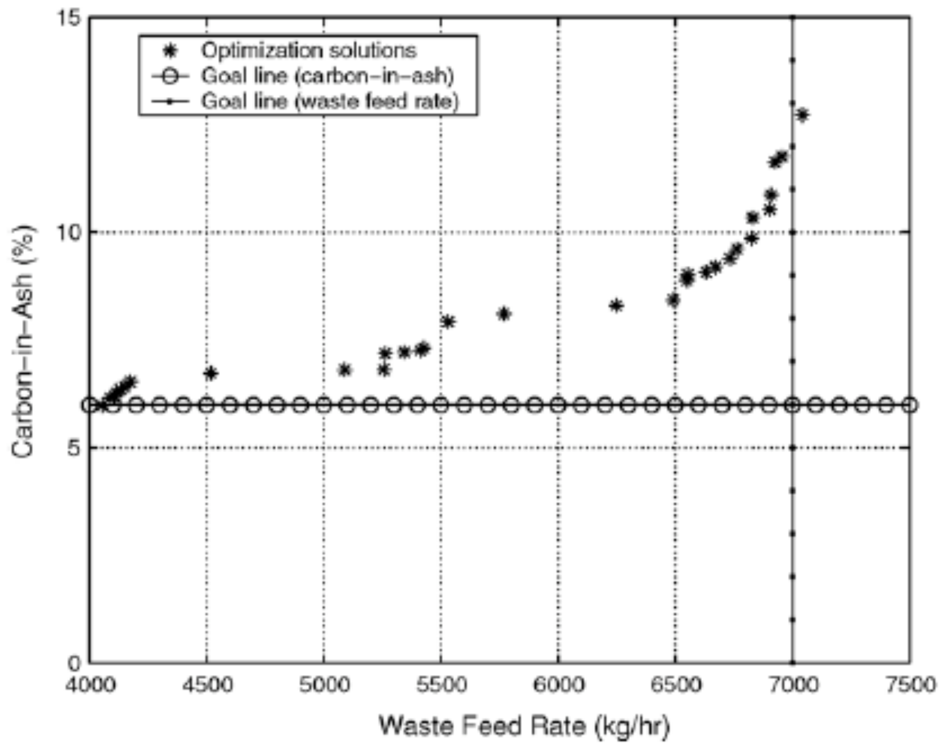
Analysis of Results (Contd.)

- Additional temperature constraints
  - 1605<T(K)<1615
- Front does not cross the preferred region
  - Temperature too low for area of operation.

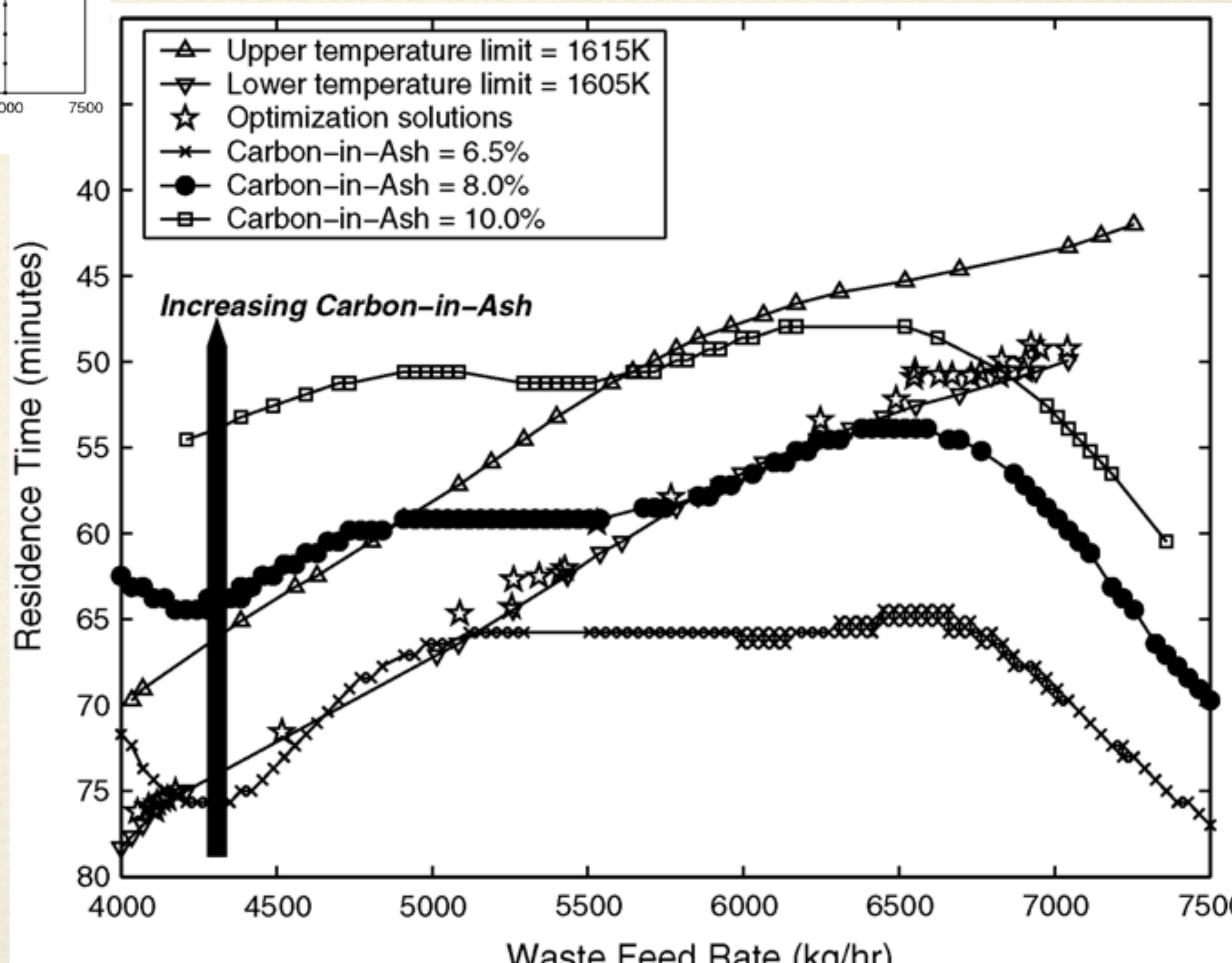


Analysis of Results (Contd.)

- Between 6500 kg/hr and 7000 kg/hr - steep increase in carbon-in-ash feed rates.
  - Low residence time and high feed rate.
- Between 4000 kg/hr and 6500 kg/hr - small penalty increasing carbon-in-ash



Optimization solutions
Goal line (carbon-in-ash)
Goal line (waste feed rate)
Carbon-in-Ash (%)
Waste Feed Rate (kg/hr)



Upper temperature limit = 1615K
Lower temperature limit = 1605K
Optimization solutions
Carbon-in-Ash = 6.5%
Carbon-in-Ash = 8.0%
Carbon-in-Ash = 10.0%
Increasing Carbon-in-Ash
Residence Time (minutes)
Waste Feed Rate (kg/hr)

Opinion about the proposed model and solution approach

- Positive opinions :
  - Paper considers a practical optimization problem and finds a entire Pareto front for decision making and learning.
  - Modeling the problem based only on most important inputs, and considering others as constant.
    - Important when we study practical problems.
  - Preference information used inside MOGA.
- Negative opinions:
  - Pareto-optimality defined for min-min and problem considered as min-max.
  - Improper training of RBF network.
  - Too much emphasis on the RBF model during analysis.
  - High RMSE error for RBFN.
  - The discontinuous part of Pareto front is considered as a set of weakly Pareto optimal solutions.

Thank you